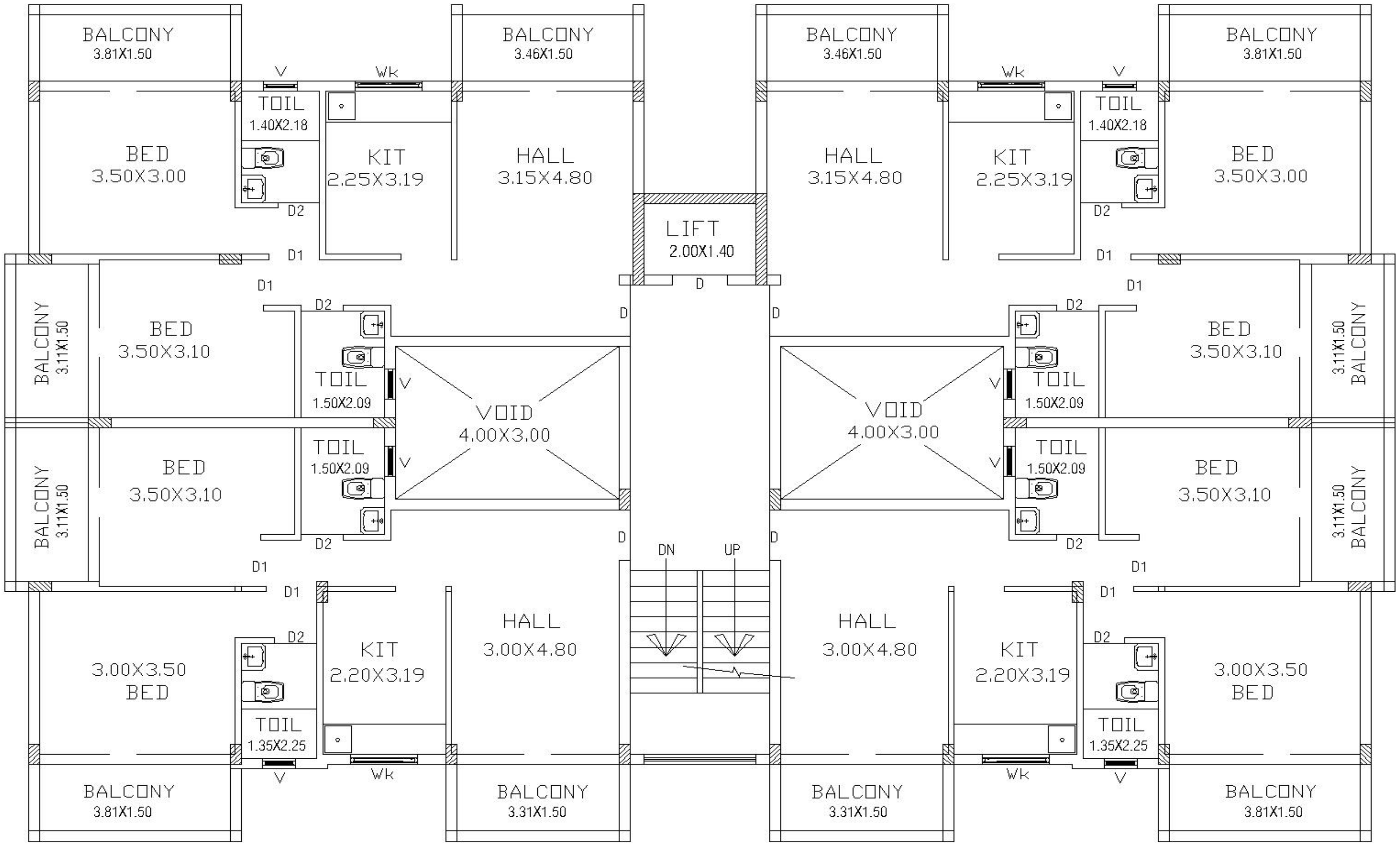
CASE STUDY 1- DESIGN OF G+4 RCC STRUCTURE

