## 1.7 ANALYSIS AND DESIGN OF SINGLY REINFORCED RECTANGULAR BEAMS BY WORKING STRESS METHOD

1. **Design a R.C beam to carry a load of 6 kN/m inclusive of its own weight on an effect span of 6m keep the breath to be 2/3 $^{rd}$ of the effective depth .the permissible stressed in the concrete and steel are not to exceed 5N/mm$^2$ and 140 N/mm$^2$.take m=18**

**Step 1: Design constants.**

Modular ratio, m =18.

A Coefficient n =$\frac{m\sigma_{cbc}}{m\sigma_{cbc}+\sigma_{st}}$ = 0.39

Lever arm Coefficient, j=1-(n/3) = 0.87

Moment of resistance Coefficient Q =$\frac{\sigma_{cbc}}{2}$. n. j = 0.84 N/mm²

**Step 2: Moment on the beam.**

M = (w.l$^2$)/8

= (6x6$^2$)/8

= 27kNm

M = Qbd$^2$

d$^2$ = M/Qb

= (27x10$^6$)/ (0.84x2/3xd)

d = 245mm.

**Step 3: Balanced Moment.**

$M_{bal}$ = Qbd$^2$

= 0.84x245x365$^2$

= 27.41kNm. > M.

It can be designed as singly reinforced section.

**Step 4: Area of steel.**

Ast = $M_{bal}$ / ($\sigma_{st}$.j.d)

= 616.72mm$^2$

Use 20mm dia bars ast = π/4 (20$^2$) = 314.15mm$^2$

No. of bars =Ast/ast

= 616.72/314.15

= 1.96 say 2nos.

Provide 2#20mm dia bars at the tension side

**2. Design a beam subjected to a bending moment of 40kNm by working stress design. Adopt width of beam equal to half the effective depth. Assume the permissible stressed in the concrete and steel are not to exceed 5N/mm$^2$ and 140 N/mm$^2$.take m=18.**

**Step 1: Design constants.**

Modular ratio, m =18.

A Coefficient n $=\frac{m\sigma_{cbc}}{m\sigma_{cbc}+\sigma_{st}}$ = 0.39

Lever arm Coefficient, j=1-(n/3) = 0.87

Moment of resistance Coefficient Q $=\frac{\sigma_{cbc}}{2}$. n. j = 0.84 N/mm²

**Step 2: Moment on the beam.**

M = 40kNm

M = Qbd$^2$

d$^2$ = M/Qb

= (40x10$^6$)/ (0.84x1/2xd)

d = 456.2 say 460 mm.

b= 0.5 ,d = 0.5x460

= 230mm

**Step 3: Balanced Moment.**

$M_{bal}$ = Qbd$^2$

= 0.84x230x460$^2$

= 40.88kNm. > M.

It can be designed as singly reinforced section.

**Step 4: Area of steel.**

Ast =$M_{bal}$ / ($\sigma_{st}$.j.d)

= (40.88x10$^6$)/(140x0.87x460)

= 729.64mm$^2$

Use 20mm dia bars ast π/4 (20$^2$) = 314.15mm$^2$

No. of bars = Ast/ast

= 729.64/314.15

= 2.96 say 3nos.

Provide 3#20mm dia bars at the tension side.

**3 Determine the moment of resistance of a singly reinforced beam 160X300mm effective section, if the stress in steel and concrete are not to exceed 140N/mm$^2$ and 5N/mm$^2$.effectve span of the beam is 5m and the beam carries 4 nos of 16mm dia bars. Take m=18.find also the minimum load the bam can carry. Use WSD method.**

**<u>Step 1: Actual NA.</u>**

b xa$^2$/2 = m.Ast.(d- xa)

160. xa$^2$/2 = 18 X 804.24(300 -xa)

Xa = 159.42mm

**<u>Step 2: Critical NA.</u>**

xc = $\sigma_{bc}$.d/($\sigma_{st}$/.m + $\sigma_{cbc}$)

= 117.39mm

xc < Xa = 159.42mm

it is Over reinforced Section.

**<u>Step 3: Moment of Resistance</u>**

M = (b.$\frac{x_a}{2}$.$\sigma_{cbc}$ )(d- xa/3)

= (160x159.42/2x5)(300-159.42/3)

= 15.74kNm

<u>Step 4: Safe load.</u>

M = (w.l$^2$)/8

W = (8 x 15.74)/5$^2$

= 5.03 kN/m

**4. A reinforced concrete rectangular section 300 mm wide and 600 mm overall depth is reinforced with 4 bars of 25 mm diameter at an effective cover of 50 mm on the tension side. The beam is designed with M 20 grade concrete and Fe 415 grade steel. Determine the allowable bending moment and the stresses developed in steel and concrete under this moment. Use working stress method.**

**<u>Step 1: Actual NA.</u>**

b xa$^2$/2 = m.Ast.(d- xa)

300. xa$^2$/2 = 18 X 1963.50(550 - xa)

Xa = 117.81mm

**Step 2: Critical NA.**

Xc = $\sigma_{bc}$.d/($\sigma_{st}$/.m + $\sigma_{cbc}$)

= 194.66mm >Xa

= 117.81mm

it is Under reinforced Section.

**Step 3: Moment of Resistance For steel:**

M = (Ast.$\sigma_{st}$)(d- xa/3)

= (1963.5x230)(550-117.81/3)

= 230.64kNm

**For concrete:**

M = (b.$\frac{x_a}{2}$. $\sigma_{cbc}$)(d- $x_a$/3)

= (300x117.81/2x7)(550-117.81/3)

= 63.17kNm