

Design Calculation Sheet for Grad Proj

Designer: Mohamed

Location: Cairo

City: Cairo

Country: Egypt

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- Design For Flexural and shear
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Secondary Beams

Beam ID	Start Point	End Point	Span (m)	Mmax (t.m)	Vmax (ton)
44	(20,4,4)	(20,8,4)	4	0.04	0.04

Design Limit state:

Combo: 1*Dead + 1*Live

Md: 0.04 t.m

Vd: 0.04 ton

Service Limit State

Combo: LIVE

Span: 4 m

Load: 0 t/m'

Design Checks

1-Check Local Buckling

$d_w/t_w = 15.58 < 81.98 \Rightarrow$ Compact Web

$c/t_f = 3.06 < 10.91 \Rightarrow$ Compact Flange

2-Check Lateral Torsional Buckling

$L_{uact} = 0 \text{ m} < L_{umax} = 59.39 \text{ m} \Rightarrow$ Supported (No LTB)

3-Check Bending Stress

Section: IPE270

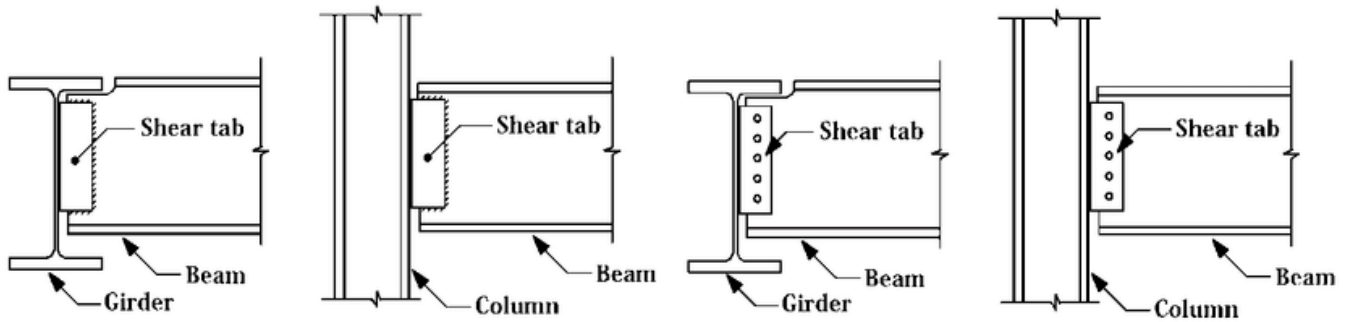
$f_{act} = 0.22 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

4-Check Shear Stress

$q_{act} = 0.01 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$

5-Check Deflection

$d_{act} = 0 \text{ cm} < d_{all} = 1.33 \text{ cm}$



Group Connection Design (Simple Shear Plate Connection)

1-Bolts Design

Bolts: M20 of Grade 8.8

$V_d = 0.04$ ton

$R_{least} = 2.85$ ton

$N = 3$ with Pitch = 63 mm & Full Layout: (31;63 63 31.5)

2-Stresses Induced in Fillet Weld Lines at Plane(1-1)

$f = 0$ t/cm² & $q = 0$ t/cm² $\Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0$ t/cm² $< 1.1 * 0.2F_u = 0.79$ t/cm² \Rightarrow OK

3-Stresses Induced in Fillet Weld Lines at Plane(2-2)

$q = 0$ t/cm² & $q_{mt} = 0$ t/cm² $\Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0$ t/cm² $< 0.2F_u = 0.72$ t/cm² \Rightarrow OK

4-Check Thickness of Plate

$f = (6 * V_d * e) / (t_p * L^2) = 0$ t/cm² $< 0.72 * F_y = 1.73$ t/cm² \Rightarrow OK

Plate Layout $\Rightarrow L = 189$ mm & $t_p = 10$ mm & $S_w = 6$ mm

Beam ID	Start Point	End Point	Span (m)	Mmax (t.m)	Vmax (ton)
14	(0,4,4)	(0,8,4)	4	1.04	1.04
65	(10,7,4)	(14,7,4)	4	1.04	1.04
34	(14,0,4)	(14,4,4)	4	1.04	1.04
36	(14,8,4)	(14,12,4)	4	1.04	1.04
37	(16,0,4)	(16,4,4)	4	1.04	1.04
39	(16,8,4)	(16,12,4)	4	1.04	1.04
40	(18,0,4)	(18,4,4)	4	1.04	1.04
42	(18,8,4)	(18,12,4)	4	1.04	1.04
43	(20,0,4)	(20,4,4)	4	1.04	1.04