SECTION 1- BASICS

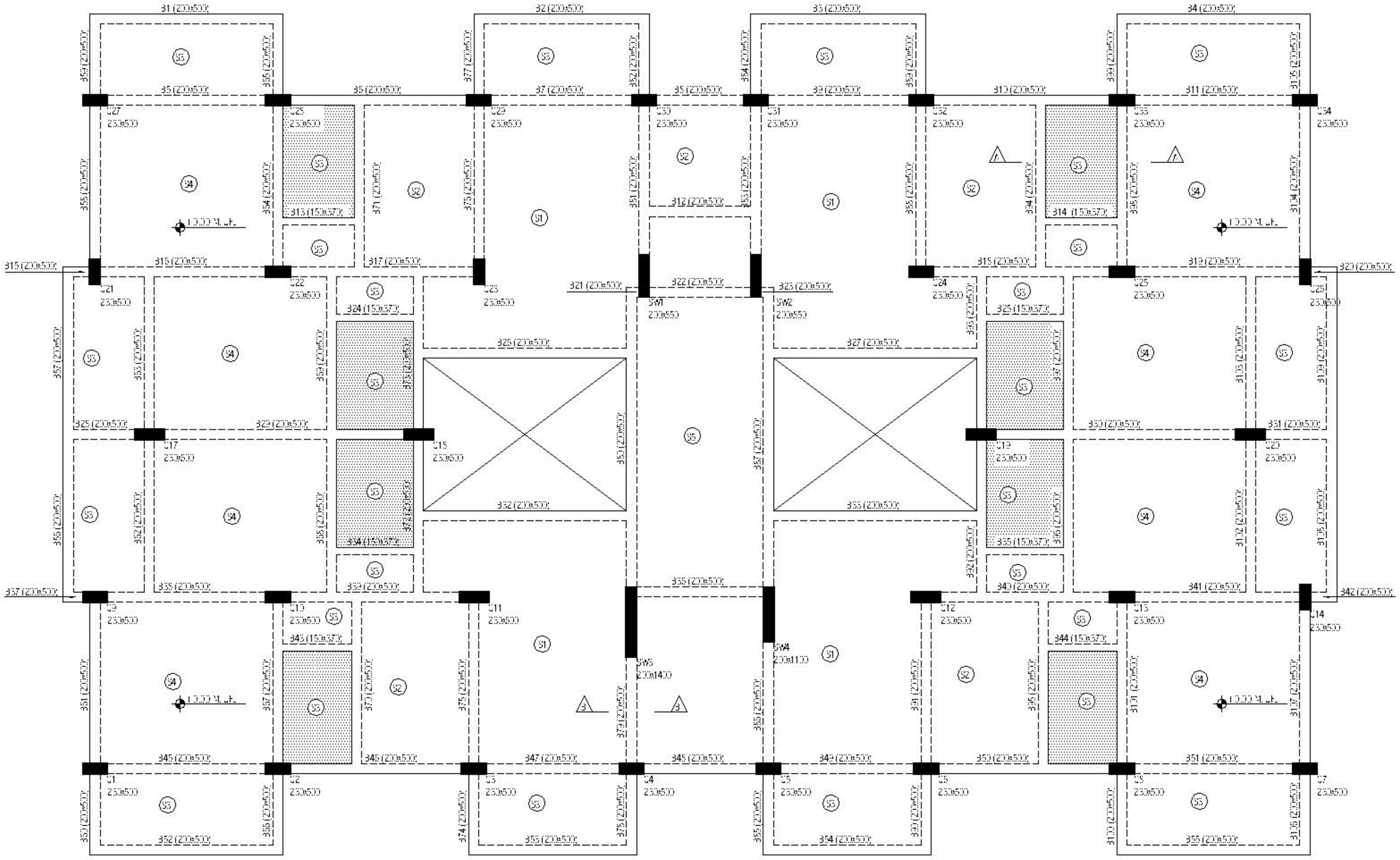
- Ground + 4 floor RCC frame structure in Goa
- Floor to floor height is 3.0m
- Plan dimension, 24.0 m x 13.5 m
- SBC = 20 t/sqm, hard Strata is consider for seismic analysis
- Analysis done using structural designing software

