PROBLEMS ON COMPRESSION MEMBERS

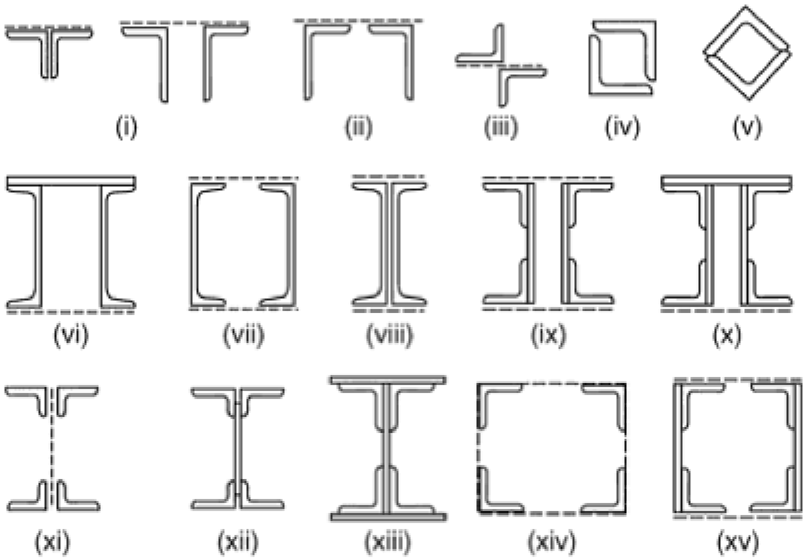
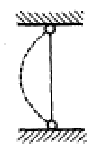
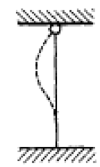
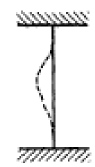
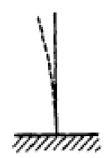


Fig. 17.11 *Typical built-up sections for compression members*

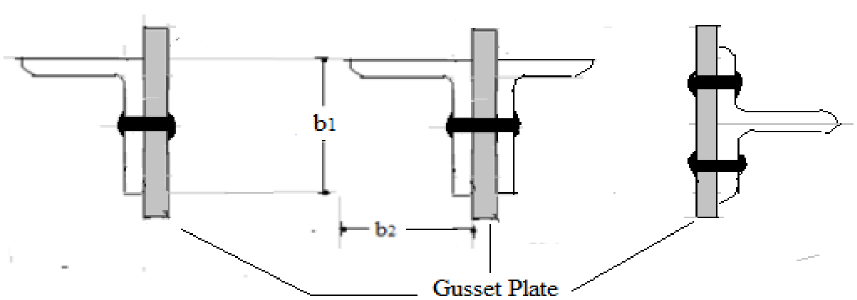
Table 11 Effective Length of Prismatic Compression Members
(*Clause* 7.2.2) ; *IS 800-2007; Pg. 45*

No.	*End Conditions*	Boundary Conditions: At One End — Translation *(Position)*	At One End — Rotation *(Direction)*	At the Other End — Translation *(Position)*	At the Other End — Rotation *(Direction)*	Schematic Representation	Effective Length (K L)
1	**Both Ends Hinged (pinned)**	Restrained	Free	Restrained	Free		**1.00 L**
		i) Column is restrained in position but not in drection at both Ends. **ii) Column is restrained in position but not in drection at each Ends.** **iii) Column is restrained in position but not held against Rotation.**					
2	**One Fixed other is Hinged (Pinned)**	Restrained	Restrained	Restrained	Free		**0.8 L**
		i) One end is restrained against translation and rotation and upper end is pinned . **ii) Both Ends held in position and only one end is not restrained against rotation .** **iii) Both Ends held in position and only one end is not restrained against Direction .**					
3	**Both Ends Fixed**	Restrained	Restrained	Restrained	Restrained		**0.65 L**
		i) Both Ends Held in Position & Restrained Against Rotation . **ii) Both Ends Restrained Against Translation & Rotation .** **iii) Restrained in Direction & Rotation at Both Ends.** **iv) Column is Held in Position & Restrained Against Rotation at Both Ends.**					
4	**One End is Fixed Other is Free**	Restrained	Restrained	Free	Free		**2.00 L**
		i) Column is Restrained against translation and Rotation & Upper end is Free .					

a) Single angle connected to Gusset plate.

b) Two equal angles connected on each /opposite/either sides Of Gusset plate.

c) Two equal angles connected on same side Of Gusset plate.



Problem 1) Design a single angle Discontinuous strut connected at each end to 10 mm thick gusset plate carrying an factored load of 50 KN In cases given below. It is 2.75

mt. long between intersections which is restrained in position but not in direction at each end. ? Take $f_y = 250 \quad Mpa$

a) 20 mm Ø bolts of grade 4.6.

b) Welded connection

Answer : Given a) P = 50 KN

b) Length of member (clear) = 2.75 mt = 2.75×10^3 mm

$\therefore$ l_{eff} = K L = $1 \times 2.75 \times 10^3 = 2.75 \times 10^3$ mm……………......*IS 800-2007; pg. 45*

Assuming an approximate Design compressive stress $(\sigma_{ac}) = 60 \quad {}^{N}/_{mm^2}$

Area Reqd. For the strut $(A_{Req}) = \frac{50 \times 10^3}{60} = 833.33 \text{ mm}^2$

Refer the steel table and select ISA $60 \times 60 \times 8$ mm

For this angle ; A = 896 mm^2 , $r_{min} = r_{xx} = r_{yy}$ = Min. Radius of Gyration = 18 mm

Design Compressive stress (f_{cd}) : *….(refer pg. 04 for values)*

$$f_{cd} = \frac{f_y / \gamma_{m0}}{\phi + \left[\phi^2 - \lambda^2\right]^{0.5}}$$ ……………………………. IS 800-2007, Pg. 34 ; 7.1.2.1

