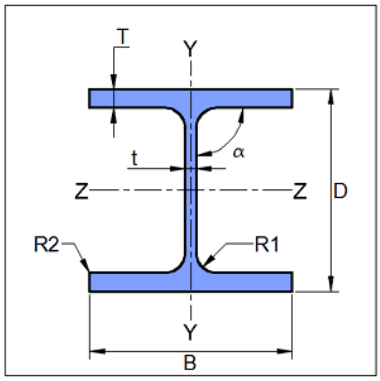
Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.1.2
Date	17 /12 /2020	Client	V Kalyanaraman, Retd. Professor, IIT Madras

1 Input Parameters

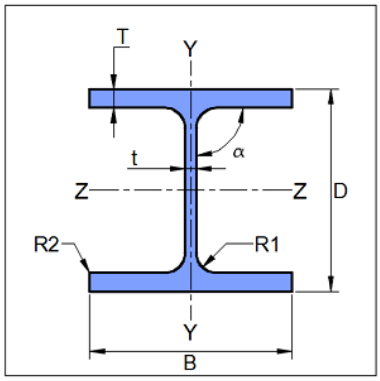
Main Module	Shear Connection
Module	End Plate
Connectivity	Column Flange-Beam Web
Shear Force (kN)	250.0
Axial Force (kN)	80.0

Supporting Section - Mechanical Properties



Supporting Section		UC 254 x 254 x 89	
Material		E 300 (Fe 440)	
Ultimate Strength, Fu (MPa)		440	
Yield Strength, Fy (MPa)		300	
Mass, m (kg/m)	88.9	I_z (cm^4)	14268.0
Area, A (cm^2)	113.3	I_y(cm^4)	4857.0
D (mm)	260.3	r_z (cm)	11.2
B (mm)	256.3	r_y (cm)	6.55
t (mm)	10.3	Z_z (cm^3)	1096.0
T (mm)	17.3	Z_y (cm^3)	379.0
Flange Slope	90	Z_{pz} (cm^3)	1224.0
R_1 (mm)	12.7	Z_{py} (cm^3)	575.0
R_2 (mm)	0.0		

Supported Section - Mechanical Properties



Supported Section		UB 356 x 127 x 39	
Material		E 300 (Fe 440)	
Ultimate Strength, Fu (MPa)		440	
Yield Strength, Fy (MPa)		300	
Mass, m (kg/m)	39.1	I_z (cm^4)	10172.0
Area, A (cm^2)	49.8	I_y(cm^4)	358.0
D (mm)	353.0	r_z (cm)	14.3
B (mm)	126.0	r_y (cm)	2.7
t (mm)	6.6	Z_z (cm^3)	576.0
T (mm)	10.7	Z_y (cm^3)	57.0
Flange Slope	90	Z_{pz} (cm^3)	659.0
R_1 (mm)	10.2	Z_{py} (cm^3)	89.1
R_2 (mm)	0.0		

Company Name	IIT Bombay	Project Title	Sample Connection Design
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Designer	Engineer #1	Job Number	1.1.2.1.2
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Bolt Details - Input and Design Preference	
Diameter (mm)	[24]
Property Class	[8.8]
Type	Friction Grip Bolt
Hole Type	Standard
Bolt Tension	Pretensioned
Slip Factor, (mu_f)	0.25
Detailing - Design Preference	
Edge Preparation Method	Sheared or hand flame cut
Gap Between Members (mm)	10.0
Are the Members Exposed to Corrosive Influences?	False
Plate Details - Input and Design Preference	
Thickness (mm)	[18]
Material	E 250 (Fe 410 W)A
Ultimate Strength, Fu (MPa)	410
Yield Strength, Fy (MPa)	250
Weld Details - Input and Design Preference	
Weld Type	Fillet
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, Fu (MPa)	440.0

2 Design Checks

Design Status	Pass

2.1 Section Design Check

Check	Required	Provided	Remarks
Shear Capacity (kN)	250.0	$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{353.0 \times 6.6 \times 300}{\sqrt{3} \times 1.1 \times 1000}$ $= 366848.36104308814$ $[Ref. IS\ 800 : 2007, Cl. 10.4.3]$	Pass
Tension Capacity (kN)	80.0	$T_{dg} = \frac{A_g f_y}{\gamma_{mo}}$ $A_g = l \times t = 353.0 \times 6.6$ $= \frac{2329.8 \times 300}{1.1 \times 10^3}$ $= 635400.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 6.2]$	Pass

2.2 Bolt Design

Check	Required	Provided	Remarks
Diameter (mm)		24	
Property Class		8.8	
Plate Thickness (mm)		18	
No. of Bolt Columns	2	2	Pass
No. of Bolt Rows		4	Pass
Min. Pitch Distance (mm)	$p_{min} = 2.5\ d$ $= 2.5 \times 24$ $= 60.0$ $[Ref\ IS\ 800 : 2007,\ Cl.\ 10.2.2]$	60	Pass

