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CIHAN UNIVERSITY
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CONCRETE DESIGN

CHAPTER 5

Shear and Diagonal Tension in Beams

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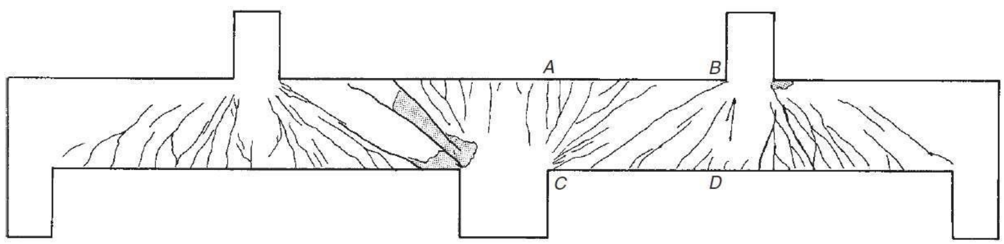
MSc Structural Engineering

CHAPTER 5 SHEAR AND DIAGONAL TENSION IN BEAMS

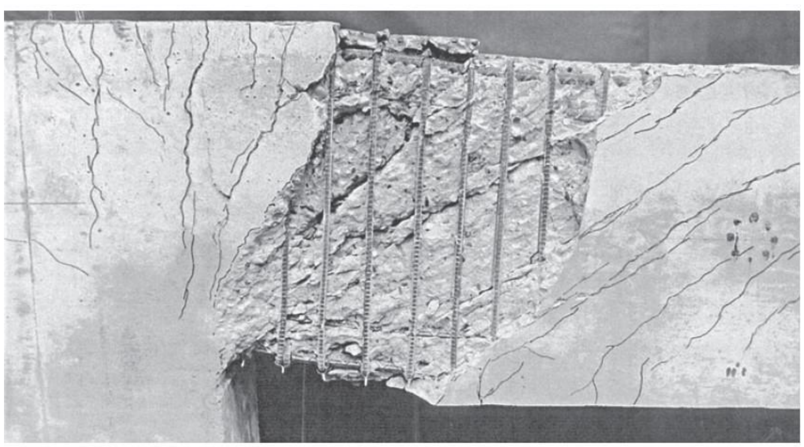
5.1 Summary

Shear reinforcement restrains the growth of inclined cracking so that ductility of the beam is improved and a warning of failure is provided. In an unreinforced web, the formation of inclined cracking might lead directly to failure without warning.

When the factored shear, V_u, is high, it shows that large cracks are going to occur unless some type of additional reinforcing is provided. This reinforcing usually takes the form of stirrups that enclose the longitudinal reinforcing along the faces of the beam.

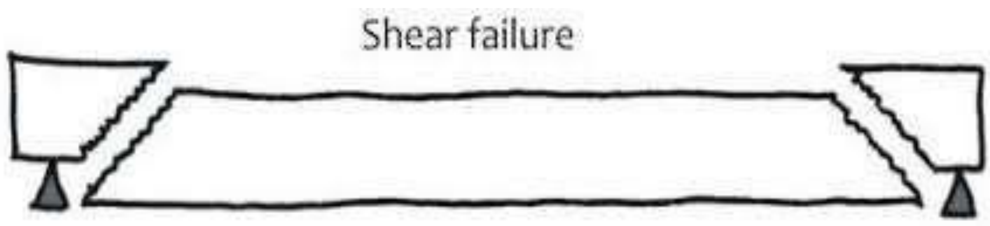


(a) Test specimen.



5.2 Introduction [6]

- The objective of today's reinforced concrete designer is to produce ductile members that provide warning of impending failure.
- To achieve this goal, the code provides design shear values that have larger safety factors against shear failures than do those provided for bending failures.
- The failures of reinforced concrete beams in shear are quite different from their failures in bending.



- Shear failures occur suddenly with little or no advance warning. Therefore, beams are designed to fail in bending under loads that are appreciably smaller than those that would cause shear failures. As a result, those members will fail in a ductile mode.

- During the bending failure, the beam may crack and sag a great deal if overloaded, but they will not fall apart, as they might if shear failures were possible.

