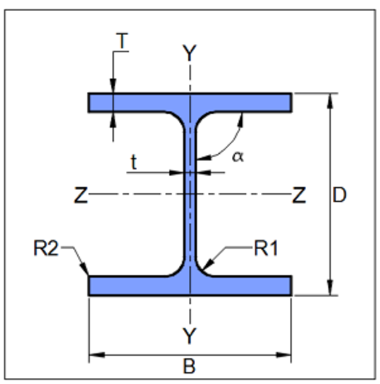
		Created with	
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	Base Plate Connection
Designer	Engineer #1	Job Number	1.3.2.1
Date	18 /12 /2020	Client	S R Satish Kumar, Professor, IIT Madras

1 Input Parameters

Main Module	Moment Connection
Module	Base Plate
Connectivity	Moment Base Plate
End Condition	Fixed
Axial Compression (kN)	900.0
Axial Tension/Uplift (kN)	27.0
Shear Force (kN)	
- Along major axis (z-z)	85.0
- Along minor axis (y-y)	12.0
Bending Moment (kNm)	
- Major axis (M_{z-z})	123.0
- Minor axis (M_{y-y})	0.0

Column Section - Mechanical Properties



Column Section		PBP 400 X 140.2	
Material		E 350 (Fe 490)	
Ultimate Strength, f_u (MPa)		490.0	
Yield Strength, f_y (MPa)		350.0	
Mass, m (kg/m)	140.2	I_z (cm^4)	40200.0
Area, A (cm^2)	178.0	I_y(cm^4)	16000.0
None	None	r_z (cm)	15.0
D (mm)	352.0	r_y (cm)	9.5
B (mm)	392.0	Z_z (cm^3)	2280.0
T (mm)	16	Z_y (cm^3)	820.0
t (mm)	16.0	Z_{pz} (cm^3)	2540.0
Flange Slope	90	Z_{py} (cm^3)	1250.0
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)	230

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)	['M24', 'M30']
Property Class	['12.9']
Anchor Bolt Type	End Plate Type
Anchor Bolt Galvanized?	Yes
Designation	M24X559.7 IS5624 GALV
Hole Type	Over-sized
Total Length (mm)	559.7
Material Grade, f_u (MPa)	1220.0
Anchor Bolt Inside Column Flange - Input and Design Preference	
Diameter (mm)	['M20', 'M24']
Property Class	['8.8', '9.8']
Anchor Bolt Type	End Plate Type
Anchor Bolt Galvanized?	Yes
Designation	M20X409.5 IS5624 GALV
Hole Type	Over-sized
Total Length (mm)	409.5
Material Grade, f_u (MPa)	830.0
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	Elastic Analysis Method

2 Design Checks

Design Status	Pass

2.1 Design Parameters

Check	Required	Provided	Remarks
Bearing Strength of Concrete (N/mm^2)		$\sigma_{br} = 0.45 fck$ $= 0.45 \times 30$ $= 13.5$ $[Ref.\ IS\ 456:2000,\ Cl.\ 34.4]$	**OK**
Grout Thickness (mm)		t_g = 50	**OK**
Modular Ratio		$E_s = 2 \times 10^5\ (N/mm^2)$ $E_c = 5000\ \sqrt{f_{ck}}\ (N/mm^2)$ $= 5000\ \times \sqrt{30}\ =\ 27386.128$ $n = \frac{E_s}{E_c}$ $n = \frac{200000}{27386.128}$ $= 7.303$ $[Ref.\ IS\ 800:2007,\ IS\ 456:2000]$	**OK**
Epsilon - stiffener plate		$\epsilon_{st} = \sqrt{\frac{250}{fy_{st}}}$ $= \sqrt{\frac{250}{250}}$ $= 1.0$ $[Ref.\ IS\ 800:2007,\ Table\ 2]$	**OK**

2.2 Load Consideration

Check	Required	Provided	Remarks
Axial Compression (kN)	$P_x = 900.0$	$P_u = max(P_x,\ 0.3P_d),\ but,\ \leq P_d$ $= max(900.0,\ 0.3 \times 5663.64)$ $= max(900.0,\ 1699.09)$ ≤ 5663.64 $= 1699.09$ $[Ref. IS\ 800:2007, Cl.\ 10.7]$ $Note:\ P_d\ is\ the\ design\ axial\ capacity\ of\ the\ column$	Pass
Axial Tension/Uplift (kN)		$P_{up} = 27.0$	OK
Shear Force - along major (z-z) axis (kN)	$V_d = 564.33$	$V_1 = 85.0$	Pass
Shear Force - along minor (y-y) axis (kN)	$V_d = 564.33$	$V_2 = 12.0$	Pass
Bending Moment - major (z-z) axis (kNm)	$M_z = 123.0$	$M_{z\,min} = 0.5 * M_{d\,z-z}$ $= 0.5 \times 808.18$ $= 404.09$ $M_{u\,zz} = max(M_z,\ M_{z\,min}),\ but, \leq M_{d\,z-z}$ $= max(123.0,\ 404.09)$ ≤ 808.18 $= 404.09$ $Note: The\ column\ is\ classified\ as\ compact$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	Pass

Check	Required	Provided	Remarks
Interaction Ratio	IR < 1.0	$IR,\ axial = P_x/P_d = 900.0/5663.64 = 0.159$ $IR,\ moment = M_z/M_{dzz} = 123.0/808.18 = 0.152$ $IR,\ sum = IR,\ axial + IR,\ moment = 0.159 + 0.152 = 0.311$	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

2.4 Plate Washer and Nut Details - Anchor Bolt Inside 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**

2.5 Anchor Bolt Summary - Outside Column Flange

Check	Required	Provided	Remarks
Diameter (mm)		30	**Pass**
Number of Bolts		$n_{out} = 4$	**Pass**
Property Class		12.9	**Pass**