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.1.2
Date	17 /12 /2020	Client	V Kalyanaraman, Retd. Professor, IIT Madras

Check	Required	Provided	Remarks
Max. Pitch Distance (mm)	$p/g_{max} = \min(32\ t,\ 300\ mm)$ $= \min(32 \times 6.6,\ 300\ mm)$ $= \min(211.2,\ 300\ mm)$ $= 211.2$ $Where,\ t = min(18.0, 6.6)$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.2.3]$	60	**Pass**
Min. End Distance (mm)	$e_{min} = 1.7\ d_0$ $= 1.7 \times 26.0$ $= 44.2$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.2.4.2]$	45	**Pass**
Max. End Distance (mm)	$e_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 18 \times \sqrt{\frac{250}{250}} = 216.0$ $e_2 = 12 \times 17.3 \times \sqrt{\frac{250}{300}} = 189.51$ $e_{max} = min(e_1, e_2) = 189.51$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.2.4.3]$	45	**Pass**
Min. Edge Distance (mm)	$e'_{min} = 1.7\ d_0$ $= 1.7 \times 26.0$ $= 44.2$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.2.4.2]$	45	**Pass**

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Designer	Engineer #1	Job Number	1.1.2.1.2
Date	17 /12 /2020	Client	V Kalyanaraman, Retd. Professor, IIT Madras

Check	Required	Provided	Remarks
Max. Edge Distance (mm)	$e'_{max} = 12\ t\ \varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 18 \times \sqrt{\frac{250}{250}} = 216.0$ $e_2 = 12 \times 17.3 \times \sqrt{\frac{250}{300}} = 189.51$ $e'_{max} = min(e_1, e_2) = 189.51$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.2.4.3]$	45	**Pass**
Min. Gauge Distance (mm)	$g_1 = 2(e'_{min} + s) + t_w$ $= 2(44.2 + 5) + 6.6$ $= 105.0$ $g_2 = 2(e'_{min} + R_r) + T_w$ $= 2(44.2 + 12.7) + 10.3$ $= 124.1$ $g_{min} = max(g_1, g_2)$ $= 124.1$	126	**Pass**
Slip Resistance (kN)		$V_{dsf} = \frac{\mu_f\ n_e\ K_h\ F_o}{\gamma_{mf}}$ $Where\ , F_o = 0.7 f_{ub} A_{nb}$ $V_{dsf} = \frac{0.25 \times 1 \times 1.0 \times 0.7 \times 830.0 \times 353}{1.25 \times 10^3}$ $= 41018.6$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.4.3]$	
Capacity (kN)	$V_{bv} = \frac{V}{n}$ $= \frac{250.0}{8}$ $= 31.25$	41018.6	

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.1.2
Date	17 /12 /2020	Client	V Kalyanaraman, Retd. Professor, IIT Madras

Check	Required	Provided	Remarks
Long Joint Reduction Factor		$l_j = (n_r - 1) \times p$ $= (4 - 1) \times 60 = 180$ $l = 180$ $15 \times d = 15 \times 24 = 360$ $since,\ l_j < 15 \times d\ then\ \beta_{lj} = 1.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.3.3.1]$	
Large Grip Length Reduction Factor		$l_g = \Sigma\ (t_p + t_{member})$ $= 45.3$ $5d = 120$ $8d = 192$ $since,\ l_g < 5d\ ;\ \beta_{lg} = 1.0$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.3.3.2]$	
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)	31.25	$V_{rd} = \beta_{lj}\ \beta_{lg}\beta_{pk} \times V_{db}$ $= 1.0 \times 1.0 \times 1.0 \times 41.02$ $= 41.02$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.3.3]$	
Bolt Tension Force (kN)	$T_{ba} = \frac{P}{n}$ $= \frac{80.0}{8}$ $= 10.0$		

Company Name	IIT Bombay	Project Title	Sample Connection Design
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Designer	Engineer #1	Job Number	1.1.2.1.2
Date	17 /12 /2020	Client	V Kalyanaraman, Retd. Professor, IIT Madras