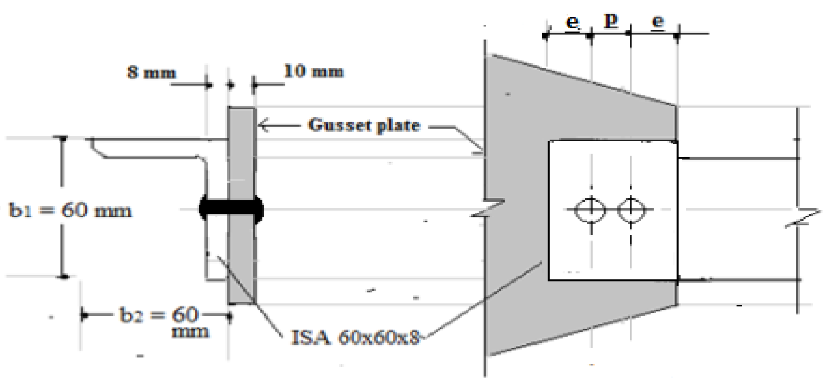
Where ; $\phi = 0.5\,[1 + \alpha\,(\lambda - 0.2) + \lambda^2] = 0.5[1 + 0.49\,(1.696 - 0.2) + 1.696^2] = 2.305$

λ_{m0} = partial safety factor for material Strength = 1.10 (Yielding Consideration)

(IS 800-2007 ; Table 5, Pg. 30)

$$\therefore \; f_{cd} = \frac{f_y / \gamma_{m0}}{\phi + \left[\phi^2 - \lambda^2\right]^{0.5}} = \frac{(250/1.10)}{2.305 + [2.305^2 - 1.696^2]^{0.5}} = 58.79 \; \frac{\text{N}}{\text{mm}^2}$$

$\therefore$ Design Compressive load = $f_{cd} \times A_{prov.}$ = 58.79×896 = 52.67 KN $>$ 50 KN ; Safe.



As per IS 800-2007; Pg. 35

Table 7 Imperfection Factor, α

(*Clauses* 7.1.1 *and* 7.1.2.1)

Buckling Class	a	b	c	d
α	0.21	0.34	0.49	0.76

7.5.1.2 *Loaded through one leg* (IS 800-2007; Pg. 48)

The flexural torsional buckling strength of single angle loaded in compression through one of its legs may be evaluated using the equivalent slenderness ratio, λ_e, as given below:

$$\lambda_e = \sqrt{k_1 + k_2\,\lambda_{vv}^2 + k_3\,\lambda_\varphi^2}$$

where

k_1, k_2, k_3 = constants depending upon the end condition, as given in Table 12,

$$\lambda_{vv} = \frac{\left(\frac{l}{r_{vv}}\right)}{\varepsilon\sqrt{\frac{\pi^2 E}{250}}} \quad \text{and} \quad \lambda\varphi = \frac{(b_1 + b_2)/2t}{\varepsilon\sqrt{\frac{\pi^2 E}{250}}}$$

where

l = centre-to-centre length of the supporting member, = 2.75×10^3 mm

r_{vv} = radius of gyration about the minor axis = 11.5

b_1, b_2 = width of the two legs of the angle. = 60 mm

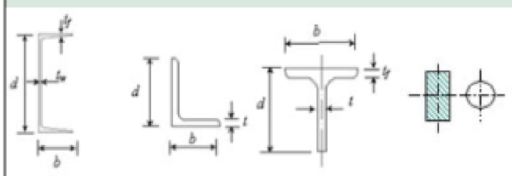
t = thickness of the leg. = 8 mm

ε = yield stress ratio ($250/f_y)^{0.5}$ = 1

E = Modulus Of Elasticity = 2×10^5 Mpa

IS 800 - 2007; Pg. 44; Table5.3 Buckling class of cross sections (Section 7.1.2.2)

Cross Section	Limits	Buckling about axis	Buckling Class
Channel, Angle, T and Solid Sections		Any	c



$$\lambda_{vv} = \frac{\left(\frac{l}{r_{vv}}\right)}{\varepsilon\sqrt{\frac{\pi^2 E}{250}}}$$

$$= \frac{(2.75 \times 10^3 / 11.5)}{(1)\sqrt{\frac{\pi^2 \times 2 \times 10^5}{250}}}$$

$$= 2.691$$

Table 12 Constants k_1, k_2 and k_3

Sl No.	No. of Bolts at Each End Connection	Gusset/Connecting Member Fixity	k_1	k_2	k_3
(1)	(2)	(3)	(4)	(5)	(6)
i)	≥ 2	Fixed	0.20	0.35	20
		Hinged	0.70	0.60	5
ii)	1	Fixed	0.75	0.35	20
		Hinged	1.25	0.50	60

$$\lambda\varphi = \frac{(b_1 + b_2)/2t}{\varepsilon\sqrt{\frac{\pi^2 E}{250}}} = \frac{(60+60)/2\,(8)}{(1)\sqrt{\frac{\pi^2 \times 2 \times 10^5}{250}}} = 0.0844$$

$$\therefore \quad \lambda_e = \sqrt{k_1 + k_2\,\lambda_{vv}^2 + k_3\,\lambda_\varphi^2} = 1.696$$

Design :

Case 1) Using 20 mm ∅ bolts of grade 4.6 ;

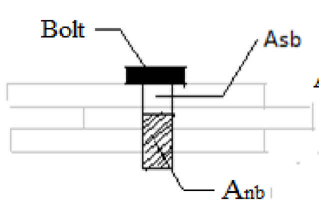
Step i) : Design Strength of one Bolt in Shear (V_{ds})………(*single shear*)

$V_{ds} = 1/\gamma\ [\frac{F_u}{\sqrt{3}}\ (n_n\, A_{nb})]$.................................*IS 800-2007; cl. 10.3.3 ; pg. 75*

Where $F_u = F_{ub} = 400\ {}^{N}/_{mm^2}$……………………*IS 1367 For grade 4.6*

n_n = No. of shear planes with threads intercepting shear planes. = 1 (single Shear)

A_{nb} = Nominal Plain Shank Area of the Bolt. = 0.78 $\times\ \frac{\pi\,(20)^2}{4}$



