# Basic Design of RCC Structure

# INDEX

# Part -1
# Introduction

The basic aim of the design of the structure is the achievement of an acceptable reliability that the structure being designed will perform satisfactorily during its intended life.

**Methods of design:**

Limit state design

Working stress method

**Different Limit States:**

**Limit State of Strength**

1) Tension
2) Compression
3) Bending
4) Shear
5) Torsion

**Limit State of Serviceability:**

1) Deflection
2) Vibration
3) Corrosion
4) Durability
5) Fire

**Codes and Standards:**

The design shall comply with the latest editions and revisions of the codes, specifications, and standards listed below as noted, supplemented, or modified herein:

**Loads:**

- IS: 875 (Part 1) – 1987 – *Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 1 – Dead Loads)*, Second Revision, Bureau of Indian Standards (BIS).
- IS: 875 (Part 2) – 1987 – *Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 2 – Imposed Loads)*, Second Revision, Bureau of Indian Standards (BIS).
- IS: 875 (Part 3) – 1987 – *Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 3 – Wind Loads)*, Second Revision, Bureau of Indian Standards (BIS).

- IS 1893 (Part 1): 2002 – *Criteria for Earthquake Resistant Design of Structures (Part 1 – General Provisions and Buildings)*, Fifth Revision, Bureau of Indian Standards (BIS).

**Structural Reinforced Concrete Works:**

1. IS 456: 2000 – *Plain and Reinforced Concrete – Code of Practice,* Fourth Revision, Bureau of Indian Standards (BIS).
2. SP-16: 1980 – *Design Aids for Reinforced Concrete to IS 456: 1978,* Eleventh Edition, Bureau of Indian Standards (BIS).
3. SP-34: 1987 – *Hand Book of Concrete Reinforcement and Detailing,* Fifth Edition, Bureau of Indian Standards (BIS).

**Design Basic Data**

**Concrete Mix**

**a) Reinforced Cement Concrete (RCC)**

The Minimum grade of reinforced cement concrete to be used for different structures and foundations shall be **M20.**

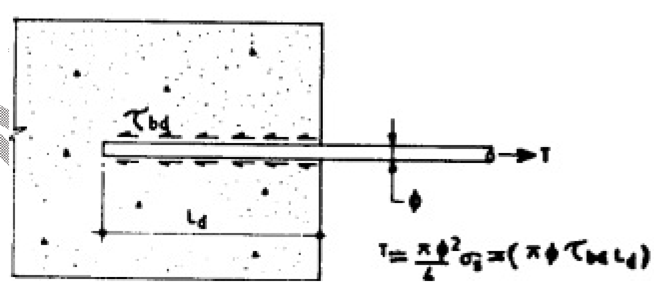
**b) Lean Concrete**

Lean concrete of grade **1:4:8 (by weight**) shall be used as filler material wherever loose sub grade exists by removing the loose soil/fill.

**c) Reinforcement Bars**

High strength deformed thermo mechanically treated (TMT) Steel bars of grade **Fe 415/Fe 500**, conforming to IS: 1786(latest) shall be followed. For the shear reinforcements **Fe 415** grade shall be used as per cl. No. 40.4 of IS 456-2000.

d) **Development Length:**




The development length Ld is given by $L_d = \frac{\phi\sigma_s}{4\tau_{bd}}$

Where $\phi$ =nominal diameter of the bar

$\sigma_s$ =stress at bar at the section considered at design load

$\tau_{bd}$ =design bond stress given in cl no 26.2.1 of IS 456 (2000)

e) **Clear Cover to Reinforcement**

The following minimum clear covers are provided for RCC works.

**Table: 1.1 Clear covers generally adopted for different structural components**

| | |
|---|---|
| - Column | 40mm |
| - Foundation slab, Base slab | 50mm |
| - Floor Slabs (Top and Bottom) | 20mm |
| -Plinth Beam | 50mm |
| -Floor Beams | 25mm |
| -RCC wall | 50 mm |

Different common softwares used for analysis and design of RCC structures are as follows

a) STAAD Pro
b) E TABS
c) SAP 2000
d) ABAQUOUS
etc

# Part -2

# Loads and Load Combination

There are few basic loads to be considered for the analysis and design of the RCC structures.

**a) Dead Load (DL)**

In the Dead load of the structure the following loads to be applied

i. Self-weight of slab and Frame

Suppose 120mm thk slab. So self weight of the slab=0.120*25=3.00kN/sqm.

ii. Floor finish weight + Ceiling plaster weight

iii. Weight of outer wall -200/250thk outer wall load shall be calculated as UDL on supporting beam.

iv. Weight of light partition wall - As provided in code

v. Weight of parapet wall – As per the height and thickness of the parapet wall.

vi. Weight of the roof treatment – As per the requirement of the roof treatment

vii. Weight of any equipment load which are fixed

(Please refer IS 875(part-1) (1987) for weight of different materials)

**b) Live Load (LL)**

- Floor live load - For residential building dowelling house LL is 2.0kn/sqm
- Roof live load – For flat accessible roof it is 1.5kn/sqm . For inaccessible roof it is 0.75kN/sqm And for sloped roof it shall be as per IS: 875(part-II)

(Please refer IS 875(part-II) (1987) for weight of different materials)

**c) Earthquake Load (EQL)**

RCC framed structure foundations and other structural elements shall be designed to resist the effects of earthquakes in accordance with IS 1893 (Part 1):2016 .

1) **Zone Factor (Z):** Based on Intensity and magnitude of the previous earthquakes and the probabilistic behavior of the earthquake.

**India is broadly divided into four zones:**

Zone-II (zone factor=0.10)

Zone-III (zone factor=0.16)

Zone-IV (zone factor=0.24)

Zone-V (zone factor=0.36)

