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COIMBATORE

DEPARTMENT OF CIVIL ENGINEERING

19CET302-DESIGN OF RC STRUCTURAL ELEMENTS

III YEAR / V SEMESTER

Unit 2 : Limit state design of Beams

Shear Reinforcement

- Shear design of reinforced concrete (RC) beam involves the determination of spacing between stirrups.
- Shear is a word used for forces that work perpendicular to the longitudinal axis of RC beam.
- Commonly, shear forces are maximum at supports of beams and decrease towards the middle of the beam span.
- RC concrete beams cracks in flexure due to principal tension stresses which are horizontal in the middle of the beam span.
- These principal stresses change direction from horizontal at the longitudinal reinforcement to 45 degrees at the neutral axis and vertical at the location of maximum compression stress.
- So, shear reinforcement or stirrups restrict shear cracks and withstand shear stresses in combination with the shear resistance of concrete.
- Therefore, the shear capacity of the RC beam is the combination of shear strength from concrete plus shear strength from shear reinforcement, as per ACI code.

Modes of Shear Failure

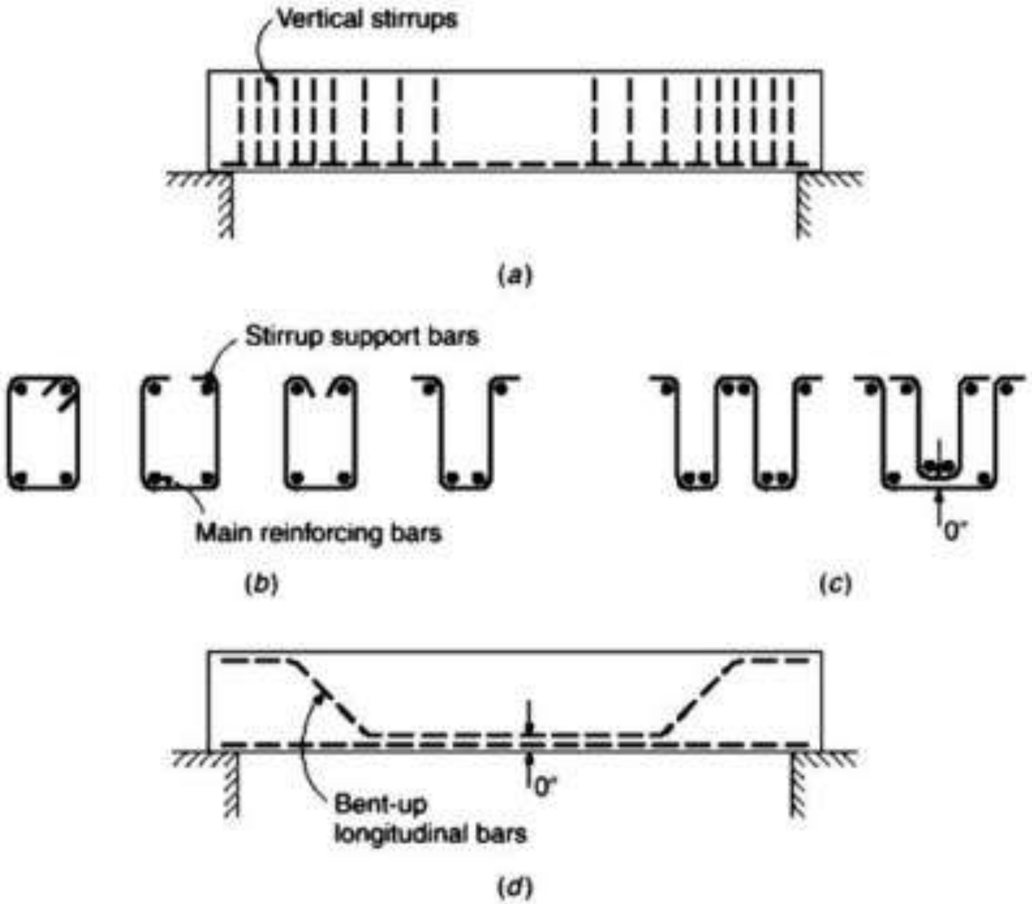
Three modes of failure or their combination occur:

- Flexural failure in which cracks are mainly vertical in the middle third of the beam span.
- Diagonal tension failure, where the strength of the beam in diagonal tension is lower than its strength in flexure.
- Shear compression failure, where the beam has a small shear span/depth ratio of the magnitude of 1-2.5 for concentrated loading and less than 5 for distributed loading.