Check	Required	Provided	Remarks
Bolt Prying Force (kN)	$Q = \frac{l_v}{2 \times l_e}\left[T_e - \frac{\beta \times \eta \times f_o \times b_e \times t^4}{27 \times l_e \times l_v^2}\right]$ $l_v = e - \frac{R_1}{2}$ $= 45 - \frac{10.2}{2} = 54.7\ mm$ $f_o = 0.7 \times f_{ub}$ $= 0.7 \times 830.0$ $= 581.0\ N/mm^2$ $l_e = min\left(e, 1.1\ t\ \sqrt{\frac{\beta\ f_o}{f_y}}\right)$ $= min\left(45, 1.1 \times 18 \times \sqrt{\frac{1 \times 581.0}{250}}\right)$ $= min(45, 30.18) = 30.18\ mm$ $\beta = 1\ (pre - tensioned\ bolt)$ $\eta = 1.5$ $b_e = \frac{B}{n_c}$ $= \frac{126.0}{2} = 60\ mm$ $Q = \frac{54.7}{2 \times 30.18} \times$ $\left[10.0 - \left(\frac{1 \times 1.5 \times 581.0 \times 60 \times 18^4}{27 \times 30.18 \times 54.7^2}\right) \times 10^{-3}\right]$ $Q = 4.34$ $[Ref.\ IS\ 800 : 2007,\ Cl.\ 10.4.7]$		

Company Name	IIT Bombay	Project Title	Sample Connection Design
Group/Team Name	Osdag	Subtitle	End Plate
Designer	Engineer #1	Job Number	1.1.2.1.2
Date	17 /12 /2020	Client	V Kalyanaraman, Retd. Professor, IIT Madras

Check	Required	Provided	Remarks
Bolt Tension Force (kN)	$T_f = T_1 + Q$ $= 10.0 + 4.34$ $= 14.34$	$T_{db} = 0.90\ f_{ub}\ A_n\ /\ \gamma_{mb}$ $<\ f_{yb}\ A_{sb}\ (\gamma_{mb}\ /\ \gamma_{m0})$ $= min\Big(0.90\ \times 830.0 \times 353\ /\ 1.25,$ $830.0 \times 452 \times (1.25/1.1)\Big)$ $= min(210.95,\ 426.32)$ $= 210.95$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.5]$	**Pass**
Interaction Ratio	≤ 1	$\left(\frac{V_{sb}}{V_{db}}\right)^2 + \left(\frac{T_b}{T_{db}}\right)^2 \leq 1.0$ $\left(\frac{31.25}{41.02}\right)^2 + \left(\frac{14.34}{210.95}\right)^2 = 0.58$ $[Ref.\ IS\ 800:2007,\ Cl.\ 10.3.6]$	**Pass**

2.3 Plate Design

Check	Required	Provided	Remarks
Min. Plate Height (mm)	$0.6\times(d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (353.0 - 2 \times 10.7 - 2 \times 10.2)$ $= 186.72$ $[Ref.\ INSDAG - Chpt.5,\ Sect.5.2.3]$	270	**Pass**
Max. Plate Height (mm)	$d_b - 2(t_{bf} + r_{b1} + gap)$ $= 353.0 - 2 \times (10.7 + 10.2 + 10)$ $= 311.2$	270	**Pass**
Min. Plate Thickness (mm)	$t_w = 6.6$	18	**Pass**
Min. Plate Width (mm)	$w_{p_{min}} = g` + e`_{min}\ 2$ $= 126 + 44.2 \times 2$ $= 214.4$	216	**Pass**
Max. Plate Width (mm)	$w_{p_{max}} = T_f$ $= 256.3$	216	**Pass**

Company Name	IIT Bombay	Project Title	Sample Connection Design
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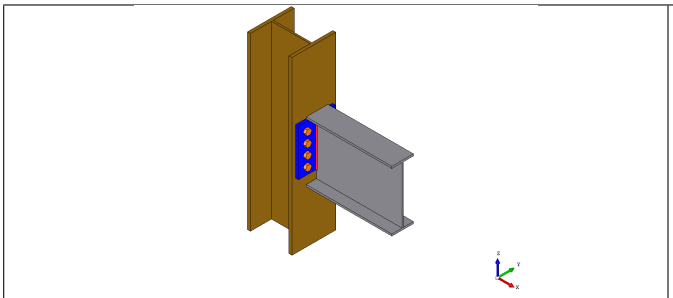
Check	Required	Provided	Remarks
Shear Yielding Capacity (kN)		$V_{dy} = \frac{A_v\ f_y}{\sqrt{3}\ \gamma_{mo}}$ $= \frac{270 \times 18 \times 250}{\sqrt{3} \times 1.1 \times 1000}$ $= 637.71$ $[Ref. IS\ 800:2007, Cl. 10.4.3]$	
Block Shear Capacity in Shear (kN)		$V_{dbl1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}$ $V_{dbl2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$ $V_{db} = min(V_{db1}, V_{db2}) = 779.27$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.4]$	
Shear Capacity (kN)	250.0	$V_d = min(S_c, V_{db})$ $= min(637.71, 779.27)$ $= 637.71$ $[Ref.\ IS\ 800:2007,\ Cl.\ 6.1]$	**Pass**
Moment Capacity (kNm)	$M = T_e \times ecc$ $ecc_1 = \frac{g}{2} - \frac{t_w}{2} - s = 54.7$ $ecc_2 = \frac{g}{2} - \frac{T_w}{2} - R_r = 45.15$ $max(ecc_1, ecc_2) = 54.7$ $M = 10.0 \times 54.7 \times 10^{-3} = 0.545$	$M_{dzz} = \frac{\beta_b \times Z_p \times fy}{\gamma_{mo} \times 10^6}$ $= \frac{1.0 \times 21870.0 \times 250}{1.1 \times 10^6}$ $= 1.105$ $[Ref.\ IS\ 800:2007,\ Cl.\ 8.2.1.2]$	**Pass**