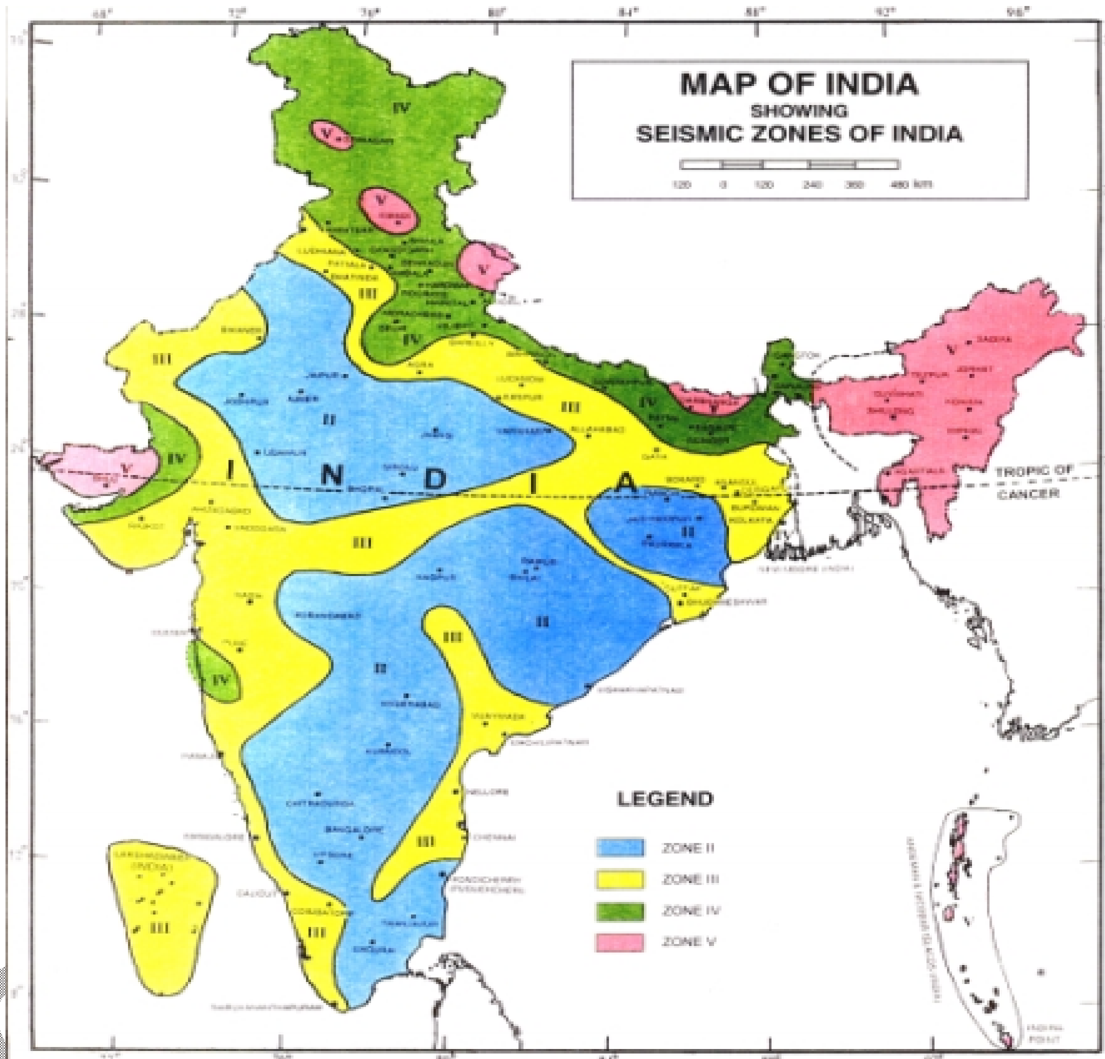



Fig.2.1 Map of India showing different earthquake Zones

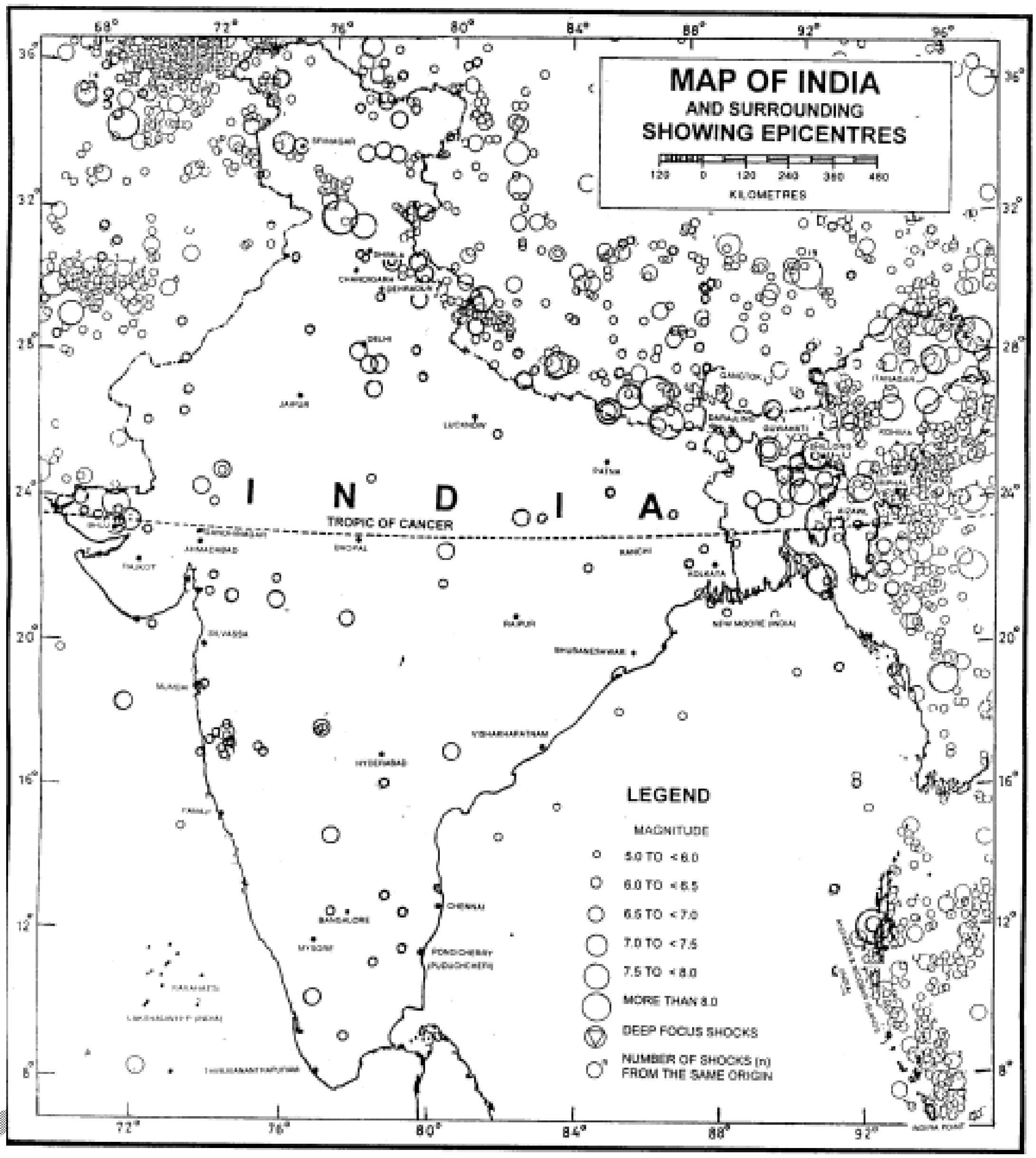



Fig.2. 2 Map of India Showing different earthquake Intensity

Table. 2.1(a) Different Zone factors as per IS 1893

| Seismic Zone | II | III | IV | V |
|---|---|---|---|---|
| Seismic Intensity | Low | Moderate | Severe | Very Severe |
| Z | 0.10 | 0.16 | 0.24 | 0.36 |

Table. 2.1(b) Different Zone factors as per IS 1893

**ZONE FACTORS FOR SOME IMPORTANT TOWNS**

| *Town* | *Zone* | *Zone Factor, Z* | *Town* | *Zone* | *Zone Factor, Z* |
|---|---|---|---|---|---|
| Agra | III | 0.16 | Chitradurga | II | 0.10 |
| Ahmedabad | III | 0.16 | Coimbatore | III | 0.16 |
| Ajmer | II | 0.10 | Cuddalore | III | 0.16 |
| Allahabad | II | 0.10 | Cuttack | III | 0.16 |
| Almora | IV | 0.24 | Darbhanga | V | 0.36 |
| Ambala | IV | 0.24 | Darjeeling | IV | 0.24 |
| Amritsar | IV | 0.24 | Dharwad | III | 0.16 |
| Asansol | III | 0.16 | Dehra Dun | IV | 0.24 |
| Aurangabad | II | 0.10 | Dharampuri | III | 0.16 |
| Bahraich | IV | 0.24 | Delhi | IV | 0.24 |
| Bangalore | II | 0.10 | Durgapur | III | 0.16 |
| Barauni | IV | 0.24 | Gangtok | IV | 0.24 |
| Bareilly | III | 0.16 | Guwahati | V | 0.36 |
| Belgaum | III | 0.16 | Goa | III | 0.16 |
| Bhatinda | III | 0.16 | Gulbarga | II | 0.10 |
| Bhilai | II | 0.10 | Gaya | III | 0.16 |
| Bhopal | II | 0.10 | Gorakhpur | IV | 0.24 |
| Bhubaneswar | III | 0.16 | Hyderabad | II | 0.10 |
| Bhuj | V | 0.36 | Imphal | V | 0.36 |
| Bijapur | III | 0.16 | Jabalpur | III | 0.16 |
| Bikaner | III | 0.16 | Jaipur | II | 0.10 |
| Bokaro | III | 0.16 | Jamshedpur | II | 0.10 |
| Bulandshahr | IV | 0.24 | Jhansi | II | 0.10 |
| Burdwan | III | 0.16 | Jodhpur | II | 0.10 |
| Calicut | III | 0.16 | Jorhat | V | 0.36 |
| Chandigarh | IV | 0.24 | Kakrapara | III | 0.16 |
| Chennai | III | 0.16 | Kalpakkam | III | 0.16 |

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2) **Importance Factor(I):** Based on Intensity and magnitude of the previous earthquakes and the probabilistic behavior of the

1.5 For critical and lifeline structure

**1.**2 For business community structure

**1.**0 For the rest.

Table. 2.2 Different Importance factors as per IS: 1893

| Sl No. | Structure | Importance Factor |
|---|---|---|
| (1) | (2) | (3) |
| i) | Important service and community buildings, such as hospitals; schools; monumental structures; emergency buildings like telephone exchange, television stations, radio stations, railway stations, fire station buildings; large community halls like cinemas, assembly halls and subway stations, power stations | 1.5 |
| ii) | All other buildings | 1.0 |

NOTES

1 The design engineer may choose values of importance factor *I* greater than those mentioned above.

2 Buildings not covered in Sl No. (i) and (ii) above may be designed for higher value of *I*, depending on economy, strategy considerations like multi-storey buildings having several residential units.

3 This does not apply to temporary structures like excavations, scaffolding etc of short duration.

3) **Response Reduction Factor(R)**: Depending upon the structural geometry and the overall ductility of the structure the responses reduction capacity of the structure due to earthquake may vary.
Ref Table 9 of IS 1893(2016)

Table. 2.3 Different Response Reduction factors as per IS: 1893

| Sl No. | Lateral Load Resisting System | R |
|---|---|---|
| (1) | (2) | (3) |
| | *Building Frame Systems* | |
| i) | Ordinary RC moment-resisting frame ( OMRF )[2] | 3.0 |
| ii) | Special RC moment-resisting frame ( SMRF )[3] | 5.0 |
| iii) | Steel frame with | |
| | a) Concentric braces | 4.0 |
| | b) Eccentric braces | 5.0 |
| iv) | Steel moment resisting frame designed as per SP 6 ( 6 ) | 5.0 |
| | *Building with Shear Walls*[4] | |
| v) | Load bearing masonry wall buildings[5] | |
| | a) Unreinforced | 1.5 |
| | b) Reinforced with horizontal RC bands | 2.5 |
| | c) Reinforced with horizontal RC bands and vertical bars at corners of rooms and jambs of openings | 3.0 |
| vi) | Ordinary reinforced concrete shear walls[6] | 3.0 |
| vii) | Ductile shear walls[7] | 4.0 |
| | *Buildings with Dual Systems*[8] | |
| viii) | Ordinary shear wall with OMRF | 3.0 |
| ix) | Ordinary shear wall with SMRF | 4.0 |
| x) | Ductile shear wall with OMRF | 4.5 |
| xi) | Ductile shear wall with SMRF | 5.0 |

**Joint weight calculation**: Joint weight is the weight of the structure from Dead and Live load combination and it is associated with the earthquake load calculation. In case of joint weight calculation the Full Dead load of the structure shall be considered and imposed load shall be reduced.

Table.2.4 Different Live Load Reduction percentage per IS: 1893

| Imposed Uniformity Distributed Floor Loads ( kN/ m² ) | Percentage of Imposed Load |
|---|---|
| (1) | (2) |
| Upto and including 3.0 | 25 |
| Above 3.0 | 50 |

**Fundamental Natural Time Period:**

The Fundamental natural time period (s) of a structure is

$T = 0.75 * h$^0.75 for RC Frame Building

$T = 0.75 * h$^0.85 for Steel Frame Building

$T = 0.09/\sqrt{d}$ for Moment Resisting Frame with Brick Infill panel

Where d is the width of the base along the consideration of the earthquake.