2.6 Anchor Bolt Summary - Inside Column Flange

Check	Required	Provided	Remarks
Diameter (mm)		20	**Pass**
Number of Bolts		$n_{in} = 2$	**Pass**
Property Class		8.8	**Pass**

2.7 Detailing Checks - Outside Column Flange

Check	Required	Provided	Remarks
Min. End Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 30.0$ $= 45.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	90	**Pass**
Max. End Distance (mm)	$e_{max} = 40 + 4t$ $Where, t = min(75, 75)$ $= 40 + (4 \times 75)$ $e_{max} = 340.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	90	**Pass**
Min. Edge Distance (mm)	$e'_{min} = 1.5\ d_0$ $= 1.5 \times 30.0$ $= 45.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	90	**Pass**
Max. Edge Distance (mm)	$e'_{max} = 40 + 4t$ $Where, t = min(75, 75)$ $= 40 + (4 \times 75)$ $e'_{max} = 340.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	90	**Pass**
Min. Pitch Distance (mm)	N/A	0.0	**N/A**
Max. Pitch Distance (mm)	N/A	0.0	**N/A**

2.8 Detailing Checks - Inside Column Flange

Check	Required	Provided	Remarks
Min. End Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 24.0$ $= 36.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	45	Pass
Max. End Distance (mm)	$e_{max} = 40 + 4t$ $Where, t = min(75, 75)$ $= 40 + (4 \times 75)$ $e_{max} = 340.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	45	Pass
Min. Edge Distance (mm)	$e'_{min} = 1.5\ d_0$ $= 1.5 \times 24.0$ $= 36.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2]$	45	Pass
Max. Edge Distance (mm)	$e'_{max} = 40 + 4t$ $Where, t = min(75, 75)$ $= 40 + (4 \times 75)$ $e'_{max} = 340.0$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	45	Pass

2.9 Base Plate Dimension (L X W)

Check	Required	Provided	Remarks
Length (mm)	$L = D\ +\ 2\ (e\ +\ e)$ $= 352.0\ +\ 2 \times (90\ +\ 90)$ $= 712.0$ $[Ref.\ based\ on\ detailing\ requirement]$	715	Pass

Check	Required	Provided	Remarks
Width (mm)	$W = (0.85B) + 2\ (e' + e')$ $= (0.85 \times 392.0) + 2 \times (90 + 90)$ $= 693.2$ $[Ref.\ based\ on\ detailing\ requirement]$	695	**Pass**

2.10 Base Plate Analysis

Check	Required	Provided	Remarks
Eccentricity - about major axis (mm)		$e_{zz} = \frac{M_{uzz}}{P_u}$ $= \frac{404.09 \times 10^6}{1699.09 \times 10^3}$ $= 237.83$	**OK**
Base Plate Type	$e_{zz} \geq \frac{L_{min}}{3}$ $237.83 \geq \frac{712.0}{3}$ $237.83 \geq 237.33$	Case 3: A smaller part of the base plate is under compression/bearing while a large tension force being transferred through the anchor bolts outside column flange on the tension side	**OK**
k1	$k_1 = 3 \left(e_{zz} - \frac{L}{2}\right)$ $= 3 \left(237.83 - \frac{715}{2}\right)$ $= -359.01$ $[Ref.\ Design\ of\ Welded\ Structures$ $-\ Omer\ W\ Blodgett\ , section\ 3.3]$		**OK**
Total Area of Anchor Bolt - under tension (mm^2)	$A_s = n \times \left(\frac{\pi}{4}\right)\ d^2$ $= 2 \times \left(\frac{\pi}{4}\right)\ \times 30^2$ $= 1414.0$		**OK**

Check	Required	Provided	Remarks
Lever Arm - distance between the centre of the column and the C.G of the bolt group under tension (mm)	$f = \left(\frac{L}{2} - e\right)$ $= \left(\frac{715}{2} - 90\right)$ $= 267.5$ $[Ref.\ Design\ of\ Welded\ Structures$ $-\ Omer\ W\ Blodgett\ ,section\ 3.3]$		**OK**
k2	$k_2 = \frac{6\ n\ A_s}{W}\left(f\ +\ e_{zz}\right)$ $= \frac{6\ \times 7.303\ \times 1414.0}{695} \times \left(267.5\ +\ 237.83\right)$ $= 45049.73$ $Note:\ n\ is\ the\ modular\ ratio$ $[Ref.\ Design\ of\ Welded\ Structures$ $-\ Omer\ W\ Blodgett\ ,section\ 3.3]$		**OK**
k3	$k_3 = -\ k_2\left(\frac{L}{2}\ +\ f\right)$ $= -\ 45049.73\left(\frac{715}{2}\ +\ 267.5\right)$ $= -28156081.25$ $[Ref.\ Design\ of\ Welded\ Structures$ $-\ Omer\ W\ Blodgett\ ,section\ 3.3]$		**OK**
Effective Bearing Length (mm)	$y^3\ +\ k_1\ y^2\ +\ k_2\ y\ +\ k_3 = 0$ $y^3\ - 359.01 \times y^2\ + 45049.73 \times y\ - 28156081.25 = 0$ $y = 414.0$ $[Ref.\ Design\ of\ Welded\ Structures$ $-\ Omer\ W\ Blodgett\ ,section\ 3.3]$		**OK**