5.3 Types of Cracks

1. Shear Crack, Diagonal Crack, Web Crack (Pure Shear)
2. Flexure-shear crack
3. Flexural Cracks

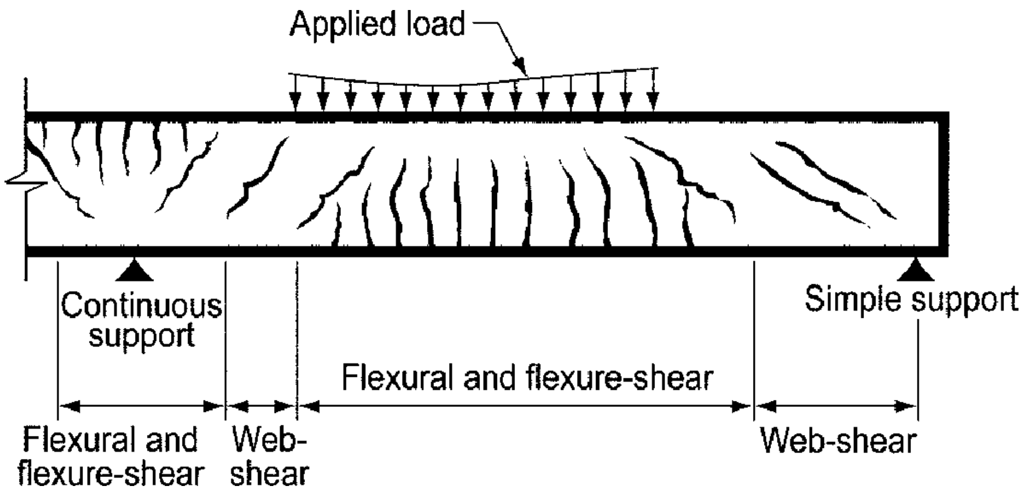


Figure 14 Types of cracking in concrete beams [8]

5.4 Shear Stress Distribution of Homogeneous Beams

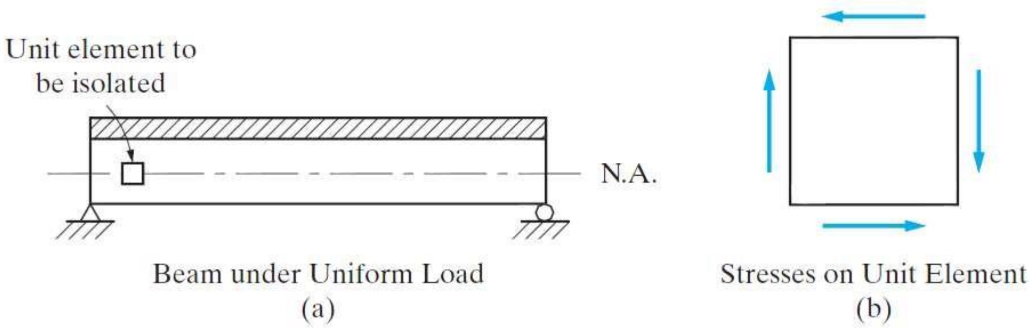
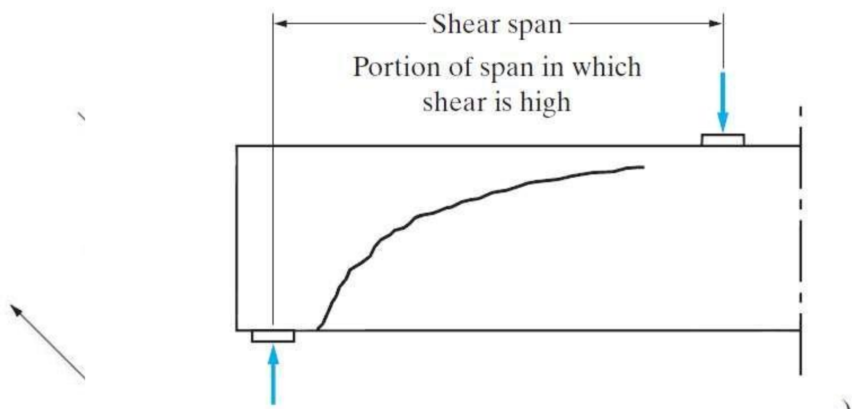


FIGURE 4-1 Shear stress relationship.