**Spectral Acceleration Coefficient($\frac{Sa}{g}$):** It is the average response acceleration coefficient.

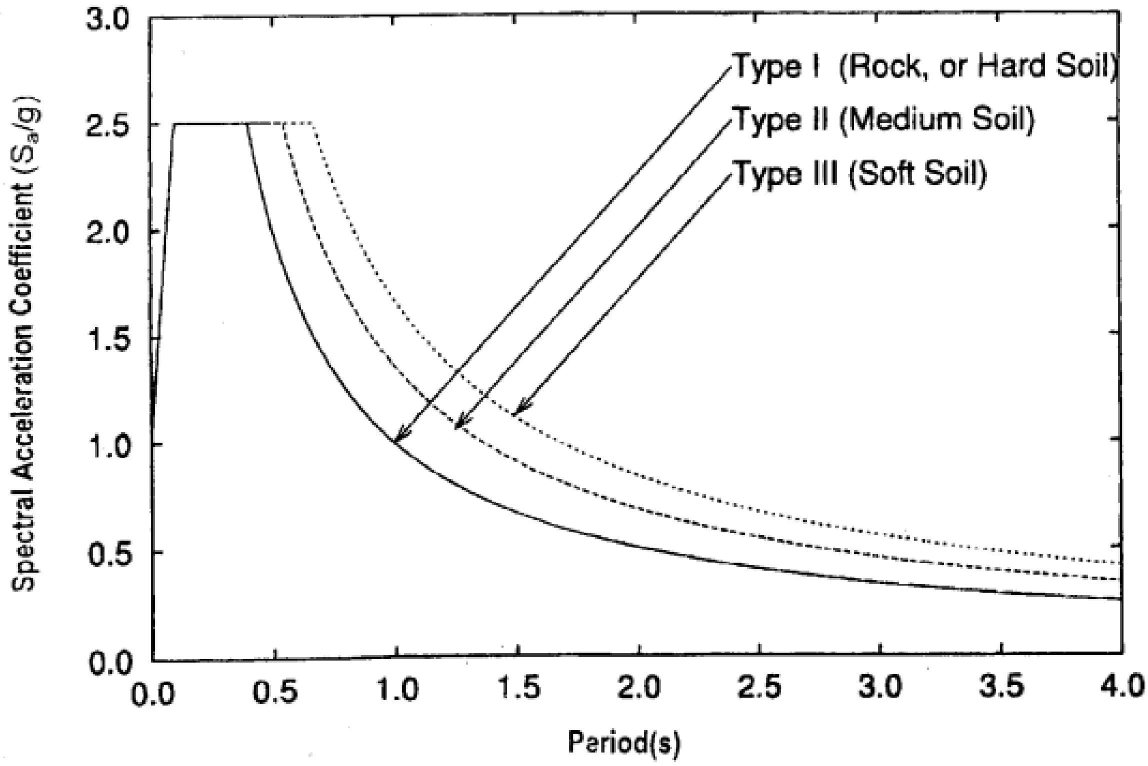



Fig.2. 3 Spectral Acceleration Coefficient

**Base Shear calculation:** It is the total horizontal earthquake load developed in the structure.

$$Vb = \left(\frac{Z}{2}\right) * \left(\frac{I}{R}\right) * \left(\frac{Sa}{g}\right) * W$$

**Vertical Distribution of base shear in different floors:**

$$Q_i = V_B \frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2}$$

where

$Q_i$ = Design lateral force at floor $i$,

$W_i$ = Seismic weight of floor $i$,

$h_i$ = Height of floor $i$ measured from base, and

$n$ = Number of storeys in the building is the number of levels at which the masses are located.



- Dynamic analysis shall be performed if required by Time history analysis or Response Spectrum method.
- Earthquake shall be applied in both the orthogonal direction and it shall be reversed.

(Please refer IS 1893(part-I) (2016 or 2002) for earthquake load calculation)

**d) Wind Load (WL)**

- Wind load shall be calculated as per IS: 875(part-III)-1987.
- Basic wind speed (Vb) of a place is known to us. It is provided in the IS 875 part III.
- k1, k2, k3 factors are to be decided. K1=Probability factor, k2= Height factor,K3= Topographic factor.
- Design wind speed to be calculated. (Vz=k1xk2xk3xVb)
- Design wind pressure to be calculated.(Pz=0.6xVz^2)
- External and Internal pressure coefficient shall be calculated from IS 875(part-III):1987
- Wind shall be applied in both the orthogonal direction and it shall be reversed.

(Refer IS: 875(part-III) (1987) for Wind load calculation)

**Load Combinations:**

**Un-factored Load combinations** (For Foundation base Pressure Checking and Limit State of Serviceability):

1) 1.0(DL+LL)
2) 1.0(DL+LL+EQX/WLX)
3) 1.0(DL+LL-EQX/WLX)
4) 1.0(DL+LL+EQZ/WLZ)
5) 1.0(DL+LL-EQZ/WLZ)
6) 1.0(DL+EQX/WLX)
7) 1.0(DL-EQX/WLX)
8) 1.0(DL+EQZ/WLZ)
9) 1.0(DL-EQZ/WLZ)

Proper Live load reduction shall be done as per IS: 875(part-II) (1987) for the multistoried Buildings

**Factored Load combinations as per IS: 456-2000** for RCC Member Design

1) 1.5(DL+LL)
2) 1.2(DL+LL+EQX/WLX)
3) 1.2(DL+LL-EQX/WLX)
4) 1.2(DL+LL+EQZ/WLZ)
5) 1.2(DL+LL-EQZ/WLZ)
6) 1.5(DL+EQX/WLX)
7) 1.5(DL-EQX/WLX)
8) 1.5(DL+EQZ/WLZ)
9) 1.5(DL-EQZ/WLZ)
10) 0.9DL+1.5EQX/WLX
11) 0.9DL-1.5EQX/WLX
12) 0.9DL+1.5EQZ/WLZ
13) 0.9DL-1.5EQZ/WLZ

# Part -3

# Design of Foundation

Foundations are of two types. Deep foundation and shallow foundation

Shallow foundations are of several types .These are as follows

a) Isolated footing
b) Combined footing
c) Strip footing
d) Strip footing with strap beam
e) Raft foundation

Deep Foundation are of several types:

a) Pile foundations
b) Well foundations

## Design of Isolated Footing:

**Basic Design Criteria:**

1) Base pressure checking: Base Pressure developed at the bottom of foundation shall be less safe Bearing capacity of the soil as described in the soil testing report.
2) Permissible net safe bearing capacity shall be increased upto suitable limit as described in IS: 1893 part -I(2016) for earthquake and wind load.
3) Bending moments shall be calculated at the column face
4) Calculate the depth of foundation and the Required longitudinal reinforcement along both directions
5) Check for one and two way shear stress. Shear stress must be within the permissible limit as described in IS 456 (2000)
6) Prepare the drawing for footing

**Detailing of Reinforcement for foundation:**

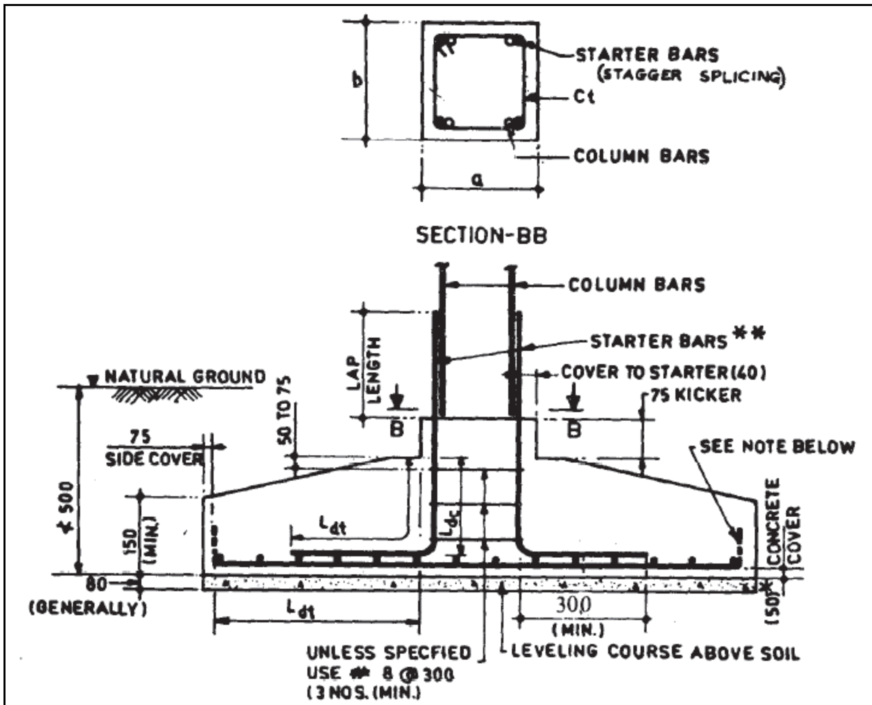



Fig: 3.1 Typical detailing (section) of an isolated footing as described in SP 34