Check	Required	Provided	Remarks
Total Tension Demand (kN)	$P_t = -P_u \left[\frac{\frac{L}{2} - \frac{y}{3} - e_{zz}}{\frac{L}{2} - \frac{y}{3} + f}\right]$ $= -1699.09 \times \left[\frac{\frac{715}{2} - \frac{414.0}{3} - 237.83}{\frac{715}{2} - \frac{414.0}{3} + 267.5}\right]$ $= 63.95$ $[Ref.\ Design\ of\ Welded\ Structures$ $-\ Omer\ W\ Blodgett\ , section\ 3.3]$		**OK**
Critical Section - compression side (mm)	$y_{critical} = \frac{L - 0.95D}{2}$ $= \frac{715 - (0.95 \times 352.0)}{2}$ $= 190.3$ $y\ >\ y_{critical}\quad (414.0\ >\ 190.3)$ $Therefore,\ y_{critical} = 190.3$ $Note: The\ critical\ section\ lies\ at$ $0.95D\ of\ the\ column\ section$		**OK**
Bending Moment - at critical section (due to bearing stress) $(N-mm)$	$M_{critical\,1} = 0.45 f_{ck} W y_{critical} \times \left(\frac{y_{critical}}{2}\right)$ $= 0.45 \times 30.0 \times 695 \times 190.3 \times \left(\frac{190.3}{2}\right)$ $= 169.89 \times 10^6$		**OK**
Lever Arm - distance between center of the flange and bolt group (tension side) (mm)	$l = \frac{L}{2} - \frac{D}{2} + \frac{T}{2} - e$ $= \frac{715}{2} - \frac{352.0}{2} + \frac{16}{2} - 90$ $= 99.5$		**OK**
Bending Moment - at critical section (due to tension in the anchor bolts) $(N-mm)$	$M_{critical\,2} = P_t\ l$ $= 63.95 \times 1000 \times 99.5$ $= 6.36 \times 10^6$		**OK**

Check	Required	Provided	Remarks
Maximum Bending Moment $(N-mm)$	$M_{critical} = max\left(M_{critical1},\ M_{critical2}\right)$ $= max\left(169.89\times10^6,\ 6.36\times10^6\right)$ $= 169.89\times10^6$	Bending of the base plate is governed by the bearing stress caused by the footing	OK
Moment Capacity of Base Plate	$z_{eplate} = \dfrac{W{t_p}^2}{6}$ $M_{dplate} = 1.5 z_{eplate} f_{y_p}\ /\ \gamma_{m0}$ $= \dfrac{1.5\left(\frac{W\times t_p^2}{6}\right) f_{y_p}}{\gamma_{m0}}$ $[Ref.\ IS\ 800:2007,\ Cl.8.2.1.2]$		OK
Thickness of Base Plate (mm)	$t < t_p \leq 120$ $16 < t_p \leq 120$	$M_{dplate} = M_{critical}$ $t_p = \left[\dfrac{4\ M_{critical}}{W\ (f_{y_p}/\gamma_{m0})}\right]^{0.5}$ $t_p = \left[\dfrac{4\ \times169.89\times10^6}{695\times\ (250/1.1)}\right]^{0.5}$ $= 65.59$ $= 75$	Pass
Maximum Bearing Stress on Footing (N/mm^2)	$\sigma_{c_{allowable}} = \sigma_{br}$ $= 13.5$	$\sigma_{c_{max}} = \dfrac{P_t\ y}{A_s\ n\left(\frac{L}{2}-y+f\right)}$ $= \dfrac{63.95\times10^3\times414.0}{1414.0\times7.303\times\left\|\left(\frac{715}{2}-414.0+267.5\right)\right\|}$ $= 12.15$	Pass

2.11 Anchor Bolt Design - Outside Column Flange

Check	Required	Provided	Remarks
Shear Capacity (kN)		$V_{dsb} = \dfrac{f_{ub}\ n_n\ A_{nb}}{\sqrt{3}\ \gamma_{mb}}$ $= \dfrac{1220.0\times1\times561}{1000\times\sqrt{3}\ \times\ 1.25}$ $= 316.12$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3]$	OK

Check	Required	Provided	Remarks
Kb		$k_b = min\left(\frac{e}{3d_0}, \frac{f_{ub}}{f_u}, 1.0\right)$ $= min\left(\frac{90}{3 \times 30.0}, \frac{1220.0}{490.0}, 1.0\right)$ $= min(1.0, 2.49, 1.0)$ $= 1.0$ $[Ref\ IS\ 800:2007,\ Cl.\ 10.3.4]$	**OK**
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5\ k_b\ d\ t\ f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 1.0 \times 30 \times 75 \times 410}{1000 \times 1.25}$ $= 1457.54$ $= 0.7 \times 1457.54$ $= 1020.28$ $Note:\ The\ bearing\ capacity\ is\ reduced$ $since\ the\ hole\ type\ is\ Over-sized$ $or\ Short-slotted$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.4]$	**OK**
Bolt Capacity (kN)		$V_{db} = min\ (V_{dsb}, V_{dpb})$ $= min\ (316.12, 1020.28)$ $= 316.12$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.2]$	**OK**
Tension Demand - per anchor bolt (kN)	$T_b = \frac{P_t}{n_{out}/2}$ $= \frac{63.95}{4/2}$ $= \frac{63.95}{2}$ $= 31.98$	$T_{db} = 0.90\ f_{ub}\ A_n\ /\ \gamma_{mb}$ $<\ f_{yb}\ A_{sb}\ (\gamma_{mb}\ /\ \gamma_{m0})$ $= min\Big(0.90\ \times 1220.0 \times 561\ /\ 1.25,$ $1100.0 \times 707 \times (1.25/1.1)\Big)$ $= min(492.78,\ 883.75)$ $= 492.78$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.5]$	**Pass**

Check	Required	Provided	Remarks
Anchor Length - above concrete footing (mm)		$l_1 = t_g + t_p + t_w + t_n + 20$ $= 50 + 75 + 8.5 + 25.6 + 20$ $= 179.1$	Pass
Anchor Length - below concrete footing (mm)		$l_2 = \left[\frac{T_{db}}{15.5\sqrt{f_{ck}}}\right]^{0.67}$ $= \left[\frac{492.78 \times 10^3}{15.5 \times \sqrt{30.0}}\right]^{0.67}$ $= 332.44$ $= 335$ $= max(335,\ 320)$ $= 335$ $= 335 + t_n + 20$ $= 335 + 25.6 + 20$ $= 380.6$ $[Reference:\ Design\ of\ Steel\ Structures$ $-\ N.Subramanian,\ (2019\ edition),$ $Chapter\ 15,\ Example\ 15.5]$	Pass
Anchor Length - total (mm)	$320 \leq\ l_a\ \leq 2000$ $[Reference:\ IS\ 5624:1993,\ Table\ 1]$	$l_a = l_1 + l_2$ $= 179.1 + 380.6$ $= 559.7$	Pass