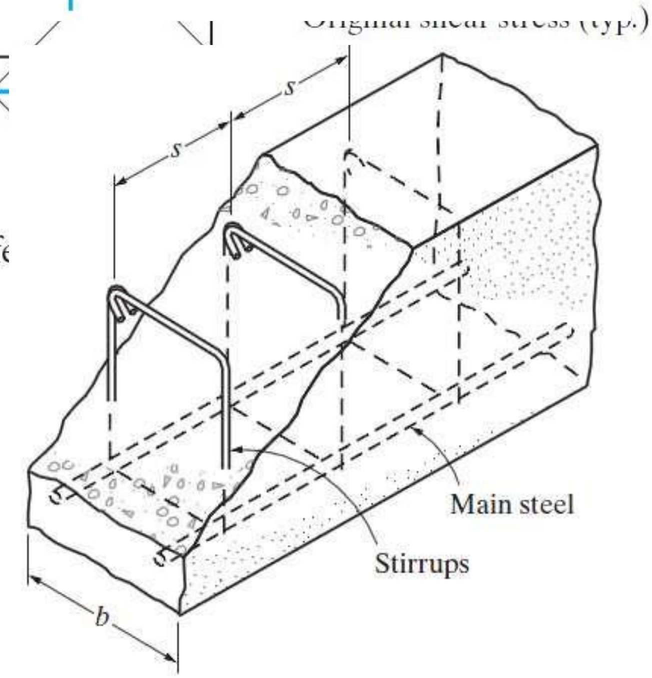
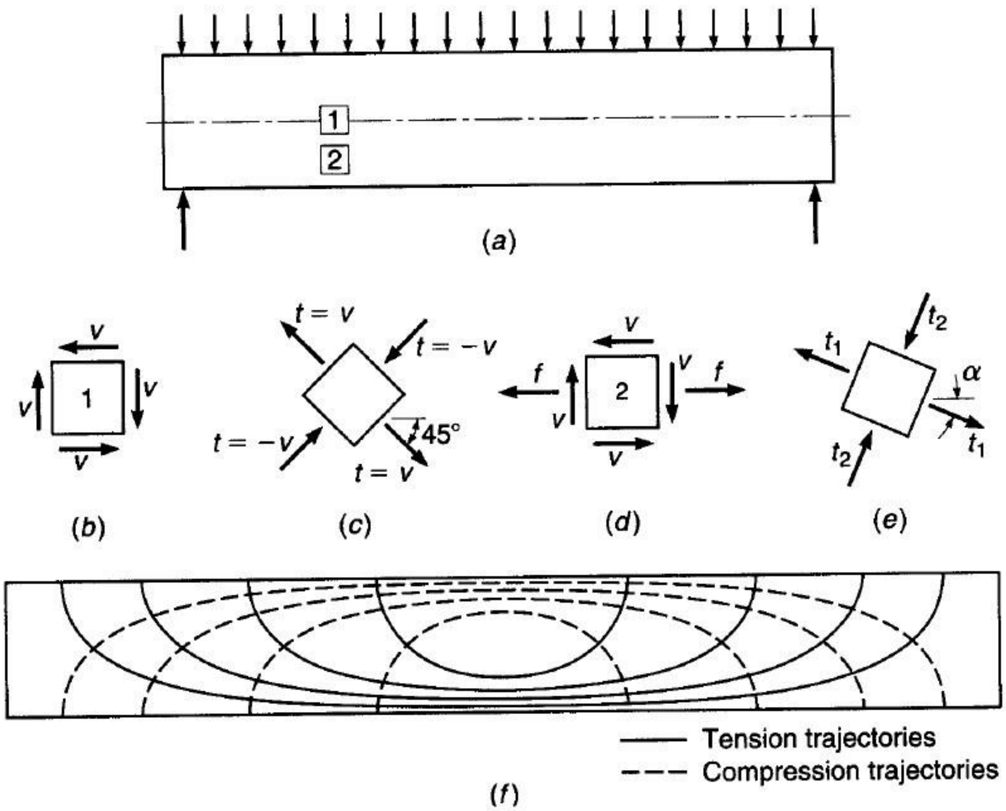


FIGURE 4-2 Effe



5.5 Types of Shear Reinforcement

1. Stirrups, ties and hoops
2. Spiral reinforcement
3. Bent bars
4. Combined bent and stirrups
5. Welded wire reinforcement
6. Others

5.6 Shear Reinforcement Performance

1. Carries a portion of the external factored shear force, Vu
2. Restrict the growth of the diagonal cracks
3. Holds the longitudinal reinforcing bars
4. Provide some confinement to the concrete in the compression zone.
5. Others