Anb = 0.78 to 0.80 (π d²/4)

= 245.044

γ = Partial safety factor for Bolt Material = 1.25 .... *IS 800-2007 ;Table 5 ; pg. 30*

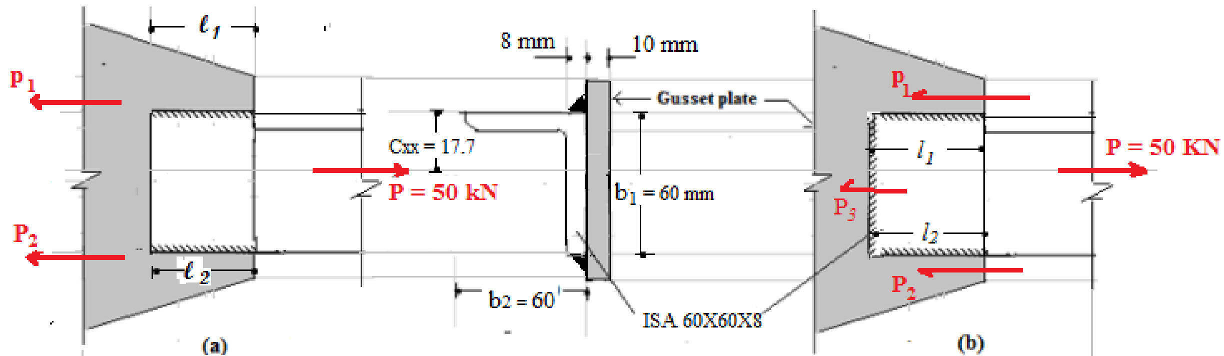
$$V_{ds} = 1/\,1.25\ \left[\frac{400}{\sqrt{3}}\ (1 \times\ 245.044)\right] = 45.27 \text{ KN}$$

$$\therefore\ \text{No. Of Bolts} = \frac{\text{Load}}{\text{Design strength of Bolt}} = \frac{50}{45.27} = 02\ \text{No.}$$

Dia. Of Bolt Hole = d_0 = 20 + 2 = 22 mm and Pitch (P) = 2.5 × Ø = 2.5 × 20 = 50 mm

∴ Edge Distance (e) = 1.5 × d_0 = 1.5 × 22 = 33 say 40 mm

Case 2) Welded connection ;



Design stress for weld = $\dfrac{f_{up}}{\sqrt{3}\,\gamma}$ .... *IS 800-2007 ; 10.5.7 ; Pg. 79*

(f_{up} – Ultimate stress for plate material)

$$= \frac{410}{\sqrt{3} \times 1.25} = 189.37\ \ {}^{N}/_{mm^2}$$

(γ – Table No. 05 ; Pg. 30)

∴ Design strength of weld per mm length = 189.37 × 1 × 0.7 s

Let the size of weld = S = 6 mm

= 189.37 x 1 x 0.7 x 6

= 795.354 N/mm

t = 0.7 S

S

Case (a)

We have, P = P_1 + P_2 = 50 KN

Taking Miment @ Top Weld ;

P_2 x 60 = 50 x 10^3 x 17.7 ∴ P_2 = 14.75 KN

∴ P_1 = 50 - 14.75 = 35.25 KN

1] Length of Top Weld (l_1) =

$$\frac{P_1}{795.354} = \frac{35.25 \times 10^3}{795.354} = 44.31 \text{ mm}$$

2] Length Of Bottom weld (l_2) =

$$= \frac{14.75 \times 10^3}{795.354} = 18.54 \text{ mm}$$

Case (b)

$$\text{length Of Weld Required} = \frac{50 \times 10^3}{795.354}$$

$$= 62.865 \text{ mm}$$

$l_1 + l_2 + 60 = 62.865$

∴ $l_1 + l_2$ = 2.865

Taking Moment @ Top Weld ;

$$(795.354 \times l_2 \times 60) + (795.354 \times 60 \times \frac{60}{2}) = 50 \times 10^3 \times 17.7$$

∴ l_2 = 11.455 mm

∴ l_1 = 8.59 mm

Problem 2) Determine Design compressive strength (L.C.C.) of a single angle Discontinuous strut 2.75 mt. consist of equal angle 60 × 60 × 8 mm Long connected at each end to 10 mm thick gusset plate . Take $f_y = 250\ \ Mpa$

Answer : Given a) Length of member (clear) = 2.75 mt = 2.75 × 10^3 mm

Let the condition be Both Ends Hinged.

$\therefore$ l_{eff} = K L = 1 × 2.75 × 10^3 = 2.75 × 10^3 mm……………......*IS 800-2007; pg. 45*

For ISA 60 × 60 × 8 mm ; A = 896 mm^2,

r_{min}= r_{xx} = r_{yy} = Min. Radius of Gyration = 18 mm

Follow steps upto statement *Case 1) Using 20 mm ∅ bolts of grade 4.6* in above problem.

Problem 3) Design a Double angle Discontinuous strut connected on either side of 10 mm thick gusset plate carrying an factored load of 200 KN In cases given below. It is 3.00 mt. long between intersections which is Effectively held in position at both ends and restrained in direction at one end only. ? Take $f_y = 250 \quad Mpa$

a) 20 mm ∅ bolts of grade 4.6.

b) Welded connection

Answer : Given a) P = 200 KN

b) Length of member (clear) = 3.00 mt = 3.00 × 10^3 mm

Given case is **One End Fix And Other Is Hinge (case 02)**

$\therefore$ l_{eff} = K L = 0.8 × 3 × 10^3 = 2.4 × 10^3 mm……………......*IS 800-2007; pg. 45*