2.12 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)	$P_{uplift} = 27.0$		**OK**

Check	Required	Provided	Remarks
Tension Capacity (kN)		$T_{db} = 0.90\ f_{ub}\ A_n\ /\ \gamma_{mb}$ $<\ f_{yb}\ A_{sb}\ (\gamma_{mb}\ /\ \gamma_{m0})$ $= min\Big(0.90\ \times 830.0 \times 245\ /\ 1.25,$ $660.0 \times 314 \times (1.25/1.1)\Big)$ $= min(146.41,\ 235.5)$ $= 146.41$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.5]$	**OK**
Anchor Bolts Required (kN)	$n_{in} = \frac{P_{uplift}}{T_{db}}$ $= \frac{27.0}{146.41}$ $= 0.18$	2	**Pass**
Anchor Length - above concrete footing (mm)		$l_1 = t_g\ +\ t_p\ +\ t_w\ +\ t_n\ +\ 20$ $= 50\ +\ 75\ +\ 8.5\ +\ 18.0\ +\ 20$ $= 171.5$	**Pass**
Anchor Length - below concrete footing (mm)		$l_2 = \left[\frac{T_{db}}{15.5\sqrt{f_{ck}}}\right]^{0.67}$ $= \left[\frac{146.41 \times 10^3}{15.5 \times \sqrt{30.0}}\right]^{0.67}$ $= 147.43$ $= 150$ $= max(150,\ 200)$ $= 200$ $= 200 + t_n + 20$ $= 200 + 18.0 + 20$ $= 238.0$ $[Reference:\ Design\ of\ Steel\ Structures$ $-\ N.Subramanian,\ (2019\ edition),$ $Chapter\ 15,\ Example\ 15.5]$	**Pass**

Check	Required	Provided	Remarks
Anchor Length - total (mm)	$200 \leq \ l_a \ \leq 800$ $[Reference: \ IS\ 5624:1993, \ Table\ 1]$	$l_a = l_1 \ + \ l_2$ $= 171.5 \ + \ 238.0$ $= 409.5$	**Pass**

2.13 Stiffener Design - Along Column Flange

Check	Required	Provided	Remarks
Length of Stiffener (mm)		$L_{stf} = \dfrac{W - B}{2}$ $= \dfrac{695 - 392.0}{2}$ $= 151.5$ $[Ref.\ based\ on\ detailing\ requirement]$	**OK**
Height of Stiffener (mm)		$H_{stf} = L_{stf} \ + \ 50$ $= 151.5 \ + \ 50$ $= 201.5$	**OK**
Thickness of Stiffener (mm)	$t_{stf} = \left(\dfrac{L_{stf}}{13.6 \times \epsilon_{st}}\right) \geq T$ $= max\left(\left(\dfrac{151.5}{13.6 \times 1.0}\right), \ 16\right)$ $= max(11.14, 16)$ $Note: \ The\ stiffener\ is\ assumed$ $to\ be\ semi-compact$ $[Ref.\ IS\ 800:2007, \ Table\ 2]$	25	**Pass**
Stress (average) at Stiffener (N/mm^2)	$= \sigma_{callowable}$ $= 13.5$	$Since, \ y > y_{critical} \quad (414.0 > 190.3)$ $\sigma_{stf} = \dfrac{\sigma_{cmax}}{2}$ $= \dfrac{12.15}{2}$ $= 6.08$	**Pass**

Check	Required	Provided	Remarks
Shear on Stiffener (kN)	$V_{stf} = \sigma_{stf} \left(y \times L_{stf} \right)$ $= 6.08 \times \left(414.0 \times 151.5 \right) \times 10^{-3}$ $= 381.344$	$V_{df} = \frac{A_{vg}\ f_{y\,st}}{\sqrt{3}\ \gamma_{m0}}$ $= \frac{(H_{stf} \times t_{stf}) f_{y\,st}}{\sqrt{3}\ \gamma_{m0}}$ $= \frac{(201.5 \times 25) \times 250}{\sqrt{3} \times 1.1 \times 10^3}$ $= 661.0$ $Note:\ Stiffener\ is\ not\ restricted\ to\ low\ shear$ $[Ref.\ IS\ 800:2007\ (Cl.\ 8.4.1)$	**Pass**
Section Modulus of the Stiffener (mm^3)		$z_{e\,st} = 169.18 \times 10^3$	**OK**
Moment on Stiffener (kNm)	$M_{stf} = \sigma_{stf} \left(y \times \frac{{L_{stf}}^2}{2} \right)$ $= 6.08 \times \left(414.0 \times \frac{151.5^2}{2} \right) \times 10^{-6}$ $= 28.887$	$M_{df} = \frac{\beta_b\ z_{e\,st}\ f_{y\,st}}{\gamma_{m0}}$ $= \frac{1 \times\ z_{e\,st}\ f_{y\,st}}{\gamma_{m0}} \quad (\beta_b = 1)$ $= \frac{1 \times\ 169.18 \times 10^3 \times 250}{1.1 \times 10^6}$ $= 38.449$ $[Ref.\ IS\ 800:2007\ (Cl.\ 8.2.1.2)$	**Pass**
Weld Size (mm)	10	12	**Pass**

