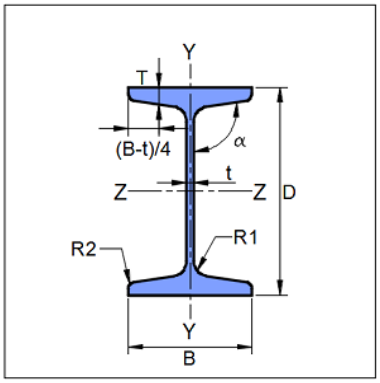
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.2.2
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

1 Input Parameters

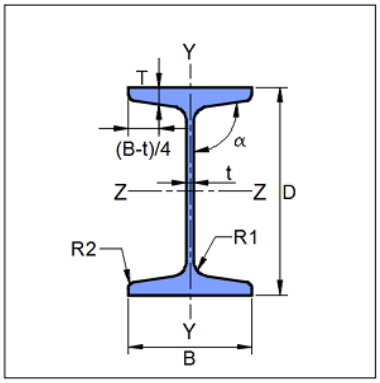
Main Module	Shear Connection
Module	End Plate
Connectivity	Column Web-Beam Web
Shear Force (kN)	275.0
Axial Force (kN)	0.0

Supporting Section - Mechanical Properties



Supporting Section		HB 350	
Material		E 300 (Fe 440)	
Ultimate Strength, Fu (MPa)		440	
Yield Strength, Fy (MPa)		300	
Mass, m (kg/m)	67.42	I_z (cm^4)	19100.0
Area, A (cm^2)	85.9	I_y(cm^4)	2450.0
D (mm)	350.0	r_z (cm)	14.9
B (mm)	250.0	r_y (cm)	5.34
t (mm)	8.3	Z_z (cm^3)	1090.0
T (mm)	11.6	Z_y (cm^3)	196.0
Flange Slope	94	Z_{pz} (cm^3)	1210.0
R_1 (mm)	12.0	Z_{py} (cm^3)	324.0
R_2 (mm)	6.0		

Supported Section - Mechanical Properties



Supported Section		MB 400	
Material		E 300 (Fe 440)	
Ultimate Strength, Fu (MPa)		440	
Yield Strength, Fy (MPa)		300	
Mass, m (kg/m)	61.55	I_z (cm^4)	20400.0
Area, A (cm^2)	78.4	I_y(cm^4)	622.0
D (mm)	400.0	r_z (cm)	16.1
B (mm)	140.0	r_y (cm)	2.81
t (mm)	8.9	Z_z (cm^3)	1020.0
T (mm)	16.0	Z_y (cm^3)	88.8
Flange Slope	98	Z_{pz} (cm^3)	1170.0
R_1 (mm)	14.0	Z_{py} (cm^3)	149.0
R_2 (mm)	7.0		

Company Name	IIT Bombay	Project Title	Sample Connection Design
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Designer	Engineer #1	Job Number	1.1.2.2.2
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

Bolt Details - Input and Design Preference	
Diameter (mm)	[20]
Property Class	[9.8]
Type	Bearing Bolt
Hole Type	Standard
Bolt Tension	Non pre-tensioned
Slip Factor, (mu_f)	0.3
Detailing - Design Preference	
Edge Preparation Method	Rolled, machine-flame cut, sawn and planed
Gap Between Members (mm)	10.0
Are the Members Exposed to Corrosive Influences?	False
Plate Details - Input and Design Preference	
Thickness (mm)	[20]
Material	E 250 (Fe 410 W)A
Ultimate Strength, Fu (MPa)	410
Yield Strength, Fy (MPa)	240
Weld Details - Input and Design Preference	
Weld Type	Fillet
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, Fu (MPa)	410.0

Company Name	IIT Bombay	Project Title	Sample Connection Design
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Designer	Engineer #1	Job Number	1.1.2.2.2
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

2 Design Checks

Design Status	Pass

2.1 Section Design Check

Check	Required	Provided	Remarks
Shear Capacity (kN)	275.0	$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{400.0 \times 8.9 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 560554.6249950185$ $[Ref. IS\ 800 : 2007, Cl. 10.4.3]$	Pass
Tension Capacity (kN)	0.0	$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 400.0 \times 8.9$ $= \frac{3560.0 \times 300}{1.1 \times 10^3}$ $= 970909.09$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 6.2]$	

2.2 Bolt Design

Check	Required	Provided	Remarks
Diameter (mm)		20	
Property Class		9.8	
Plate Thickness (mm)		20	
No. of Bolt Columns	2	2	Pass
No. of Bolt Rows		3	Pass
Min. Pitch Distance (mm)	$p_{min} = 2.5\ d$ $= 2.5 \times 20$ $= 50.0$ $[Ref\ IS\ 800 : 2007,\ Cl.\ 10.2.2]$	70	Pass