Shear Reinforcement

- When the concrete cross-section has an insufficient area to maintain shear stresses below permissible values, additional resistance to shear may be provided in two ways.
- One from shear reinforcement consisting of hoops or stirrups, which may be placed vertically or inclined at some angle with horizontal.

- Another is in the form of web reinforcement that may consist of flexural reinforcement which can be bent diagonally upward (where it is no longer needed to resist bending) to reinforce the web



a) Vertical ***Stirrups,***
b) U-shaped bars single stirrups.
c) Multiple-leg stirrups
d) Bent-up longitudinal (inclined) bars

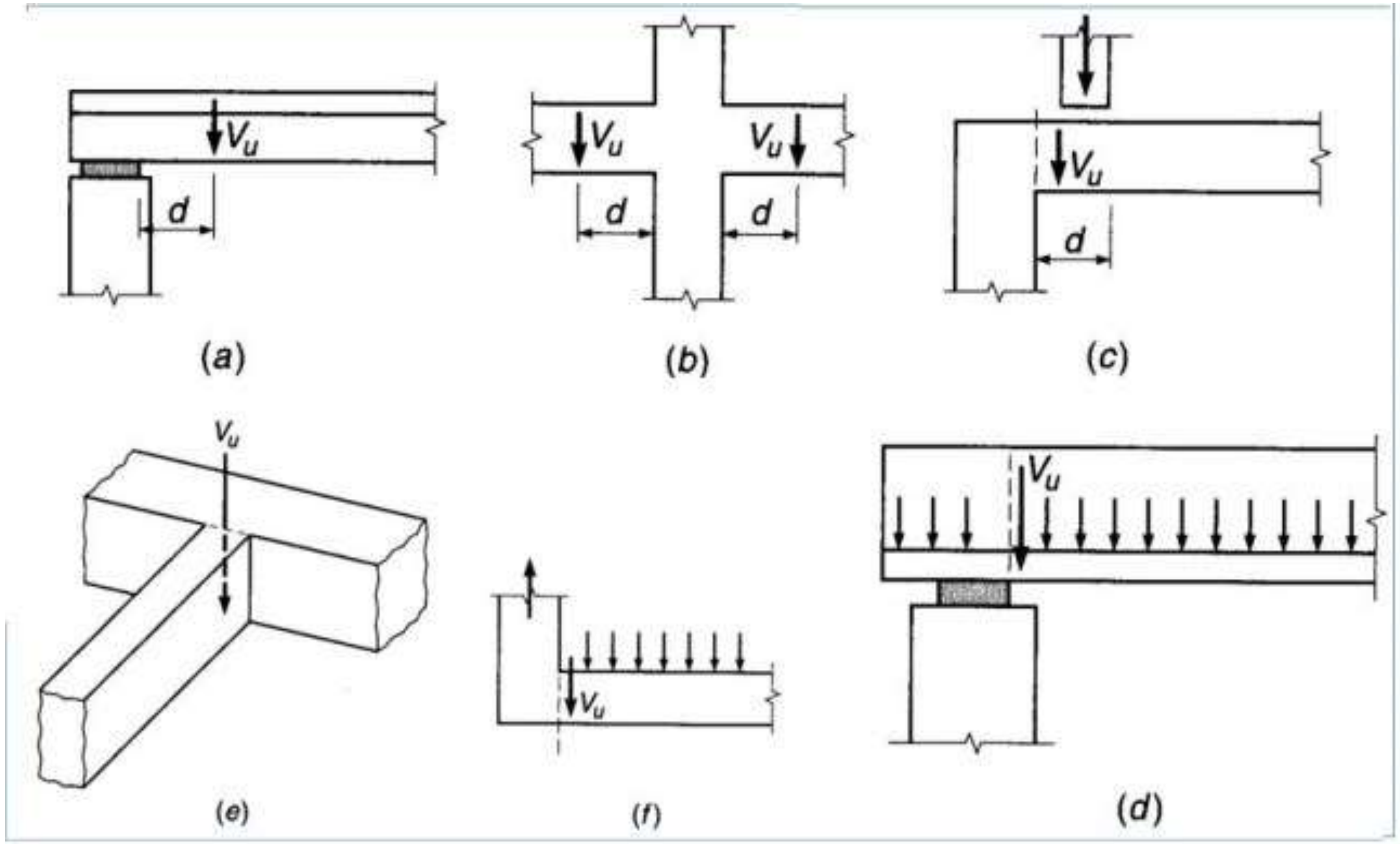
Functions of Stirrups

1. Carries a portion of flexural factored shear force.
2. Restricts the growth of diagonal cracks.
3. Holds the longitudinal reinforcement bars in place.
4. Provides some confinement to the concrete in the compression zone if the stirrups are in the form of closed ties.

Location of Critical Section for Shear Design

The location of critical section for shear design is determined based on the conditions at the supports. The location of critical shear is at a distance of effective depth (d) for condition (a, b, and c) in Figure-3, whereas critical section for shear design is at the face of supports for condition (e, f, and g) in Figure-3.

a- End-supported beam
b- Beam supported by columns
c- Concentrated load within distance d of the face of the support
d- Member loaded near the bottom
e- Beam supported by girder of similar depth
f- Beam supported by monolithic vertical element



V_u
d
(a)
V_u
V_u
d
d
(b)
V_u
d
(c)
V_u
(e)
V_u
(f)
V_u
(d)

