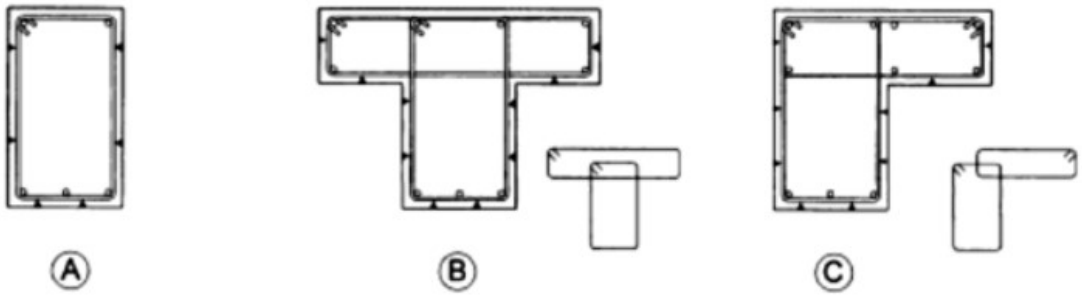
Detailing of Beams

Chapter 3
Section
3.6

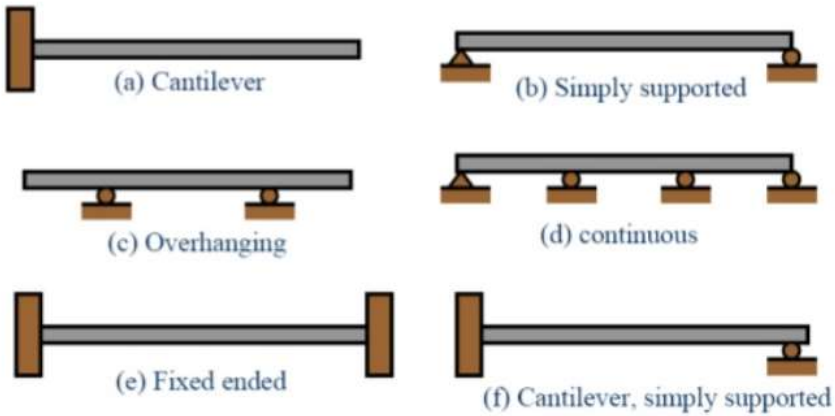
Introduction

- Beams are the structural members that receives the slab loads and transform it to the columns. Beams are usually horizontal members with rectangular cross-section. Their width is commonly the same as the columns that support them. Their depth usually includes the floor slab.
- Sometimes beams are fully enclosed within the floor (hidden beams), when they become highly reinforced bands of floor between the columns.

