

# Secondary Beams

Beam ID	Start Point	End Point	Span (m)	Mmax (t.m)	Vmax (ton)
22	(20,4,6)	(20,8,6)	4	2.05	2.05
21	(20,0,6)	(20,4,6)	4	2.05	2.05
2	(0,4,6)	(0,8,6)	4	2.05	2.05
1	(0,0,6)	(0,4,6)	4	2.05	2.05

## Design Limit state:

Combo: 1.2D+1.4L

Md: 2.05 t.m

Vd: 2.05 ton

## Service Limit State

Combo: LIVE

Span: 4 m

Load: -0.5 t/m'

## Design Checks

### 1-Check Local Buckling

$dw/tw = 29.65 < 81.98 \Rightarrow$  Compact Web

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

### 2-Check Lateral Torsional Buckling

$Lu_{act} = 0 \text{ m} < Lu_{max} = 129.1 \text{ m} \Rightarrow$  Supported (No LTB)

### 3-Check Bending Stress

Section: IPE270

$f_{act} = 1.06 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

### 4-Check Shear Stress

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

### 5-Check Deflection

$d_{act} = 0.41 \text{ cm} < d_{all} = 1.33 \text{ cm}$

## Group Connection Design (Simple Shear Plate Connection)

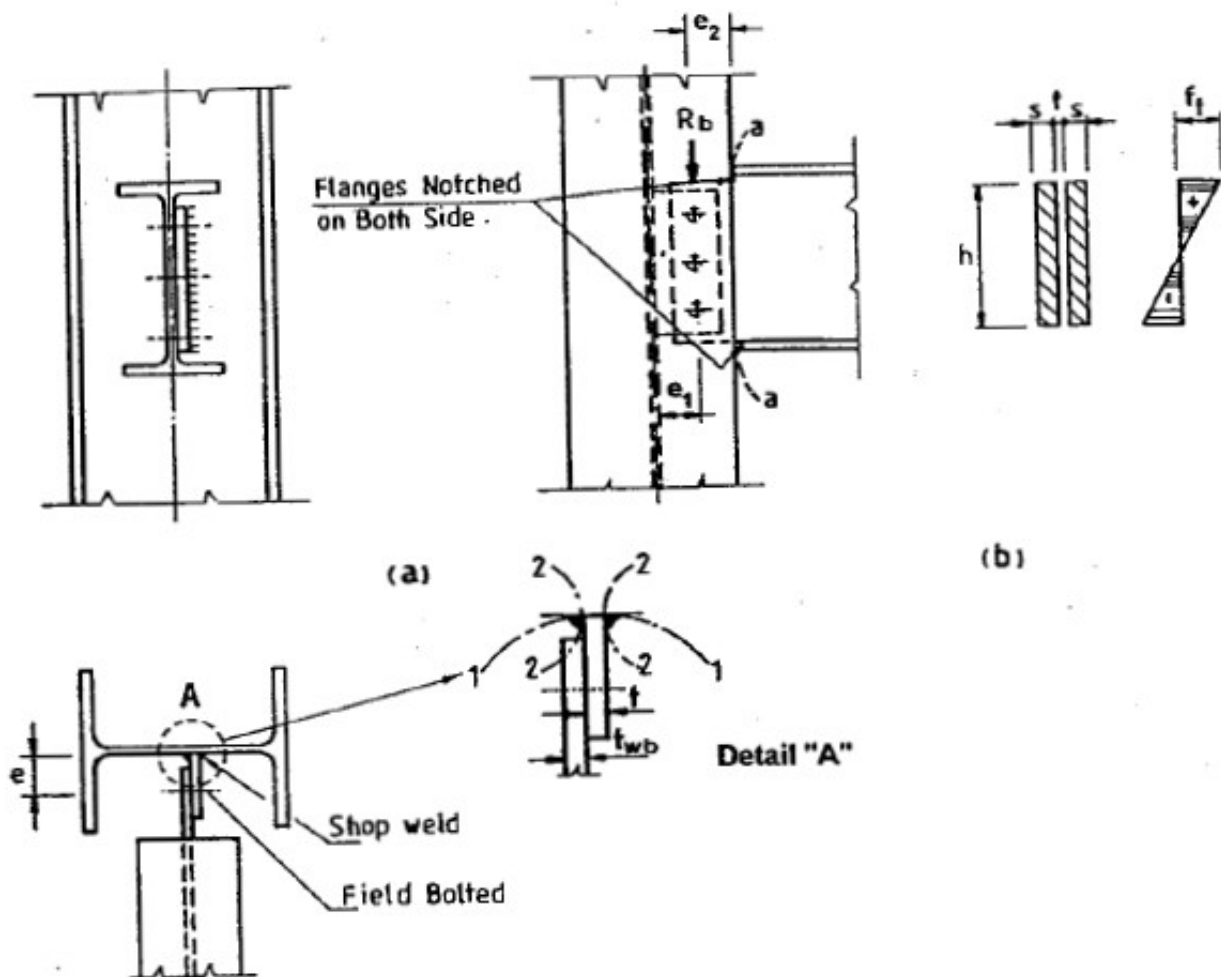


Fig. 4.8 Cleat Plate

#### 1-Bolts Design

Bolts: M20 of Grade 8.8

Vd= 2.05 ton

Rleast= 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)

$f = 0.14 \text{ t/cm}^2$  &  $q = 0.09 \text{ t/cm}^2 \Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.22 \text{ t/cm}^2 < 1.1 * 0.2F_u = 0.79 \text{ t/cm}^2 \Rightarrow \text{OK}$

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