Where Ldt= Effective Development Length Considering Tension

Ldc= Effective Development Length Considering Compression

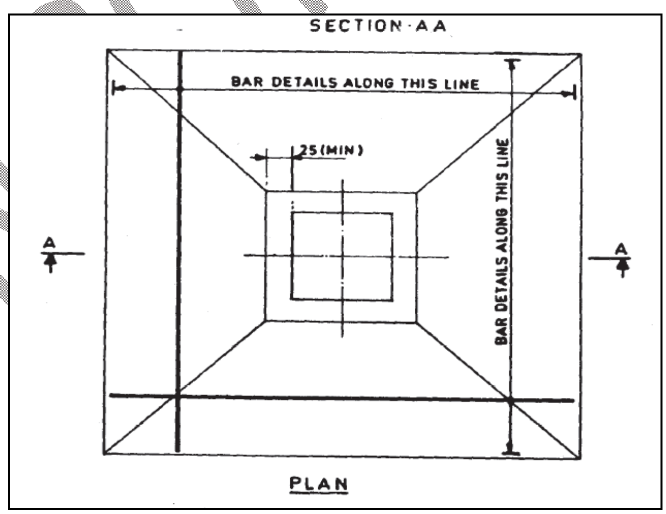



Fig: 3.2 Typical detailing (plan) of an isolated footing as described in SP 34

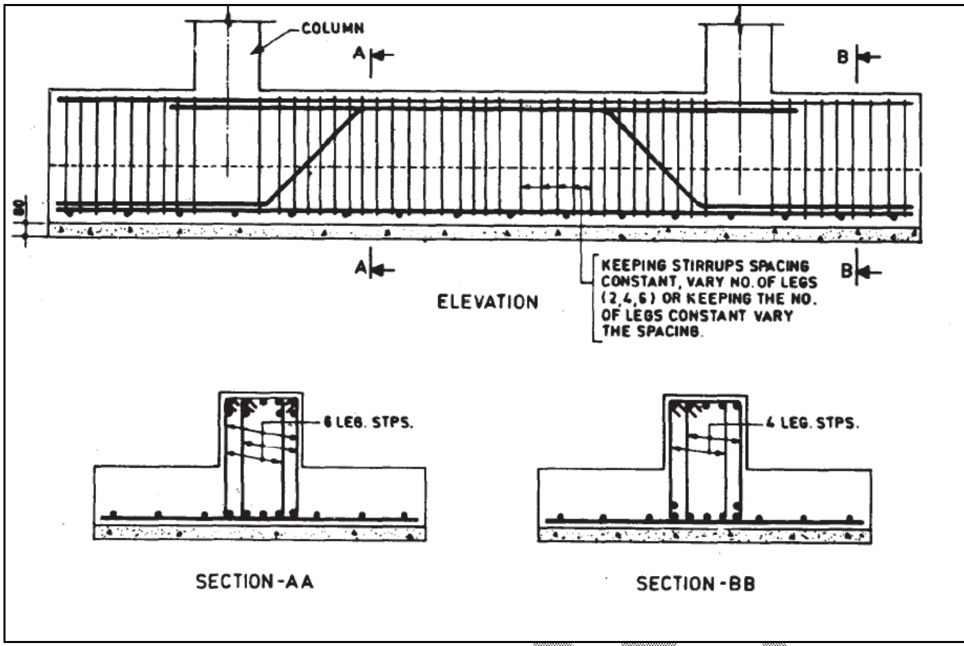



Fig: 3.3 Typical detailing of a foundation beam as described in SP 34

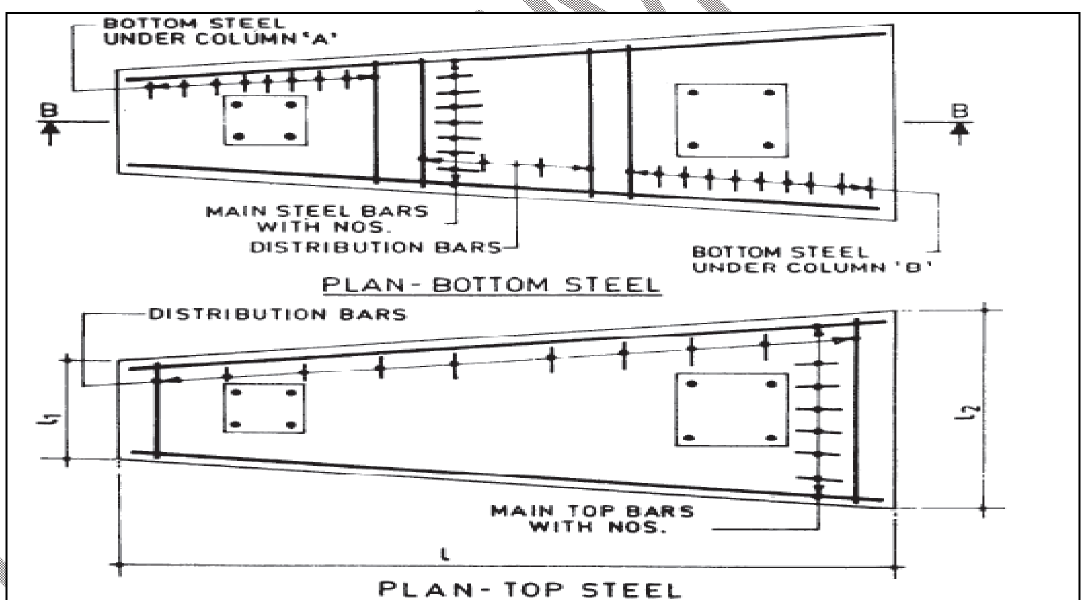



Fig: 3.4 Typical detailing of a combined footing as described in SP 34

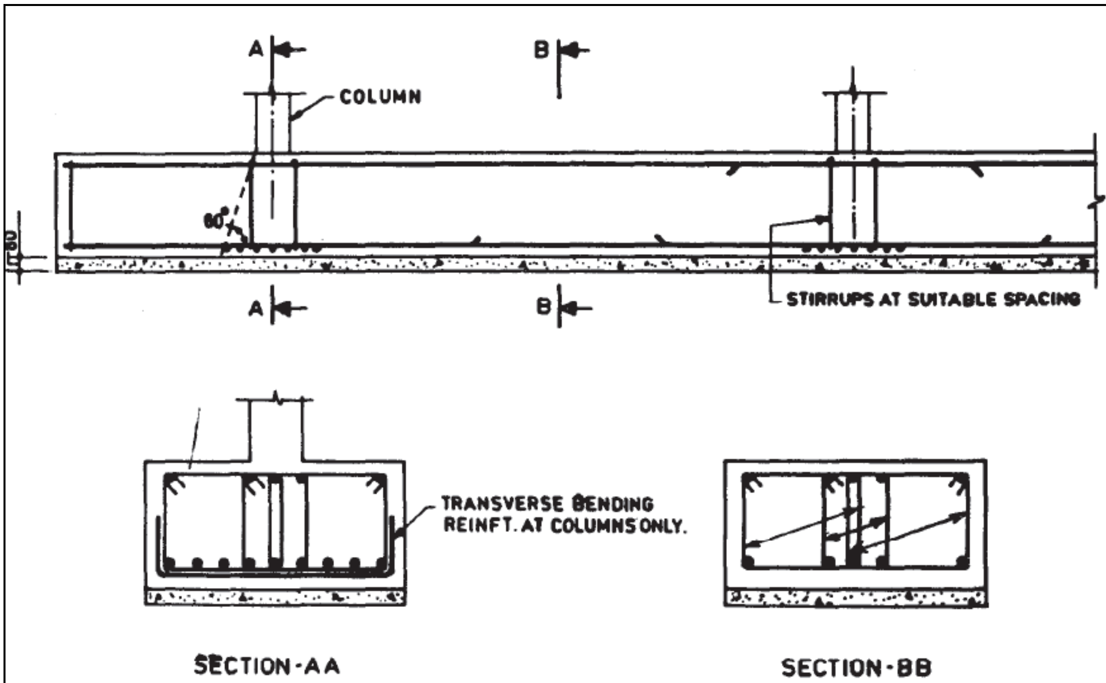



Fig: 3.5 Typical detailing of a strip footing as described in SP 34

# Part -4

# Design of Column

Column shall be designed for the axial force and biaxial moments

**Basic Design Criteria:**

**Short axially loaded column:**

$$P_u = 0.4 f_{ck} A_c + 0.67 f_y A_{sc}$$

Where $P_u$ = axial load on member

$f_{ck}$ =characteristic compressive strength of concrete

$f_y$ = characteristic strength of compression reinforcement

$A_c$ =area of concrete

$A_{sc}$ =Area of longitudinal reinforcement

**Axially loaded column along with biaxial moments:**

For the biaxial moment check shall be like this

$$\left[\frac{M_{ux}}{M_{ux1}}\right]^{\alpha} + \left[\frac{M_{uy}}{M_{uy1}}\right]^{\alpha} \leq 1.0$$

$M_{ux}$ =moment about x due to design load

$M_{ux1}$ =maximum uniaxial moment capacity about x for an axial load of Pu

$M_{uy}$ = moment about x due to design load

$M_{uy1}$ = maximum uniaxial moment capacity about y for an axial load of Pu

For slender columns additional moments about both directions shall be calculated as below.

$$M_{ax} = \frac{P_u D}{2000}\left\{\frac{l_{ex}}{D}\right\}^2$$

$$M_{ay} = \frac{P_u b}{2000}\left\{\frac{l_{ey}}{b}\right\}^2$$

where

$P_u$ = axial load on the member,

$l_{ex}$ = effective length in respect of the major axis,

$l_{ey}$ = effective length in respect of the minor axis,

$D$ = depth of the cross-section at right angles to the major axis, and

$b$ = width of the member.

**And also the axial load capacity calculation:**

$$P_{uz} = 0.45 f_{ck} A_c + 0.75 f_y A_{sc}$$

**Imp notes related to longitudinal Reinforcement:**

a) The c/s area of reinforcement shall not be less than 0.8% and it should not exceed 6% of the gross cross sectional area of the column.

b) The minimum no of bar shall be four in rectangular column and it shall be six in case of circular column

c) Minimum dia of bar is 12 mm

**Detailing of Reinforcement for column:**

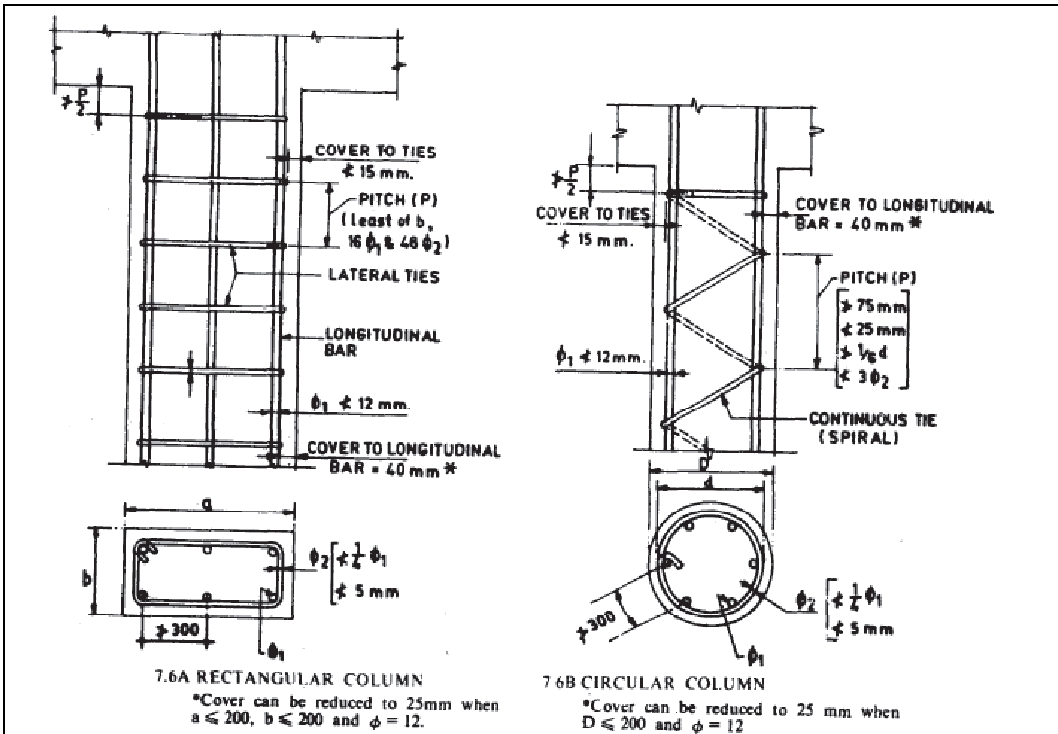



Fig: 4.1 Typical detailing of rectangular and circular column as described in SP 34