Types of beams

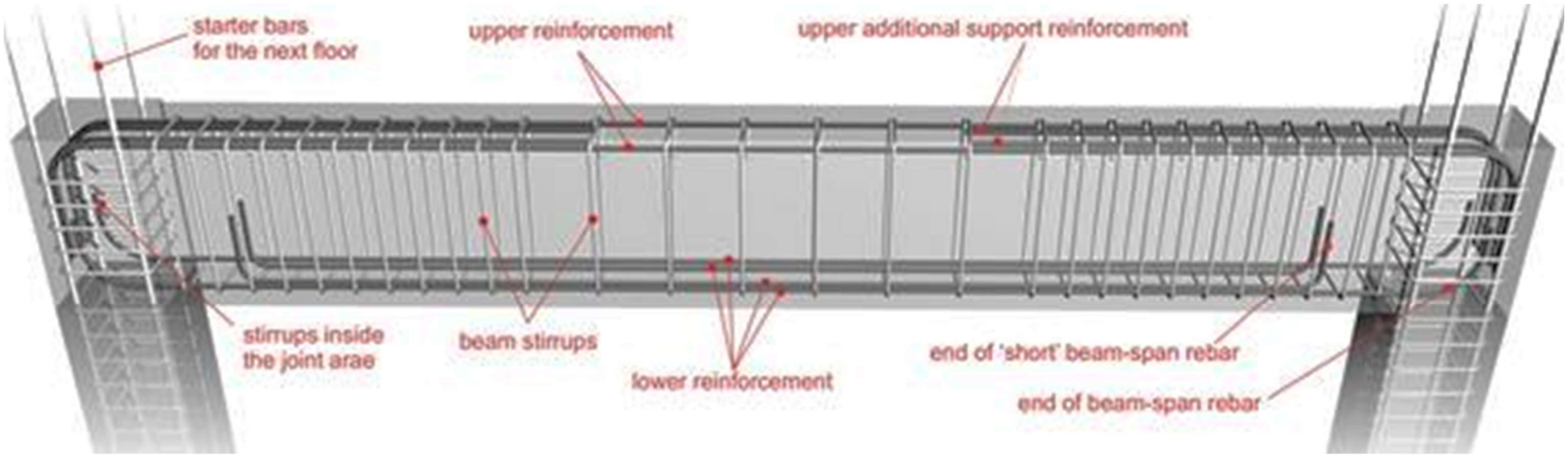


Based on cross section

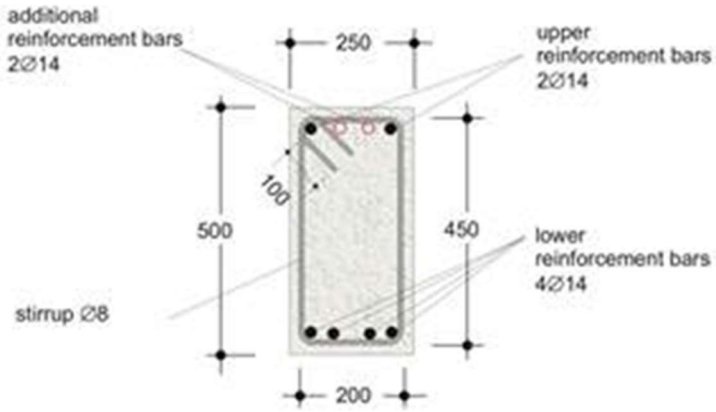


Based on support conditions

Beams Reinforcement



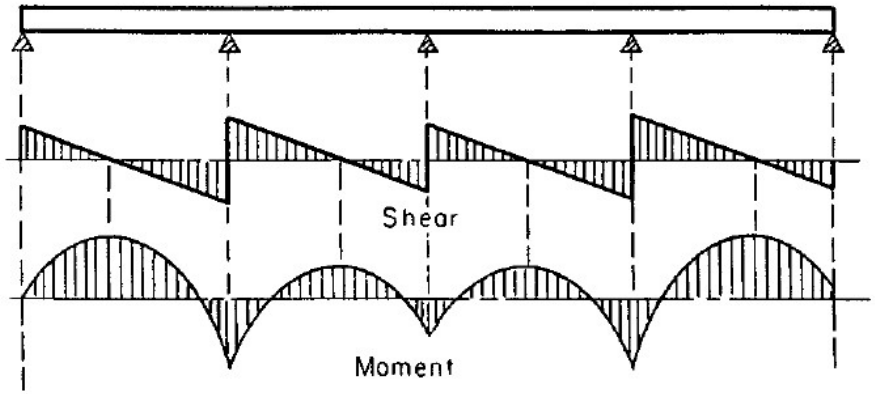
- Main bars (bottom/ top) to resist deal tension.
- Stirrups to resist shear, torsion and provide confinement.
- Anchor bars to hold stirrups in their position
- Crack control bars.
- Bars to reduce long term deflection.