$q = 0.09 \text{ t/cm}^2$  &  $q_{mt} = 0.14 \text{ t/cm}^2 \Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.17 \text{ t/cm}^2 < 0.2F_u = 0.72 \text{ t/cm}^2 \Rightarrow \text{OK}$

#### 4-Check Thickness of Plate

$f = (6 * V_d * e) / (t_p * L^2) = 0.17 \text{ t/cm}^2 < 0.72 * F_y = 1.73 \text{ t/cm}^2 \Rightarrow \text{OK IPE270}$

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)
18	(16,4,6)	(16,8,6)	4	4.05	4.05
17	(16,0,6)	(16,4,6)	4	4.05	4.05
20	(18,4,6)	(18,8,6)	4	4.05	4.05
3	(2,0,6)	(2,4,6)	4	4.05	4.05
4	(2,4,6)	(2,8,6)	4	4.05	4.05
5	(4,0,6)	(4,4,6)	4	4.05	4.05
6	(4,4,6)	(4,8,6)	4	4.05	4.05
7	(6,0,6)	(6,4,6)	4	4.05	4.05
8	(6,4,6)	(6,8,6)	4	4.05	4.05
9	(8,0,6)	(8,4,6)	4	4.05	4.05
10	(8,4,6)	(8,8,6)	4	4.05	4.05
19	(18,0,6)	(18,4,6)	4	4.05	4.05
12	(10,4,6)	(10,8,6)	4	4.05	4.05
13	(12,0,6)	(12,4,6)	4	4.05	4.05
14	(12,4,6)	(12,8,6)	4	4.05	4.05
15	(14,0,6)	(14,4,6)	4	4.05	4.05
16	(14,4,6)	(14,8,6)	4	4.05	4.05
11	(10,0,6)	(10,4,6)	4	4.05	4.05

#### Design Limit state:

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Combo: 1.2D+1.4L

Md: 4.05 t.m

Vd: 4.05 ton

#### Service Limit State

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Combo: LIVE

Span: 4 m

Load: -1 t/m'

#### Design Checks

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##### 1-Check Local Buckling

$dw/tw = 32.39 < 81.98 \Rightarrow$  Compact Web

$c/tf = 4.81 < 10.91 \Rightarrow$  Compact Flange

##### 2-Check Lateral Torsional Buckling

$L_{uact} = 0 \text{ m} < L_{umax} = 154.92 \text{ m} \Rightarrow$  Supported (No LTB)