Assuming an approximate Design compressive stress (σ_{ac}) = 60 ${}^{N}/_{mm^2}$

Area Reqd. For the strut (A_{Req}) = $\frac{200 \times 10^3}{60}$ = 3333.34 mm^2

Area of Each angle = $\frac{3333.34}{2}$ = 1666.67 mm^2

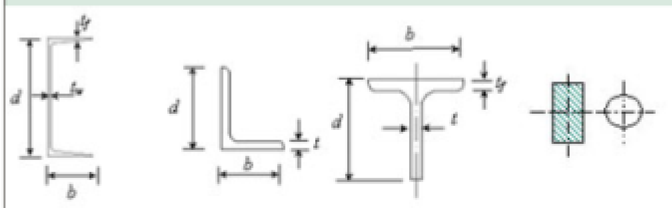
Refer the steel table and select ISA 125 × 95 × 8 mm

For this angle ; A = 1698 mm^2; Center of gravity ; C_{xx} = 38 mm , C_{yy} = 23.1 mm

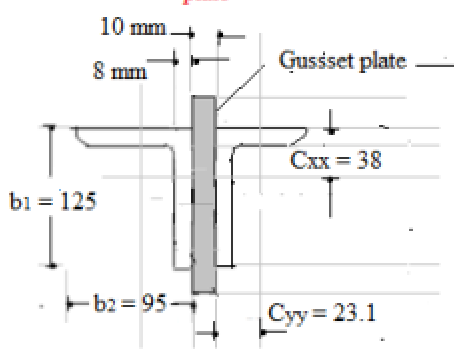
I_{xx} = 266 × 10^4 mm^4 , I_{yy} = 133.3 × 10^4 mm^4; r_{xx} = 39.6 mm , r_{yy} = 28 mm

IS 800 - 2007; Pg. 44; ***Table5.3 Buckling class of cross sections (Section 7.1.2.2)***

Cross Section	Limits	Buckling about axis	Buckling Class
Channel, Angle, T and Solid Sections		Any	c



a) Longer leg connected to Gusset plate



b) Shorter leg connected to Gusset plate

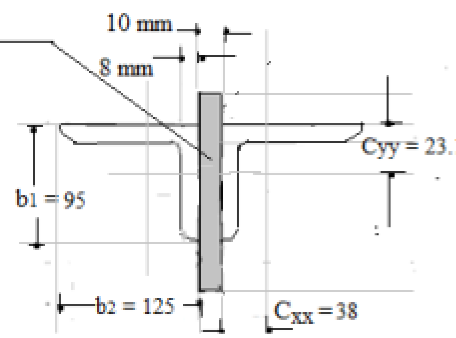


Table 9(c) Design Compressive Stress, f_{cd} (MPa) for Column Buckling Class c

IS 800-2007 ; Pg. 42; (*Clause* 7.1.2.1)

a)

$(\lambda) = \frac{l_{eff}}{r_{min}} = KL/r$ $= \frac{2.4 \times 10^3}{39.6} = 60.60$	**Yield Stress, f_y (MPa)** = 250 Mpa
60	168
60.60	???
70	152

Interpolation :

$$\left\{\frac{(168 - 152)}{(70 - 60)} \times (70 - 60.60)\right\} - 168$$

$\therefore$ $(f_{cd}) = 152.96 \ \frac{N}{mm^2}$

$\therefore$ Compressive strength $= f_{cd} \times A_{gross}$

$= 152.96 \times (2 \times 1698) = 519.45$ KN

b)

$(\lambda) = \frac{l_{eff}}{r_{min}} = KL/r$ $= \frac{2.4 \times 10}{28} = 85.71$	**Yield Stress, f_y (MPa)** = 250 Mpa
80	136
85.71	???
90	121

Interpolation :

$$\left\{\frac{(136 - 121)}{(90 - 80)} \times (90 - 85.71)\right\} - 136$$

$\therefore$ $(f_{cd}) = 129.56 \ \frac{N}{mm^2}$

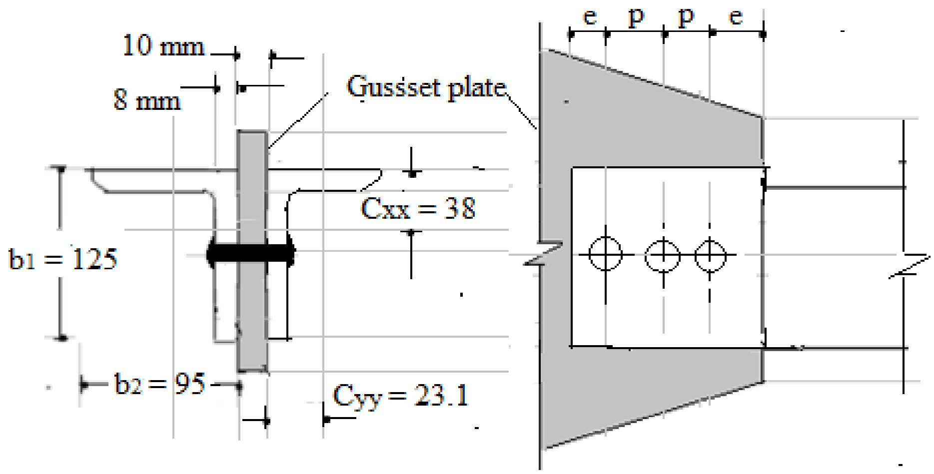
$\therefore$ Compressive strength $= f_{cd} \times A_{gross}$

$= 129.56 \times (2 \times 1698) = 440$ KN

Design :

Case 1) Using 20 mm ∅ bolts of grade 4.6 ;

Let us provide ISA 125 × 95 × 8 mm double angle longer leg back to back on either sides of 10 mm thick gusset plate Using 20 mm ∅ bolts of grade 4.6.