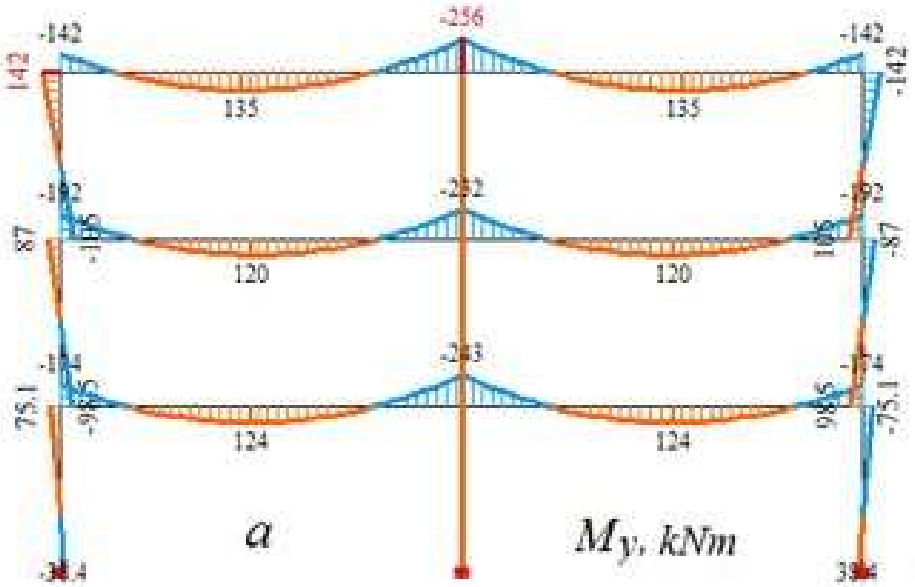


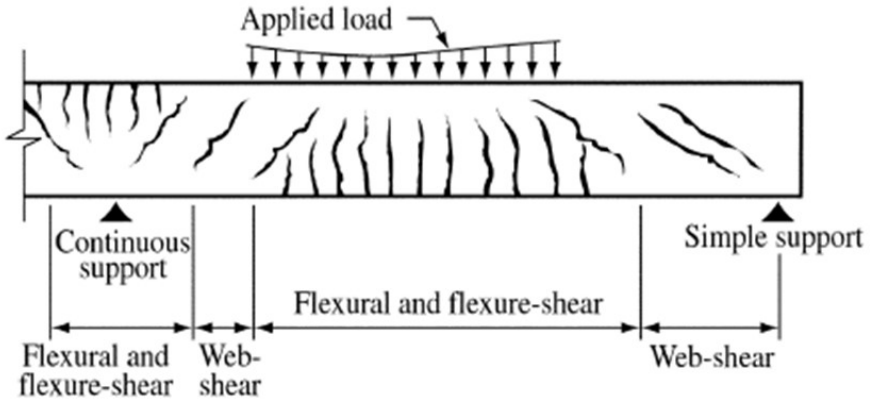
Beams Modeling

Beams can be modeled as

- Continuous members supported by columns.
- Or as part of continues frames







Cut of longitudinal reinforcement in beams

Bar cut off shall be kept as minimum as possible to decline design and construction complexities. Furthermore, it is important to extend the cut off bars beyond cut off point by development length (l_{bd}) to ensure adequate bond between bar and concrete.

