Module 1

Part A

1. what are the two type of members on truss based on stress developed- strut and Tie. strut is compression member and tie is tension member in roof truss

2. define tension, compression members (tension member- cl 6.1 page 32, of IS:800), compression members – A member in which axial forces tend to cause compression

3.define actual length, effective length, slenderness ratio of compression member-actual and effective length refer cl 7.2 page 35 of IS:800, slenderness rato is the ratio of effective length to least radius of gyration

4.difference between column and strut- column-vertical compression members in a building to support floors is called column, strut- compression member used in roof truss is called strut

Part B

5.short note / codal provision for lacing(write any six provisions in cl 7.6 page 48) and battening systems(write any six provisions in cl 7.7 page 50 of IS:800)

6. explain design procedure of tension, compression members

Steps involved in the design of copression members :
1.Design stress in compression is to be assumed (fcd)
2. Determine effective sectional area A=Pd/fcd
3.Select a section to give effective area required and calculate rmin
4.Knowing the end conditions and deciding the type of connection determine effective length
5.Find slenderness ratio and hence design stress **fcd** and load carrying capacity **Pd**
6.Revised the section if calculated **Pd** deffers considerab from the design load

steps to design tension members

1. Find the required gross area to carry the factored load considering strength in yielding

2.Select suitable shape of section

3.Determine length of weld required

4.find strength considering (a)strength in gross yielding

(b)strength in rupture of critical section

(c)strength in block shear

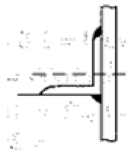
least value is selected as design tension capacity

5.design strength obtained should greater than factored load

6. check the slenderness ratio as per IS 800

7. Different modes of failure of tension members- (cl 6.2,6.3,6.4 page 32-34 of IS:800)

Part C



8. A single angle ISA 200 × 100 × 15 mm is connected to a Gusset plate of 12 mm thick by fillet weld 4 mm size. Determine the design strength with fy = 300N/mm², fu = 400N/mm² and length of weld is 240mm.

Solution :

Given data:

ISA 200 × 100 × 15 mm

Properties:

$A_g = 4278 \text{ mm}^2$

t_g = thickness of gusset plate = 12 mm

S = size of weld = 4 mm

$f_y = 300 \text{ N/mm}^2$

$f_u = 440 \text{ N/mm}^2, L_w = 240 \text{ mm}$

Design strength due to yielding of gross section:

$$T_{dg} = \frac{A_g f_y}{\gamma_{m0}}$$

$$A_g = \text{gross area} = \left[L - \frac{t}{2}\right]t + \left[b - \frac{t}{2}\right]t$$

$$A_g = 4278 \text{ mm}^2$$

$$T_{dg} = \frac{4278 \times 300}{1.1}$$

$$T_{dg} = 1166.7 \text{ kN}$$

Design strength due to rupture:

$$T_{dn} = \frac{0.9 A_{nc} f_u}{\gamma_{m1}} + \frac{\beta A_{go} f_y}{\gamma_{m0}}$$

where $\beta = 1.4 - 0.076\left(\frac{W}{t}\right)\left(\frac{f_y}{f_u}\right)\left(\frac{b_s}{L_c}\right)$

W = length of out standing leg

W = 100 mm

$b_s = W$ [for welding joint]

from fig 6, page no. 33 of (IS 800-2007)