45	(20,8,4)	(20,12,4)	4	1.04	1.04
64	(10,5,4)	(14,5,4)	4	1.04	1.04
63	(6,6,4)	(10,6,4)	4	1.18	1.18

Design Limit state:

Combo: 1*Dead + 1*Live

Md: 1.18 t.m

Vd: 1.18 ton

Service Limit State

Combo: LIVE

Span: 4 m

Load: -0.3 t/m'

Design Checks

1-Check Local Buckling

$dw/tw = 26.08 < 81.98 \Rightarrow$ Compact Web

$c/tf = 4.21 < 10.91 \Rightarrow$ Compact Flange

2-Check Lateral Torsional Buckling

$Lu_{act} = 0 \text{ m} < Lu_{max} = 105.86 \text{ m} \Rightarrow$ Supported (No LTB)

3-Check Bending Stress

Section: IPE270

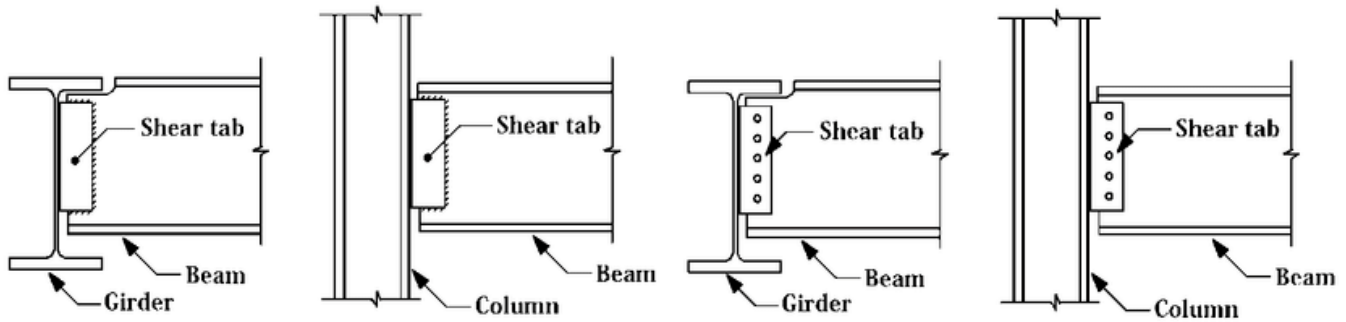
$f_{act} = 1.08 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

4-Check Shear Stress

$q_{act} = 0.15 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$

5-Check Deflection

$d_{act} = 0.55 \text{ cm} < d_{all} = 1.33 \text{ cm}$



Group Connection Design (Simple Shear Plate Connection)

1-Bolts Design

Bolts: M20 of Grade 8.8

$V_d = 1.18$ ton

$R_{least} = 2.85$ ton

$N = 3$ with Pitch = 63 mm & Full Layout: (31;63 63 31.5)

2-Stresses Induced in Fillet Weld Lines at Plane(1-1)

$f = 0.08$ t/cm² & $q = 0.05$ t/cm² $\Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.12$ t/cm² < $1.1 * 0.2F_u = 0.79$ t/cm² \Rightarrow OK

3-Stresses Induced in Fillet Weld Lines at Plane(2-2)

$q = 0.05$ t/cm² & $q_{mt} = 0.08$ t/cm² $\Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.1$ t/cm² < $0.2F_u = 0.72$ t/cm² \Rightarrow OK

4-Check Thickness of Plate

$f = (6 * V_d * e) / (t_p * L^2) = 0.1$ t/cm² < $0.72 * F_y = 1.73$ t/cm² \Rightarrow OK

Plate Layout $\Rightarrow L = 189$ mm & $t_p = 10$ mm & $S_w = 6$ mm

Beam ID	Start Point	End Point	Span (m)	Mmax (t.m)	Vmax (ton)
20	(4,4,4)	(4,8,4)	4	2.04	1.54
17	(2,4,4)	(2,8,4)	4	2.04	1.54
66	(8,10,4)	(12,10,4)	4	2.04	1.54
62	(0,10,4)	(6,10,4)	6	2.41	1.61