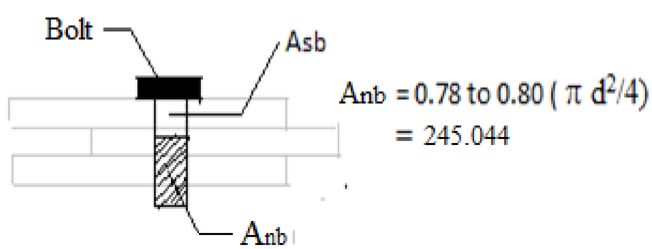
Step i) : Design Strength of Bolt in Shear (V_{ds}) ;

V_{ds} = 1/ ɣ [$\frac{F_u}{\sqrt{3}}$ ($n_n A_{nb}$)]...................................*IS 800-2007; cl. 10.3.3 ; pg. 75*

Where $F_u = F_{ub} = 400 \ {N}/{mm^2}$........................*IS 1367 For grade 4.6*

n_n = No. of shear planes with threads intercepting shear planes. = 2 (*Double Shear*)

A_{nb} = Nominal Plain Shank Area of the Bolt. = 0.78 × $\frac{\pi (20)^2}{4}$



ɣ = Partial safety factor for Bolt Material = 1.25 .... *IS 800-2007 ;Table 5 ; pg. 30*

$$V_{ds} = 1/\ 1.25\ [\frac{400}{\sqrt{3}}\ (2 \times\ 245.044)\ ] = 90.54 \text{ KN}$$

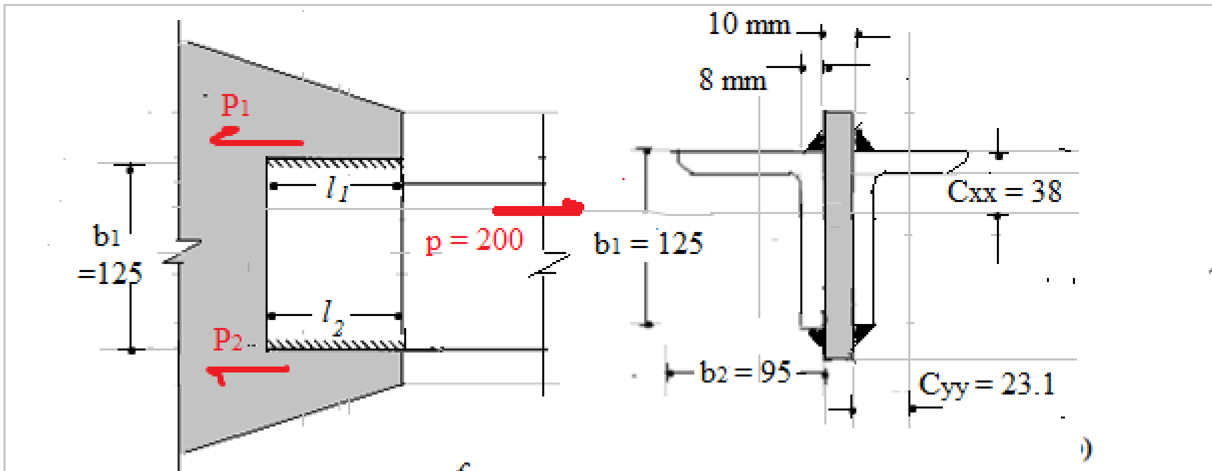
$$\therefore \text{ No. Of Bolts} = \frac{\text{Load}}{\text{Design strength of Bolt}} = \frac{200}{90.54} = 2.20 \text{ say } 03 \text{ No.}$$

Dia. Of Bolt Hole = d_0 = 20 + 2 = 22 mm and Pitch (P) = 2.5 × ∅ = 2.5 × 20 = 50 mm

∴ Edge Distance (e) = 1.5 × d_0= 1.5 × 22 = 33 say 40 mm

Case 2) Welded connection :

Let us provide ISA 125 × 95 × 8 mm double angle longer leg back to back on either sides of 10 mm thick gusset plate Using Welded connection.



Design stress for weld = $\dfrac{f_{up}}{\sqrt{3}\,\gamma}$ .... *IS 800-2007 ; 10.5.7 ; Pg . 79*

Ultimate stress for plate material

$= \dfrac{410}{\sqrt{3} \times 1.25} = 189.37 \ N/mm^2$

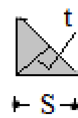
Table No. 05 ; Pg. 30

∴ Design strength of weld per mm length = 189.37 × 1 × 0.7 s

Let the size of weld = S = 6 mm

= 189.37 x 1 x 0.7 x 6

= 795.354 N/mm



We have, $P = P_1 + P_2 = 200$ KN

Taking Miment @ Top Weld ;

$P_2 \times 125 = 200 \times 10^3 \times 38$ ∴ $P_2 = 60.8$ KN

∴ $P_1 = 200 - 60.8 = 139.20$ KN

1] Length of Top Weld (l_1) =

$\dfrac{P_1}{\text{Strength}} = \dfrac{139.20 \times 10^3}{2}\left\{\dfrac{1}{795.35}\right\} = 87.50$ mm

2] Length Of Bottom weld (l_2) =

$= \dfrac{60.8 \times 10^3}{2}\left\{\dfrac{1}{795.35}\right\} = 38.22$ mm

or

Length of weld Reqd. = $\dfrac{200 \times 10^3}{795.354} = 251.46$

Length of weld for each angle = $\dfrac{251.46}{2} = 125.73$

$l_1 + l_2 = 125.73$ mm

Taking Moment @ Top Weld ;

$(795.354 \times l_2 \times 125) = (200 \times 10^3 \times 38)$

∴ $l_2 = 76.44$ mm

∴ $l_1 = 125.73 - 76.44 = 49.30$ mm

Problem 4) Determine Design compressive strength (L.C.C.) of a double angle Discontinuous strut 3.00 mt. consist of unequal angle $125 \times 95 \times 8$ mm Long connected at each end to 10 mm thick gusset plate for following cases ? Take $f_y = 250 \quad Mpa$

a) longer legs are connected on either sides of gusset plate.

b) Shorter legs are connected on either sides of gusset plate.

Answer : Given , a) Length of member (clear) = 3.00 mt = 3.00×10^3 mm

case is not given hence assume **One End Fix And Other Is Hinge (case 02)**

$\therefore \; l_{eff}$ = K L = $0.8 \times 3 \times 10^3 = 2.4 \times 10^3$ mm**……………......***IS 800-2007; pg. 45*

Refer the steel table and select ISA $125 \times 95 \times 8$ mm

For this angle ; A = 1698 mm^2; Center of gravity ; C_{xx} = 38 mm , C_{yy} = 23.1 mm

$I_{xx} = 266 \times 10^4 \; mm^4$, $I_{yy} = 133.3 \times 10^4 \; mm^4$; r_{xx} = 39.6 mm , r_{yy} = 28 mm

Follow steps on pg. 07 in Problem no. 03.

