Defⁿ of Ductility :⇒ To enable the structure to absorb energy during earthquake to avoid sudden collapse.

Details & Code for ductility in ⇒ Is 13920 : 1993

Is 13920 : 1993 code for Ductile Detailing of Reinforced Concrete Structure Subjected to seismic forces.

* This Standard provides requirements for designing and detailing of Reinforced Concrete structure in order with adequate toughness and ductility to withstand serious earthquake shocks without collapse.

Needs for ductility :⇒

* Is-13920-1993 detailing for Ductility.
* Design criteria is no-collapse design.
* Provisions for Ductility for once in life earthquake.
* Cost Increases geometrically for no damage design.
* Prevent brittle failure mechanisms to take place prior to ductile yielding

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⇒ Principles of Ductility :→

* Avoid Shear failure
* Avoid Compression failure
* Ensure continuity
* Confine the critical areas where Hinge can form.

⇒ Is 13920 - 1993

Applicable for structure located in

- Zone IV and V
- Zone III and I > 1
- Zone III and is an Industrial structure.
- Zone III and more than five stories.

⇒ Critical Zones in R.C. frames :→

Where Plastic hinge can form and requires proper confinement :-

* Ends of Beams upto length of 2d. (large -ve Moments)
* Moments reversal is possible
* Beam column joins - (causes diagonal cracks)
* Bond failure :- Brittle
* Shear failure :- Brittle

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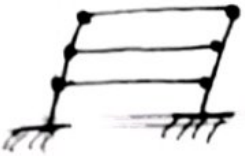
⇒ Collapse Mechanism in Beam :- Hinge Mechanism (Sway Mechanism)



⇒ Beams :-
* Depth not greater than 0.25 times span.
* Min. No. of Bars - 2
* Width Not less than 200 mm
* Width of Depth Ratio ≥ 0.3

⇒ Detailing of Beams :-

* Members size proportions
  - Web Width ≥ 200 mm

for proper Detailing and confinement

- overall depth $D \leq 0.25$ of clear span.

* longitudnal Reinforcement

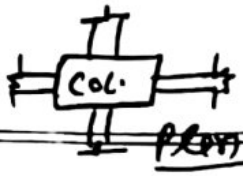
- Min. two bars throughout the length of Beam at top and Bottom.
- Min. compression steel ≥ 0.5 Ast (Ast = Area of steel)
- Max. long steel on any face 0.025.
- Full Bond length = Ld + 10 times dia. of Bar.

(Ld = Development length in tension)

* Transverse Reinforcement

- Spacing of stirrups

Confinement :- • provided by the beams around the joints



• By the reinforcement.

- Transverse stirrups designed to ensure shear capacity exceeds the flexure load capacity.

⇒ Fig 1 Anchorage of Beam Bars in an Exterior joint

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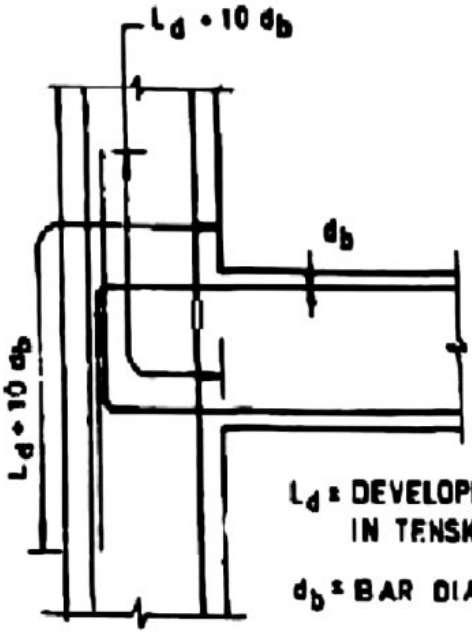

FIG. 1 ANCHORAGE OF BEAM BARS IN AN EXTERNAL JOINT

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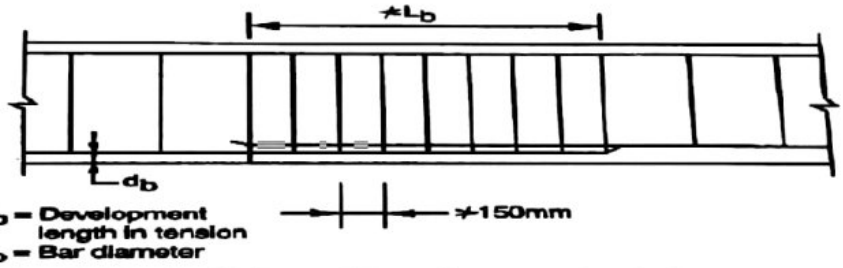
⇒ Fig 2:→ Lap, splice in Beam.