Company Name	IIT Bombay	Project Title	Sample Connection Design
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Designer	Engineer #1	Job Number	1.1.2.2.2
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

Check	Required	Provided	Remarks
Max. Pitch Distance (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 8.9,\ 300\ mm)$ $= \min(284.8,\ 300\ mm)$ $= 284.8$ $Where,\ t = min(20.0, 8.9)$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.2.3$]	70	**Pass**
Min. End Distance (mm)	$e_{min} = 1.5\ d_0$ $= 1.5 \times 22.0$ $= 33.0$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2$]	35	**Pass**
Max. End Distance (mm)	$e_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 20 \times \sqrt{\frac{250}{240}} = 244.95$ $e_2 = 12 \times 8.3 \times \sqrt{\frac{250}{300}} = 90.92$ $e_{max} = min(e_1, e_2) = 90.92$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3$]	35	**Pass**
Min. Edge Distance (mm)	$e'_{min} = 1.5\ d_0$ $= 1.5 \times 22.0$ $= 33.0$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.2$]	35	**Pass**

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.2.2
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 20 \times \sqrt{\frac{250}{240}} = 244.95$ $e_2 = 12 \times 8.3 \times \sqrt{\frac{250}{300}} = 90.92$ $e'_{max} = min(e_1, e_2) = 90.92$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3$]	35	**Pass**
Min. Gauge Distance (mm)	$g_{min} = 2(e'_{min} + s) + t_w$ $= 2(33.0 + 6) + 8.9$ $= 86.9$	92	**Pass**
Shear Capacity (kN)		$V_{dsb} = \frac{f_{ub}\ n_n\ A_{nb}}{\sqrt{3}\ \gamma_{mb}}$ $= \frac{900.0 \times 1 \times 245}{1000 \times \sqrt{3}\ \times\ 1.25}$ $= 101.84$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3$]	
Kb		$k_b = min\left(\frac{e}{3d_0},\ \frac{p}{3d_0} - 0.25,\ \frac{f_{ub}}{f_u},\ 1.0\right)$ $= min\left(\frac{35}{3 \times 22.0},\ \frac{70}{3 \times 22.0} - 0.25,\ \frac{900.0}{440},\ 1.0\right)$ $= min(0.53, 0.81, 2.05, 1.0)$ $= 0.53$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.3.4$]	
Bearing Capacity (kN)		$V_{dpb} = \frac{2.5\ k_b\ d\ t\ f_u}{\gamma_{mb}}$ $= \frac{2.5 \times 0.53 \times 20 \times 8.3 \times 440}{1000 \times 1.25}$ $= 77.42$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.3.4$]	

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.2.2
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

Check	Required	Provided	Remarks
Capacity (kN)	$V_{bv} = \frac{V}{n}$ $= \frac{275.0}{6}$ $= 45.83$	$V_{db} = min\ (V_{dsb}, V_{dpb})$ $= min\ (101.84, 77.42)$ $= 77422.40000000001$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.3.2$]	
Long Joint Reduction Factor		$l_j = (n_r - 1) \times p$ $= (3-1) \times 70 = 140$ $l = 140$ $15 \times d = 15 \times 20 = 300$ $since,\ l_j < 15 \times d\ then\ \beta_{lj} = 1.0$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3.1$]	
Large Grip Length Reduction Factor		$l_g = \Sigma\ (t_p + t_{member})$ $= 38.3$ $5d = 100$ $8d = 160$ $since,\ l_g < 5d\ ;\ \beta_{lg} = 1.0$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3.2$]	
Packing Plate Reduction Factor		$t_{pk} = gap$ $= 10.0mm$ $since,\ t_{pk} \geq 6mm\ then\ V_{rd} = \beta_{pk}\ V_{db}$ $\beta_{pk} = 1.0 - 0.0125 \times 10.0 = 0.875$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3.3$]	
Bolt Capacity (post reduction factor) (kN)	45.83	$V_{rd} = \beta_{lj}\ \beta_{lg}\beta_{pk} \times V_{db}$ $= 1.0 \times 1.0 \times 0.875 \times 77.42$ $= 67.74$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.3.3$]	

Check	Required	Provided	Remarks
Bolt Tension Force (kN)	$T_{ba} = \frac{P}{n}$ $= \frac{0.0}{6}$ $= 0.0$		

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.2.2
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