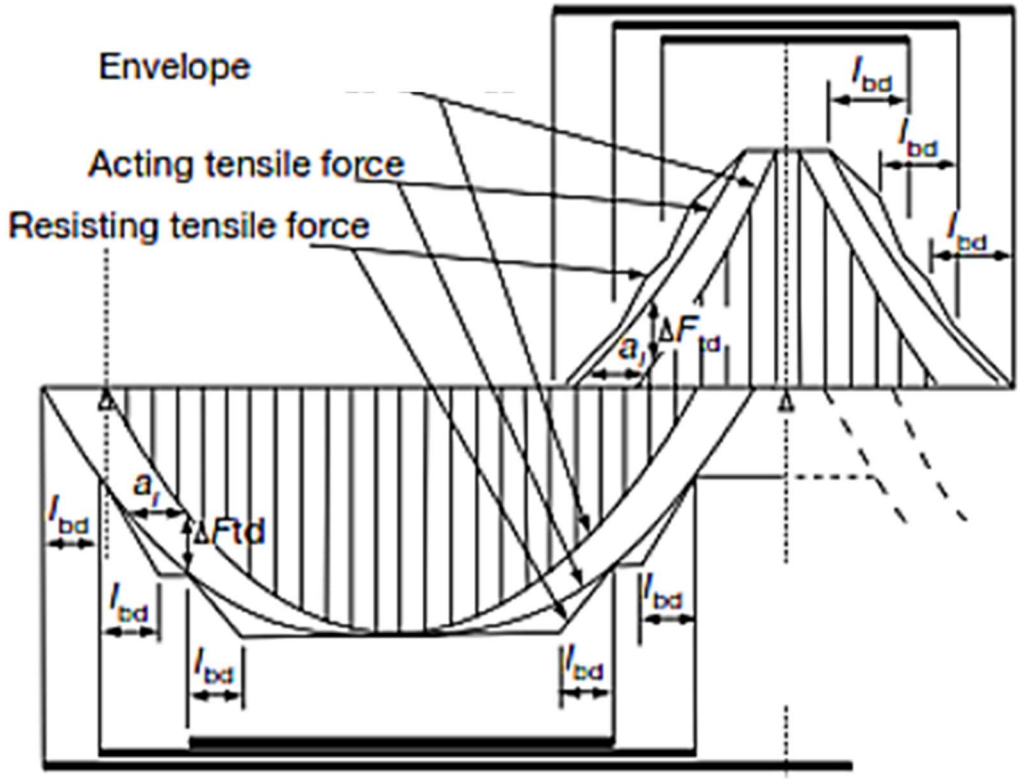


Table 6.4 Typical values of anchorage and lap lengths

	Bond conditions	Length in bar diameters			
		f_{ck}/f_{cu} = 25/30	f_{ck}/f_{cu} = 28/35	f_{ck}/f_{cu} = 30/37	f_{ck}/f_{cu} = 32/40
Full tension and compression anchorage length, $l_{b,rqd}$[1]	good	36	34	32	31
	poor	48	45	43	41
Full tension and compression lap length[2]	good	42	39	37	35
	poor	56	52	49	47

Notes

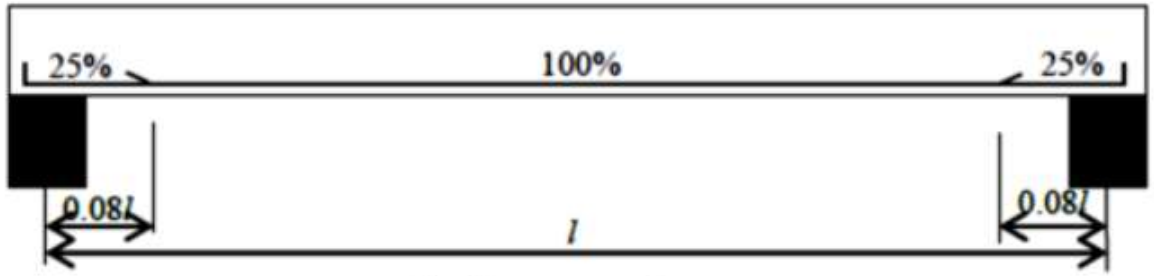
1 It is assumed that the bar size is not greater than 32mm and α_1, α_2, α_4 and α_5 all equal 1 and that α_3 = 0.9 (λ = 1.35 and K = 0.05).

2 It is assumed α_6 = 1.15 (not more than 33% of the bars are lapped at one place).

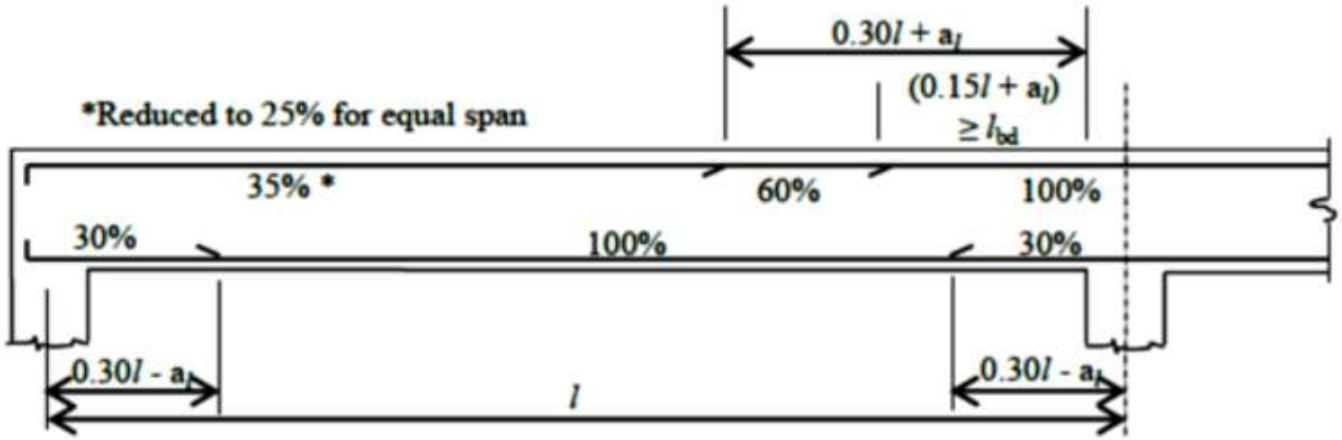
For other situations refer to EC2, Clause 8.4.4.