### 3-Check Bending Stress

Section: IPE270

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

### 4-Check Shear Stress

$q_{act} = 0.27 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$

### 5-Check Deflection

$d_{act} = 0.41 \text{ cm} < d_{all} = 1.33 \text{ cm}$

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

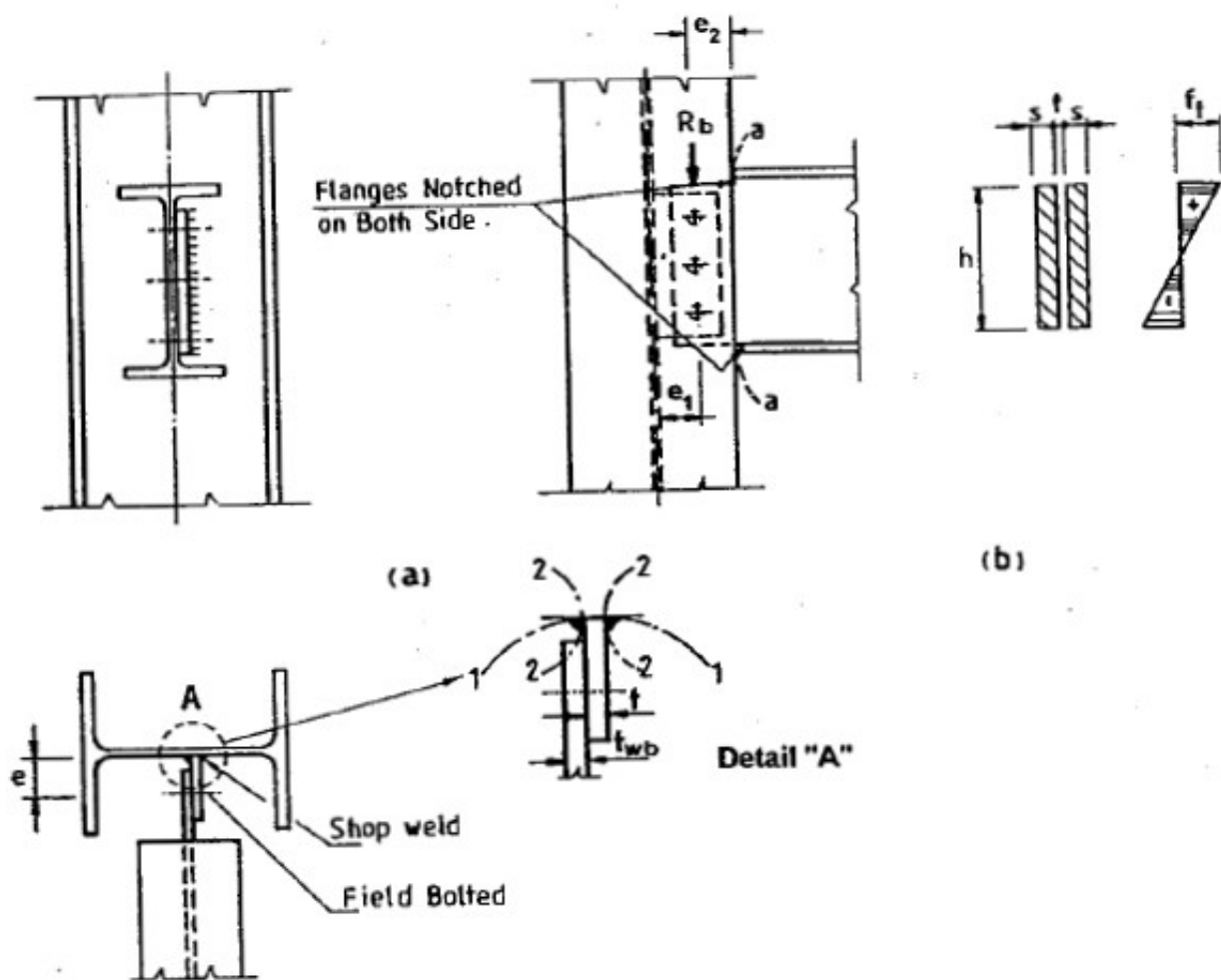


Fig. 4.8 Cleat Plate

### 1-Bolts Design

Bolts: M20 of Grade 8.8

$V_d = 4.05 \text{ ton}$

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

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

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

$f = 0.28 \text{ t/cm}^2$  &  $q = 0.18 \text{ t/cm}^2 \Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.43 \text{ t/cm}^2 < 1.1 * 0.2F_u = 0.79 \text{ t/cm}^2 \Rightarrow \text{OK}$