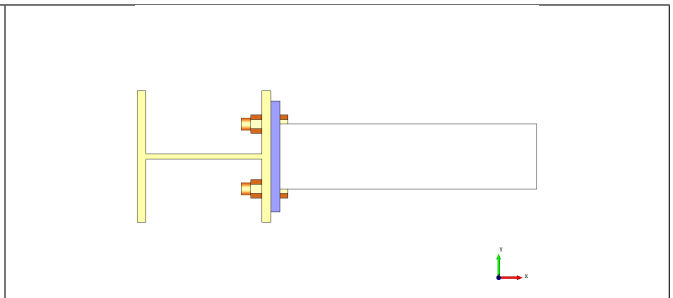
2.4 Weld Design

Check	Required	Provided	Remarks
Min. Weld Size (mm)	$t_{w_{min}}$ *based on thinner part* $= 6$ *or* 6 s_{min} *based on thicker part* $= 5$ [$Ref\ IS\ 800:2007, Table\ 21\ (Cl 10.5.2.3)$]	5	**Pass**
Max. Weld Size (mm)	*Thickness of thinner part* $= min(18, 6.6) = 6.6$ $s_{max} = 8$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.5.3.1$]	5	**Pass**
Weld Strength (N/mm)	$R_w = \sqrt{(A_{wh})^2 + (V_{wv})^2}$ $V_{wv} = \frac{V}{l_w} = \frac{250000.0}{520.0}$ $A_{wh} = \frac{A}{l_w} = \frac{80000.0}{520.0}$ $R_w = \sqrt{(153.85)^2 + (480.77)^2}$ $= 504.78$	$f_w = \frac{t_t\ f_u}{\sqrt{3}\ \gamma_{mw}}$ $= \frac{3.5 \times 410}{\sqrt{3} \times 1.25}$ $= 662.8$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.1.1$]	
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* $0.6 \leq \beta_{l_w} \leq 1.0$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.3$]	$l_w = h$ $= 270$ $150t_t = 150 \times 3.5 = 525.0$ *since,* $l < 150t_t$ *then* $f_{wrd} = f_w$ $f_{wrd} = 662.8$ [$Ref.\ IS\ 800:2007,\ Cl.\ 10.5.7.3$]	
Weld Strength (N/mm)	504.78	662.8	**Pass**

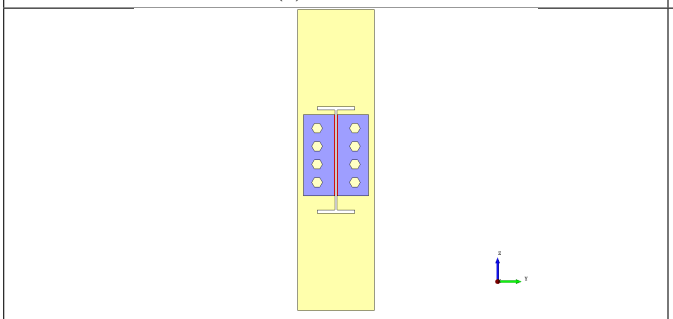
3 3D Views



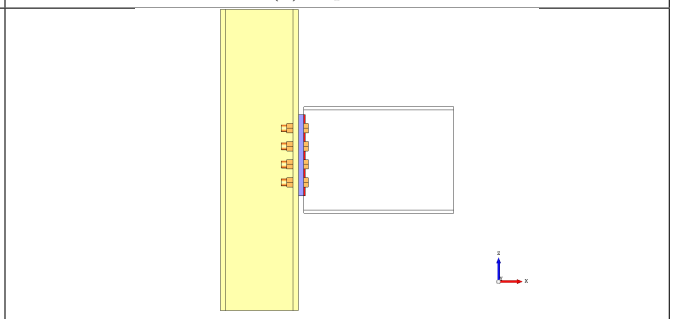
(a) 3D View



(b) Top View



(c) Side View



(d) Front View

4 Design Log