2.14 Stiffener Design - Along Column Web

Check	Required	Provided	Remarks
Length of Stiffener (mm)		$L_{stw} = \frac{L - D}{2}$ $= \frac{715 - 352.0}{2}$ $= 181.5$ $[Ref.\ based\ on\ detailing\ requirement$	**OK**
Height of Stiffener (mm)		$H_{stw} = L_{stw}\ +\ 50$ $= 181.5\ +\ 50$ $= 231.5$	**OK**

Check	Required	Provided	Remarks
Thickness of Stiffener (mm)	$t_{st_w} = \left(\frac{L_{st_w}}{13.6 \times \epsilon_{st}}\right) \geq t$ $= max\left(\left(\frac{181.5}{13.6 \times 1.0}\right), 16.0\right)$ $= max(13.35, 16.0)$ $[Ref.\ IS\ 800:2007\ ,Table\ 2]$	40	**Pass**
Stress (average) at Stiffener (mm)	$= \sigma_{c_{allowable}}$ $= 13.5$	$\sigma_{st_w} = \frac{\sigma_{cmax} + \sigma_{crt}}{2}$ $= \frac{12.15 + 6.57}{2}$ $= 9.36$	**Pass**
Shear on Stiffener (kN)	$V_{st_w} = \sigma_{st_w}\left(B\ L_{st_w}\right)$ $= 9.36 \times \left(392.0 \times 181.5\right) \times 10^{-3}$ $= 665.945$	$V_{dw} = \frac{A_{vg}\ f_{y_{st}}}{\sqrt{3}\ \gamma_{m0}}$ $= \frac{(H_{st_w} \times t_{st_w}) f_{y_{st}}}{\sqrt{3}\ \gamma_{m0}}$ $= \frac{(231.5 \times 40) \times 250}{\sqrt{3} \times 1.1 \times 10^3}$ $= 1215.06$ $Note:\ Stiffener\ is\ not\ restricted\ to\ low\ shear$ $[Ref.\ IS\ 800:2007\ (Cl.\ 8.4.1)$	**Pass**
Section Modulus of the Stiffener (mm^3)		$z_{e_{st}} = 357.28 \times 10^3$	**OK**
Moment on Stiffener (kNm)	$M_{st_w} = \left(\sigma_{crt} \times B \times \frac{{L_{st_w}}^2}{2}\right) +$ $\left(\left(\sigma_{cmax} - \sigma_{crt}\right) \times B \times \frac{{L_{st_w}}^2}{3}\right)$ $= \left[\left(6.57 \times 392.0 \times \frac{181.5^2}{2}\right) +\right.$ $\left.\left(\left(12.15 - 6.57\right) \times 392.0 \times \frac{181.5^2}{3}\right)\right] \times 10^{-6}$ $= 66.439$	$M_{dw} = \frac{\beta_b\ z_{e_{st}}\ f_{y_{st}}}{\gamma_{m0}}$ $= \frac{1 \times\ z_{e_{st}}\ f_{y_{st}}}{\gamma_{m0}} \quad (\beta_b = 1)$ $= \frac{1 \times\ 357.28 \times 10^3 \times 250}{1.1 \times 10^6}$ $= 81.2$ $[Ref.\ IS\ 800:2007\ (Cl.\ 8.2.1.2)$	**Pass**
Weld Size (mm)	10	12	**Pass**

2.15 Shear Design

Check	Required	Provided	Remarks
Shear Resistance (kN)		$V_r = P_u \times \mu$ $= 1699.09 \times 0.45$ $= 764.59$	**OK**
Shear Key Requirement - along column depth	$V_1 = 85.0 \quad kN$	$V_1 \leq V_r$ $85.0 \leq 764.59$	**Shear key not required**
Shear Key Requirement - along column width	$V_2 = 12.0 \quad kN$	$V_2 \leq V_r$ $12.0 \leq 764.59$	**Shear key not required**