Problem 5) Design a Double angle Discontinuous strut connected on same side of 10 mm thick gusset plate carrying an factored load of 200 KN In cases given below. It is 3.00 mt. long between intersections which is restrained in position but not held against rotation ? Take $f_y = 250 \quad Mpa$

a) 20 mm Ø bolts of grade 4.6.

b) Welded connection

Answer : Given a) P = 200 KN

b) Length of member (clear) = 3.00 mt = 3.00×10^3 mm

Given case is **both ends hinged (case 01)**

$\therefore \; l_{eff}$ = K L = $1.00 \times 3 \times 10^3 = 3.00 \times 10^3$ mm**……………......***IS 800-2007; pg. 45*

Let; λ (slenderness ratio) = 110 ; for ths ,

Design compressive stress (σ_{ac}) = 94.6 N/mm^2…………….. *IS 800-2007; pg. 42*

Area Reqd. For the strut $(A_{Req}) = \frac{200 \times 10^3}{94.6} = 2114.16 \quad mm^2$

Area of Each angle = $\frac{2114.16}{2} = 1057.08 \quad mm^2$

we have ; $\lambda = \frac{l_{eff}}{r_{min}}$; $110 = \frac{3.00 \times 10^3}{r_{min}}$; $r_{min(req)} = 27.27$ mm

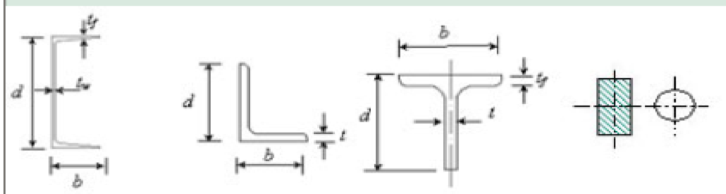
Refer the steel table and select ISA $125 \times 95 \times 12$ mm

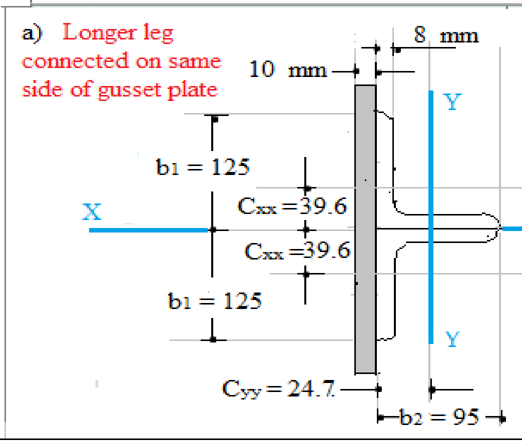
For this angle ; A = 2498 mm^2; Center of gravity ; C_{xx} = 39.6 mm , C_{yy} = 24.7 mm

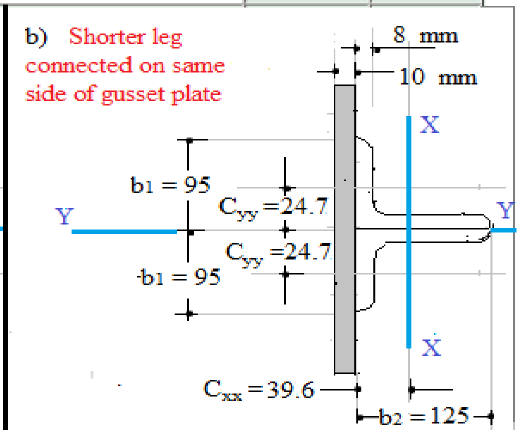
$I_{xx} = 382.6 \times 10^4\ mm^4$, $I_{yy} = 190.4 \times 10^4\ mm^4$; $r_{xx} = 39.1\ mm$, $r_{yy} = 27.6\ mm$

IS 800 - 2007; Pg. 44; Table5.3 Buckling class of cross sections (Section 7.1.2.2)

Cross Section	Limits	Buckling about axis	Buckling Class
Channel, Angle, T and Solid Sections		Any	c







Calculation Of Minimum radius of gyration (r_{min}) for

Case a)

Since C.G. Of whole assembly and angles is not lying on same plane (i.e. on X-X Axis) ;

$$\therefore I_{XX} = \{I_{xx(self)} + A(h)^2\} \times 2$$

$$= \{382.6 \times 10^4) + \overbrace{4996}^{(2\ \times 2498)}(39.6)^2\} \times 2$$

$$= 23.32 \times 10^6\ mm^4$$

&

$$I_{yy} = \{I_{yy(self)}\} \times 2$$

....same plane

$$= 190.4 \times 10^4 \times 2$$

$$= 3.80 \times 10^6\ mm^4$$

Since ; $I_{yy} < I_{xx}$; $r_{min} = r_{yy} = 27.6 mm$

Case b)

Since C.G. Of whole assembly and angles is not lying on same plane (i.e. on YY Axis) ;

$$\therefore I_{YY} = \{I_{YY(self)} + A(h)^2\} \times 2$$

$$= (190.4 \times 10^4) + \overbrace{4996}^{(2\ \times 2498)}(24.7)^2\} \times 2$$

$$= 9.904 \times 10^6\ mm^4$$

&

$$I_{XX} = \{I_{XX(self)}\} \times 2$$

....same plane

$$= 382.6 \times 10^4 \times 2$$

$$= 7.652 \times 10^6\ mm^4$$

Since ; $I_{XX} < I_{YY}$; $r_{min} = r_{XX} = 39.1$ mm

Table 9(c) Design Compressive Stress, f_{cd} (MPa) for Column Buckling Class c

IS 800-2007 ; Pg. 42; (*Clause* 7.1.2.1)

