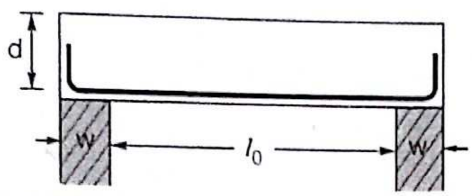
7

Beams and Slabs

Effective span

A. Simply supported beams and slabs (l_{eff})



$$\boxed{l_{eff} = \text{minimum}\begin{cases} l_0 + w \\ l_0 + d \end{cases}}$$

Here, l_0 = clear span
w = width of support
d = depth of beam or slab

B. For continuous beam

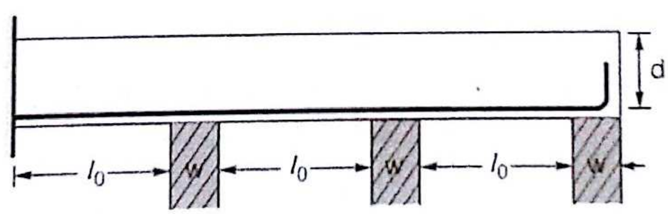
(i) If width of support $< \frac{1}{12}$ of clear span

$$\boxed{l_{eff} = \text{minimum}\begin{cases} l_0 + w \\ l_0 + d \end{cases}}$$

(ii) If width of support $> \frac{1}{12}$ of clear span

(a) When one end fixed other end continuous or both end continuous.

$$\boxed{l_{eff} = l_0}$$

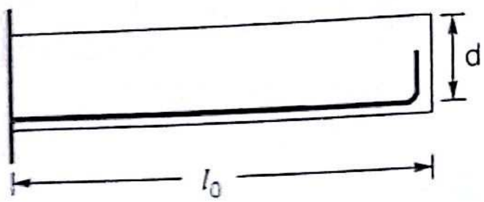


(b) When one end continuous and other end simply supported.

$$l_{eff} = \text{Minimum}\begin{cases} l_0 + w/2 \\ l_0 + d/2 \end{cases}$$

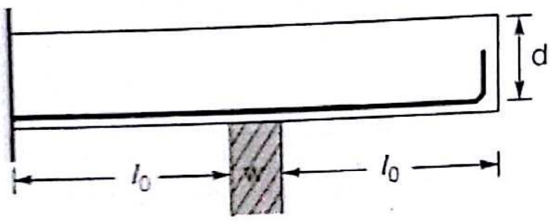
C. Cantilever

(i)



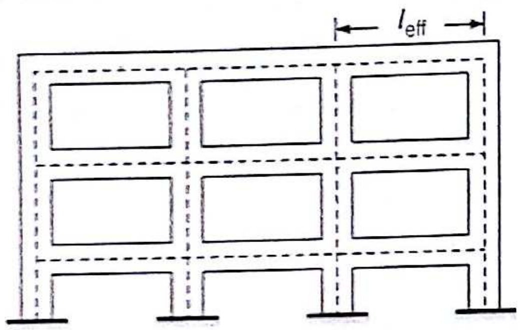
$$l_{eff} = l_0 + \frac{d}{2}$$

(ii)



$$l_{eff} = \left(l_0 + \frac{w}{2}\right)$$

D. Frames



l_{eff} = Centre to centre distance

Control of deflection

(i) This is one of the most important check for limit state of serviceability

(a) The final deflection due to all loads including the effect of temperature, creep and shrinkage and measured from as cast level of the support of floors, roofs and other horizontal members should not normally exceed $\frac{\text{span}}{250}$.

(b) The deflection including the effect of temperature, creep and shrinkage occurring after erection of partition and application of finishes should not normally exceed $\frac{\text{span}}{350}$ or 20 mm whichever is less.

(ii) The vertical deflection limit may generally be satisfied if

(a) Basic span to effective depth ratio for span upto 10 m is

For simply supported → 20

For continuous → 26

(b) For span > 10 m effective depth = $\dfrac{(\text{span})^2}{10 \times A}$

where 'A' is span to effective depth ratio for span upto 10 m.

(c) Depending upon the tension reinforcement the value 'A' can be modify by multiplying a factor called modification factor (MF_1)

$$\boxed{\text{effective depth} = \frac{\text{span}}{A \times MF_1}}$$

where $$\boxed{f_s = 0.58\, f_y \times \frac{\text{Area of steel required}}{\text{Area of steel provided}}}$$

(d) Depending upon area of compression reinforcement, value (A) can be further modified using a modification factor (MF_2)

$$\boxed{\text{effective depth} = \frac{\text{span}}{A \times MF_1 \times MF_2}}$$

(e) For flanged beam: A reduction factor is used.

