

## Design Calculation Sheet for Mezzanine

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Location: Cairo

City: Cairo

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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

$dw/tw = 15.58 < 81.98 \Rightarrow$  Compact Web

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

#### 2-Check Lateral Torsional Buckling

$Lu_{act} = 0 \text{ m} < Lu_{max} = 59.39 \text{ m} \Rightarrow$  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/cm<sup>2</sup> &  $q = 0$  t/cm<sup>2</sup>  $\Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0$  t/cm<sup>2</sup>  $< 1.1 \cdot 0.2F_u = 0.79$  t/cm<sup>2</sup>  $\Rightarrow$  OK

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

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

### 4-Check Thickness of Plate

$f = (6 \cdot V_d \cdot e) / (t_p \cdot L^2) = 0$  t/cm<sup>2</sup>  $< 0.72 \cdot F_y = 1.73$  t/cm<sup>2</sup>  $\Rightarrow$  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

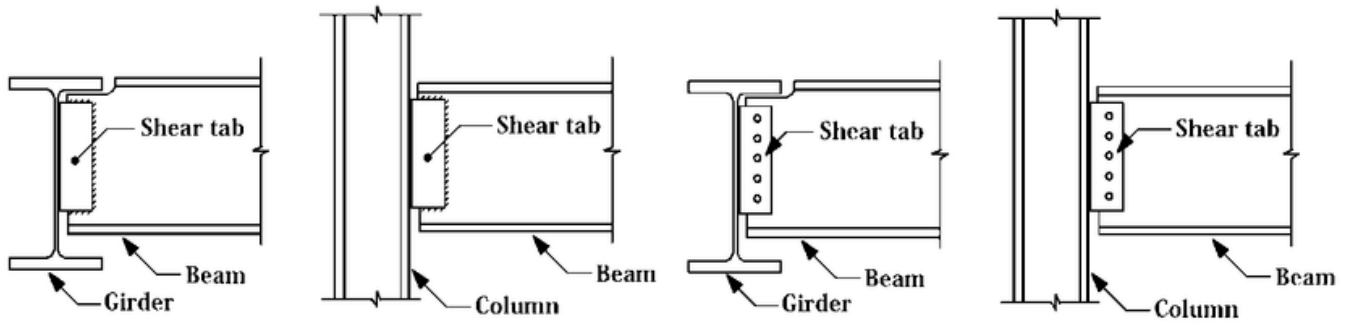
$f_{act} = 1.08 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

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

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

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

#### 4-Check Thickness of Plate

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

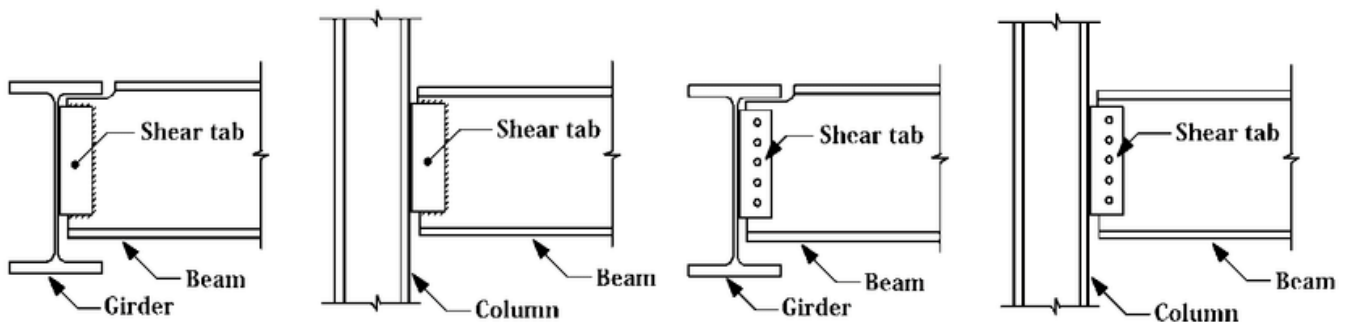
$f_{act} = 1.24 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

### 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	2.09	2.09
23	(6,4,4)	(6,8,4)	4	2.23	1.64
12	(14,12,4)	(20,12,4)	6	2.25	1.15
3	(14,0,4)	(20,0,4)	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
10	(0,12,4)	(6,12,4)	6	2.41	1.61
27	(8,8,4)	(8,12,4)	4	2.59	1.82
33	(12,8,4)	(12,12,4)	4	2.59	1.82
15	(0,8,4)	(0,12,4)	4	2.65	1.85
24	(6,8,4)	(6,12,4)	4	2.65	1.85