ARCHITECTURAL PLAN



TYPICAL FLOOR PLAN

RCC FRAMING PLAN



STRUCTURAL LAYOUT AT TYPICAL FLOOR LEVEL

BASIS OF DESIGN

Grade of concrete: M25

Grade of steel: Fe500D

- The design is based on the following Indian Codes:

Sr. No	Codes	Code detail
1	IS 456: 2000	Code of practice for plain and reinforced concrete.
2	IS 1893 (part-1): 2002	Criteria for earthquake resistance Design of Structure.
3	IS 875 (part-1): 1987	Code of Practice for Design loads (other than Earthquake) for Buildings and Structures (Dead loads – Unit weights of building materials and stored materials)
4	IS 875 (part-2): 1987	Code of Practice for Design loads (other than Earthquake) for Buildings and Structures (Imposed load)
5	IS 875 (part-3): 1987	Code of Practice for Design loads (other than Earthquake) for Buildings and Structures (wind load).
6	IS 13920: 1993	Ductile detailing of reinforced concrete structures subjected to seismic force.
7	IS 800: 2007	Code of Practice for general Construction in steel.

SECTION 2 -FORCES ACTING ON THE STRUCTURE

LOADS CONSIDERED

- **Dead Loads (IS 875 Part-1, 1987)**

Sr. No.	Material	Density
1	concrete	2500 Kg/m^3
2	Brick wall	2000 Kg/m^3
3	Soil	1800 Kg/m^3
4	Water	1000 Kg/m^3
5	plaster	2000 Kg/m^3

- **Imposed Loads (IS 875 Part-II, 1987)**

Sr. No.	Occupancy	Loads
1	Residential floors	200 Kg/m^2
2	Basement with car parking	250 Kg/m^2
3	Toilets and Baths	200 Kg/m^2
4	Staircases	300 Kg/m^2
5	Corridors	300 Kg/m^2
6	Terraces (accessible)	150 Kg/m^2

LOADS CONSIDERED

- **Wind load:** *(IS 875 Part-III, 1987)*

Sr. No	Parameter	Value	Remark
1	Basic wind Speed (Vb)	39 m/s	For GOA
2	Height of the building	19.82m	
3	Terrain Category	2	Clause 5.3.2
4	Terrain Class	B	
5	Probability factor (K_1)	1.0	Clause 5.3.1
6	Terrain Height and structure size (K'_2)	1.03	Clause 8.2 & 8.2.1, Table-33
7	Topography Factor (K_3)	1.00	Clause 5.3.3

Design Wind Pressure, $P_z = 0.6 \text{ x } (V_b \text{ x } k_1 \text{ x } k'_2 \text{ x } k_3)^2 = 968 \text{ N/mm}^2$

Total wind force in X-Direction =18.30 Tons

Total wind force in Y-Direction = 28.17 Tons

- **Lateral Sway**
  ……*IS 456 : 2000 clause 20.5*

Lateral Sway @ top (H/500)		Allowable (mm)
X (mm)	Y (mm)	
4.394	8.33	29.2

LOADS CONSIDERED

- **Seismic load** ***(IS 1893 Part-I, 2002)***

Sr. No.	Parameter	Value	Remark
1	Seismic Zone	III	For GOA
2	Zone Factor (Z)	0.16	Clause 6.4.2
3	Importance Factor (I)	1.0	Clause 6.4.2
4	Response Reduction factors (R)	4.0	Clause 6.4.2
5	Type of Soil	medium	
6	Empirical Time Periods (T)	Tx=0.36 Ty=0.44	Clause 7.6.2
7	Sa/g	2.5	Clause 6.4.5

Total Gravitational weight of the bldg. = 3192.45 Tons

Base Shear, V_b =154.83 Tons

- **Lateral Sway due to seismic load**
  ……IS 1893 (Part 1) : 2002 clause 7.11.1

  - h/250 (where 'h' is storey height)

Floor	Lateral Sway		Allowable (mm)
	X (mm)	Y (mm)	
G. Floor	0.184	0.331	11.2
1^{st} Floor	1.125	2	12
2^{nd} Floor	2.27	4.27	12
3^{rd} Floor	3.22	6.22	12
4^{th} Floor	3.89	7.57	12
Terrace Floor	4.28	8.33	11.2