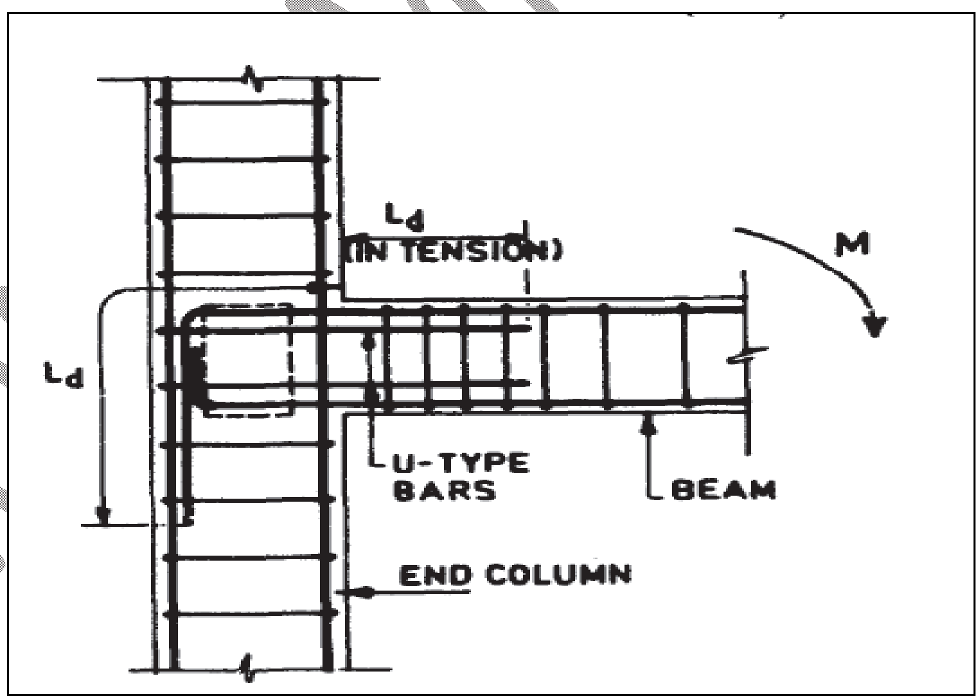



Fig: 4.2 Typical detailing of column beam junction as described in SP 34

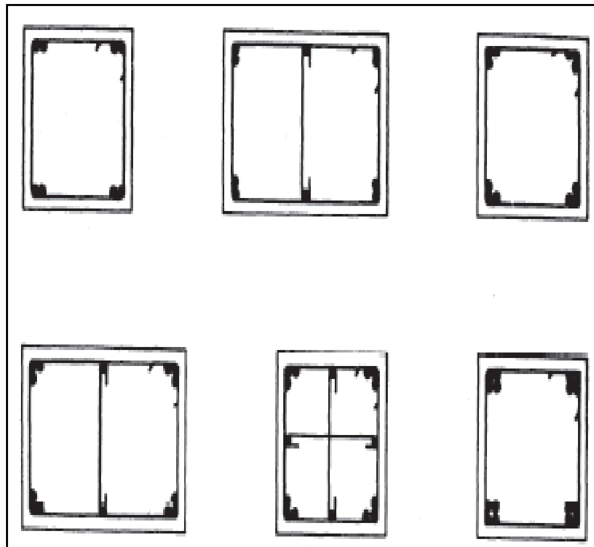


Fig: 4.3 Typical detailing of column stirrups as described in SP 34

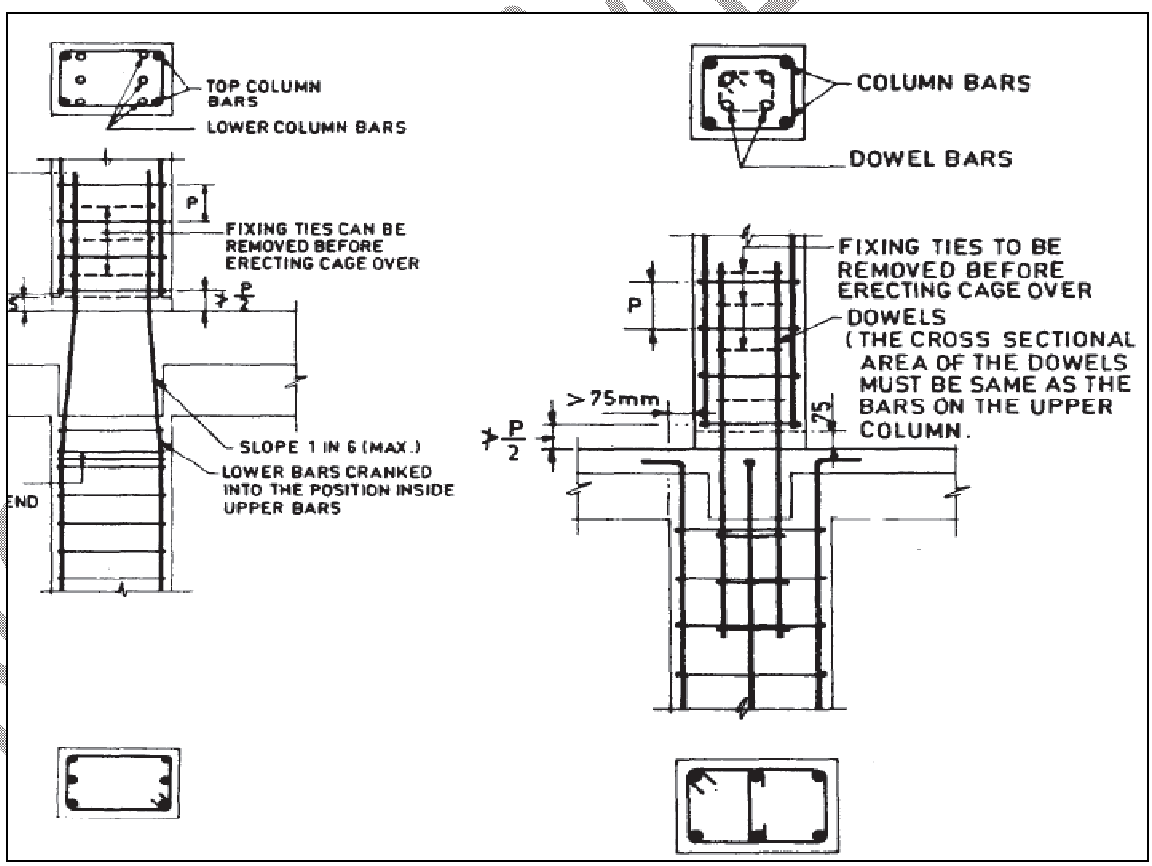



Fig: 4.4 Typical detailing of column continuation junction as described in SP 34

# Part -5

# Design of Beam

**Basic Design Criteria:**

1) Calculate total udl on the beam and also the maximum sagging and hogging bending moment in the beam. Also calculate the maximum shear force in the beam. Assume a size of the beam from deflection criteria for self-weight calculation

Basic values of span to effective depth ratios for spans up to 10 m:

| | |
|---|---|
| Cantilever | 7 |
| Simply supported | 20 |
| Continuous | 26 |

2) Calculate the required depth of the beam considering the singly reinforced or doubly reinforced section as per the suitability.

$$M = 0.138 f_{ck} b d^2$$

3) Calculate the required area of steel for designed sagging and hogging moments.
4) Check for shear stress. Shear stress must be within the permissible limit as described in IS 456 (2000) or provide shear reinforcement.

Nominal shear stress= $\tau_v = \frac{V_u}{bd}$

Where Vu=designed shear force, b=width of the beam and d= effective depth of the beam

Table 5.1: design shear strength for limit state method

| $100\frac{A_s}{bd}$ | Concrete Grade | | | | | |
|---|---|---|---|---|---|---|
| | M 15 | M 20 | M 25 | M 30 | M 35 | M 40 and above |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| ≤0.15 | 0.28 | 0.28 | 0.29 | 0.29 | 0.29 | 0.30 |
| 0.25 | 0.35 | 0.36 | 0.36 | 0.37 | 0.37 | 0.38 |
| 0.50 | 0.46 | 0.48 | 0.49 | 0.50 | 0.50 | 0.51 |
| 0.75 | 0.54 | 0.56 | 0.57 | 0.59 | 0.59 | 0.60 |
| 1.00 | 0.60 | 0.62 | 0.64 | 0.66 | 0.67 | 0.68 |
| 1.25 | 0.64 | 0.67 | 0.70 | 0.71 | 0.73 | 0.74 |
| 1.50 | 0.68 | 0.72 | 0.74 | 0.76 | 0.78 | 0.79 |
| 1.75 | 0.71 | 0.75 | 0.78 | 0.80 | 0.82 | 0.84 |
| 2.00 | 0.71 | 0.79 | 0.82 | 0.84 | 0.86 | 0.88 |
| 2.25 | 0.71 | 0.81 | 0.85 | 0.88 | 0.90 | 0.92 |
| 2.50 | 0.71 | 0.82 | 0.88 | 0.91 | 0.93 | 0.95 |
| 2.75 | 0.71 | 0.82 | 0.90 | 0.94 | 0.96 | 0.98 |
| 3.00 and above | 0.71 | 0.82 | 0.92 | 0.96 | 0.99 | 1.01 |

NOTE — The term $A_s$ is the area of longitudinal tension reinforcement which continues at least one effective depth beyond the section being considered except at support where the full area of tension reinforcement may be used provided the detailing conforms to **26.2.2** and **26.2.3**

Table 5.2: maximum shear stress for limit state method

| Concrete Grade | M 15 | M 20 | M 25 | M 30 | M 35 | M 40 and above |
|---|---|---|---|---|---|---|
| $\tau_{c\,max}$, N/mm² | 2.5 | 2.8 | 3.1 | 3.5 | 3.7 | 4.0 |

Provide shear reinforcement for

$$V_{us} = \frac{0.87 f_y A_{sv} d}{s_v}$$

Where $V_{us}$ =the strength of shear reinforcement

$A_{sv}$ =total cross sectional area of the stirrups

5) Check for deflection based on the provided area of steel ( cl no 23.2.1 of IS 456 -2000)

6) Check for development length.