Design Limit state:

Combo: 1*Dead + 1*Live

$M_d = 2.41$ t.m

$V_d = 1.61$ ton

Service Limit State

Combo: LIVE

Span: 6 m

Load: -0.3 t/m'

Design Checks

1-Check Local Buckling

$d_w/t_w = 29.65 < 81.98 \Rightarrow$ Compact Web

$c/t_f = 4.56 < 10.91 \Rightarrow$ Compact Flange

2-Check Lateral Torsional Buckling

$L_{uact} = 0 \text{ m} < L_{umax} = 129.1 \text{ m} \Rightarrow$ Supported (No LTB)

3-Check Bending Stress

Section: IPE270

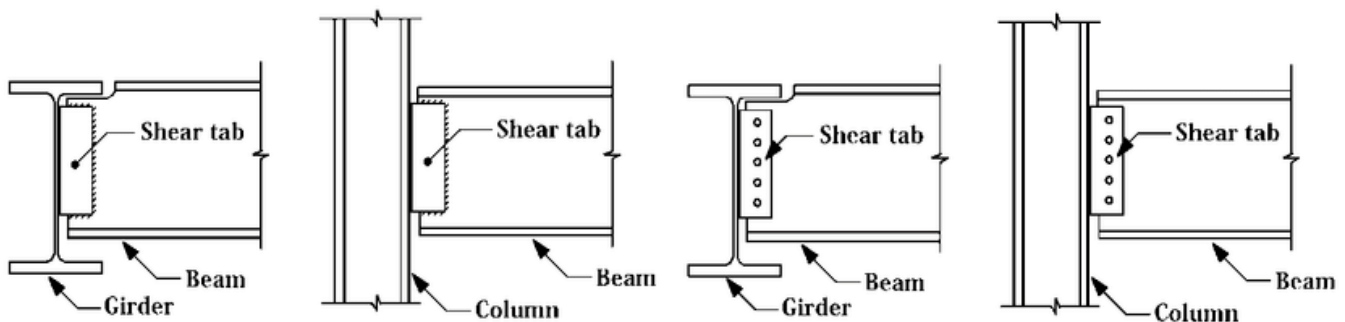
$f_{act} = 1.24 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

4-Check Shear Stress

$q_{act} = 0.14 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$

5-Check Deflection

$\delta_{act} = 1.24 \text{ cm} < \delta_{all} = 2 \text{ cm}$



Group Connection Design (Simple Shear Plate Connection)

1-Bolts Design

Bolts: M20 of Grade 8.8

$V_d = 1.61 \text{ ton}$

$R_{least} = 2.85 \text{ ton}$

$N = 3$ with Pitch = 63 mm & Full Layout: (31;63 63 31.5)

2-Stresses Induced in Fillet Weld Lines at Plane(1-1)

$f = 0.11 \text{ t/cm}^2$ & $q = 0.07 \text{ t/cm}^2 \Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.17 \text{ t/cm}^2 < 1.1 * 0.2F_u = 0.79 \text{ t/cm}^2 \Rightarrow \text{OK}$

3-Stresses Induced in Fillet Weld Lines at Plane(2-2)

$q = 0.07 \text{ t/cm}^2$ & $q_{mt} = 0.11 \text{ t/cm}^2 \Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.13 \text{ t/cm}^2 < 0.2F_u = 0.72 \text{ t/cm}^2 \Rightarrow \text{OK}$

4-Check Thickness of Plate

$f = (6 * V_d * e) / (t_p * L^2) = 0.14 \text{ t/cm}^2 < 0.72 * F_y = 1.73 \text{ t/cm}^2 \Rightarrow \text{OK}$

Plate Layout $\Rightarrow L = 189 \text{ mm}$ & $t_p = 10 \text{ mm}$ & $S_w = 6 \text{ mm}$

Main Beams

Beam ID	Start Point	End Point	Span (m)	Mmax (t.m)	Vmax (ton)
35	(14,4,4)	(14,8,4)	4	1.09	1.09

Design Limit state:

Combo: 1*Dead + 1*Live

Md: 1.09 t.m

Vd: 1.09 ton

Service Limit State

Combo: LIVE

Span: 4 m

Load: -0.3 t/m'