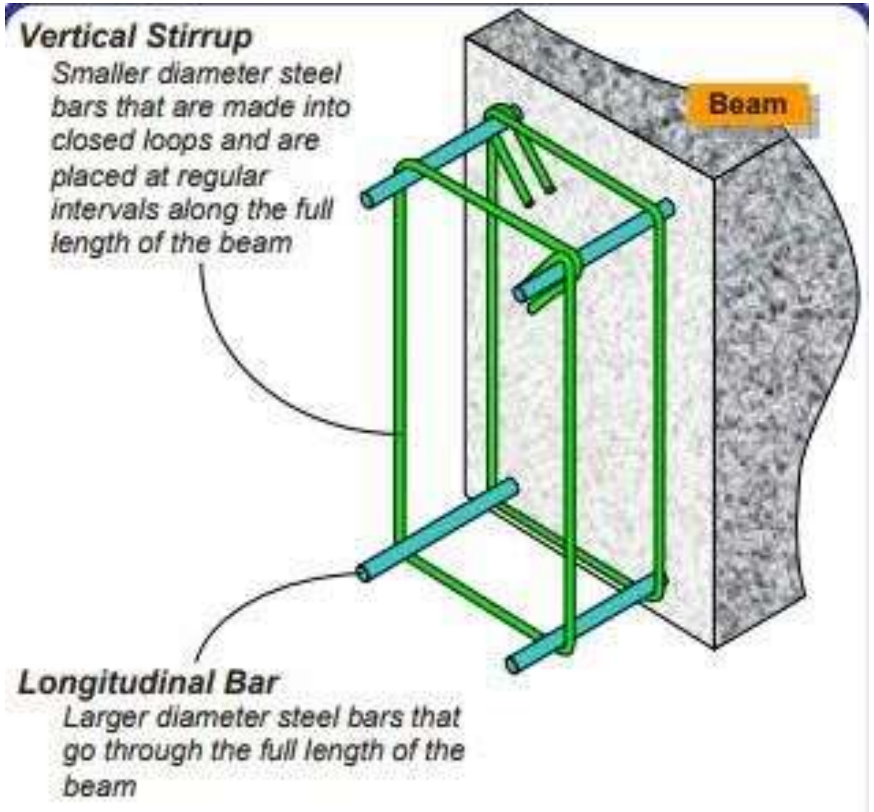
Types of Shear Reinforcement

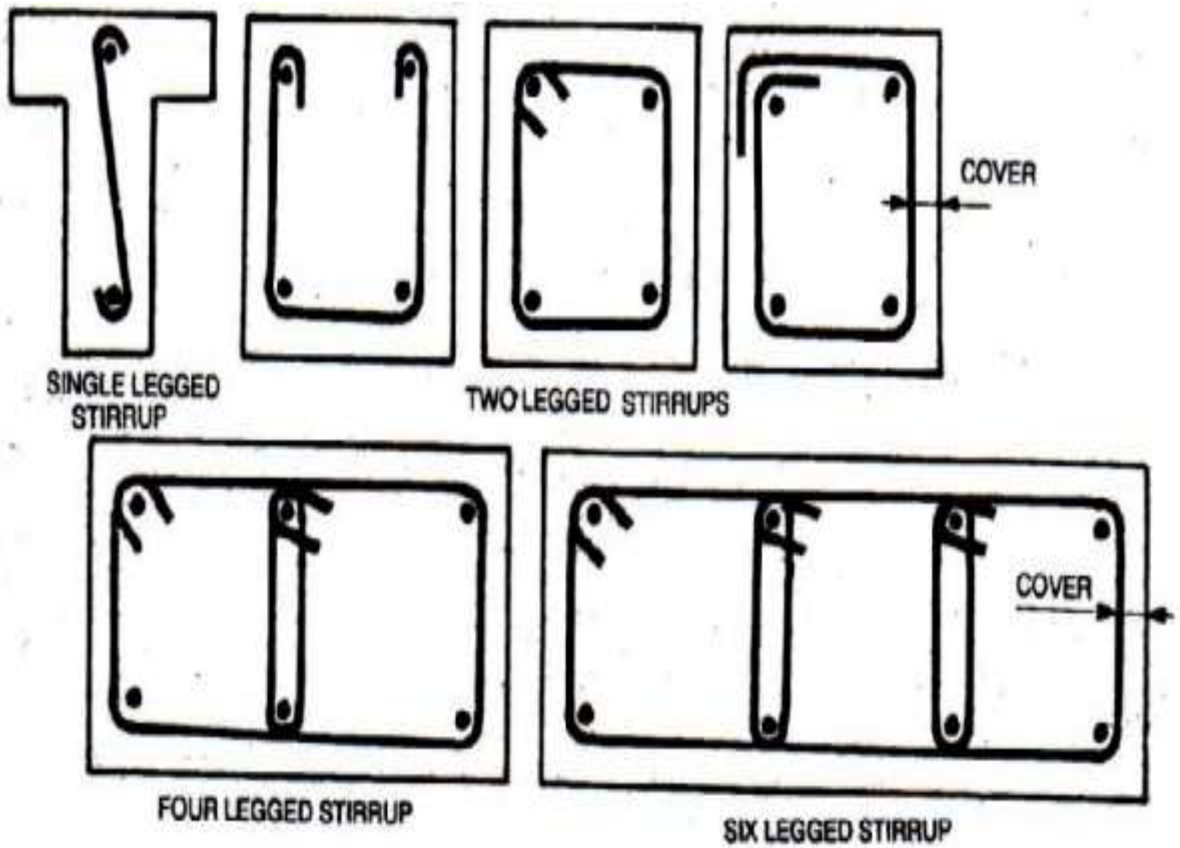
The following three types of shear reinforcement are used

- Vertical stirrups
- Bent up bars along with stirrups.
- Inclined stirrups.

Vertical stirrups

- These are the steel bars vertically placed around the tensile reinforcement at suitable spacing along the length of the beam. Their diameter varies from 6mm to 16mm.
- The free ends of the stirrups are anchored in the compression zone of the beam to the anchor bars (hanger bar) or the compressive reinforcement.
- The spacing of stirrups near the supports is less as compared to spacing near the midspan since shear force is maximum at the supports.