LOAD CASES COMBINATION

Sr. No	Load Combinations
1	1.5 (Dead Loads + Live Loads)
2	1.2 (Dead Loads + Live Loads +/- Seismic load in X direction)
3	1.2 (Dead Loads + Live Loads +/- Seismic load in Y direction)
4	1.5 (Dead Loads +/- Seismic load in X direction)
5	1.5 (Dead Loads +/- Seismic load in Y direction)
6	1.2 (Dead Loads + Live Loads +/- Wind load in X direction)
7	1.2 (Dead Loads + Live Loads +/- Wind load in Y direction)
8	1.5 (Dead Loads +/- Wind load in X direction)
9	1.5 (Dead Loads +/- Wind load in Y direction)

SECTION 3- DURABILITY REQUIREMENT

- moderate exposure condition: External concrete surfaces are sheltered from severe rain or freezing whilst wet……*IS 456 : 2000 clause 8.2.2*

exposure	Minimum Grade of Concrete	Nominal concrete cover in mm not less than
Moderate	M25	30

- Nominal cover to meet specified period of fire resistance……*IS 456 : 2000 clause 26.4.3*

Fire resistance	Nominal Cover				
	Beams		Slabs		Columns
	Simply supported	continuous	Simply supported	continuous	
2	40	30	35	25	40

SECTION 4- DUCTILE DETAILING (I S 13920 : 1993)

GENERAL SPECIFICATIONS

For detailing & designing of the building, all the clauses of IS 13920 : 1993 have been considered.

- The Structure is located in Seismic zone III.
- *The minimum grade of concrete is M20 for more than 3 storey……****Clause 5.2***

  As it is a G+4 building, M 25 is considered.
- *High strength deformed steel bars of grades Fe 500 and Fe 550, having elongation more than 14.5 percent can be used for the reinforcement****…..Clause 5.3***

  Fe 500D has been adopted which has elongation of 16 percent.

Flexural Members

- *The factored axial stress on the members under earthquake shall not exceed $0.1f_{ck}$ ($2.5 N/mm^2$)…***Clause 6.1.1**

  Maximum axial stress in all beams is less than $2.5\ N/mm^2$.

- All the flexural members have width to depth ratio more than 0.3……*Clause 6.1.2*

Beams	B	D	B/D	>0.3
B1	200	500	0.4	OK
B14	200	600	0.33	OK
B18	150	370	0.405	OK

- Width of all the flexural members are more than 200mm……*Clause 6.1.3*
- Generally the depth of the flexural member is less than ¼ of the Clear Span……*Clause 6.1.4*

- ***<u>Longitudinal Reinforcement :</u>***
- Top and bottom reinforcement consists of at least two bars through out the member length
  ……*Clause 6.2.1 a)*
- The tension reinforcement on any tension face is not less than $0.24[f_{ck}]^{1/2}/f_y$ i.e. 0.24%……*Clause 6.2.1 b)*
- Where as for Fe415, minimum steel req. is 0.29 %
- In an exterior joint, both the top and bottom bars of the beam is provided with anchorage length, beyond the inner face of the column, equal to the development length in tension plus 10 times the bar diameter. In an interior joint, both face bars of the beam is taken continuously through the column……*Clause 6.2.5*