### Design Limit state:

Combo: 1\*Dead + 1\*Live

Md: 2.65 t.m

Vd: 1.85 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

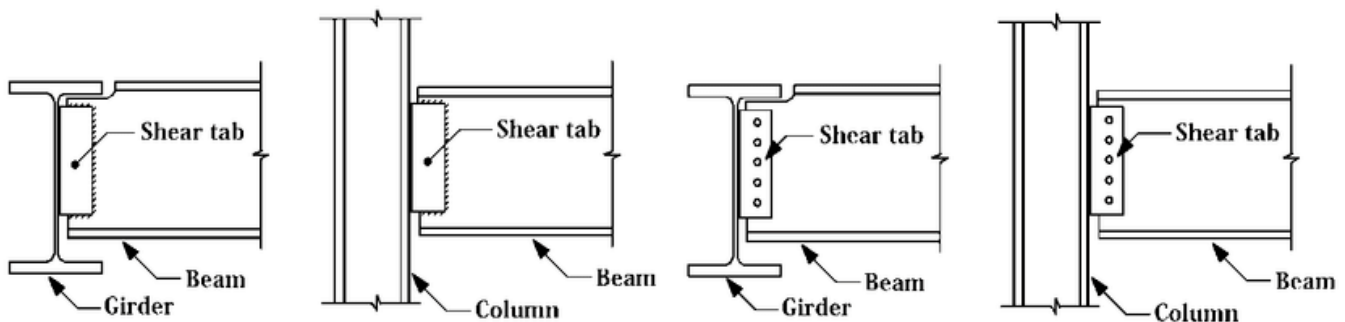
$f_{act} = 1.37 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

### 4-Check Shear Stress

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

### 5-Check Deflection

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



## Group Connection Design (Simple Shear Plate Connection)

### 1-Bolts Design

Bolts: M20 of Grade 8.8

$V_d = 1.85 \text{ ton}$

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

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

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

$f = 0.13 \text{ t/cm}^2$  &  $q = 0.08 \text{ t/cm}^2 \Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.19 \text{ t/cm}^2 < 1.1 * 0.2F_u = 0.79 \text{ t/cm}^2 \Rightarrow \text{OK}$

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

$q = 0.08 \text{ t/cm}^2$  &  $q_{mt} = 0.13 \text{ t/cm}^2 \Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.15 \text{ t/cm}^2 < 0.2F_u = 0.72 \text{ t/cm}^2 \Rightarrow \text{OK}$

### 4-Check Thickness of Plate

$$f = (6 \cdot V_d \cdot e) / (t_p \cdot L^2) = 0.16 \text{ t/cm}^2 < 0.72 \cdot F_y = 1.73 \text{ t/cm}^2 \Rightarrow \text{OK}$$

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)
4	(0,4,4)	(6,4,4)	6	3.25	1.65
29	(10,4,4)	(10,8,4)	4	3.27	2.68

### Design Limit state:

Combo: 1\*Dead + 1\*Live

Md: 3.27 t.m

Vd: 2.68 ton

### Service Limit State

Combo: LIVE

Span: 6 m

Load: -0.37 t/m'

### Design Checks

#### 1-Check Local Buckling

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

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

#### 2-Check Lateral Torsional Buckling

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

#### 3-Check Bending Stress

Section: IPE270

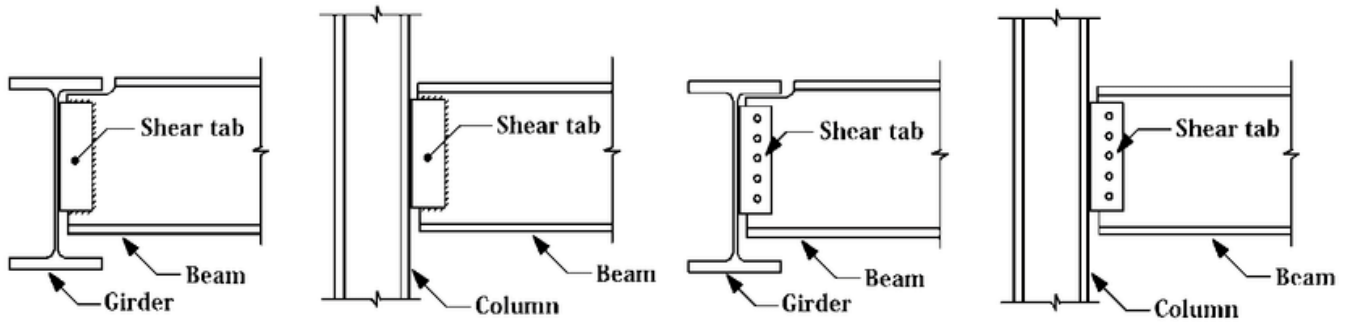
$f_{act} = 1.3 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