Design Checks

1-Check Local Buckling

$d_w/t_w = 23.92 < 81.98 \Rightarrow \text{Compact Web}$

$c/t_f = 3.95 < 10.91 \Rightarrow \text{Compact Flange}$

2-Check Lateral Torsional Buckling

$L_{uact} = 0 \text{ m} < L_{umax} = 94.24 \text{ m} \Rightarrow \text{Supported (No LTB)}$

3-Check Bending Stress

Section: IPE270

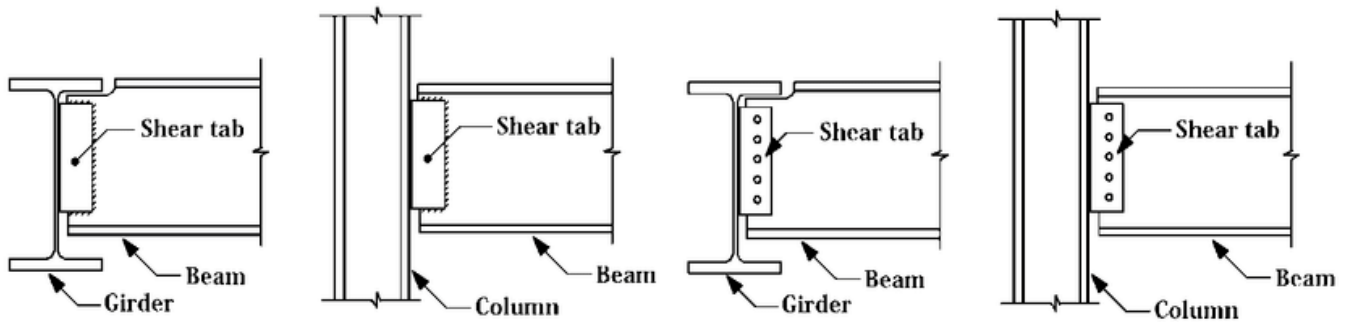
$f_{act} = 1.41 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

4-Check Shear Stress

$$q_{act} = 0.17 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$$

5-Check Deflection

$$d_{act} = 0.88 \text{ cm} < d_{all} = 1.33 \text{ cm}$$



Group Connection Design (Simple Shear Plate Connection)

1-Bolts Design

Bolts: M20 of Grade 8.8

$$V_d = 1.09 \text{ ton}$$

$$R_{least} = 2.85 \text{ ton}$$

$$N = 3 \text{ with Pitch} = 63 \text{ mm \& Full Layout: (31;63 63 31.5)}$$

2-Stresses Induced in Fillet Weld Lines at Plane(1-1)

$$f = 0.08 \text{ t/cm}^2 \text{ \& } q = 0.05 \text{ t/cm}^2 \Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.11 \text{ t/cm}^2 < 1.1 * 0.2F_u = 0.79 \text{ t/cm}^2 \Rightarrow \text{OK}$$

3-Stresses Induced in Fillet Weld Lines at Plane(2-2)

$$q = 0.05 \text{ t/cm}^2 \text{ \& } q_{mt} = 0.08 \text{ t/cm}^2 \Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.09 \text{ t/cm}^2 < 0.2F_u = 0.72 \text{ t/cm}^2 \Rightarrow \text{OK}$$

4-Check Thickness of Plate

$$f = (6 * V_d * e) / (t_p * L^2) = 0.09 \text{ t/cm}^2 < 0.72 * F_y = 1.73 \text{ t/cm}^2 \Rightarrow \text{OK}$$

$$\text{Plate Layout} \Rightarrow L = 189 \text{ mm \& } t_p = 10 \text{ mm \& } S_w = 6 \text{ mm}$$

Beam ID	Start Point	End Point	Span (m)	Mmax (t.m)	Vmax (ton)
15	(0,8,4)	(0,12,4)	4	1.65	0.85
23	(6,4,4)	(6,8,4)	4	2.23	1.64
12	(14,12,4)	(20,12,4)	6	2.25	1.15
9	(14,8,4)	(20,8,4)	6	2.25	1.15
6	(14,4,4)	(20,4,4)	6	2.25	1.15
3	(14,0,4)	(20,0,4)	6	2.25	1.15

29	(10,4,4)	(10,8,4)	4	2.27	1.68
10	(0,12,4)	(6,12,4)	6	2.41	1.61

Design Limit state:

Combo: 1*Dead + 1*Live

Md: 2.41 t.m

Vd: 1.61 ton

Service Limit State

Combo: LIVE

Span: 6 m

Load: -0.2 t/m'

Design Checks

1-Check Local Buckling

$d_w/t_w = 29.65 < 81.98 \Rightarrow$ Compact Web

$c/t_f = 4.56 < 10.91 \Rightarrow$ Compact Flange

2-Check Lateral Torsional Buckling

$L_{uact} = 0 \text{ m} < L_{umax} = 129.1 \text{ m} \Rightarrow$ Supported (No LTB)

3-Check Bending Stress

Section: IPE270

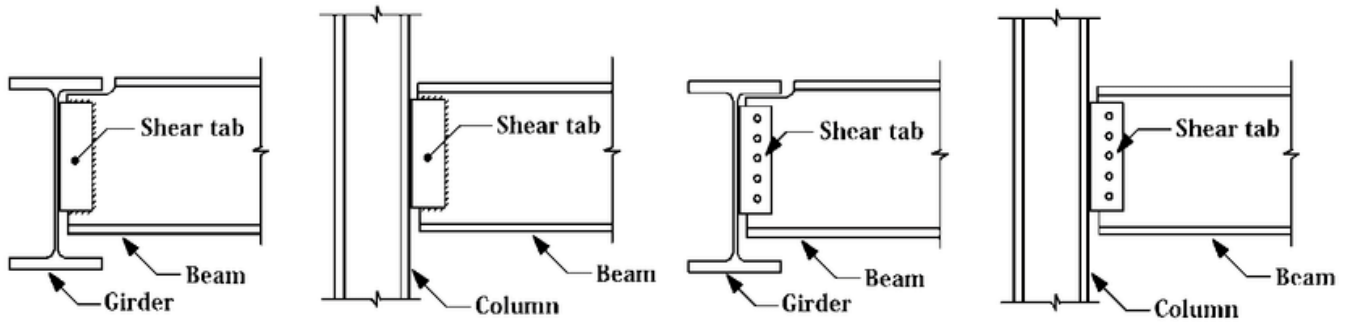
$f_{act} = 1.24 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

4-Check Shear Stress

$q_{act} = 0.14 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$

5-Check Deflection

$d_{act} = 0.83 \text{ cm} < d_{all} = 2 \text{ cm}$



Group Connection Design (Simple Shear Plate Connection)

1-Bolts Design

Bolts: M20 of Grade 8.8

$V_d = 1.61$ ton

$R_{least} = 2.85$ ton

$N = 3$ with Pitch = 63 mm & Full Layout: (31;63 63 31.5)

2-Stresses Induced in Fillet Weld Lines at Plane(1-1)

$f = 0.11$ t/cm² & $q = 0.07$ t/cm² $\Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.17$ t/cm² $< 1.1 * 0.2F_u = 0.79$ t/cm² \Rightarrow OK

3-Stresses Induced in Fillet Weld Lines at Plane(2-2)

$q = 0.07$ t/cm² & $q_{mt} = 0.11$ t/cm² $\Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.13$ t/cm² $< 0.2F_u = 0.72$ t/cm² \Rightarrow OK

4-Check Thickness of Plate

$f = (6 * V_d * e) / (t_p * L^2) = 0.14$ t/cm² $< 0.72 * F_y = 1.73$ t/cm² \Rightarrow OK

Plate Layout $\Rightarrow L = 189$ mm & $t_p = 10$ mm & $S_w = 6$ mm

Beam ID	Start Point	End Point	Span (m)	Mmax (t.m)	Vmax (ton)
27	(8,8,4)	(8,12,4)	4	2.59	1.82
33	(12,8,4)	(12,12,4)	4	2.59	1.82
24	(6,8,4)	(6,12,4)	4	2.65	1.85
4	(0,4,4)	(6,4,4)	6	3.25	1.65

Design Limit state:

Combo: 1*Dead + 1*Live

$M_d = 3.25$ t.m

$V_d = 1.65$ ton

Service Limit State

Combo: LIVE

Span: 6 m

Load: -0.37 t/m'