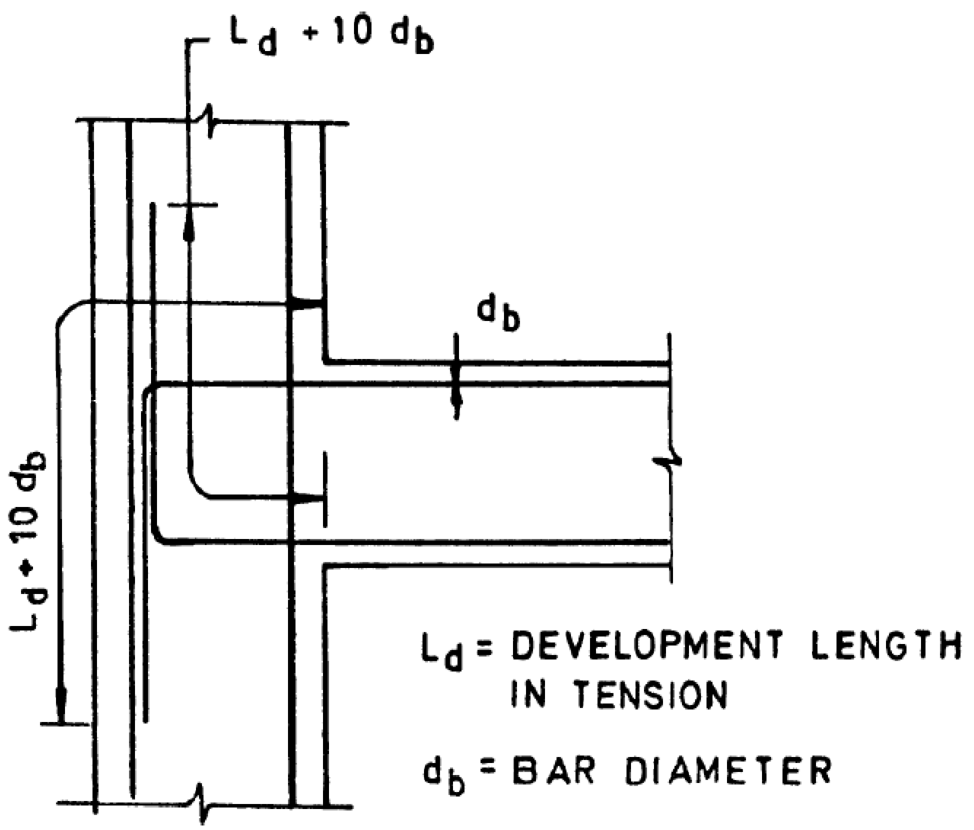


FIG. 1 ANCHORAGE OF BEAM BARS IN AN EXTERNAL JOINT

- ***Longitudinal reinforcement :***
- *Generally over the spliced length of the longitudinal bars, hoops are provided at a spacing of 150mm c/c ……**Clause 6.2.6***

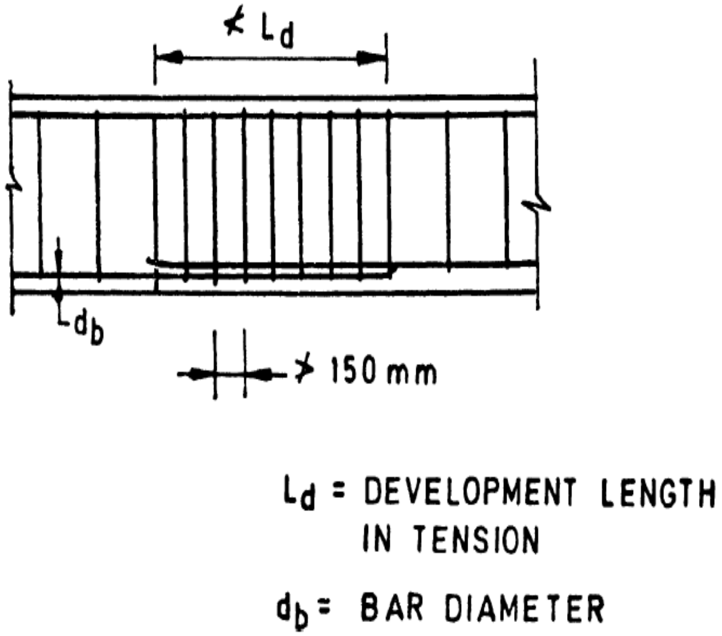


FIG. 2 LAP, SPLICE IN BEAM

- ***Web reinforcement :***
- the spacing of the hoop over a length of 2d at either end of the beam is not more than d/4……***Clause 6.2.6***