Simplified detailing rules for beams

For Gravity loads only



Simply supported beam

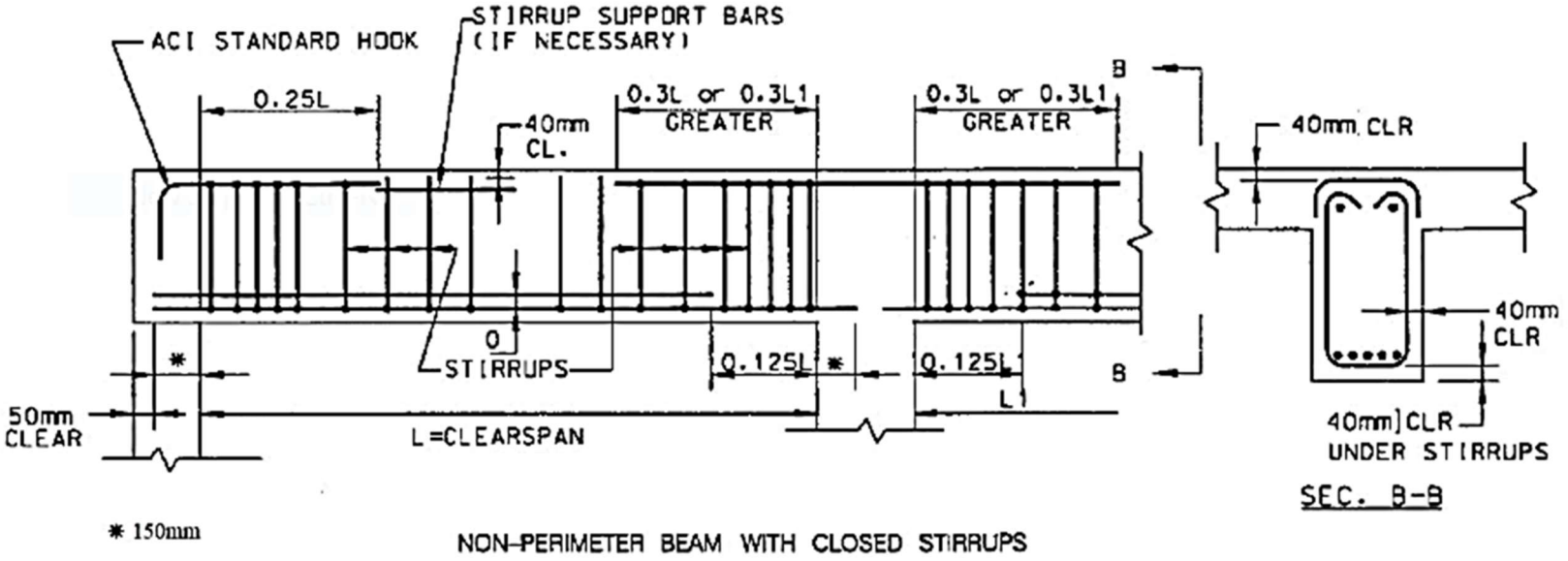


Continuous beam

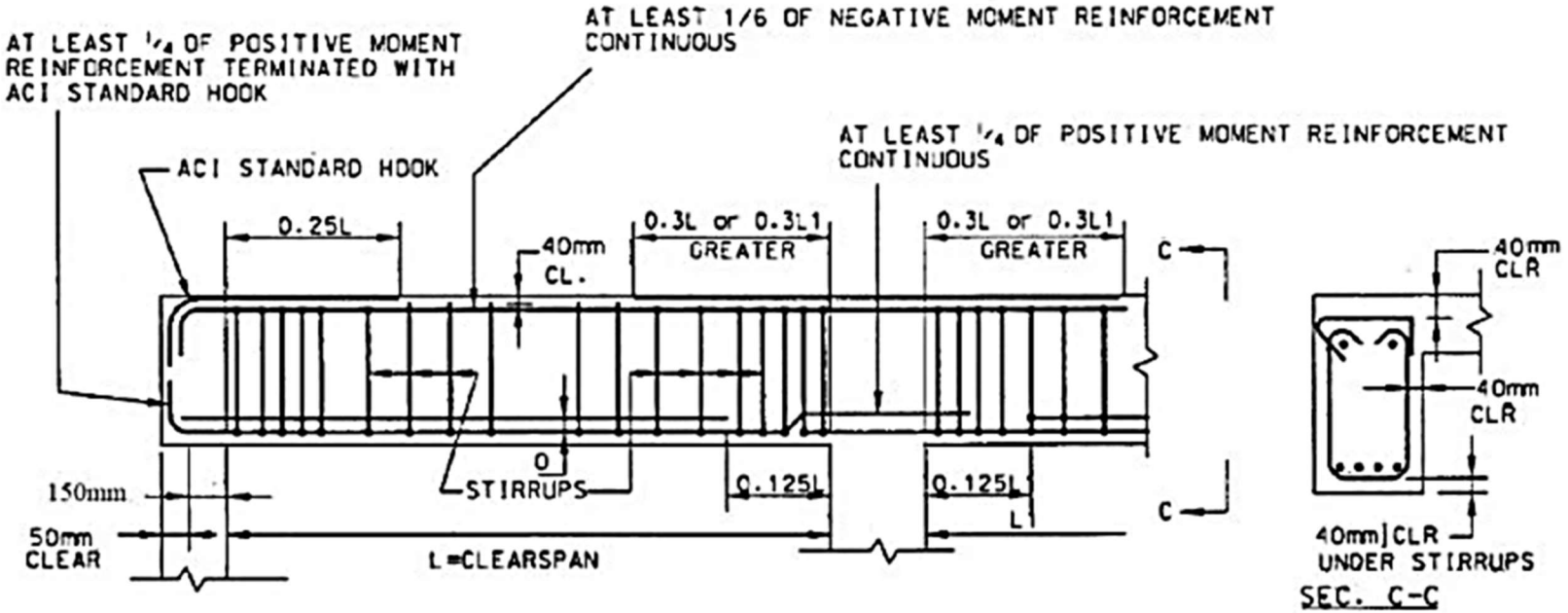
Notes:

1. l is the effective length
2. a_l is the distance to allow for tensile force due to shear force = z cot θ/2. Can conservatively taken as 1.125d
3. l_{bd} is the design anchorage length.
4. $q_k \leq g_k$
5. Minimum of two spans required
6. Applies to uniformly distributed loads only.
7. The shortest span must be greater than or equal to 0.85 times the longest span