Check	Required	Provided	Remarks
Bolt Prying Force (kN)	$Q = \frac{l_v}{2 \times l_e}\left[T_e - \frac{\beta \times \eta \times f_o \times b_e \times t^4}{27 \times l_e \times l_v^2}\right]$ $l_v = e - \frac{R_1}{2}$ $= 35 - \frac{14.0}{2} = 35.55\ mm$ $f_o = 0.7 \times f_{ub}$ $= 0.7 \times 900.0$ $= 630.0\ N/mm^2$ $l_e = min\left(e, 1.1\ t\ \sqrt{\frac{\beta\ f_o}{f_y}}\right)$ $= min\left(35, 1.1 \times 20 \times \sqrt{\frac{2 \times 630.0}{240}}\right)$ $= min(35, 50.41) = 35\ mm$ $\beta = 2\ (non\ pre-tensioned\ bolt)$ $\eta = 1.5$ $b_e = \frac{B}{n_c}$ $= \frac{140.0}{2} = 70\ mm$ $Q = \frac{35.55}{2 \times 35} \times$ $\left[0.0 - \left(\frac{2 \times 1.5 \times 630.0 \times 70 \times 20^4}{27 \times 35 \times 35.55^2}\right) \times 10^{-3}\right]$ $Q = 0.0$ *Note : The end plate is sufficiently thick to prevent yielding of the plate. Thus,* $Q = 0$ [*Ref. IS* 800 : 2007, *Cl.* 10.4.7]		

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.2.2
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

Check	Required	Provided	Remarks
Bolt Tension Force (kN)	$T_f = T_1 + Q$ $= 0.0 + 0.0$ $= 0.0$	$T_{db} = 0.90\ f_{ub}\ A_n\ /\ \gamma_{mb}$ $<\ f_{yb}\ A_{sb}\ (\gamma_{mb}\ /\ \gamma_{m0})$ $= min\Big(0.90\ \times 900.0 \times 245\ /\ 1.25,$ $900.0 \times 314 \times (1.25/1.1)\Big)$ $= min(158.76,\ 321.14)$ $= 158.76$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.5]$	
Interaction Ratio	≤ 1	$\left(\frac{V_{sb}}{V_{db}}\right)^2 + \left(\frac{T_b}{T_{db}}\right)^2 \leq 1.0$ $\left(\frac{45.83}{67.74}\right)^2 + \left(\frac{0.0}{158.76}\right)^2 = 0.46$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.6]$	**Pass**

2.3 Plate Design

Check	Required	Provided	Remarks
Min. Plate Height (mm)	$0.6\times(d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (400.0 - 2 \times 16.0 - 2 \times 14.0)$ $= 204.0$ $[Ref.\ INSDAG - Chpt.5,\ Sect.5.2.3]$	210	**Pass**
Max. Plate Height (mm)	$d_b - 2(t_{bf} + r_{b1} + gap)$ $= 400.0 - 2 \times (16.0 + 14.0 + 10)$ $= 340.0$	210	**Pass**
Min. Plate Thickness (mm)	$t_w = 8.9$	20	**Pass**
Min. Plate Width (mm)	$w_{p_{min}} = g` + e`_{min}\ 2$ $= 92 + 33.0 \times 2$ $= 158.0$	162	**Pass**
Max. Plate Width (mm)	$w_{p_{max}} = D - 2T_f - 2R_r$ $= 350.0 - 2 \times 250.0 - 2 \times 12.0$ $= 302.8$	162	**Pass**

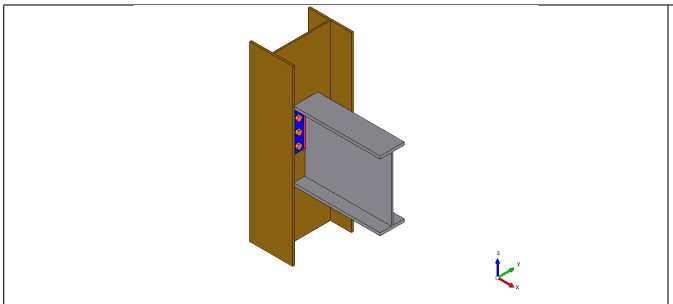
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.2.2
Date	17 /12 /2020	Client	Pradyumna M, Independent Consultant, Bengaluru

Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{210 \times 20 \times 240}{\sqrt{3} \times 1.1 \times 1000}$ $= 529.06$ $[Ref. IS\ 800:2007, Cl.10.4.3]$	
Block Shear Capacity in Shear (kN)		$V_{dbl1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{dbl2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{db} = min(V_{db1}, V_{db2}) = 714.5$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.4]$	
Shear Capacity (kN)	275.0	$V_d = min(S_c, V_{db})$ $= min(529.06, 714.5)$ $= 529.06$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	**Pass**
Moment Capacity (kNm)	$M = T_e \times ecc$ $ecc = \frac{g}{2} - \frac{t_w}{2} - s \quad = 35.55$ $M = 0.0 \times 35.55 \times 10^{-3} \quad = 0.0$	$M_{dzz} = \frac{\beta_b \times Z_p \times fy}{\gamma_{mo} \times 10^6}$ $= \frac{1.0 \times 21000.0 \times 240}{1.1 \times 10^6}$ $= 1.527$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	