Design Checks

1-Check Local Buckling

$d_w/t_w = 31.06 < 81.98 \Rightarrow$ Compact Web

$c/t_f = 4.66 < 10.91 \Rightarrow$ Compact Flange

2-Check Lateral Torsional Buckling

$L_{uact} = 0 \text{ m} < L_{umax} = 142.01 \text{ m} \Rightarrow$ Supported (No LTB)

3-Check Bending Stress

Section: IPE270

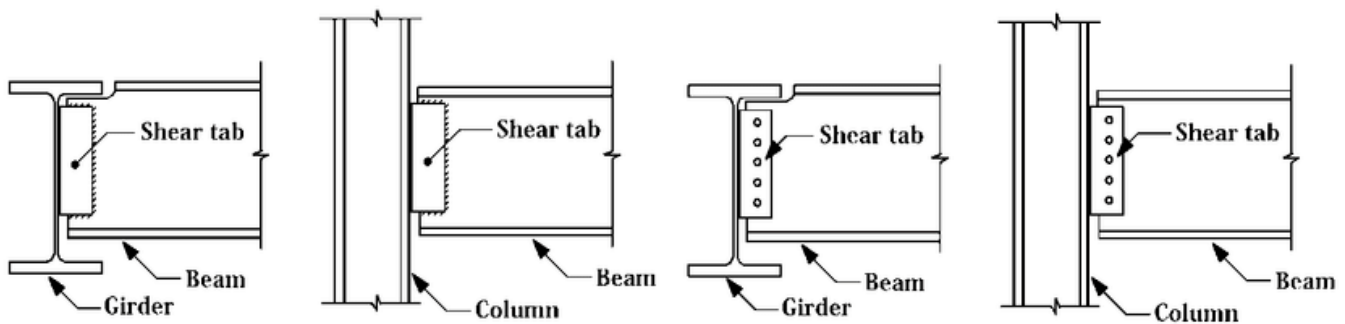
$f_{act} = 1.29 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

4-Check Shear Stress

$q_{act} = 0.13 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$

5-Check Deflection

$\delta_{act} = 1.06 \text{ cm} < \delta_{all} = 2 \text{ cm}$



Group Connection Design (Simple Shear Plate Connection)

1-Bolts Design

Bolts: M20 of Grade 8.8

$V_d = 1.65 \text{ ton}$

$R_{least} = 2.85 \text{ ton}$

$N = 3$ with Pitch = 63 mm & Full Layout: (31;63 63 31.5)

2-Stresses Induced in Fillet Weld Lines at Plane(1-1)

$f = 0.12 \text{ t/cm}^2$ & $q = 0.08 \text{ t/cm}^2 \Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.17 \text{ t/cm}^2 < 1.1 * 0.2F_u = 0.79 \text{ t/cm}^2 \Rightarrow \text{OK}$

3-Stresses Induced in Fillet Weld Lines at Plane(2-2)

$q = 0.08 \text{ t/cm}^2$ & $q_{mt} = 0.12 \text{ t/cm}^2 \Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.14 \text{ t/cm}^2 < 0.2F_u = 0.72 \text{ t/cm}^2 \Rightarrow \text{OK}$

4-Check Thickness of Plate

$f = (6 * V_d * e) / (t_p * L^2) = 0.14 \text{ t/cm}^2 < 0.72 * F_y = 1.73 \text{ t/cm}^2 \Rightarrow \text{OK}$

Plate Layout $\Rightarrow L = 189 \text{ mm}$ & $t_p = 10 \text{ mm}$ & $S_w = 6 \text{ mm}$

Beam ID	Start Point	End Point	Span (m)	Mmax (t.m)	Vmax (ton)
7	(0,8,4)	(6,8,4)	6	5.5	3.15
5	(6,4,4)	(14,4,4)	8	7.65	2.98
11	(6,12,4)	(14,12,4)	8	7.92	3.96

Design Limit state:

Combo: 1*Dead + 1*Live

Md: 7.92 t.m

Vd: 3.96 ton

Service Limit State

Combo: LIVE

Span: 8 m

Load: -0.41 t/m'

Design Checks

1-Check Local Buckling

$d_w/t_w = 36.23 < 81.98 \Rightarrow \text{Compact Web}$

$c/t_f = 5.68 < 10.91 \Rightarrow \text{Compact Flange}$

2-Check Lateral Torsional Buckling

$L_{uact} = 0 \text{ m} < L_{umax} = 193.65 \text{ m} \Rightarrow \text{Supported (No LTB)}$