8. Applies where 15% redistribution has been used.

Typical Detailing – (ACI gravity loads)



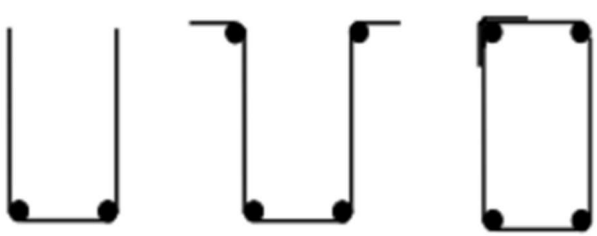
NON-PERIMETER BEAM WITH CLOSED STIRRUPS



PERIMETER BEAM

Beams Stirrups

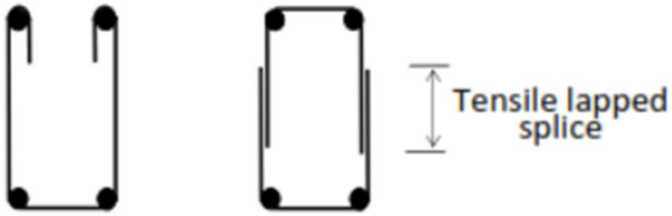
In beam detailing, the detailer or designer shall provide sizes, spacing, location, and types of all stirrups which include open and closed stirrups.



(a) Incorrect

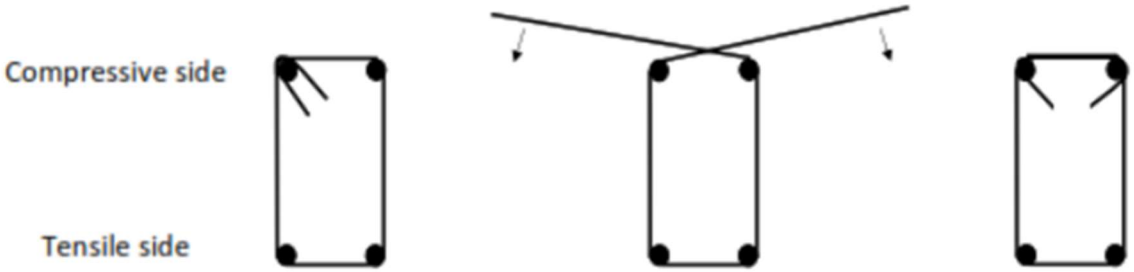
Inadequate anchorage

A 90° cog is ineffective if the cover concrete is lost



(b) Undesirable (but satisfactory)