Vertical Stirrup
Smaller diameter steel bars that are made into closed loops and are placed at regular intervals along the full length of the beam
Beam
Longitudinal Bar
Larger diameter steel bars that go through the full length of the beam


COVER
SINGLE LEGGED STIRRUP
TWO LEGGED STIRRUPS
COVER
FOUR LEGGED STIRRUP
SIX LEGGED STIRRUP

Type of vertical stirrups:

- Single Legged Stirrup
- Two Legged Stirrup
- Four Legged Stirrup
- Six Legged Stirrup

Bent up Bars along with Vertical Stirrups

These bent up bars resist diagonal tension. These bars are usually bent at 45°

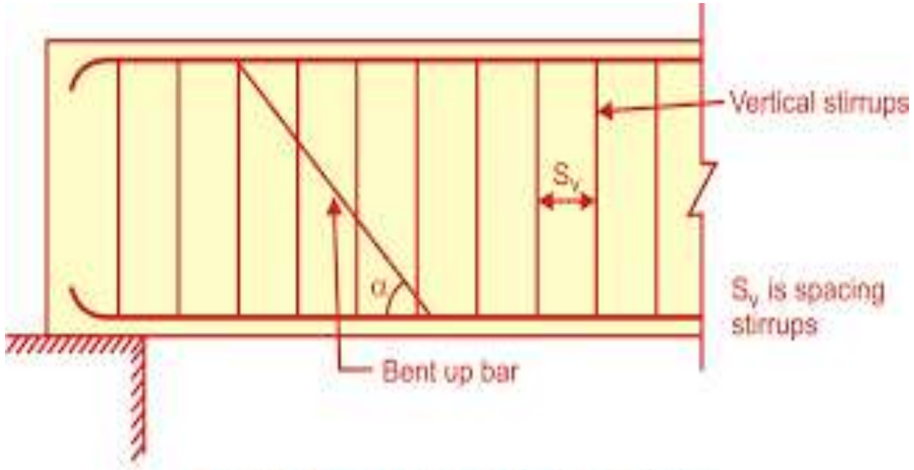


Fig. 5.6. Bent up bars alongwith stirrups.

Inclined Stirrups

Inclined stirrups are also provided generally at 45° for resisting diagonal tension. They are provided throughout the length of the beam.

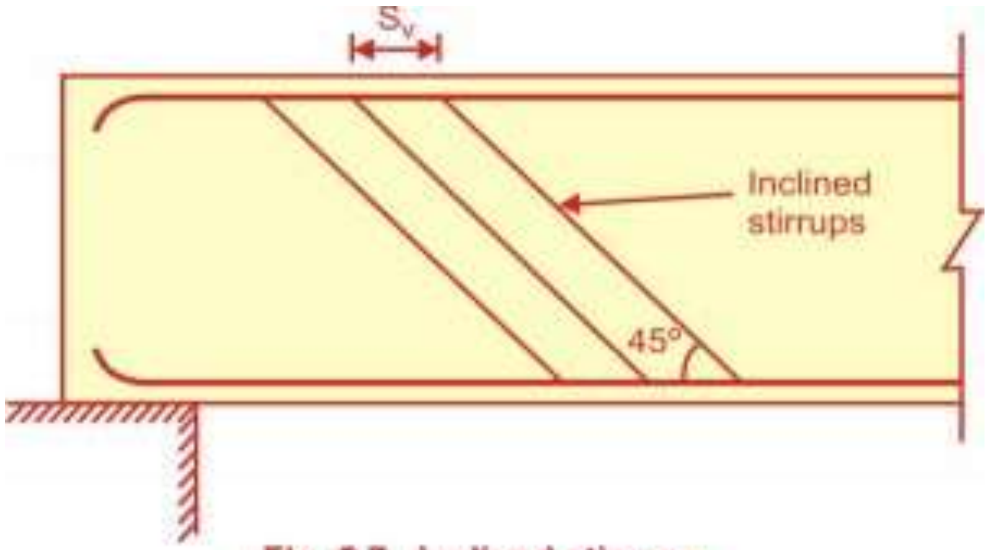


Fig. 5.7. Inclined stirrups.

THANK YOU