3-Check Bending Stress

Section: IPE300

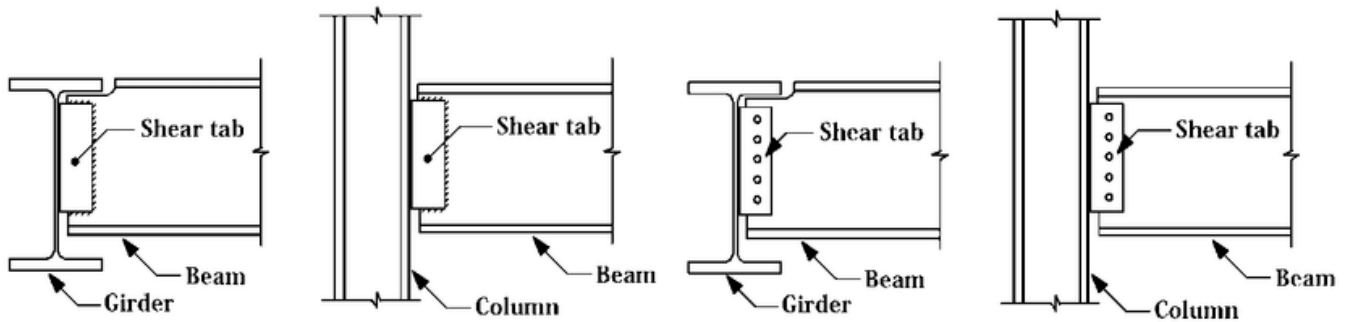
$f_{act} = 1.42 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

4-Check Shear Stress

$$q_{act} = 0.19 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$$

5-Check Deflection

$$\delta_{act} = 1.25 \text{ cm} < \delta_{all} = 2.67 \text{ cm}$$



Group Connection Design (Simple Shear Plate Connection)

1-Bolts Design

Bolts: M20 of Grade 8.8

$$V_d = 3.96 \text{ ton}$$

$$R_{least} = 3.07 \text{ ton}$$

N = 3 with Pitch = 70 mm & Full Layout: (35;70 70 35)

2-Stresses Induced in Fillet Weld Lines at Plane(1-1)

$$f = 0.23 \text{ t/cm}^2 \text{ \& } q = 0.16 \text{ t/cm}^2 \Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.35 \text{ t/cm}^2 < 1.1 * 0.2F_u = 0.79 \text{ t/cm}^2 \Rightarrow \text{OK}$$

3-Stresses Induced in Fillet Weld Lines at Plane(2-2)

$$q = 0.16 \text{ t/cm}^2 \text{ \& } q_{mt} = 0.23 \text{ t/cm}^2 \Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.28 \text{ t/cm}^2 < 0.2F_u = 0.72 \text{ t/cm}^2 \Rightarrow \text{OK}$$

4-Check Thickness of Plate

$$f = (6 * V_d * e) / (t_p * L^2) = 0.27 \text{ t/cm}^2 < 0.72 * F_y = 1.73 \text{ t/cm}^2 \Rightarrow \text{OK}$$

Plate Layout \Rightarrow L = 210 mm & t_p = 10 mm & S_w = 6 mm

Beam ID	Start Point	End Point	Span (m)	Mmax (t.m)	Vmax (ton)
8	(6,8,4)	(14,8,4)	8	11.28	4.8

Design Limit state:

Combo: 1*Dead + 1*Live

Md: 11.28 t.m

Vd: 4.8 ton

Service Limit State

Combo: LIVE

Span: 8 m

Load: -0.64 t/m'

Design Checks

1-Check Local Buckling

$d_w/t_w = 38.65 < 81.98 \Rightarrow$ Compact Web

$c/t_f = 5.38 < 10.91 \Rightarrow$ Compact Flange

2-Check Lateral Torsional Buckling

$L_{uact} = 0 \text{ m} < L_{umax} = 219.47 \text{ m} \Rightarrow$ Supported (No LTB)