L_b = Development length in tension
d_b = Bar diameter

Fig. 4.15 : Splicing of tension steel reinforcement

⇒ Fig 3:→ Beam Web Reinforcement

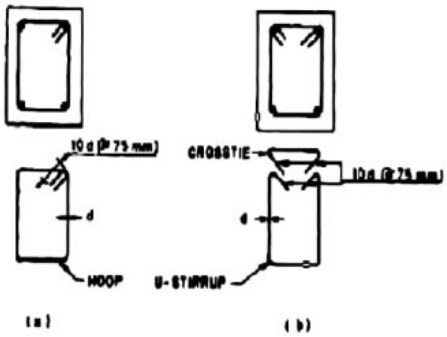


FIG. 3 BEAM WEB REINFORCEMENT

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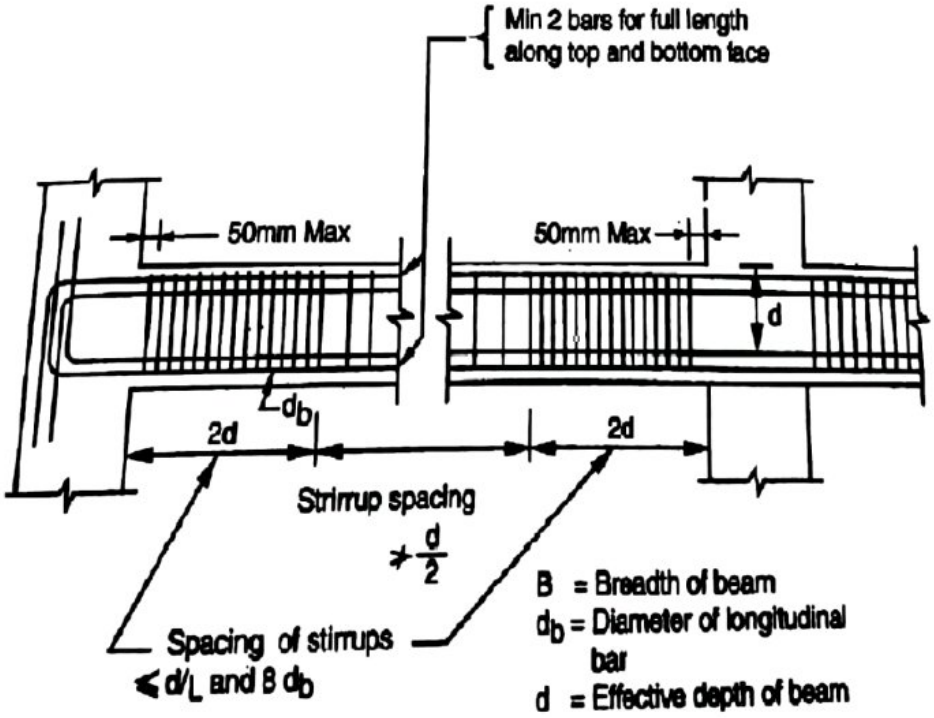
* Splicing

- Hoops of 100 mm c/c
- No lops of joins within 2 dia
- Not more than $\frac{1}{2}$ the bars to be lapped

* Web Reinforcement

- Bent-up Bars cannot take shear

⇒ Fig: Beam Reinforcement



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⇒⇒ Columns

* Min dimension Not less than 200 mm.
* Footing stirrup shall continue 300 mm into footing.

Detailing of columns:

* Member size proportion
  - Min. side dimensions
    - b ≥ 200 mm and
    - b ≥ 300 mm if beam span exceed 5m or unsupported column height exceed 4m.

* Longitudinal Reinforcement
  - Splices not more than 50% at any section
  - Proper detailing where column area extends more than 100mm beyond confined core.

* Transverse Reinforcement
  - Transverse tie
    - Ends bent through 135° with length 10 mm dia. of stirrups

- Spacing elsewhere $\leq b/2$, b is smaller dimension.
- Area of cross section of bar forming special confining hoop

⇒ Fig 5:→ Reinforcement requirement for column with more than 100 mm projection

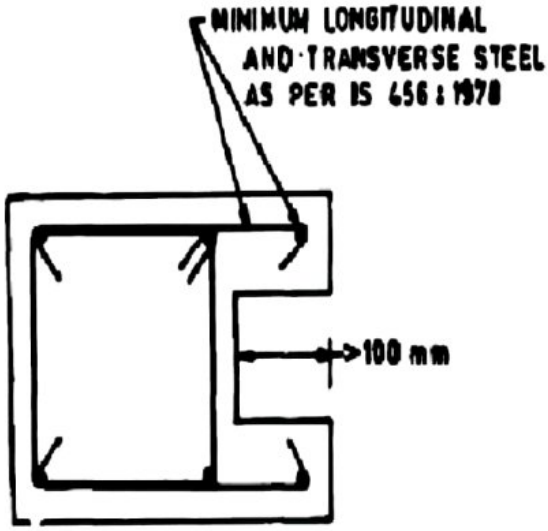

FIG. 6 REINFORCEMENT REQUIREMENT FOR COLUMN WITH MORE THAN 100 mm PROJECTION BEYOND CORE

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⇒ Shear Walls :→

- Minm. thickness 150 mm
- Preferably 200 mm with 2 layer steel
- Min steel 0.0025 inch in each direction
- Check for shear

⇒ Boundary elements :→

- To be designed as column
- provide diagonal steel
- openings
- provide the Interrupted beam on either side

Fig:→ Columns with varying stiffness

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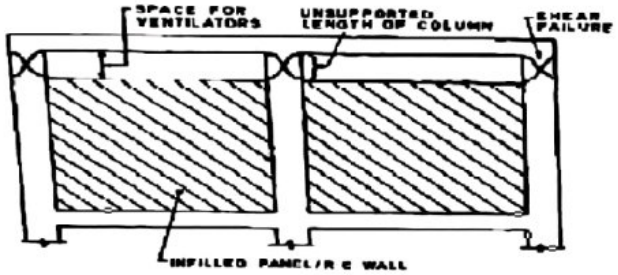

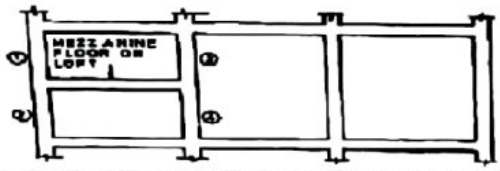

(1), (2), (3) and (4) relatively stiff columns — They attract large seismic shear force.

FIG. 12 COLUMNS WITH VARYING STIFFNESS

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