In regions where ductility is required, the open stirrups (commonly used in post-tensioned beams) do not confine the compressive concrete

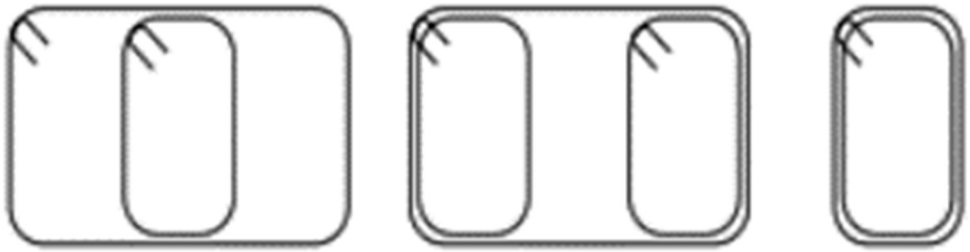


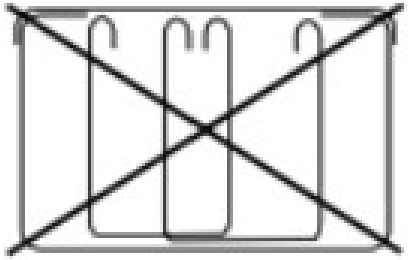
(c) Satisfactory

Beams Stirrups

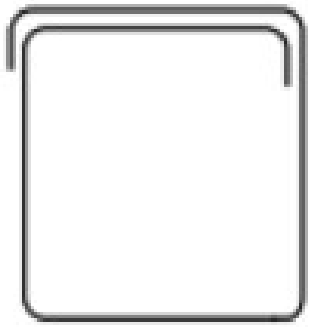
Preferred arrangement of Stirrups

Preferred arrangement

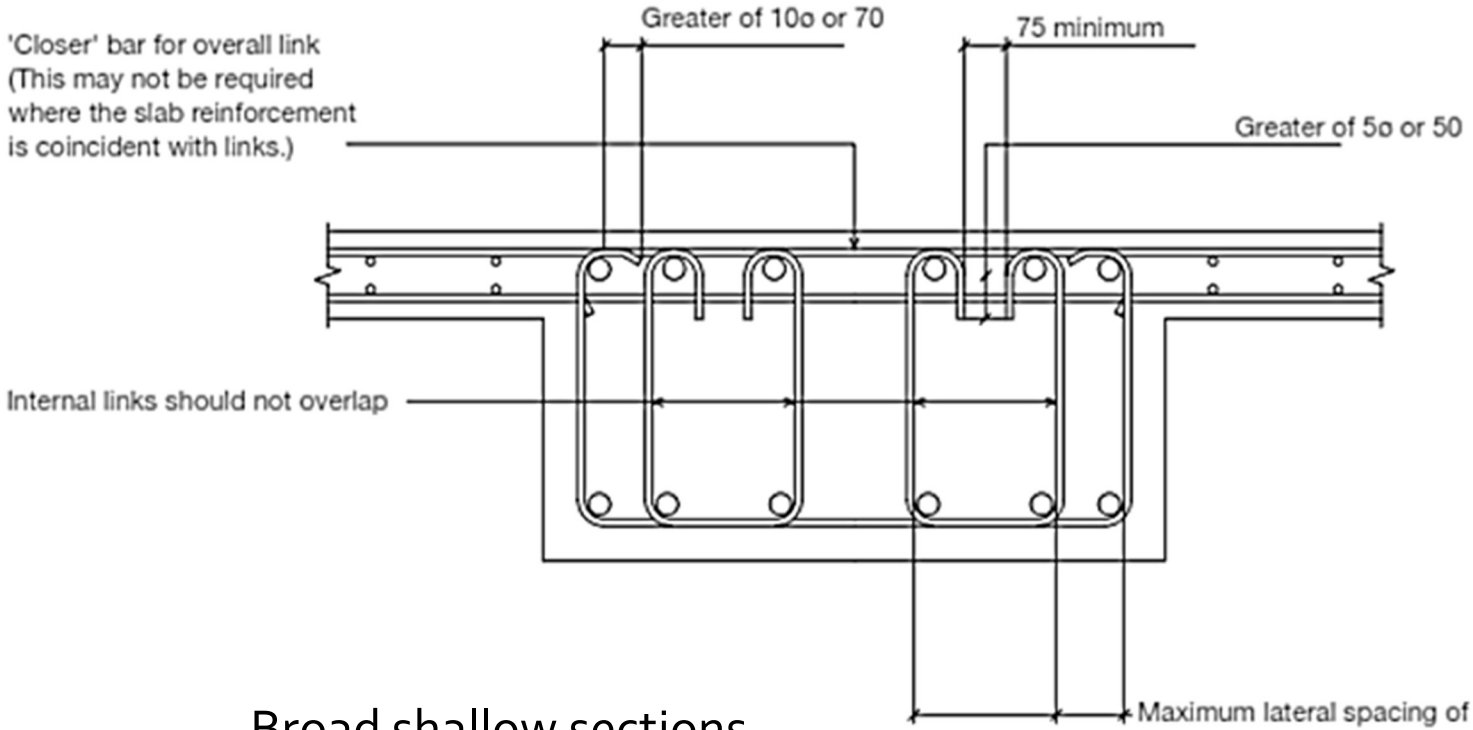




Overlapping of stirrups is not recommended



Required shape of torsion stirrups



Broad shallow sections

Issues in beams detailing

Bras spacing

Minimum horizontal pitch: in addition to the general roles given earlier 75mm spacing is required in some location to ensure sufficient space for insertion of poker vibrator.