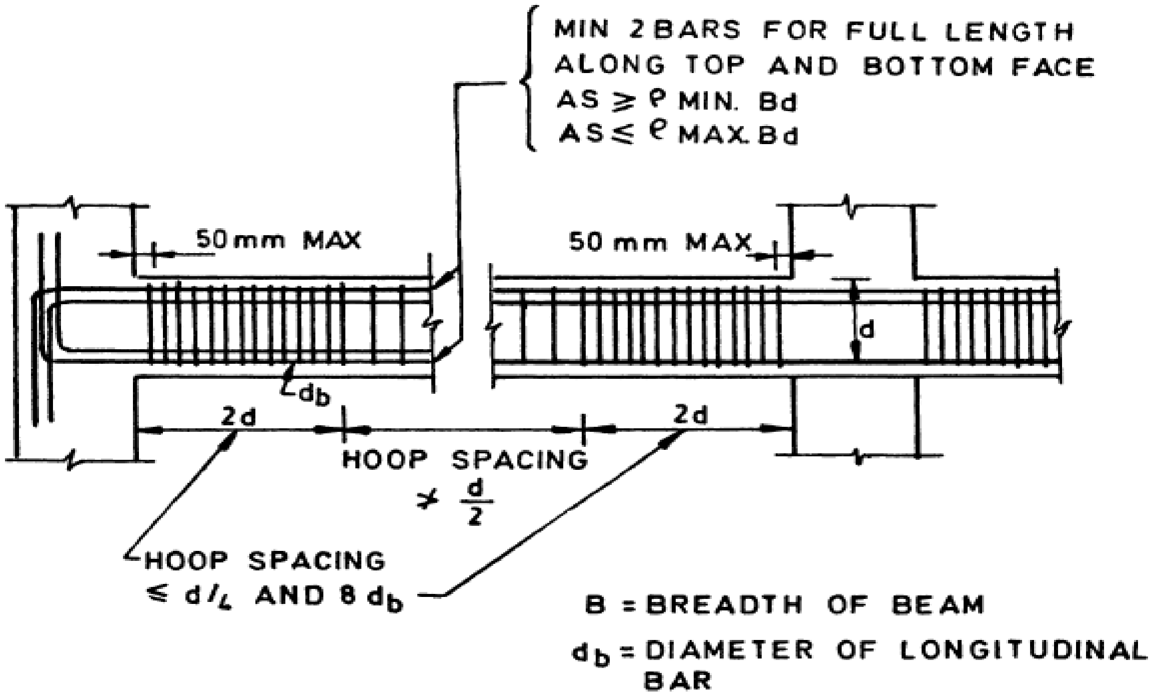


FIG. 5 BEAM REINFORCEMENT

Columns and frame members subjected to bending and axial load

- *These requirements apply to frame members, which have a factored axial stress in excess of 0.1f_{ck} under the effect of earthquake forces*……***Clause 7.1.1***

  Generally the axial stresses are found to be more then 0.1f_{ck}

- *The minimum dimension of the column is not less than 200mm*……***Clause 7.1.2***

  The minimum dimension of the column is kept as 230mm.

- *The ratio of shortest cross section dimension to the perpendicular dimension shall not be less than 0.4*……***Clause 7.1.3***

Column	B (mm)	D (mm)	B/D	>0.4
C1	230	500	0.46	OK
C17	300	600	0.5	OK

- <u>**Longitudinal Reinforcement :**</u>
- Lap splice is provided in the middle half of the member length, hoops are provided over the entire splice length at spacing not exceeding 150 mm and not more than 50% bars are lapped at one section*……Clause 7.2.1*

- <u>**Transverse Reinforcement :**</u>
- the parallel leg of the rectangular hoop is not more than 300mm in length where the length exceed 300mm crosstie is provided*……Clause 7.3.2*

SECTION 5- STEEL DIFFERENCE ANALYSIS

Structural Members	Fe415 (Kgs)	Fe500D (Kgs)
Footings	4,282	3,590
Columns		
Mains Bars	15,908	13,336
Rings	5,300	5,300
Beams		
Main Bars	19,240	16,129
Rings	6,475	6,475
Slabs	5,747	4,818
TOTAL	56,952	49,647
Kg/ sqft	3.56	3.10

- Total reduction in steel is 56,952/49,647 = 1.147 ~ 14.7%