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

$q = 0.18 \text{ t/cm}^2$  &  $q_{mt} = 0.28 \text{ t/cm}^2 \Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.34 \text{ t/cm}^2 < 0.2F_u = 0.72 \text{ t/cm}^2 \Rightarrow \text{OK}$

#### 4-Check Thickness of Plate

$f = (6 * V_d * e) / (t_p * L^2) = 0.34 \text{ t/cm}^2 < 0.72 * F_y = 1.73 \text{ t/cm}^2 \Rightarrow \text{OK IPE270}$

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

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## Main Beams

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Beam ID	Start Point	End Point	Span (m)	Mmax (t.m)	Vmax (ton)
9	(14,8,6)	(20,8,6)	6	8.3	4.18
7	(0,8,6)	(6,8,6)	6	8.3	4.18
3	(14,0,6)	(20,0,6)	6	8.3	4.18
1	(0,0,6)	(6,0,6)	6	8.3	4.18

#### Design Limit state:

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Combo: 1.2D+1.4L

Md: 8.3 t.m

Vd: 4.18 ton

#### Service Limit State

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Combo: LIVE

Span: 6 m

Load: -0.67 t/m'

#### Design Checks

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##### 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

$$f_{act} = 1.49 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$$

### 4-Check Shear Stress

$$q_{act} = 0.2 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$$

### 5-Check Deflection

$$\delta_{act} = 0.64 \text{ cm} < \delta_{all} = 2 \text{ cm}$$

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

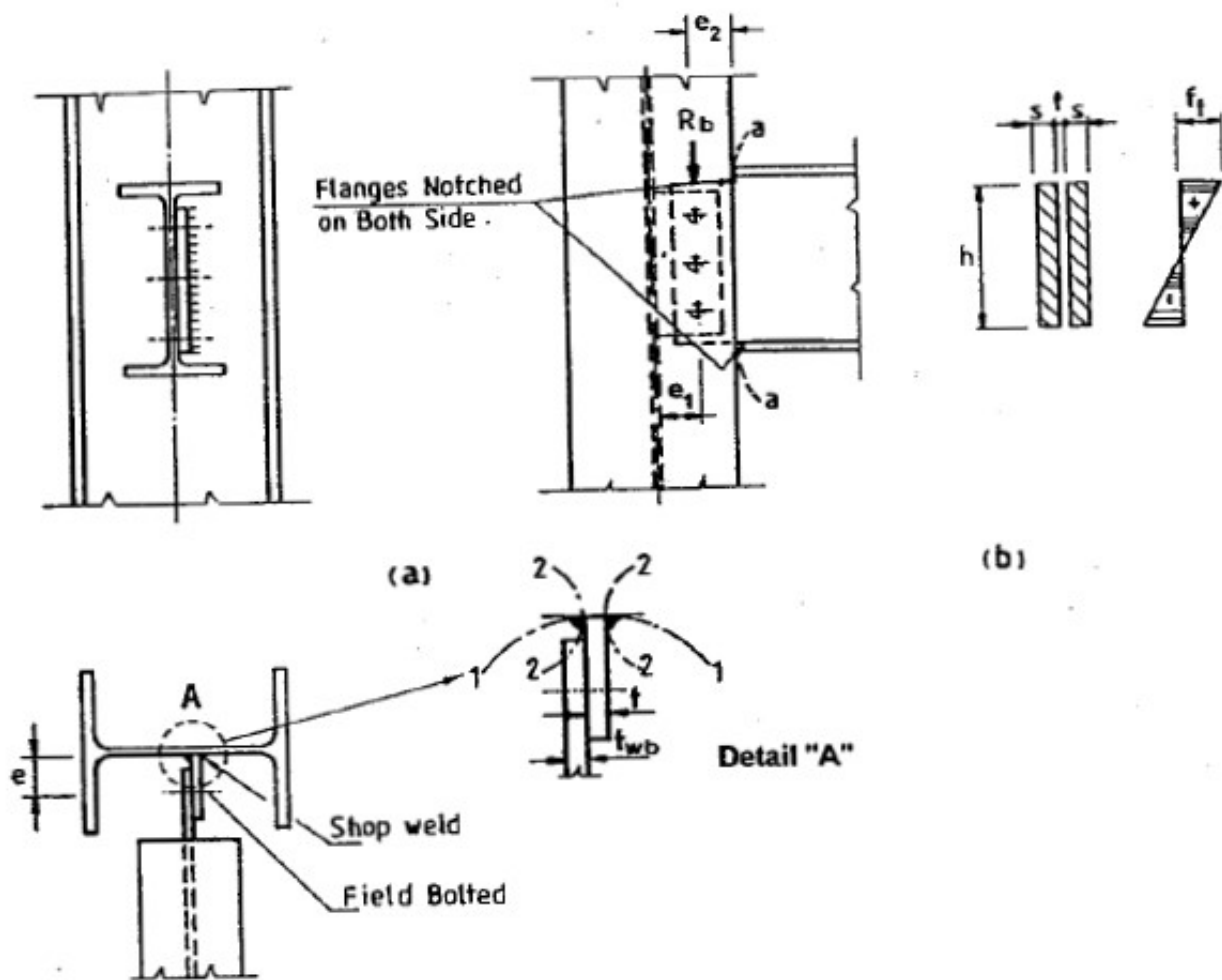


Fig. 4.8 Cleat Plate

### 1-Bolts Design

Bolts: M20 of Grade 8.8