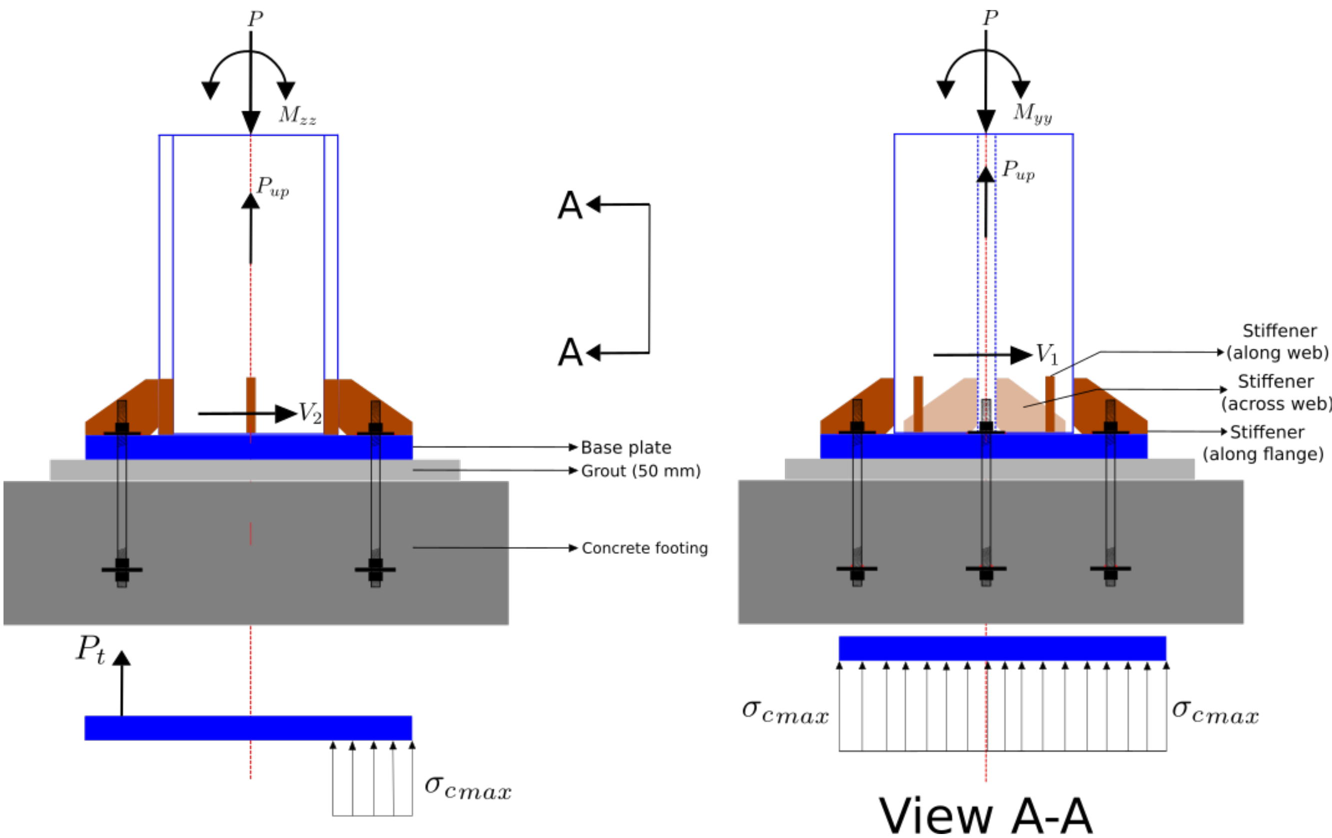


Figure 1: Typical Base Plate Details

3 2D Drawings (Typical)