7) Prepare the drawing for the beam and detail it.

**Detailing of Reinforcement:**

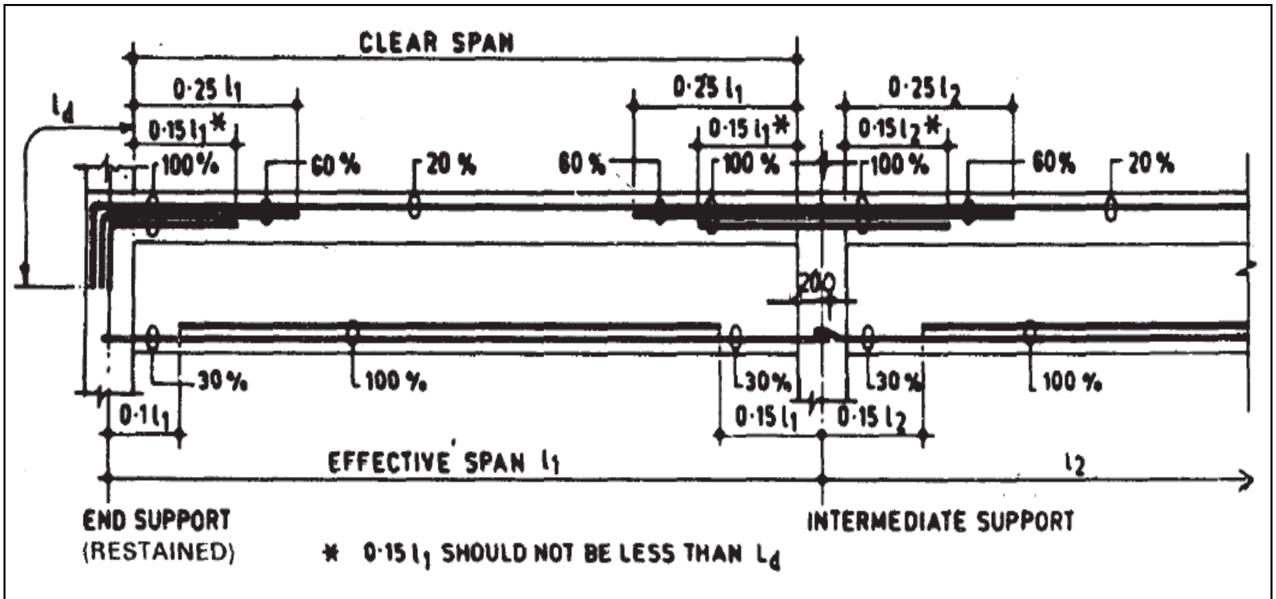



Fig: 5.1 Simplified Curtailment Rules for Continuous Beam

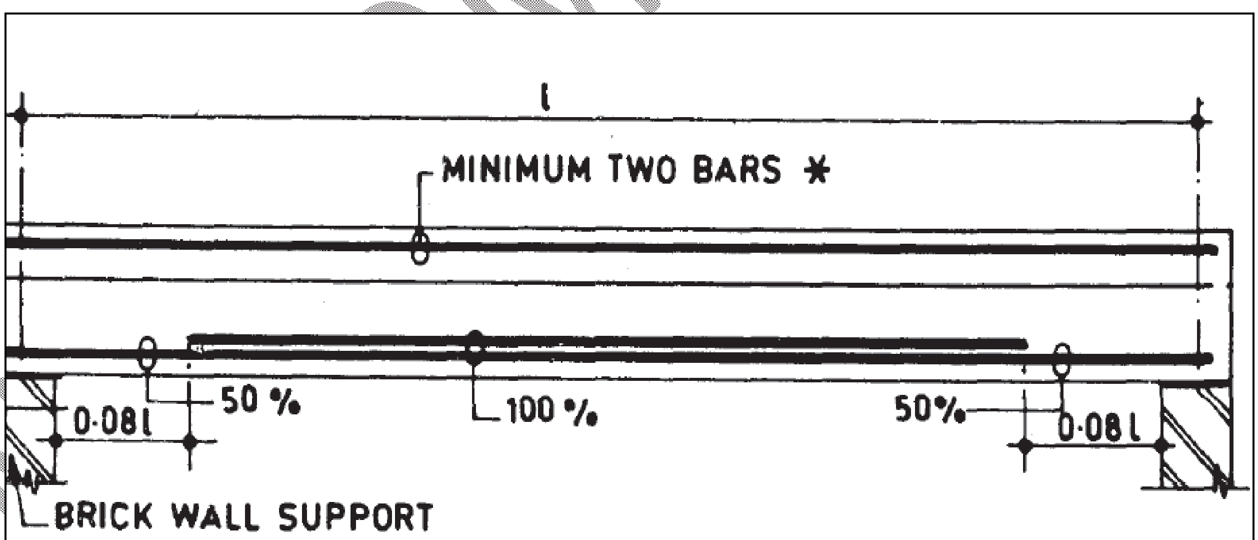



Fig: 5.2 Simplified Curtailment Rules for simply supported beam

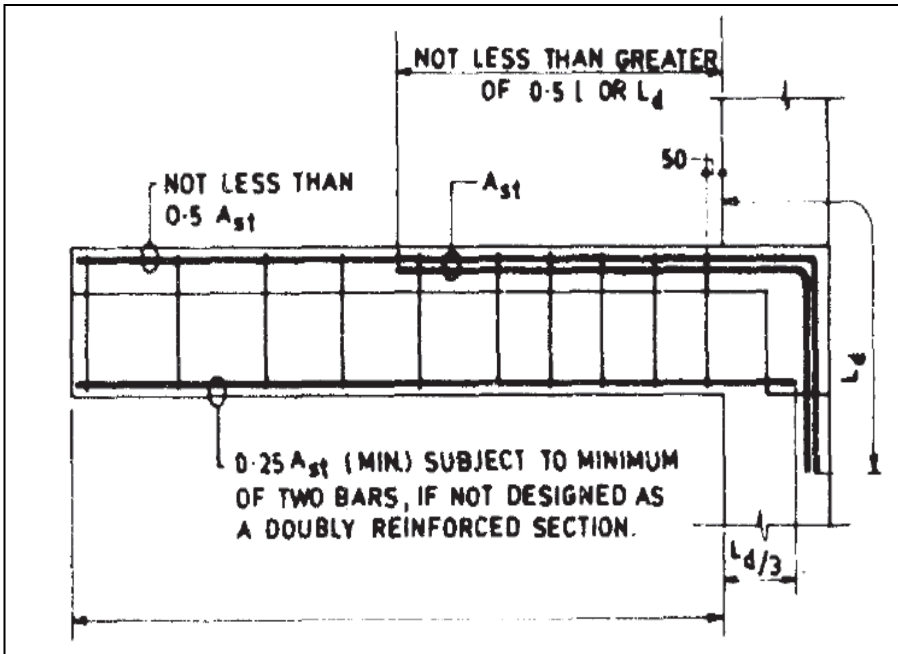



Fig: 5.3 Simplified Curtailment Rules for Cantilever Beam

# Part -6

# Design of Slab

Slabs are of several types

a) One Way slab

b) Two way slab

c) Flat slab Etc

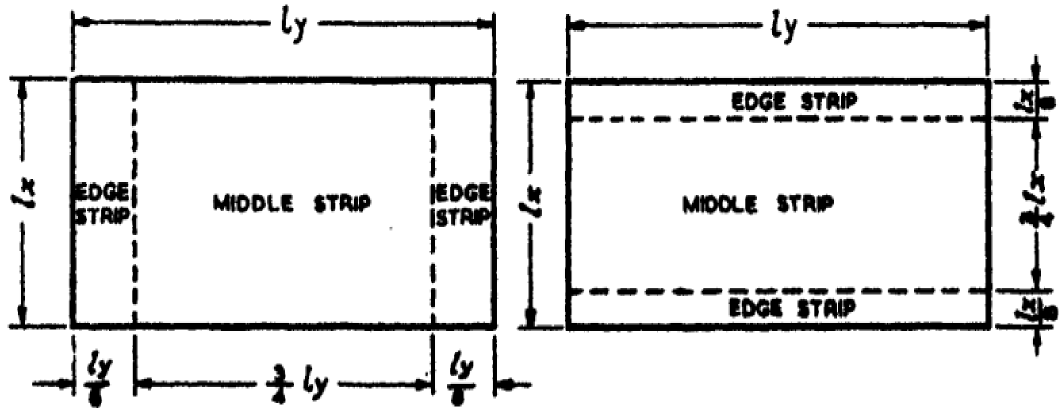



Fig 6.1 Two way slab showing middle and edge strip along both directions

Table 6.1 positive and negative moment coefficient for two way slab for different type of panels as per IS 456 (2000)