$$V_d = 4.18 \text{ ton}$$

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

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

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

$f = 0.24 \text{ t/cm}^2$  &  $q = 0.17 \text{ t/cm}^2 \Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.37 \text{ t/cm}^2 < 1.1 * 0.2F_u = 0.79 \text{ t/cm}^2 \Rightarrow \text{OK}$

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

$q = 0.17 \text{ t/cm}^2$  &  $q_{mt} = 0.24 \text{ t/cm}^2 \Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.29 \text{ t/cm}^2 < 0.2F_u = 0.72 \text{ t/cm}^2 \Rightarrow \text{OK}$

### 4-Check Thickness of Plate

$f = (6 * V_d * e) / (t_p * L^2) = 0.28 \text{ t/cm}^2 < 0.72 * F_y = 1.73 \text{ t/cm}^2 \Rightarrow \text{OK IPE300}$

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)
6	(14,4,6)	(20,4,6)	6	16.41	8.24
4	(0,4,6)	(6,4,6)	6	16.41	8.24
8	(6,8,6)	(14,8,6)	8	16.56	6.25
2	(6,0,6)	(14,0,6)	8	16.56	6.25

### Design Limit state:

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Combo: 1.2D+1.4L

Md: 16.56 t.m

Vd: 6.25 ton

### Service Limit State

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Combo: LIVE

Span: 8 m

Load: -0.75 t/m'

### Design Checks

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#### 1-Check Local Buckling

$d_w/t_w = 40.24 < 81.98 \Rightarrow \text{Compact Web}$

$c/t_f = 5.35 < 10.91 \Rightarrow \text{Compact Flange}$

#### 2-Check Lateral Torsional Buckling

$L_{uact} = 0 \text{ m} < L_{umax} = 232.38 \text{ m} \Rightarrow \text{Supported (No LTB)}$