#### 4-Check Shear Stress

$q_{act} = 0.21 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$

#### 5-Check Deflection

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



### Group Connection Design (Simple Shear Plate Connection)

#### 1-Bolts Design

Bolts: M20 of Grade 8.8

$V_d = 2.68$  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)

$f = 0.19$  t/cm<sup>2</sup> &  $q = 0.12$  t/cm<sup>2</sup>  $\Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.28$  t/cm<sup>2</sup> <  $1.1 * 0.2F_u = 0.79$  t/cm<sup>2</sup>  $\Rightarrow$  OK

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

$q = 0.12$  t/cm<sup>2</sup> &  $q_{mt} = 0.19$  t/cm<sup>2</sup>  $\Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.22$  t/cm<sup>2</sup> <  $0.2F_u = 0.72$  t/cm<sup>2</sup>  $\Rightarrow$  OK

#### 4-Check Thickness of Plate

$f = (6 * V_d * e) / (t_p * L^2) = 0.23$  t/cm<sup>2</sup> <  $0.72 * F_y = 1.73$  t/cm<sup>2</sup>  $\Rightarrow$  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)
7	(0,8,4)	(6,8,4)	6	5.5	3.15
5	(6,4,4)	(14,4,4)	8	5.65	1.48
11	(6,12,4)	(14,12,4)	8	7.92	3.96

### Design Limit state:

Combo: 1\*Dead + 1\*Live

$M_d = 7.92$  t.m

$V_d = 3.96$  ton

### Service Limit State

Combo: LIVE

Span: 8 m

Load: -0.19 t/m'

### Design Checks

#### 1-Check Local Buckling

$dw/tw = 36.23 < 81.98 \Rightarrow$  Compact Web

$c/tf = 5.68 < 10.91 \Rightarrow$  Compact Flange

#### 2-Check Lateral Torsional Buckling

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

#### 3-Check Bending Stress

Section: IPE300

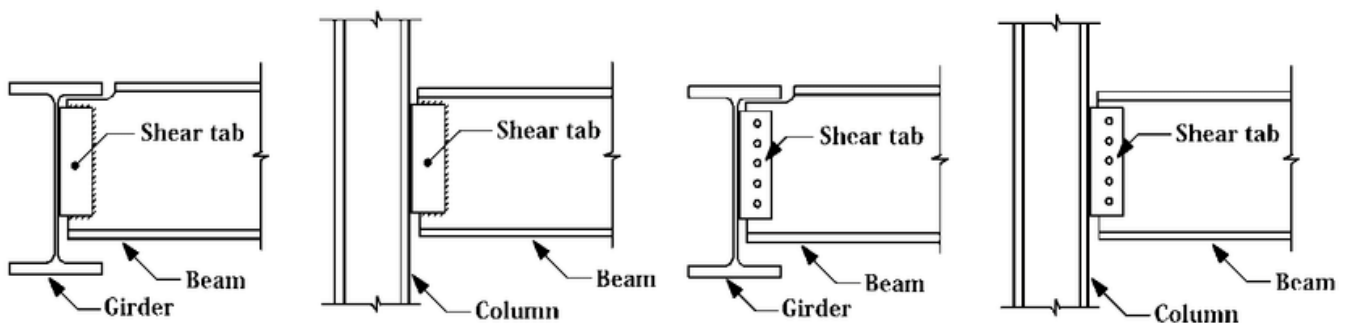
$f_{act} = 1.42 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