L_c = length of weld = 240 mm

$$\beta = 1.4 - (0.076)\left(\frac{100}{15}\right)\left(\frac{300}{440}\right)\left(\frac{100}{240}\right)$$

$$\beta = 1.256$$

$$A_{nc} = \left[L - \frac{t}{2}\right]t$$

$$= \left[200 - \frac{15}{2}\right]15$$

$$= 2887.5 \text{ mm}^2$$

$$A_{go} = \left[b - \frac{t}{2}\right]t$$

$$= \left[100 - \frac{15}{2}\right]15$$

$$= 1387.5 \text{mm}^2$$

$$T_{dn} = \frac{(0.9)(2887.5)(440)}{1.25} + \frac{(1.256)(1387.5)(300)}{1.1}$$

$$= 914.76 + 475.28$$

$$T_{dn} = 1390.04 \text{ kN}$$

Design strength due to block shear:

$$T_{db1} = \left[\frac{A_{vg} f_y}{\sqrt{3}\, \gamma_{mo}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}}\right]$$

$$T_{db2} = \left[\frac{0.9 A_{vn} f_u}{\sqrt{3}\, \gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{mo}}\right]$$

$A_{vg} = A_{vn}$ = area in shear

$= \cancel{(L_W) \times 2 \times \text{size of weld}}$

$A_{vg} = A_{vn} = \cancel{(240)(2 \times 4)}$ $\boxed{2\text{x}240\text{x}12}$

$= \cancel{(240)\ (8)}$

$= \cancel{1920 \text{ mm}^2}$

$A_{tg} = A_{tn}$ = area in tension

$= \cancel{(L \times 2S)}$ $\boxed{200\text{x}12}$

$= \cancel{(200 \times 8)}$

$= \cancel{1600 \text{ mm}^2}$

$$T_{db1} = \left[\frac{(1920)(300)}{\sqrt{3} \times 1.1} + \frac{(0.9)(1600)(440)}{1.25}\right]$$

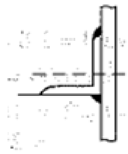
$= [302.32 + 506.88] = 809.2$ kN

$$T_{db2} = \left[\frac{(0.9)(1920)(440)}{\sqrt{3} \times 1.25} + \frac{(1600)(300)}{1.1}\right]$$

$= [35.17 + 436.36]$

$T_{db2} = 787.53$ kN

Change Values accordingly



9. Design a single angle strut connected to the gusset plate to carry 180KN factored load. The length of the strut between centre to centre connection is 3m.

) Assume fcd = 90 mpa.

$A = \frac{180 \times 10^3}{90} = 2000 \text{ mm}^2$

Try ISA ~~90×90×12mm~~ 130×130×8 mm which has A = ~~2019mm²~~ 2022 mm² (2)

$r_{min} > r_{vv}$ = ~~17.4mm~~ 25.5 mm

Assume the strut will be connected to the Gusset plate with at least 2 bolts. (2)

KL = 0.85L = 0.85×3000 = 2550 mm.

$KL/r = \frac{2550}{\cancel{17.4}\ 25.5} = \cancel{146.55}\ 100$ (2)

from table 9(c), for KL/r = 100, fcd = 107 mpa

Pcd = 2022×107 = 216354 > 180000N (2)

Provide ISA 130×130×8 mm

10. In a truss a strut 3m long consists of two angles ISA 100 × 100 × 6mm. Find the factored strength of the member, if the angles are connected on both sides of 12 mm gusset by welding.

Given : 2 ISA 100x100x 6mm

thickness of gusset plate = 12 mm.

length of ~~mem~~ strut = 3 m

r_{min} = ~~67.96~~ 30.90

Solution:

effective length KL = 0.70 L =

$= 0.70 \times 3000 = 2100$ mm

$\therefore \frac{KL}{r} = \frac{2100}{30.90} = 67.96$ ($r_{xx} = r_{min}$ from steel table)

[Area of section from table 1167 mm²]

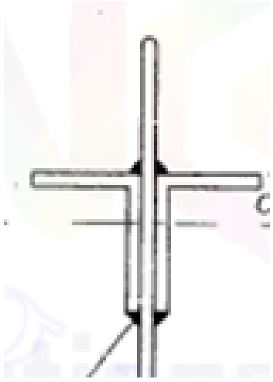
From table fcd.

for $\frac{KL}{r} = 60$, $f_{cd} = 168$ N/mm².