| Case No. | Type of Panel and Moments Considered | Short Span Coefficients $\alpha_x$ (Values of $l_y/l_x$) 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.75 | 2.0 | Long Span Coefficients $\alpha_y$ for All Values of $l_y/l_x$ |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| 1 | *Interior Panels:* | | | | | | | | | |
| | Negative moment at continuous edge | 0.032 | 0.037 | 0.043 | 0.047 | 0.051 | 0.053 | 0.060 | 0.065 | 0.032 |
| | Positive moment at mid-span | 0.024 | 0.028 | 0.032 | 0.036 | 0.039 | 0.041 | 0.045 | 0.049 | 0.024 |
| 2 | *One Short Edge Continuous:* | | | | | | | | | |
| | Negative moment at continuous edge | 0.037 | 0.043 | 0.048 | 0.051 | 0.055 | 0.057 | 0.064 | 0.068 | 0.037 |
| | Positive moment at mid-span | 0.028 | 0.032 | 0.036 | 0.039 | 0.041 | 0.044 | 0.048 | 0.052 | 0.028 |
| 3 | *One Long Edge Discontinuous:* | | | | | | | | | |
| | Negative moment at continuous edge | 0.037 | 0.044 | 0.052 | 0.057 | 0.063 | 0.067 | 0.077 | 0.085 | 0.037 |
| | Positive moment at mid-span | 0.028 | 0.033 | 0.039 | 0.044 | 0.047 | 0.051 | 0.059 | 0.065 | 0.028 |
| 4 | *Two Adjacent Edges Discontinuous:* | | | | | | | | | |
| | Negative moment at continuous edge | 0.047 | 0.053 | 0.060 | 0.065 | 0.071 | 0.075 | 0.084 | 0.091 | 0.047 |
| | Positive moment at mid-span | 0.035 | 0.040 | 0.045 | 0.049 | 0.053 | 0.056 | 0.063 | 0.069 | 0.035 |
| 5 | *Two Short Edges Discontinuous:* | | | | | | | | | |
| | Negative moment at continuous edge | 0.045 | 0.049 | 0.052 | 0.056 | 0.059 | 0.060 | 0.065 | 0.069 | — |
| | Positive moment at mid-span | 0.035 | 0.037 | 0.040 | 0.043 | 0.044 | 0.045 | 0.049 | 0.052 | 0.035 |
| 6 | *Two Long Edges Discontinuous:* | | | | | | | | | |
| | Negative moment at continuous edge | — | — | — | — | — | — | — | — | 0.045 |
| | Positive moment at mid-span | 0.035 | 0.043 | 0.051 | 0.057 | 0.063 | 0.068 | 0.080 | 0.088 | 0.035 |
| 7 | *Three Edges Discontinuous (One Long Edge Continuous):* | | | | | | | | | |
| | Negative moment at continuous edge | 0.057 | 0.064 | 0.071 | 0.076 | 0.080 | 0.084 | 0.091 | 0.097 | — |
| | Positive moment at mid-span | 0.043 | 0.048 | 0.053 | 0.057 | 0.060 | 0.064 | 0.069 | 0.073 | 0.043 |
| 8 | *Three Edges Discontinuous (One Short Edge Continuous):* | | | | | | | | | |
| | Negative moment at continuous edge | — | — | — | — | — | — | — | — | 0.057 |
| | Positive moment at mid-span | 0.043 | 0.051 | 0.059 | 0.065 | 0.071 | 0.076 | 0.087 | 0.096 | 0.043 |
| 9 | *Four Edges Discontinuous:* | | | | | | | | | |
| | Positive moment at mid-span | 0.056 | 0.064 | 0.072 | 0.079 | 0.085 | 0.089 | 0.100 | 0.107 | 0.056 |

**Basic Design Criteria:**

1) Calculate the Ly/Lx ratio and decide one way or two way slab
2) Calculate total udl on the 1 m width slab and also the maximum sagging and hogging bending moment in the slab. Assume suitable thickness of the slab for self-weight calculation.

   $M_x = \alpha_x w l_x^2$ and $M_y = \alpha_y w l_x^2$

   Where $\alpha_x$ and $\alpha_y$ are moment coefficients

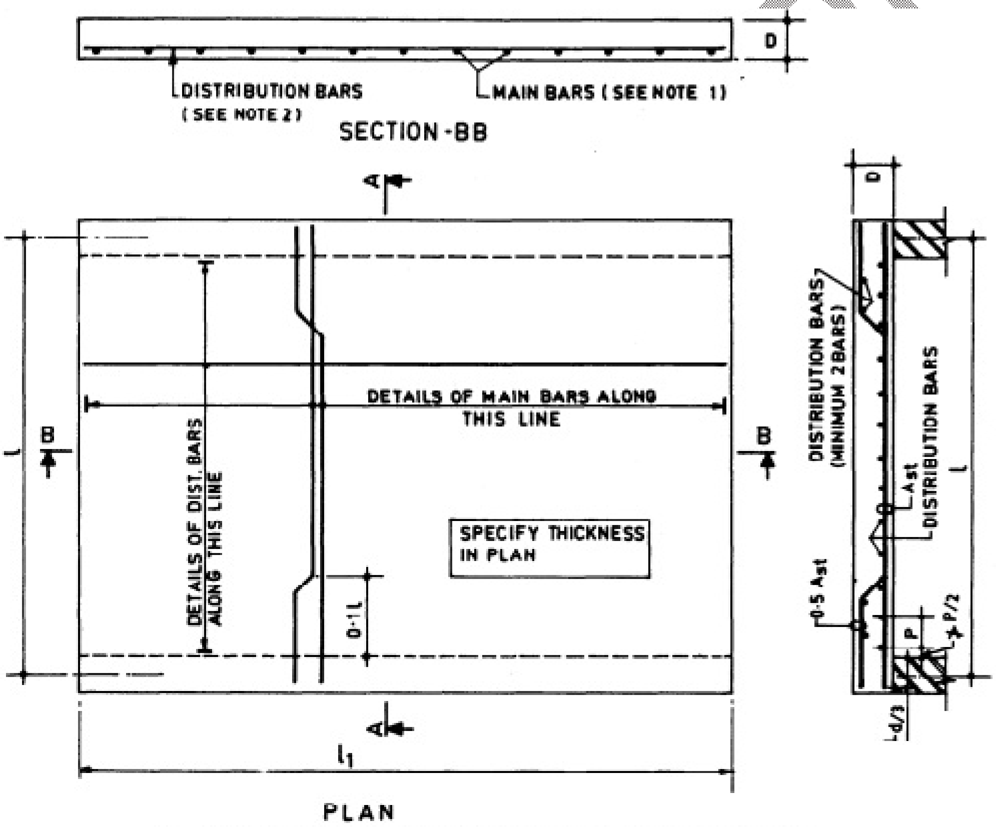
   $w$ =total design load per unit area

   $l_x$ =length in the shorter span.

3) Calculate the required depth of the slab considering maximum designed moment.
4) Calculate the required area of steel for designed sagging and hogging moment.

5) Check for shear stress. Shear stress must be within the permissible limit as described in IS 456 (2000)
6) Check for deflection based on the provided area of steel
7) Check for development length.
8) Prepare the drawing for the slab and detail it.

**Detailing of Reinforcement for slab:**




Note 1 — Diameter ≮ 8 mm for deformed bars; 10 mm for plain bars; Spacing ≯ 3d or 450 mm

Note 2 — Diameter ≮ 6 mm; Spacing ≯ 5d or 450 mm

Fig: 6.2 typical detail of simply supported slab resting on wall spanning in one direction

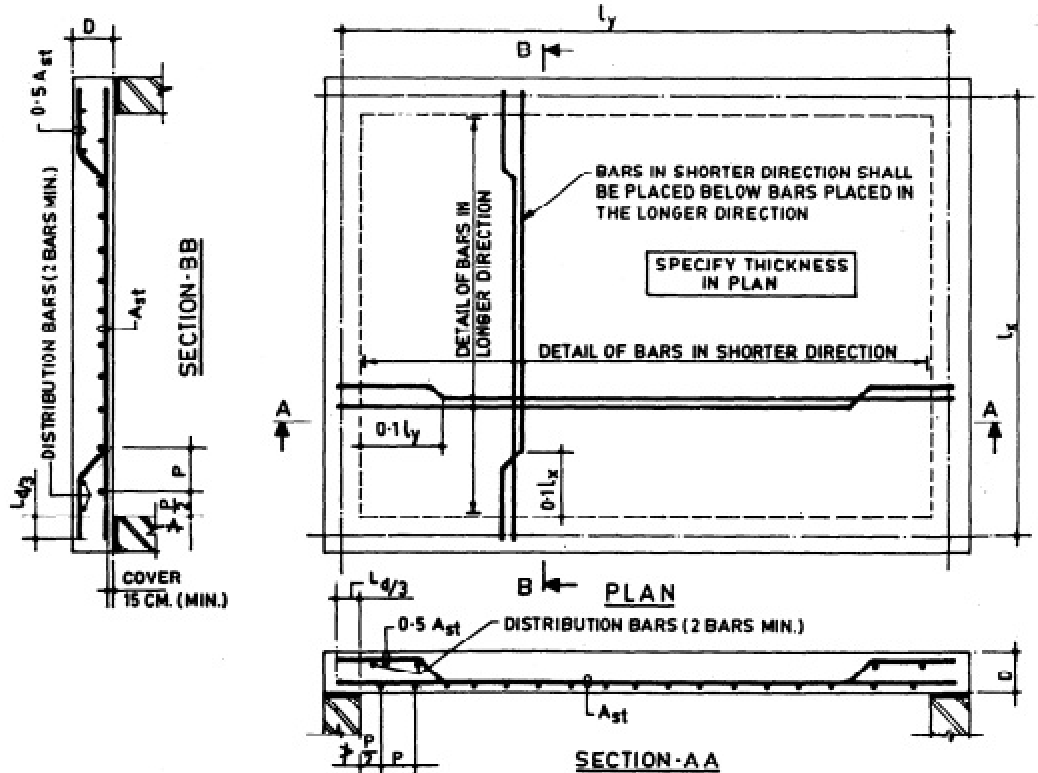



Fig: 6.3 typical detail of simply supported slab resting on wall spanning in both direction