#### 4-Check Shear Stress

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

#### 5-Check Deflection

$\delta_{act} = 0.57 \text{ cm} < \delta_{all} = 2.67 \text{ cm}$



### 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)

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

$t/cm^2 \Rightarrow OK$

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

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

### 4-Check Thickness of Plate

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

Plate Layout  $\Rightarrow L = 210 \text{ mm}$  &  $t_p = 10 \text{ mm}$  &  $S_w = 6 \text{ mm}$

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Beam ID	Start Point	End Point	Span (m)	Mmax (t.m)	Vmax (ton)
8	(6,8,4)	(14,8,4)	8	13.28	5.3

### Design Limit state:

Combo: 1\*Dead + 1\*Live

Md: 13.28 t.m

Vd: 5.3 ton

### Service Limit State

Combo: LIVE

Span: 8 m

Load: -0.71 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

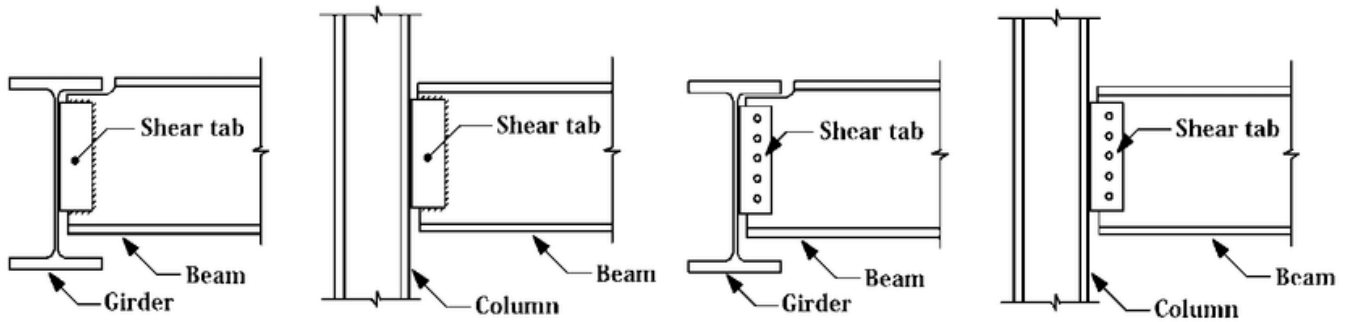
$f_{act} = 1.47 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

#### 4-Check Shear Stress

$q_{act} = 0.18 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$

#### 5-Check Deflection

$$d_{act} = 1.11 \text{ cm} < d_{all} = 2.67 \text{ cm}$$



### Group Connection Design (Simple Shear Plate Connection)

#### 1-Bolts Design

Bolts: M20 of Grade 8.8

$V_d = 5.3 \text{ ton}$

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

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

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

$$f = 0.21 \text{ t/cm}^2 \text{ \& } q = 0.18 \text{ t/cm}^2 \Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.37 \text{ t/cm}^2 < 1.1 * 0.2F_u = 0.79 \text{ t/cm}^2 \Rightarrow \text{OK}$$

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

$$q = 0.18 \text{ t/cm}^2 \text{ \& } q_{mt} = 0.21 \text{ t/cm}^2 \Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.27 \text{ t/cm}^2 < 0.2F_u = 0.72 \text{ t/cm}^2 \Rightarrow \text{OK}$$

#### 4-Check Thickness of Plate

$$f = (6 * V_d * e) / (t_p * L^2) = 0.25 \text{ t/cm}^2 < 0.72 * F_y = 1.73 \text{ t/cm}^2 \Rightarrow \text{OK}$$

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	-12.11
56	(14,8,0)	(14,8,4)	4	-9.76
59	(6,12,0)	(6,12,4)	4	-7.59
60	(14,12,0)	(14,12,4)	4	-6.33
54	(0,8,0)	(0,8,4)	4	-6.22
52	(14,4,0)	(14,4,4)	4	-5.94

51	(6,4,0)	(6,4,4)	4	-4.94
58	(0,12,0)	(0,12,4)	4	-3.63
50	(0,4,0)	(0,4,4)	4	-2.87
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: -12.11 ton

### 1-Check Local Buckling

$dw/tw = 36.23 < 37.44 \Rightarrow$  Compact Web

$c/tf = 5.68 < 10.91 \Rightarrow$  Compact Flange

### 2-Check Normal Stress

Section: IPE300

$\lambda = 119.4 > 100$

$f_c = 0.23 \text{ t/cm}^2 < F_c = 0.53 \text{ t/cm}^2$

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