3-Check Bending Stress

Section: IPE360

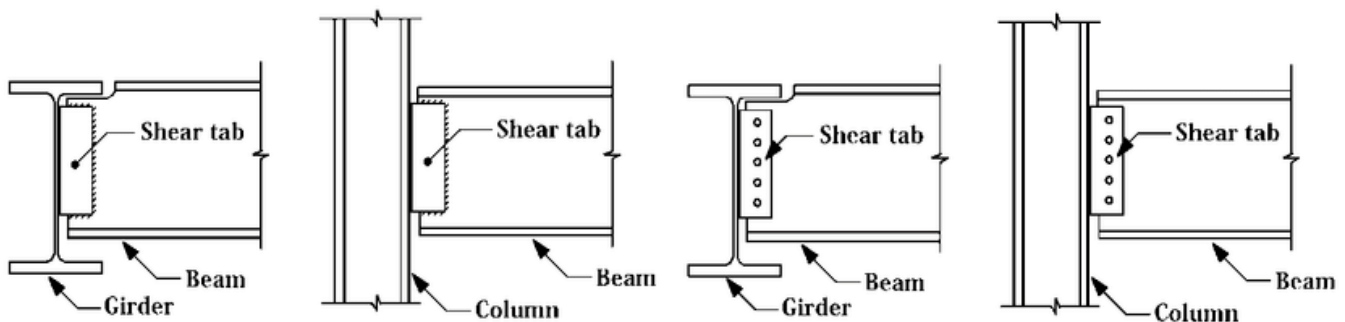
$f_{act} = 1.25 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

4-Check Shear Stress

$q_{act} = 0.17 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$

5-Check Deflection

$\delta_{act} = 1 \text{ cm} < \delta_{all} = 2.67 \text{ cm}$



Group Connection Design (Simple Shear Plate Connection)

1-Bolts Design

Bolts: M20 of Grade 8.8

$V_d = 4.8 \text{ ton}$

$R_{least} = 3.46 \text{ ton}$

$N = 3$ with Pitch = 84 mm & Full Layout: (42;84 84 42)

2-Stresses Induced in Fillet Weld Lines at Plane(1-1)

$f = 0.19 \text{ t/cm}^2$ & $q = 0.16 \text{ t/cm}^2 \Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.34 \text{ t/cm}^2 < 1.1 * 0.2F_u = 0.79 \text{ t/cm}^2 \Rightarrow \text{OK}$

3-Stresses Induced in Fillet Weld Lines at Plane(2-2)

$q = 0.16 \text{ t/cm}^2$ & $q_{mt} = 0.19 \text{ t/cm}^2 \Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.25 \text{ t/cm}^2 < 0.2F_u = 0.72 \text{ t/cm}^2 \Rightarrow \text{OK}$

4-Check Thickness of Plate

$f = (6 * V_d * e) / (t_p * L^2) = 0.23 \text{ t/cm}^2 < 0.72 * F_y = 1.73 \text{ t/cm}^2 \Rightarrow \text{OK}$

Plate Layout $\Rightarrow L = 252 \text{ mm}$ & $t_p = 10 \text{ mm}$ & $S_w = 6 \text{ mm}$

Columns

Column ID	Start Point	End Point	Height (m)	Nmax (ton)
55	(6,8,0)	(6,8,4)	4	-11.61
56	(14,8,0)	(14,8,4)	4	-8.26
59	(6,12,0)	(6,12,4)	4	-7.59
51	(6,4,0)	(6,4,4)	4	-6.44
52	(14,4,0)	(14,4,4)	4	-6.44
60	(14,12,0)	(14,12,4)	4	-6.33
54	(0,8,0)	(0,8,4)	4	-5.22
50	(0,4,0)	(0,4,4)	4	-2.87
58	(0,12,0)	(0,12,4)	4	-2.63
53	(20,4,0)	(20,4,4)	4	-2.41
57	(20,8,0)	(20,8,4)	4	-2.41
48	(14,0,0)	(14,0,4)	4	-2.37
49	(20,0,0)	(20,0,4)	4	-2.37
61	(20,12,0)	(20,12,4)	4	-2.37

Design Limit state:

Combo: 1*Dead + 1*Live

Nd: -11.61 ton

1-Check Local Buckling

$d_w/t_w = 36.23 < 37.44 \Rightarrow \text{Compact Web}$

$c/t_f = 5.68 < 10.91 \Rightarrow \text{Compact Flange}$

2-Check Normal Stress

Section: IPE300

$$\lambda = 119.4 > 100$$

$$f_c = 0.22 \text{ t/cm}^2 < F_c = 0.53 \text{ t/cm}^2$$