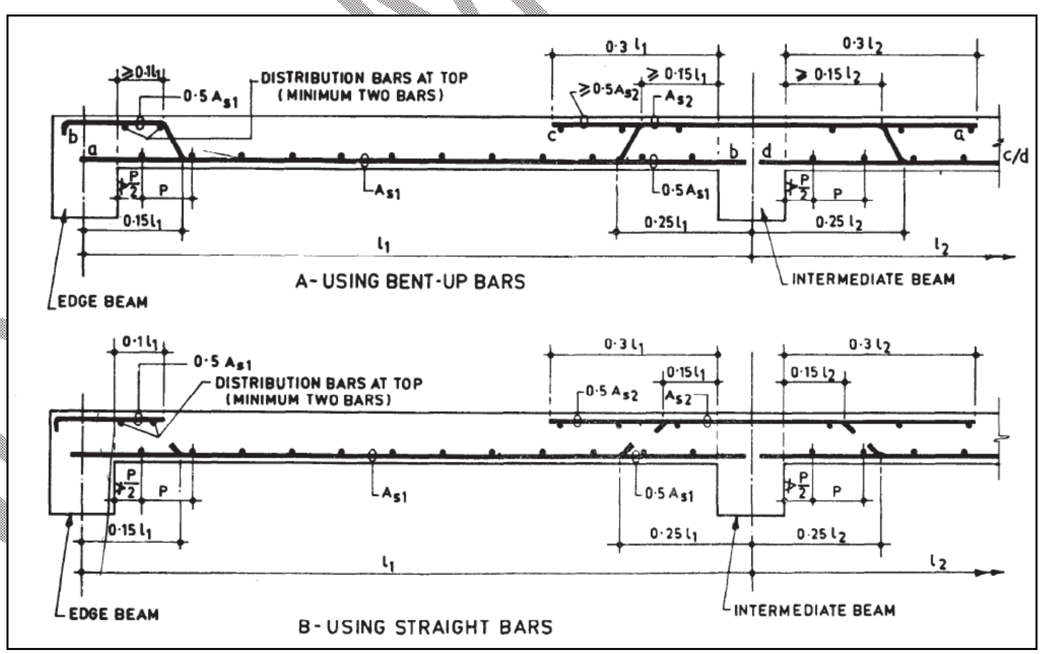



Fig: 6.4 Simplified Curtailment Rules for continuous slab

# Part -7

## Ductile Detailing

**IS 13920:1993**

Provisions of this standard shall be adopted in all lateral load resisting systems of RC structures located in Seismic Zone III, IV or V. The standard is optional in Seismic Zone II.

i) For all buildings which are more than 3 storeys in height, the minimum grade of concrete shall preferably be M20 ( fck = 20 MPa ).

ii) Steel reinforcements of grade Fe 415 ( see IS 1786 : 1985 ) shall be preferred.

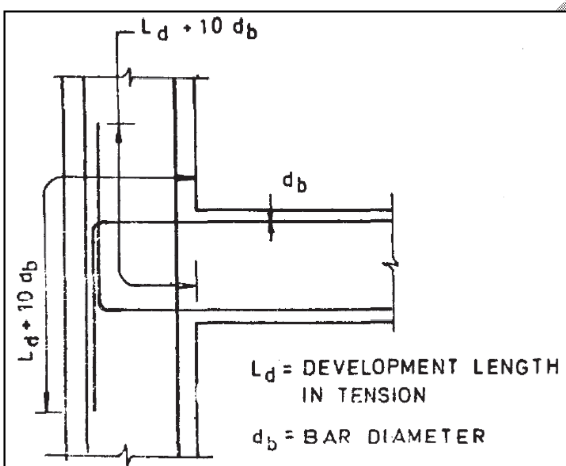



Fig 7.1 Anchorage of beam in an external joint

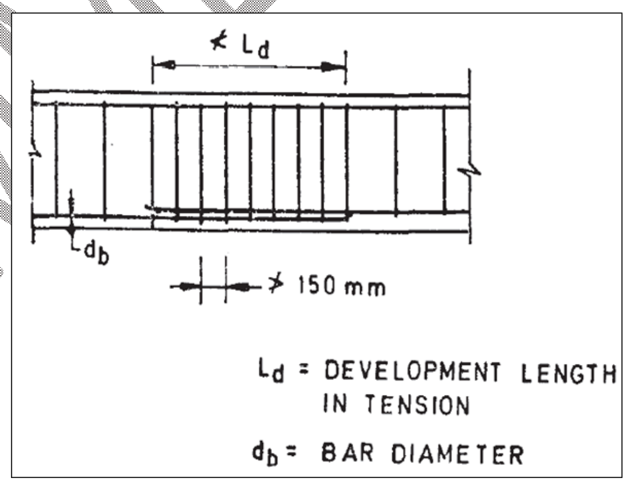



Fig 7.2 Lap Splice in a Beam

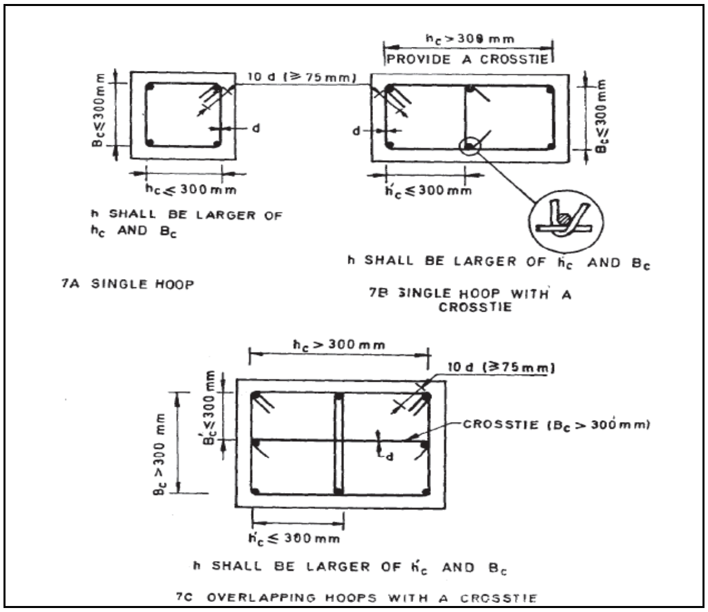



Fig 7.3 Stirrups of column

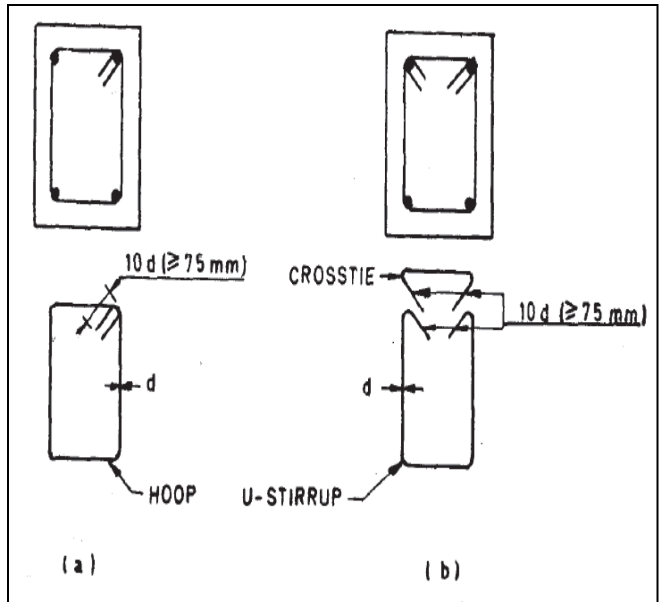



Fig 7.4 Stirrups of Beams

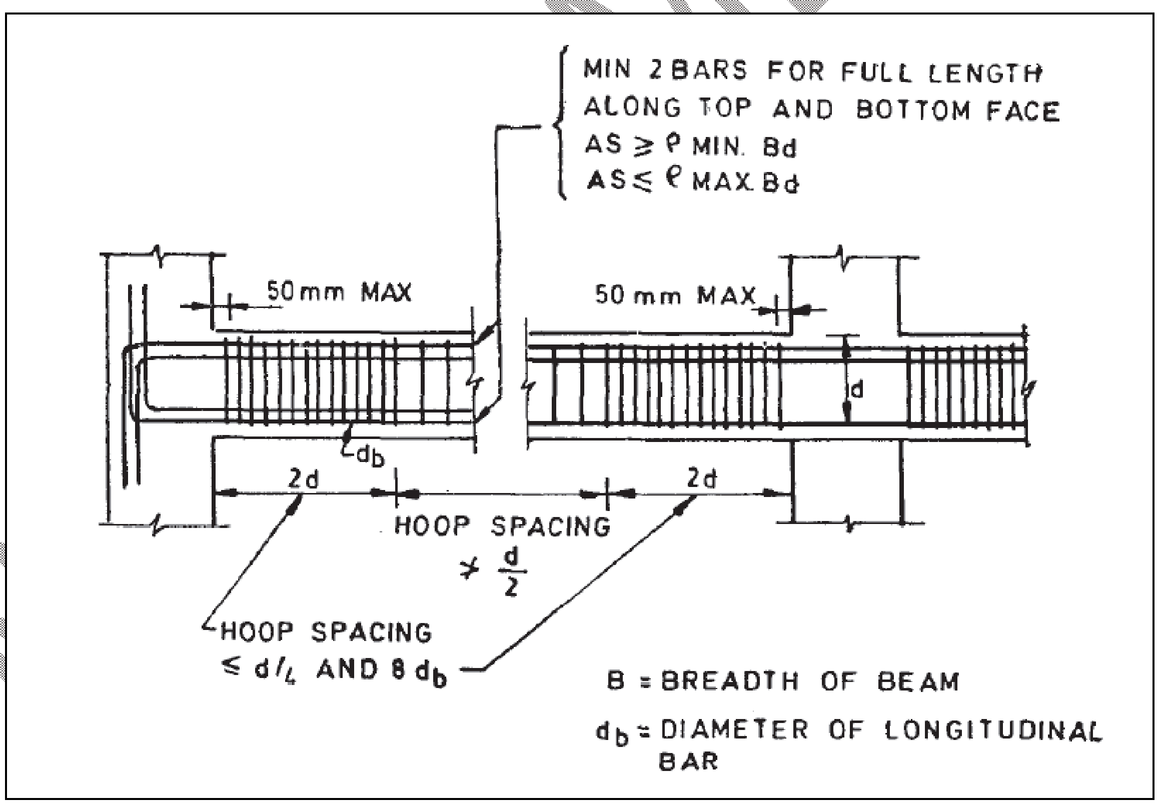



Fig 7.5 Beam reinforcement details