$(\lambda) = \frac{l_{eff}}{r_{min}} = KL/r$; $= \frac{3 \times 10^3}{27.6} = 108.70$	Yield Stress, f_y (MPa) $= 250$ Mpa
100	107
108.70	???
110	94.6

Interpolation :

$$\left\{\frac{(107 - 94.6)}{(110-100)} \times (110 - 108.70)\right\} - 107$$

$\therefore$ $(f_{cd}) = 105.38 \ \frac{N}{mm^2}$

$\therefore$ Compressive strength $= f_{cd} \times A_{gross}$

$= 105.38 \times (2 \times 2498)$

$= 526.50$ KN $>$ 200 KN

$\therefore$ Safe

$(\lambda) = \frac{l_{eff}}{r_{min}} = KL/r$; $= \frac{3 \times 10^3}{39.1} = 76.72$	Yield Stress, f_y (MPa) $= 250$ Mpa
70	152
76.72	???
80	136

Interpolation :

$$\left\{\frac{(152 - 136)}{(80 - 70)} \times (80 - 76.72)\right\} - 152$$

$\therefore$ $(f_{cd}) = 146.75 \ \frac{N}{mm^2}$

$\therefore$ Compressive strength $= f_{cd} \times A_{gross}$

$= 146.75 \times (2 \times 2498)$

$= 733$ KN $>$ 200 KN

$\therefore$ Safe

Design :

Case 1) Using 20 mm Ø bolts of grade 4.6 ;

Let us provide ISA 200 × 95 × 8 mm double angle longer leg back to back on same sides of 10 mm thick gusset plate Using 20 mm Ø bolts of grade 4.6.

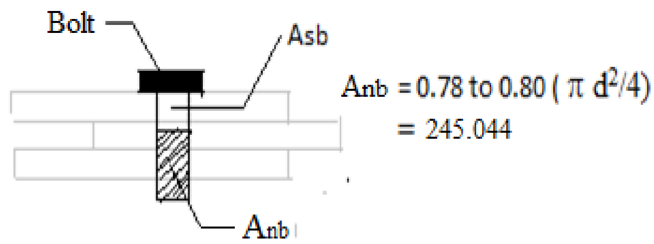
Step i) : Design Strength of Bolt in Shear (V_{ds}) ;

$V_{ds} = 1/\gamma \ [\frac{F_u}{\sqrt{3}} (n_n A_{nb})]$.................................*IS 800-2007; cl. 10.3.3 ; pg. 75*

Where $F_u = F_{ub} = 400 \ N/mm^2$........................*IS 1367 For grade 4.6*

n_n = No. of shear planes with threads intercepting shear planes. = 1 (*single Shear*)

A_{nb} = Nominal Plain Shank Area of the Bolt. = $0.78 \times \frac{\pi (20)^2}{4}$



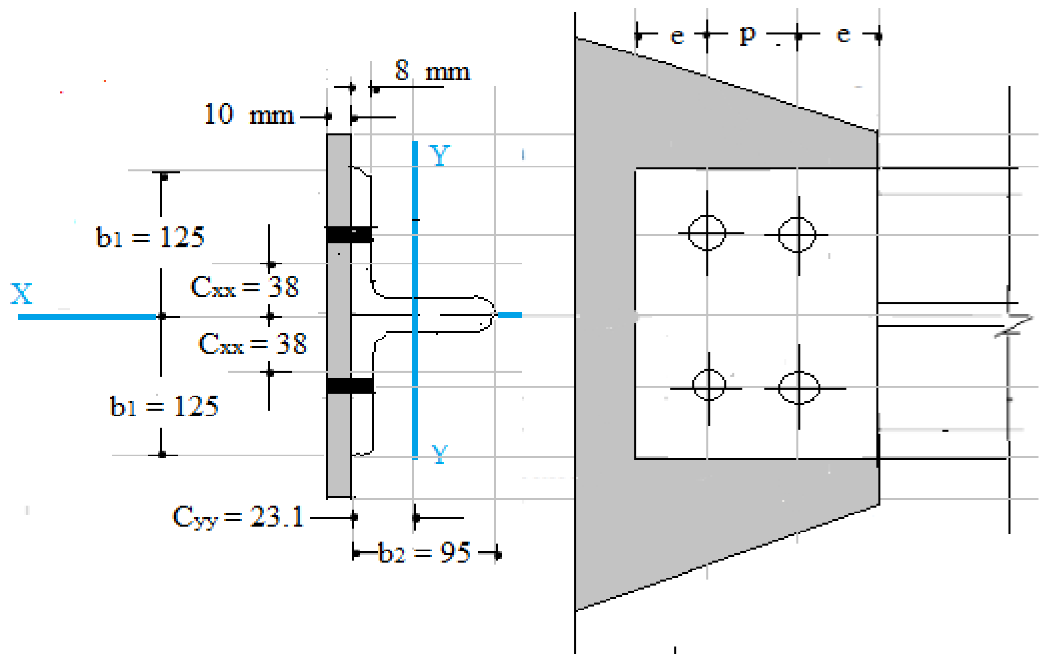
γ = Partial safety factor for Bolt Material = 1.25 ……….. *IS 800-2007 ;Table 5 ; pg. 30*

$$V_{ds} = 1/\,1.25\ \left[\frac{400}{\sqrt{3}}\ (1 \times\ 245.044)\right] = 45.27\ \text{KN}$$