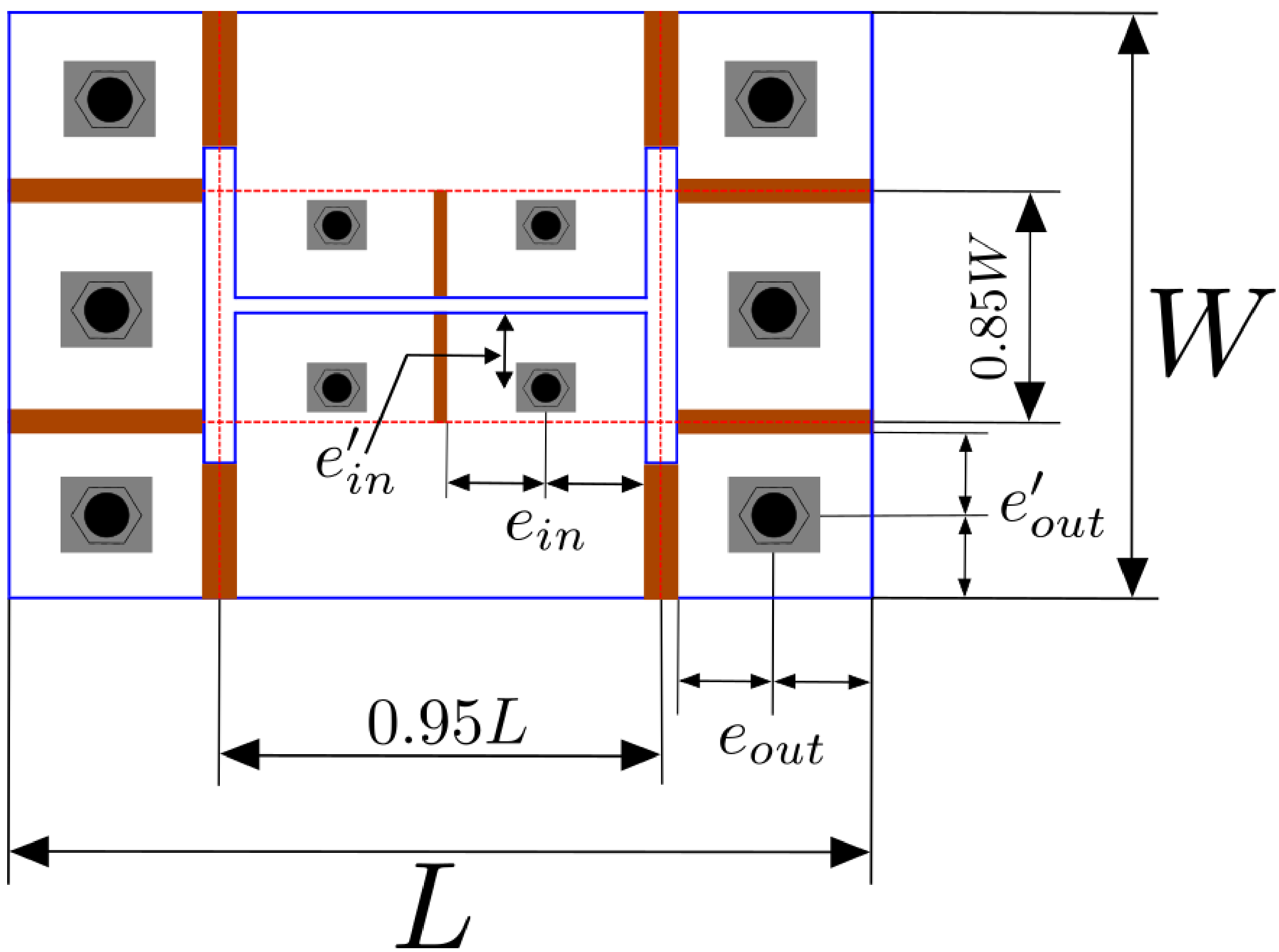


Figure 2: Typical Base Plate Detailing

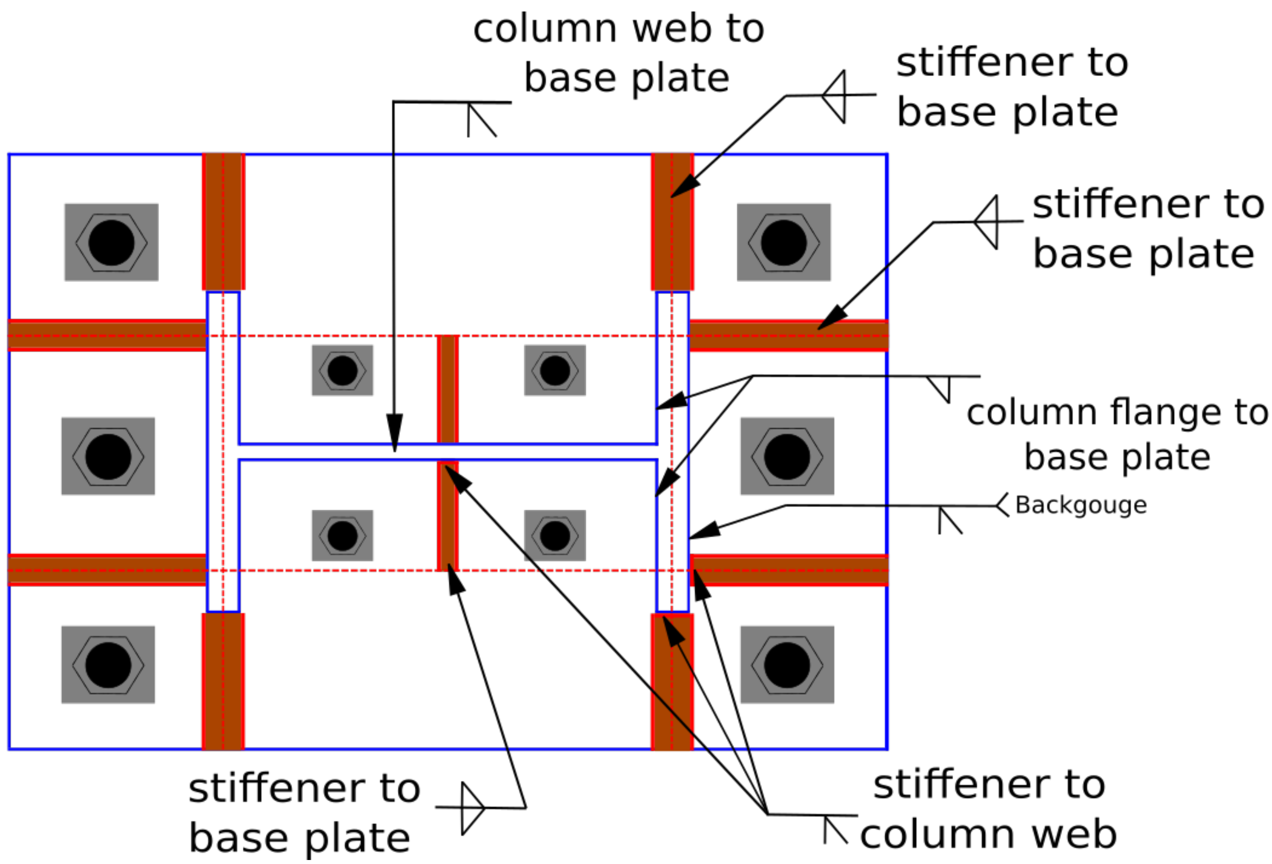


Figure 3: Typical Weld Details

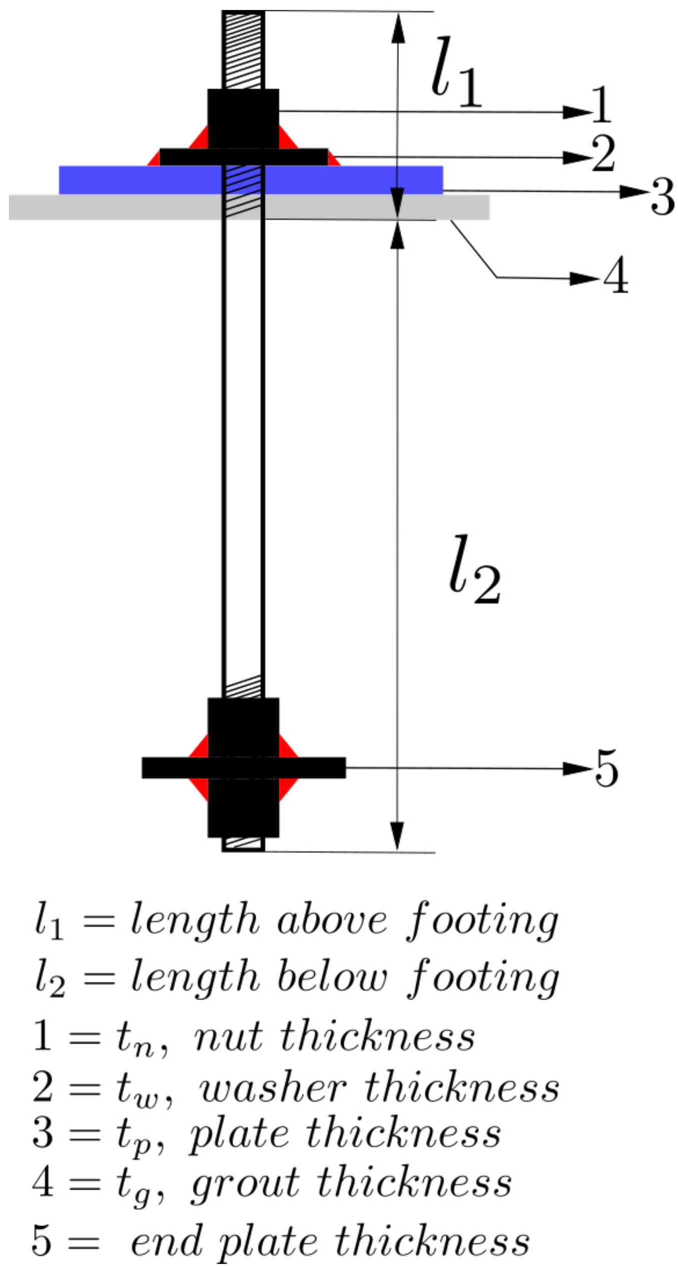
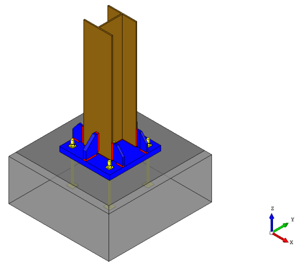
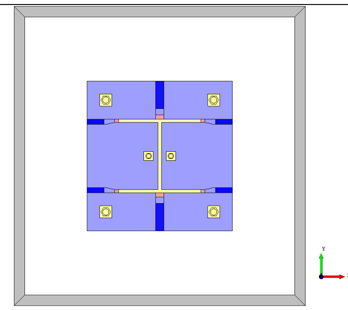