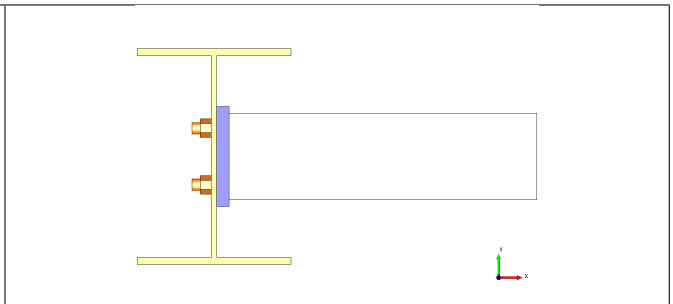
2.4 Weld Design

Check	Required	Provided	Remarks
Min. Weld Size (mm)	$t_{w_{min}}$ *based on thinner part* $= 8$ *or* 8 s_{min} *based on thicker part* $= 5$ [*Ref IS* 800 : 2007, *Table* 21 (*Cl*10.5.2.3)]	6	**Pass**
Max. Weld Size (mm)	*Thickness of thinner part* $= min(20, 8.9) = 8.9$ $s_{max} = 10$ [*Ref. IS* 800 : 2007, *Cl.* 10.5.3.1]	6	**Pass**
Weld Strength (N/mm)	$R_w = \sqrt{(A_{wh})^2 + (V_{wv})^2}$ $V_{wv} = \frac{V}{l_w} = \frac{275000.0}{386.0}$ $A_{wh} = \frac{A}{l_w} = \frac{0.0}{386.0}$ $R_w = \sqrt{(0.0)^2 + (712.44)^2}$ $= 712.44$	$f_w = \frac{t_t\ f_u}{\sqrt{3}\ \gamma_{mw}}$ $= \frac{4.2 \times 410}{\sqrt{3} \times 1.25}$ $= 795.36$ [*Ref. IS* 800 : 2007, *Cl.* 10.5.7.1.1]	
Weld Strength (post long joint) (N/mm)	*if* $l \geq 150t_t$ *then* $V_{rd} = \beta_{l_w} V_{db}$ *if* $l < 150t_t$ *then* $V_{rd} = V_{db}$ *where,* l = *pt.length or pt.height* $\beta_{l_w} = 1.2 - \frac{(0.2l)}{(150t_t)}$ *but* $0.6 \leq \beta_{l_w} \leq 1.0$ [*Ref. IS* 800 : 2007, *Cl.* 10.5.7.3]	$l_w = h$ $= 210$ $150t_t = 150 \times 4.2 = 630.0$ *since,* $l < 150t_t$ *then* $f_{wrd} = f_w$ $f_{wrd} = 795.36$ [*Ref. IS* 800 : 2007, *Cl.* 10.5.7.3]	
Weld Strength (N/mm)	712.44	795.36	**Pass**

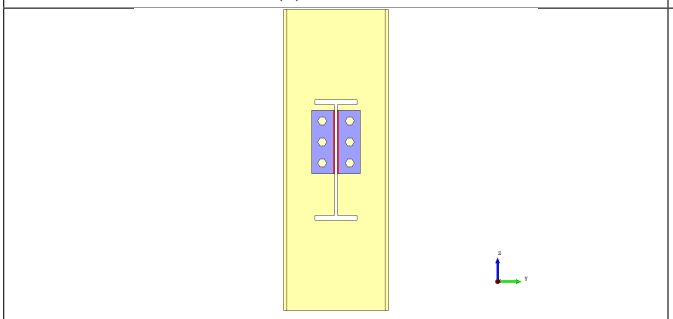
3 3D Views



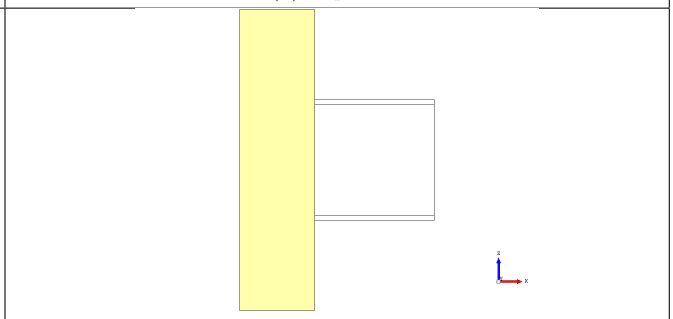
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log