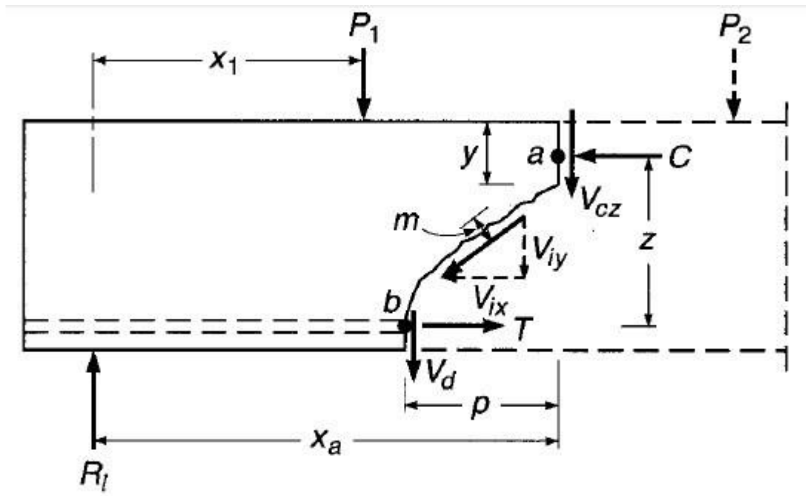
5.7 Factors affecting Shear Strength of Beams (without web reinforcement)

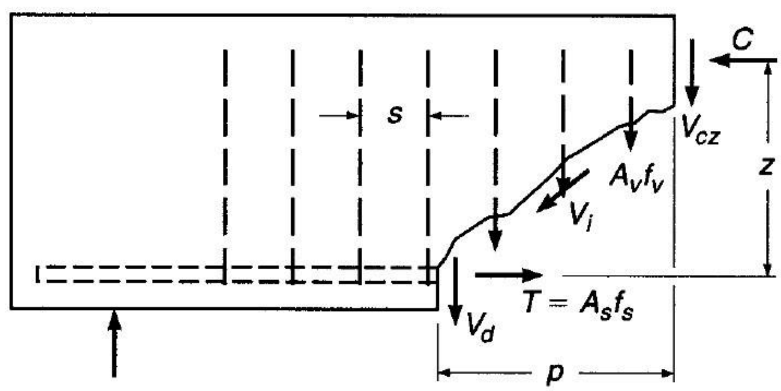
1. Tensile Strength of Concrete
2. Longitudinal Reinforcement
3. Shear span and depth ratio (a/d)
4. Size of Beams
5. Axial Forces (Compression and Tension)
6. Aggregate Interlock (type, size and roughness)

5.8 Shear Stresses in Concrete Beams [6]

- Although no one has ever been able to accurately determine the resistance of concrete to pure shearing stress, the matter is not very important because pure shearing stress is probably never encountered in concrete structures.
- Furthermore, according to engineering mechanics, if pure shear is produced in a member, a principal tensile stress of equal magnitude will be produced on another plane. Because the tensile strength of concrete is less than its shearing strength, the concrete will fail in tension before its shearing strength is reached.
- In **Plane Concrete Beams**, diagonal principal tensile stresses, called *diagonal tension*, occur at different places and angles in concrete beams, and they must be carefully considered. If they reach certain values, additional reinforcing, called *web reinforcing*, must be supplied.

- In **reinforced concrete beams**, the situation is quite different because the longitudinal bending tension stresses are resisted quite satisfactorily by the longitudinal reinforcing. These bars, however, do not provide significant resistance to the diagonal tension stresses.





5.9 Shear Cracking of Reinforced Concrete Beams [6]

- Inclined cracks can develop in the webs of reinforced concrete beams, either as extensions of flexural cracks or occasionally as independent cracks.

flexure–shear crack: the ordinary types of shear cracks found in both prestressed and nonprestressed beams.

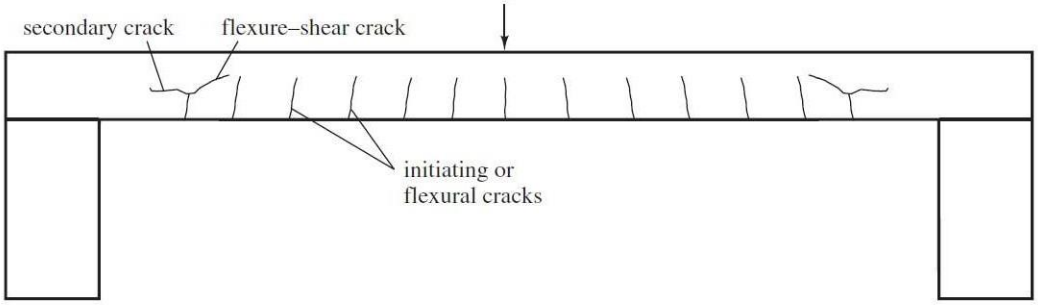


FIGURE 8.1 Flexure–shear crack.