Figure 4: Typical Anchor Bolt Details

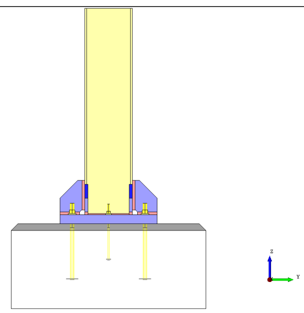
4 3D Views



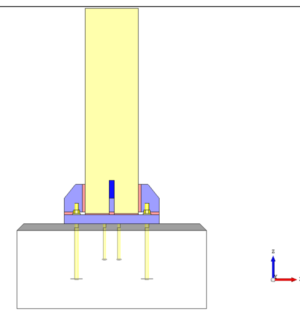
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

5 Design Log

2020-12-18 01:43:32 - Osdag - WARNING - The Load(s) defined is/are less than the minimum recommended value [Ref. IS 800:2007, Cl.10.7].

2020-12-18 01:43:32 - Osdag - WARNING - [Minimum Factored Load] The external factored bending moment (123.0 kNm) is less than 0.5 times the plastic moment capacity of the column (404.09 kNm)

2020-12-18 01:43:32 - 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

2020-12-18 01:43:32 - Osdag - INFO - The value of load(s) is/are set at minimum recommended value as per Cl.10.7

2020-12-18 01:43:32 - Osdag - INFO - Designing the connection for a factored moment of 404.09 kNm

2020-12-18 01:43:32 - Osdag - INFO - [Base Plate Type] The value of eccentricity about the major axis is 236 mm

2020-12-18 01:43:32 - Osdag - INFO - Eccentricity is greater than 210.67 (L/3) mm

2020-12-18 01:43:32 - Osdag - INFO - Case 3: A smaller part of the base plate is under pure compression/bearing with a large tension/uplift force being transferred through the anchor bolts outside column flange on the tension side

2020-12-18 01:43:32 - Osdag - INFO - [Base Plate Type] The value of eccentricity about the major axis is 236 mm

2020-12-18 01:43:32 - Osdag - INFO - Eccentricity is greater than 237.33 (L/3) mm

2020-12-18 01:43:32 - Osdag - INFO - Case 3: A smaller part of the base plate is under pure compression/bearing with a large

tension/uplift force being transferred through the anchor bolts outside column flange on the tension side
2020-12-18 01:43:32 - 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 764.5914 kN
2020-12-18 01:43:32 - Osdag - INFO - The horizontal shear force - 85.0 kN, is less than the shear resistance of the base plate
2020-12-18 01:43:32 - Osdag - INFO - Shear key is not required
2020-12-18 01:43:32 - 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 764.5914 kN
2020-12-18 01:43:32 - Osdag - INFO - The horizontal shear force - 85.0 kN, is less than the shear resistance of the base plate
2020-12-18 01:43:32 - Osdag - INFO - Shear key is not required
2020-12-18 01:43:32 - 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.
2020-12-18 01:43:32 - Osdag - INFO - [Anchor Bolt Length] The recommended range for the length of the anchor bolt of thread size 30 mm is as follows:
2020-12-18 01:43:32 - Osdag - INFO - [Anchor Bolt Length] Minimum length = 320 mm, Maximum length = 2000 mm.
2020-12-18 01:43:32 - Osdag - INFO - [Anchor Bolt Length] The provided length of the anchor bolt is 559.7 mm
2020-12-18 01:43:32 - 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 01:43:32 - Osdag - INFO - [Anchor Bolt Length] Reference: IS 5624:1993, Table 1
2020-12-18 01:43:32 - 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 01:43:32 - Osdag - INFO - [Anchor Bolt Length] Minimum length = 200 mm, Maximum length = 800 mm.
2020-12-18 01:43:32 - Osdag - INFO - [Anchor Bolt Length] The provided length of the anchor bolt is 409.5 mm
2020-12-18 01:43:32 - 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 01:43:32 - Osdag - INFO - [Anchor Bolt Length] Reference: IS 5624:1993, Table 1
2020-12-18 01:43:32 - Osdag - WARNING - [Shear Check - Stiffener] The stiffener along the flange fails the shear check
2020-12-18 01:43:32 - Osdag - WARNING - The shear demand on the stiffener (381.34 kN) exceeds 60% of it's capacity (253.82 kN)
2020-12-18 01:43:32 - Osdag - INFO - Increasing the thickness of the stiffener and re-checking against shear demand
2020-12-18 01:43:32 - Osdag - WARNING - [Shear Check - Stiffener] The stiffener along the web fails the shear check
2020-12-18 01:43:32 - Osdag - WARNING - The shear demand on the stiffener (665.94 kN) exceeds 60% of it's capacity (291.61 kN)
2020-12-18 01:43:32 - Osdag - INFO - Increasing the thickness of the stiffener and re-checking against shear demand