(f) Deflection check for two way slab:

Support Condition	Span/overall depth	
	Mild Steel	Fe415/Fe500
Simply supported	35	28
Continuous	40	32

Slenderness limit

1. For simply supported or continuous beams

$$\boxed{l_0 \ngtr \text{minimum}\begin{cases} 60b \\ 250\dfrac{b^2}{d} \end{cases}}$$

where, l_0 = Clear span

b = Width of the section

and, d = Effective depth

2. For cantilever beam $l_0 \ngtr$ minimum $\begin{cases} 25b \\ \ldots \end{cases}$

(i) Minimum tension reinforcement $\boxed{\dfrac{A_{st}}{bd} = \dfrac{0.85}{f_y}}$

(ii) Maximum tension reinforcement = 0.04 bD

(iii) Maximum compression reinforcement = 0.04 bD

where, D = overall depth of the section

(iv) Where, D > 750 mm, side face reinforcement is provided and it is equal to 0.1% of gross cross-section area (b×D). It is provided equally on both face.

(v) Maximum spacing of side face reinforcement is 300 mm.

(vi) Maximum size of reinforcement for slab/beam is 1/8 of total thickness of the member

(vii) Nominal cover for different members

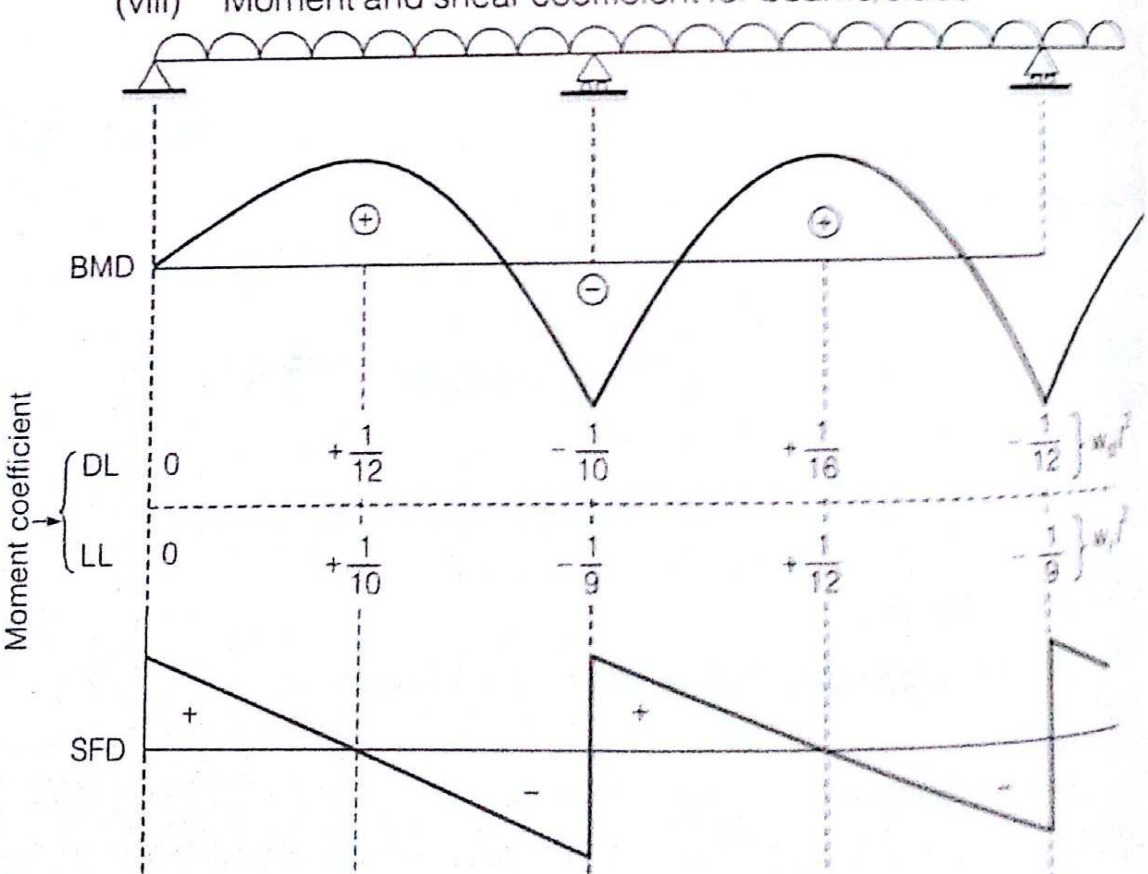
Beams → 25 mm

Slab → 20 to 30 mm

Column → 40 mm

Foundations → 50 mm

(viii) Moment and shear coefficient for beams/slabs



One way slab

(i) $\boxed{\dfrac{l_y}{l_x} > 2}$ where, l_y = length of longer span

l_x = length of shorter span

(ii) Slab is supported only on two edges.