#### 3-Check Bending Stress

Section: IPE400

$f_{act} = 1.43 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

#### 4-Check Shear Stress

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

### 5-Check Deflection

$$\delta_{act} = 0.82 \text{ cm} < \delta_{all} = 2.67 \text{ cm}$$

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

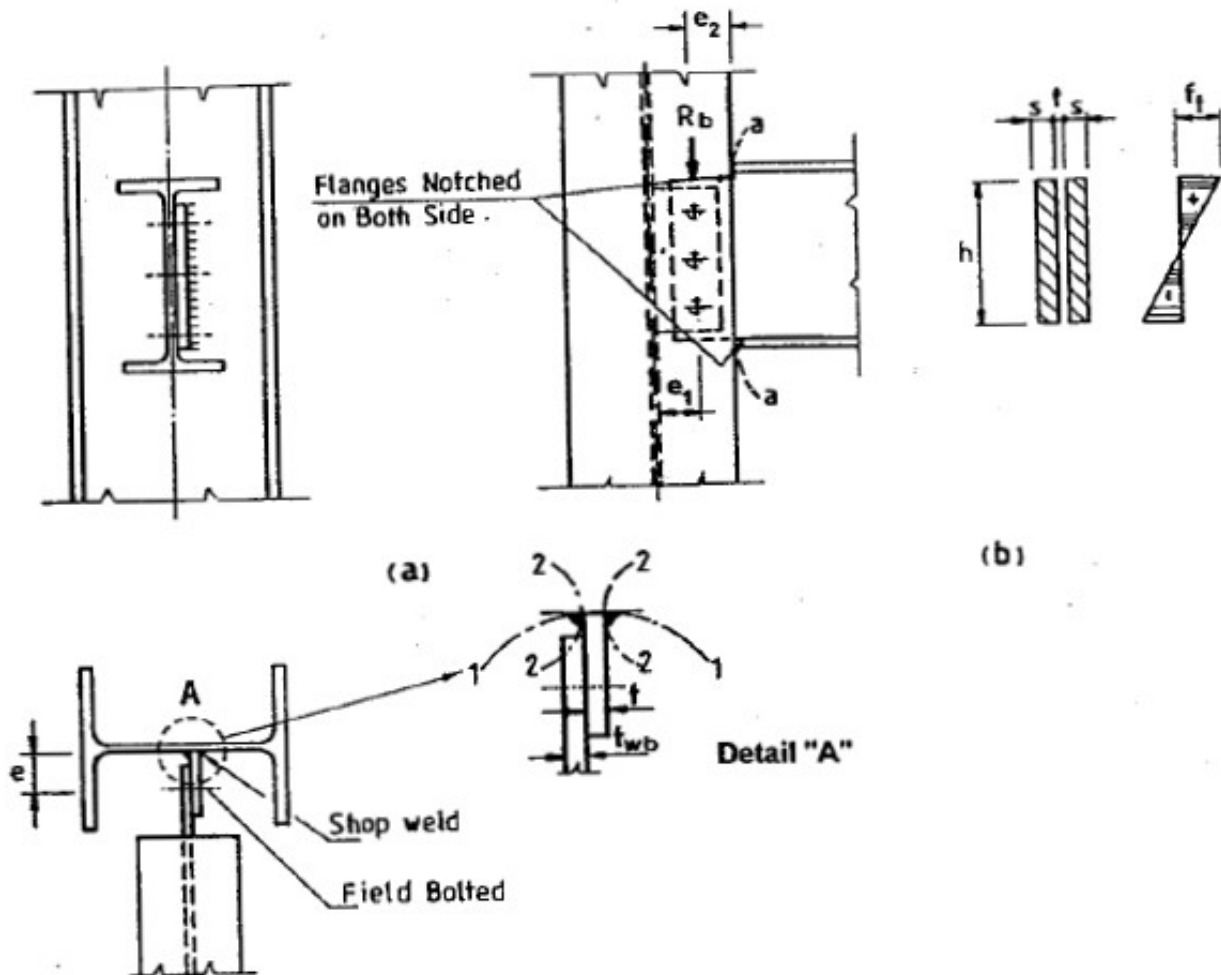


Fig. 4.8 Cleat Plate

### 1-Bolts Design

Bolts: M20 of Grade 8.8

$V_d = 6.25 \text{ ton}$

$R_{least} = 3.72 \text{ ton}$

$N = 3$  with Pitch = 93 mm & Full Layout: (46;93 93 47.5)

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

$$f = 0.2 \text{ t/cm}^2 \text{ \& } q = 0.19 \text{ t/cm}^2 \Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.38 \text{ t/cm}^2 < 1.1 * 0.2F_u = 0.79 \text{ t/cm}^2 \Rightarrow \text{OK}$$

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

$$q = 0.19 \text{ t/cm}^2 \text{ \& } q_{mt} = 0.2 \text{ t/cm}^2 \Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.28 \text{ t/cm}^2 < 0.2F_u = 0.72$$