$\frac{KL}{r} = 70$ $f_{cd} = 152$ N/mm²

$\therefore \frac{KL}{r}$ for 67.96 $f_{cd} = 155.26$ N/mm²

$\therefore P_d = 2 \times 1167 \times 155.26 = \underline{362.38\text{ kN}}$



Example 2.11 : *Calculate the design capacity of discontinuous, strut ISA 200 × 200 × 12 mm when*

(a) It is connected by two bolts at ends

(b) It is connected by one bolt

Solution:

Given l = 3 m (no condition for effective length)

$f_y = 250\text{ N/mm}^2$ $k\,l = l = 3$ m = 3000 mm

ISA 200 × 200 × 12 mm

Properties:

b_1 = 200 mm

b_2 = 200 mm

t = 12 mm

A = 4661 mm²

r_{vv} = 39.2 mm

(1) Design capacity (p_d)

$p_d = A\,f_{cd}$

(2) design compressive stress (f_{cd}):

$$f_{cd} = \frac{\frac{f_y}{r_{mo}}}{\phi + \left[\phi^2 - \lambda_e^2\right]^{1/2}}$$

(3) Constant (λ_w):

$$\lambda_w = \frac{\frac{l}{r_w}}{\varepsilon\sqrt{\frac{\pi^2 E}{250}}} \quad \left[\varepsilon = \sqrt{\frac{250}{f_y}},\ \varepsilon = \sqrt{\frac{250}{250}},\ \varepsilon = 1\right]$$

$$\lambda_w = \frac{\frac{3000}{39.2}}{\sqrt{\frac{\pi^2 \times 2 \times 10^5}{250}}}$$

$\lambda_w = 0.861$

(4) Constant 'λ_ϕ':

$$\lambda_\phi = \frac{\left(\frac{b_1 + b_2}{2t}\right)}{\varepsilon\sqrt{\frac{\pi^2 E}{250}}}$$

$$\lambda\phi = \frac{\frac{400}{24}}{\sqrt{\frac{\pi^2 \times 2 \times 10^5}{250}}}$$

$\lambda\phi = 0.187$

(5) Constants (k_1, k_2, k_3):

Constants k_1, k_2, k_3 are obtained from *(table No. 12, page No. 48)*

The values are obtained based on No. of bolts and effective length condition.

In this problem above two conditions are not given.

(Assume two bolts and hinged condition)

$k_1 = 0.7$

$k_2 = 0.6$

$k_3 = 5$

(6) Constant 'λ_e':

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

$\lambda_w = 0.861$ $k_1 = 0.7$

$k_2 = 0.6$

$\lambda_\phi = 0.187$ $k_3 = 5$

$\lambda_e = \sqrt{0.7 + 0.6(0.861)^2 + 5(0.187)^2}$

$\lambda_e = 1.148$

(7) Constant 'ϕ'

$\phi = 0.5\left[1 + \alpha(\lambda_e - 0.2) + \lambda_e^2\right]$, $\lambda_e = 1.48$

'α' Imperfection factor

for angles (or) struts, buckling under class 'c'

$\alpha = 0.49$ (table No. 7, page no 35)

$\therefore \phi = 0.5\left[1 + 0.49(1.148 - 0.2) + 1.148^2\right]$

$\phi = 1.391$

(8) Design compressive stress (f_{cd}):

$$f_{cd} = \frac{\left(\frac{f_y}{r_{mo}}\right)}{\phi + \left[\phi^2 - \lambda_e^2\right]^{1/2}} = \frac{\left(\frac{250}{1.1}\right)}{1.391 + \left[1.391^2 - 1.148^2\right]^{1/2}}$$

$$f_{cd} = \frac{\left(\frac{250}{1.1}\right)}{2.177} = 104.39\text{ N/mm}^2$$

(9) Design capacity (p_d):

$p_d = A\,f_{cd} = 4661 \times 104.39$

$p_d = 486$ kN