Steps of design

Calculation of effective span (left)

↓

Calculation of total load w

↓

Calculation of design coefficient (Q)

LSM → $0.148\, f_{ck} \rightarrow$ Fe 250; $0.138\, f_{ck} \rightarrow$ Fe 415; $0.133\, f_{ck} \rightarrow$ Fe 500

WSM → $Q = \frac{1}{2} CJK$

↓

Calculation of effective depth $d = \sqrt{\dfrac{M}{Qb}}$

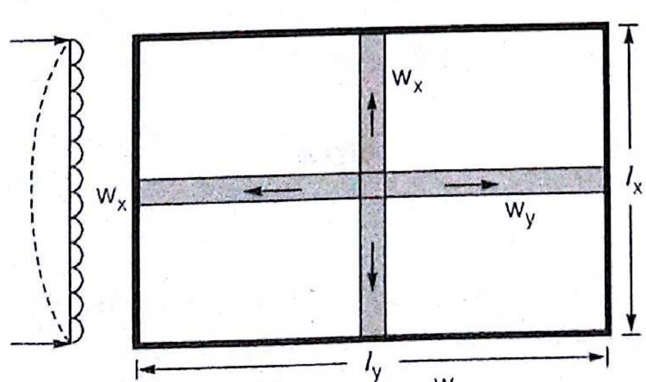
WSM → $A_{st} = \dfrac{M}{\sigma_{st} \cdot j \cdot d}$ → $\tau_v = \dfrac{V}{bd} \le \tau_c$

LSM → $A_{st} = \dfrac{0.5 f_{ck}}{f_y}\left[1 - \sqrt{1 - \dfrac{4.6 M_u}{f_{ck} b d^2}}\right] bd$ → Check for shear → $\tau_v = \dfrac{V}{bd} \le \tau_c$

Two way slab

(i) $\boxed{\dfrac{l_y}{l_x} \le 2}$ (ii) Slab is supported on all edges.

- Design of two way slab
  1. Grasoff Rankine method
     - It is used for corners not held down position.
     - It is purely simply supported case.



(i) $\boxed{w_y = \left(\frac{1}{1+r^4}\right) w}$ $\boxed{w_x = \left(\frac{r^4}{1+r^4}\right) w}$

(ii) Moment in x-direction (M_x) $\boxed{M_x = \frac{w_x l_x^2}{8}}$

Moment in y-direction (M_y) $\boxed{M_y = \frac{w_y l_y^2}{8}}$

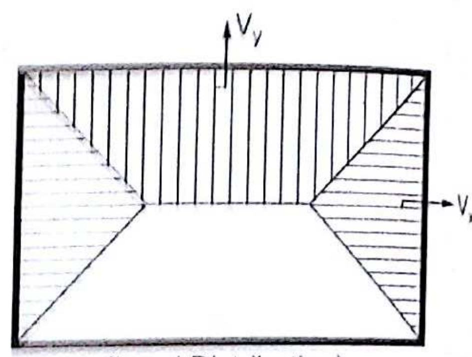
(iii) Shear force

At shorter edge (V_x)

$\boxed{V_x = \frac{1}{3} \cdot w\, l_x}$

At longer edge (V_y)

$\boxed{V_y = \left(\frac{r}{2+r}\right) w \cdot l_x}$



(Load Distribution)

2. Design of slab with corner held down position

(a) Pigeauds method:

$\boxed{M_x = r_x' \cdot \frac{w\, l_x^2}{8}}$ $\boxed{M_y = r_y' \cdot \frac{w\, l_y^2}{8}}$

where, the values of r_x' and r_y' are read from table

(c) I.S. code method

$\boxed{M_x = \alpha_x\, w\, l_y^2}$ $\boxed{M_y = \alpha_y\, w\, l_x^2}$

The values of α_x and α_y read from table (page 91, IS : 456-2000)

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