5.10 Critical Section for Shear Force (9.4.3.2)

9.4.3.2 Sections between the face of support and a critical section located ***d*** from the face of support for nonprestressed beams and ***h*/2** from the face of support for prestressed beams shall be permitted to be designed for V_u at that critical section if (a) through (c) are satisfied:

(a) Support reaction, in direction of applied shear, introduces compression into the end region of the beam
(b) Loads are applied at or near the top surface of the beam
(c) No concentrated load occurs between the face of support and critical section

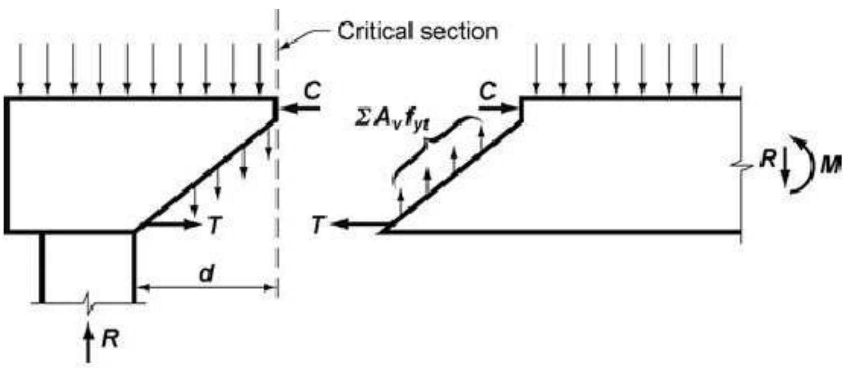


Fig. R9.4.3.2a—Free body diagrams of the end of a beam.

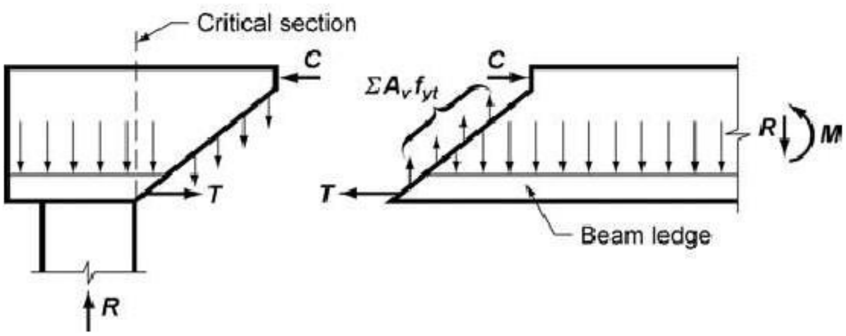


Fig. R9.4.3.2b—Location of critical section for shear in a beam loaded near bottom.

