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Subject : Design of Concrete Structure - I

Level : B.Tech VIth Semester.

Topic : Design of Beam in Torsion

Torsion

→ A curved beam subjected to a UDL & point load is always subjected to

- (i) Bending Moment (M_U)
- (ii) Shear force (V_U)
- (iii) Torsional Moment (T_U)

* Design of beam subjected to

- (i) Factored Bending Moment (M_U) = 1.5 M
- (ii) Factored Shear force (V_U) = 1.5 V
- (iii) Factored Torsional Moment (T_U) = 1.5 T

(2) Equivalent shear force (V_{ue})

$$V_{ue} = V_U + 1.6 \frac{T_U}{B}$$

Nominal shear stress (τ_{vue}) = $\frac{V_{ue}}{Bd} \neq \tau_{cmax}$

(3) Equivalent Moment (M_{ue})

$$M_{ue} = M_U + M_{T_U}$$
$$M_{ue} = M_U + \frac{T_U}{1.7} \left(1 + \frac{D}{B}\right)$$

- Design the beam for M_{ue} .
- If $M_{T_U} > M_U$ provide additional steel on compression face.

$$M_{ue2} = (M_{T_U} - M_U)$$

$$A_{st3} = \frac{M_{eu2}}{0.87 f_y J d}$$

Case 1. If ~~depth~~ size of beam is given.

$$M_{Rbalance} = Q \cdot B d^2$$

If $M_{eu} < M_{Rbalance}$ (Underreinforced or singly reinforced)

$$A_{st1} = \frac{M_{eu}}{0.87 f_y J d}$$

Case 2. If $M_{eu} > M_{Rbalance}$.
(Doubly reinforced)

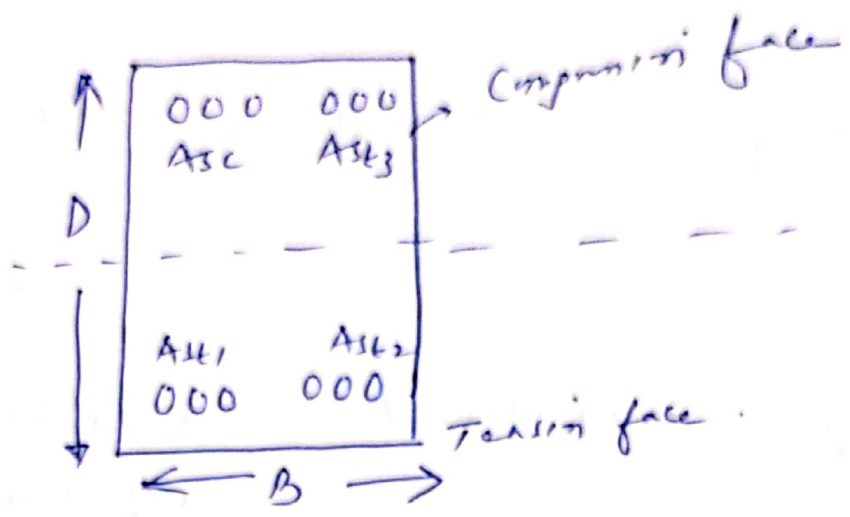
①
$$A_{st1} = \frac{M_{Rbalance}}{0.87 f_y J \cdot d}$$

②
$$A_{st2} = \frac{M_{eu} - M_{Rbalance}}{0.87 f_y (d - d_c)}$$

③
$$A_{sc} = \frac{M_{eu} - M_{Rbalance}}{(f_{sc} - 0.45 f_{ec}) (d - d_c)}$$

If $M_{TU} > M_U$
So provide additional steel on compression side

$$A_{st3} = \frac{M_{TU} - M_U}{0.87 f_y J \cdot d}$$



Design for shear reinforcement:

④

$$S_v = \frac{0.87 f_y A_{sv} \cdot d_1}{\frac{V_u}{2.5} + \frac{T_u}{b_1}}$$

⑤ Min^m shear reinforcement.

$$\frac{A_{sv}}{B \cdot S_v} \geq \frac{\tau_{V_{ue}} - \tau_c}{0.87 f_y}$$

- ⑥ Max^m spacing
- (i) x_1
 - (ii) $\frac{x_1 + y_1}{4}$
 - (iii) 300 mm
- } Whichever is less.

⑦ Side face reinforcement

Side face reinforcement are provided when.

① Depth of beam > 750 mm \rightarrow When beam is not subjected to torsion

② Depth of beam > 450 mm \rightarrow When beam is subjected to torsional moment.

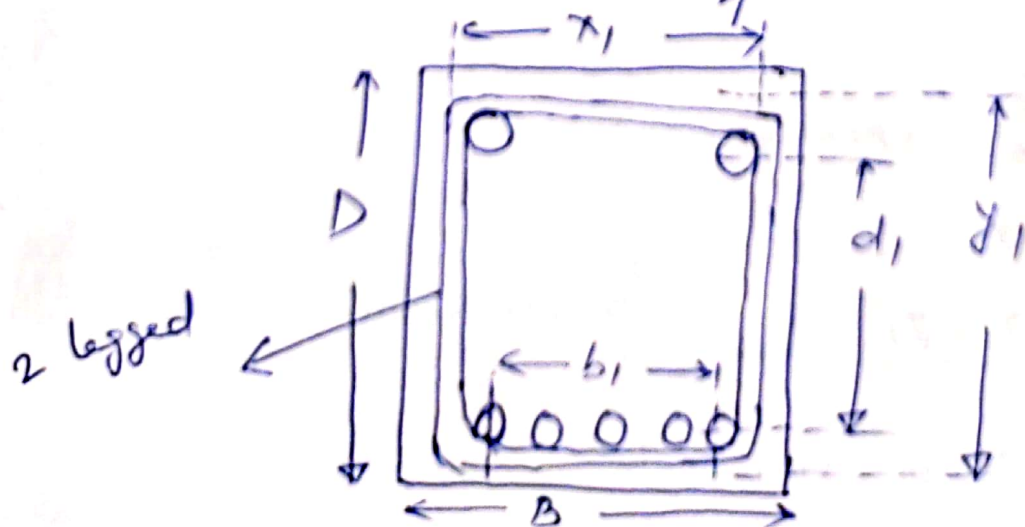
Side face reinforcement = 0.10% of total c/s area of beam.

$$A_{sf} = \frac{0.10}{100} \times B \times D$$

\rightarrow Equal distributed on both face of the beam

$$2n = \frac{A_{sf}}{\frac{\pi}{4} \times \phi^2}$$

\rightarrow spacing of side face reinforcement $\neq 300$ mm.



(35)

Note: If spacing of d_1 dia is s_1
then spacing of d_2 dia is $(d_2 > d_1)$

$$s_2 = s_1 \times \frac{d_2^2}{d_1^2}$$

Be safe, Take care of Your Health
AND

Happy Learning