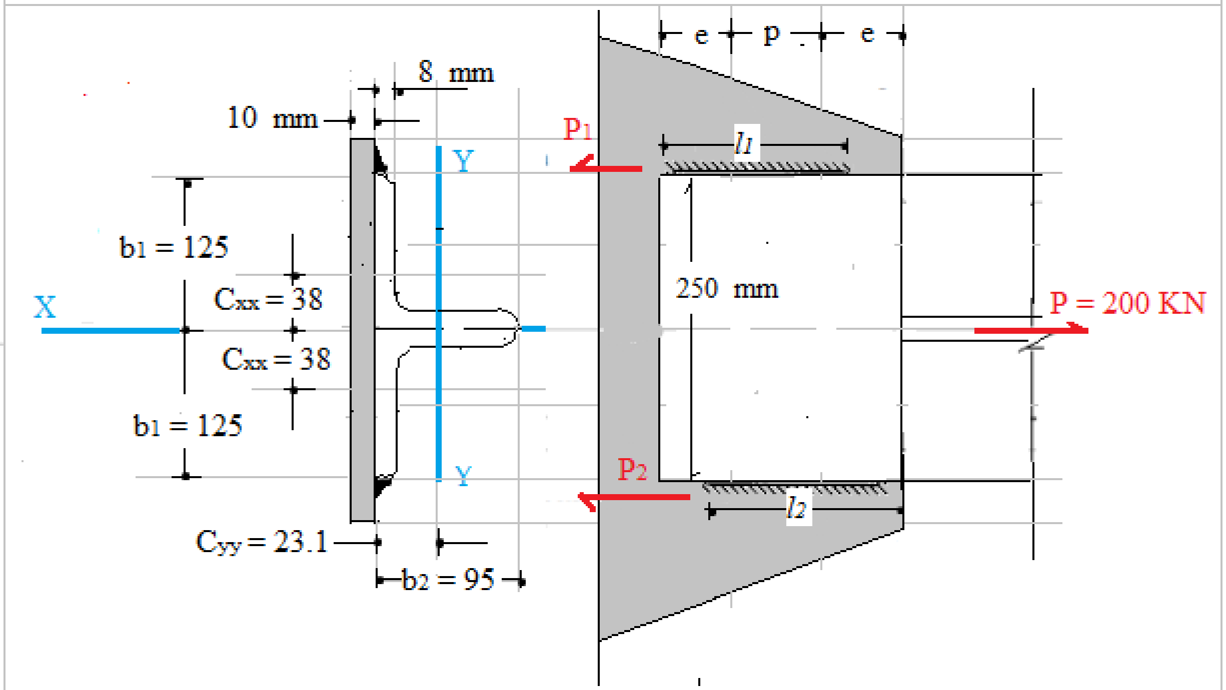
$$\therefore\ \text{No. Of Bolts} = \frac{\text{Load}}{\text{Design strength of Bolt}} = \frac{200}{45.27} = 2.20\ \text{say 04 No.}$$

Dia. Of Bolt Hole = d_0 = 20 + 2 = 22 mm and Pitch (P) = 2.5 × Ø = 2.5 × 20 = 50 mm

∴ Edge Distance (e) = 1.5 × d_0= 1.5 × 22 = 33 say 40 mm



Case 2) Welded connection :



Design stress for weld $= \frac{f_{up}}{\sqrt{3}\,\gamma}$ .... *IS 800-2007 ; 10.5.7 ; Pg. 79*

Ultimate stress for plate material

$$= \frac{410}{\sqrt{3} \times 1.25} = 189.37\ N/mm^2$$

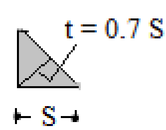
Table No. 05 ; Pg. 30

∴ Design strength of weld per mm length $= 189.37 \times 1 \times 0.7\ s$

Let the size of weld = S = 6 mm

$= 189.37 \times 1 \times 0.7 \times 6$

$= 795.354$ N/mm



Case (a)

We have, $P = P_1 + P_2 = 200$ KN

Taking Miment @ Top Weld ;

$P_2 \times 250 = 200 \times 10^3 \times 125$ ∴ $P_2 = 100$ KN

∴ $P_1 = 100$ KN

1] Length of Top Weld (l_1) =

$$\frac{P_1}{795.354} = \frac{100 \times 10^3}{795.354} = 125.7 \text{ mm}$$

2] Length Of Bottom weld (l_2) =

$$= \frac{100 \times 10^3}{795.354} = 125.7 \text{ mm}$$

Case (b)

length Of Weld Required $= \frac{200 \times 10^3}{795.354}$

$= 251.46$ mm

$l_1 + l_2 = 251.46$

Taking Moment @ Top Weld ;

$(795.354 \times l_2 \times 250)$

$= 200 \times 10^3 \times 125$

∴ $l_2 = 125.7$ mm

∴ $l_1 = 125.7$ mm

Problem 6) Determine Design compressive strength (L.C.C.) of a double angle Discontinuous strut 3.00 mt. consist of unequal angle $125 \times 95 \times 8$ mm Long connected to 10 mm thick gusset plate which is restrained against translation and rotation and other end is free. for following cases ? Take $f_y = 250 \quad Mpa$

a) longer legs are connected on same sides of gusset plate.

b) Shorter legs are connected on same sides of gusset plate.

Answer : a) Length of member (clear) = 3.00 mt = 3.00×10^3 mm

Given case is **One End Fix And Other Is free (case 04)**

$\therefore$ l_{eff} = K L = $2.00 \times 3 \times 10^3 = 6.00 \times 10^3$ mm**……………......***IS 800-2007; pg. 45*

Let; λ (slenderness ratio) $= 110$; for ths ,

Design compressive stress (σ_{ac}) = 94.6 $N/_{mm^2}$…………….. *IS 800-2007; pg. 42*

Area Reqd. For the strut (A_{Req}) = $\frac{200 \times 10^3}{94.6}$ = 2114.16 mm^2

Area of Each angle = $\frac{2114.16}{2}$ = 1057.08 mm^2

we have ; $\lambda = \frac{l_{eff}}{\text{r}_{\text{min}}}$; $110 = \frac{3.00 \times 10^3}{\text{r}_{\text{min}}}$; $\text{r}_{\text{min(req)}} = 27.27$ mm

Refer the steel table and select ISA $125 \times 95 \times 12$ mm

For this angle ; A = 2498 mm^2; Center of gravity ; C_{xx} = 39.6 mm , C_{yy} = 24.7 mm

$I_{xx} = 382.6 \times 10^4$ mm^4 , $I_{yy} = 190.4 \times 10^4$ mm^4; r_{xx} = 39.1 mm , r_{yy} = 27.6 mm

Follow steps on pages 11 and 12 for calculating comp. strength in problem no. 05