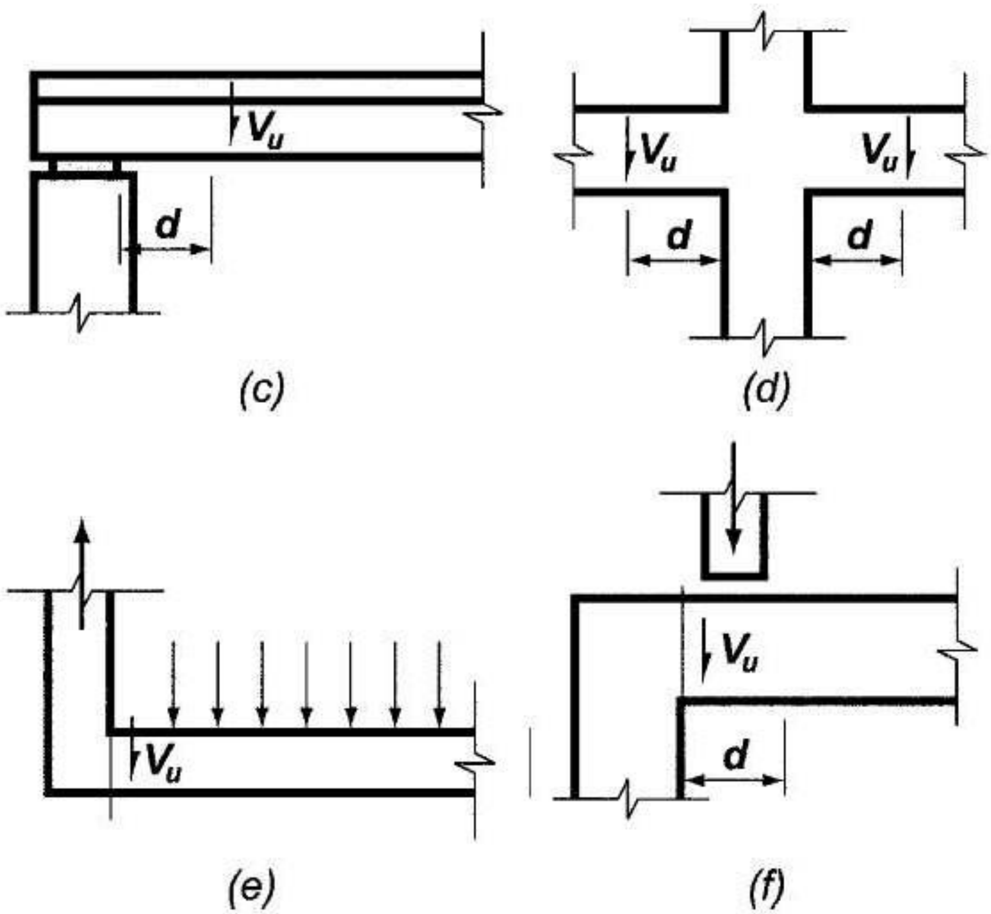


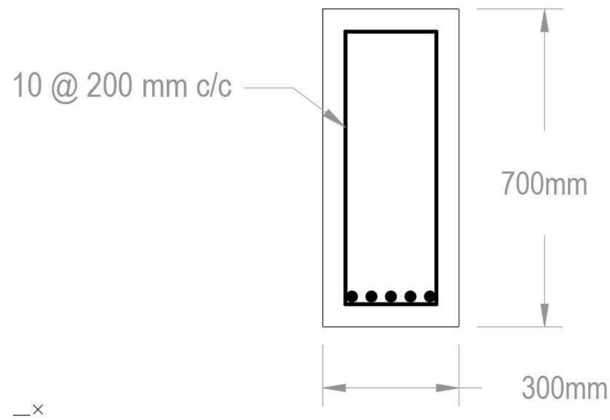
Fig. R9.4.3.2(c), (d), (e), (f)*—Typical support conditions for locating factored shear force* V_u.

5.20 Examples

5.20.1 Example 1

Find the design shear capacity of the following beam.

$f'c = 21\ Mpa,\ fy = 400\ Mpa$



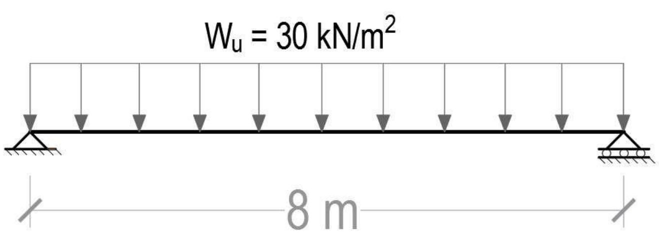
5.21 Example 2

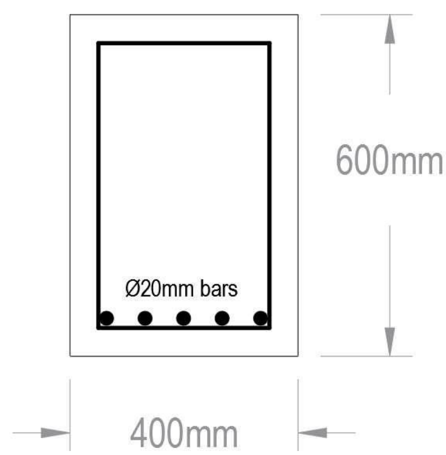
Design the simply supported beam for shear resistance using the given data.

$f'c = 21\ Mpa,\ fy = 400\ Mpa$

Use Φ20mm reinforcing bars for flexural reinforcement

Use uniform stirrup spacing.





5.24 References

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