$t/cm^2 \Rightarrow OK$

#### 4-Check Thickness of Plate

$f = (6 \cdot V_d \cdot e) / (t_p \cdot L^2) = 0.24 \text{ t/cm}^2 < 0.72 \cdot F_y = 1.73 \text{ t/cm}^2 \Rightarrow OK \text{ IPE400}$

Plate Layout  $\Rightarrow L = 280 \text{ mm} \ \& \ t_p = 10 \text{ mm} \ \& \ S_w = 6 \text{ mm}$

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Beam ID	Start Point	End Point	Span (m)	Mmax (t.m)	Vmax (ton)
5	(6,4,6)	(14,4,6)	8	32.78	12.33

#### Design Limit state:

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Combo: 1.2D+1.4L

Md: 32.78 t.m

Vd: 12.33 ton

#### Service Limit State

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Combo: LIVE

Span: 8 m

Load: -1.5 t/m'

#### Design Checks

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##### 1-Check Local Buckling

$d_w/t_w = 43.36 < 81.98 \Rightarrow \text{Compact Web}$

$c/t_f = 4.79 < 10.91 \Rightarrow \text{Compact Flange}$

##### 2-Check Lateral Torsional Buckling

$L_{uact} = 0 \text{ m} < L_{umax} = 271.11 \text{ m} \Rightarrow \text{Supported (No LTB)}$

##### 3-Check Bending Stress

Section: IPE550

$f_{act} = 1.34 \text{ t/cm}^2 < F_b = 1.54 \text{ t/cm}^2$

##### 4-Check Shear Stress

$q_{act} = 0.2 \text{ t/cm}^2 < q_{all} = 0.84 \text{ t/cm}^2$

##### 5-Check Deflection

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

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

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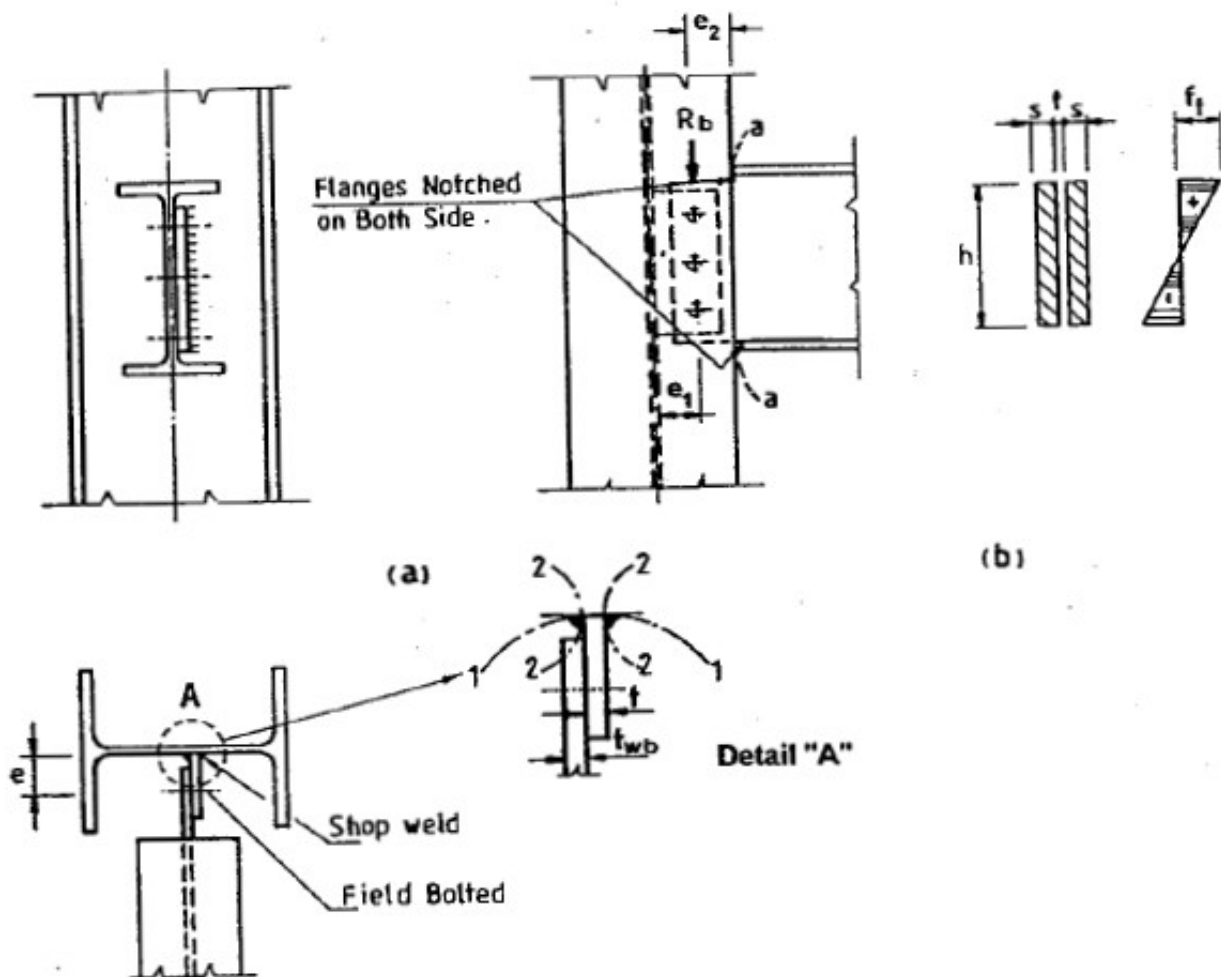


Fig. 4.8 Cleat Plate

#### 1-Bolts Design

Bolts: M20 of Grade 8.8

$V_d = 12.33$  ton

$R_{least} = 4.8$  ton

$N = 4$  with Pitch = 80 mm & Full Layout: (40;80 80 80 40)

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

$f = 0.3 \text{ t/cm}^2$  &  $q = 0.32 \text{ t/cm}^2 \Rightarrow f_{eq} = (f^2 + 3q^2)^{0.5} = 0.64 \text{ t/cm}^2 < 1.1 * 0.2F_u = 0.79 \text{ t/cm}^2 \Rightarrow \text{OK}$

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

$q = 0.32 \text{ t/cm}^2$  &  $q_{mt} = 0.3 \text{ t/cm}^2 \Rightarrow q_{res} = (q^2 + q_{mt}^2)^{0.5} = 0.44 \text{ t/cm}^2 < 0.2F_u = 0.72 \text{ t/cm}^2 \Rightarrow \text{OK}$

#### 4-Check Thickness of Plate

$f = (6 * V_d * e) / (t_p * L^2) = 0.36 \text{ t/cm}^2 < 0.72 * F_y = 1.73 \text{ t/cm}^2 \Rightarrow \text{OK IPE550}$

Plate Layout  $\Rightarrow L = 320 \text{ mm}$  &  $t_p = 10 \text{ mm}$  &  $S_w = 6 \text{ mm}$

# Columns

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Column ID	Start Point	End Point	Height (m)	Nmax (ton)
6	(6,4,0)	(6,4,6)	6	-29.09
7	(14,4,0)	(14,4,6)	6	-29.09
2	(6,0,0)	(6,0,6)	6	-14.9
3	(14,0,0)	(14,0,6)	6	-14.9
10	(6,8,0)	(6,8,6)	6	-14.9
11	(14,8,0)	(14,8,6)	6	-14.9
5	(0,4,0)	(0,4,6)	6	-12.76
8	(20,4,0)	(20,4,6)	6	-12.76
4	(20,0,0)	(20,0,6)	6	-6.65
12	(20,8,0)	(20,8,6)	6	-6.65
1	(0,0,0)	(0,0,6)	6	-6.65
9	(0,8,0)	(0,8,6)	6	-6.65

## Design Limit state:

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Combo: 1.2D+1.4L

Nd: -29.09 ton

### 1-Check Local Buckling

$41.31 > c/t_f = 38.65 > 37.44 \Rightarrow$  Non-Compact Web

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

### 2-Check Normal Stress

Section: IPE360

$\lambda = 158.31 > 100$

$f_c = 0.4 \text{ t/cm}^2 < F_c = 0.3 \text{ t/cm}^2$

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