Maximum pitch: the maximum spacing between longitudinal reinforcing bars in tension shall not exceed specified limits (see the following table as example) to control crack width in beams.

Maximum bar spacing for crack control

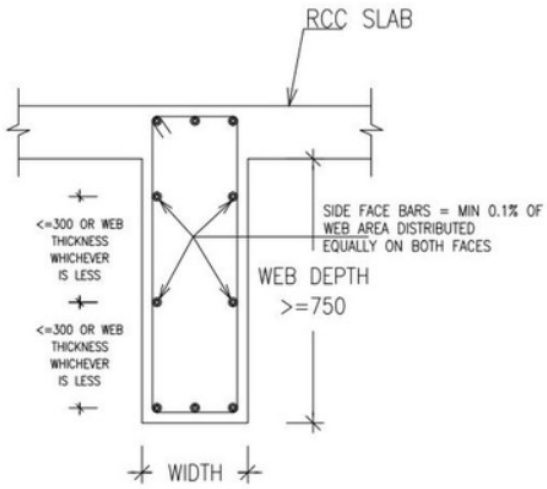
Steel stress (N/mm^2)	Maximum bar spacing (mm)	
	$w_k = 0.4$ mm	$w_k = 0.3$ mm
160	300	300
200	300	250
240	250	200
280	200	150
320	150	100
360	100	50

RECALL: why we should control cracks in concreate

Issues in beams detailing

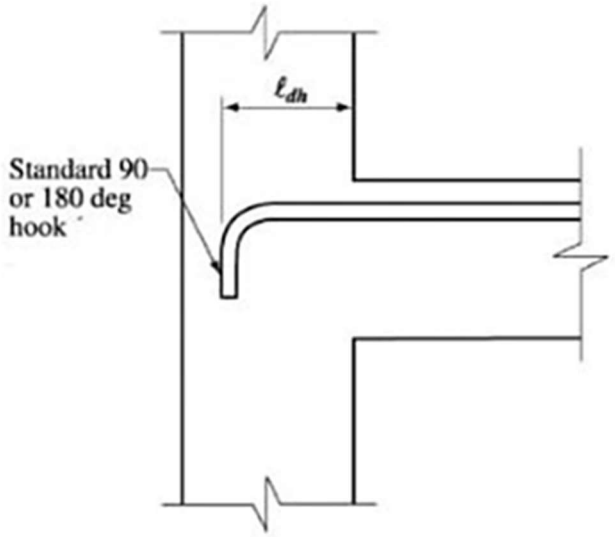
Bars along side of beams

For beams with a total depth of 750mm or more additional reinforcement is required to control cracking in the side of faces of the beam. As a simplification bars (16mm) should be placed along the sides inside the links at a maximum pitch of 250mm.



Anchorage of reinforcement

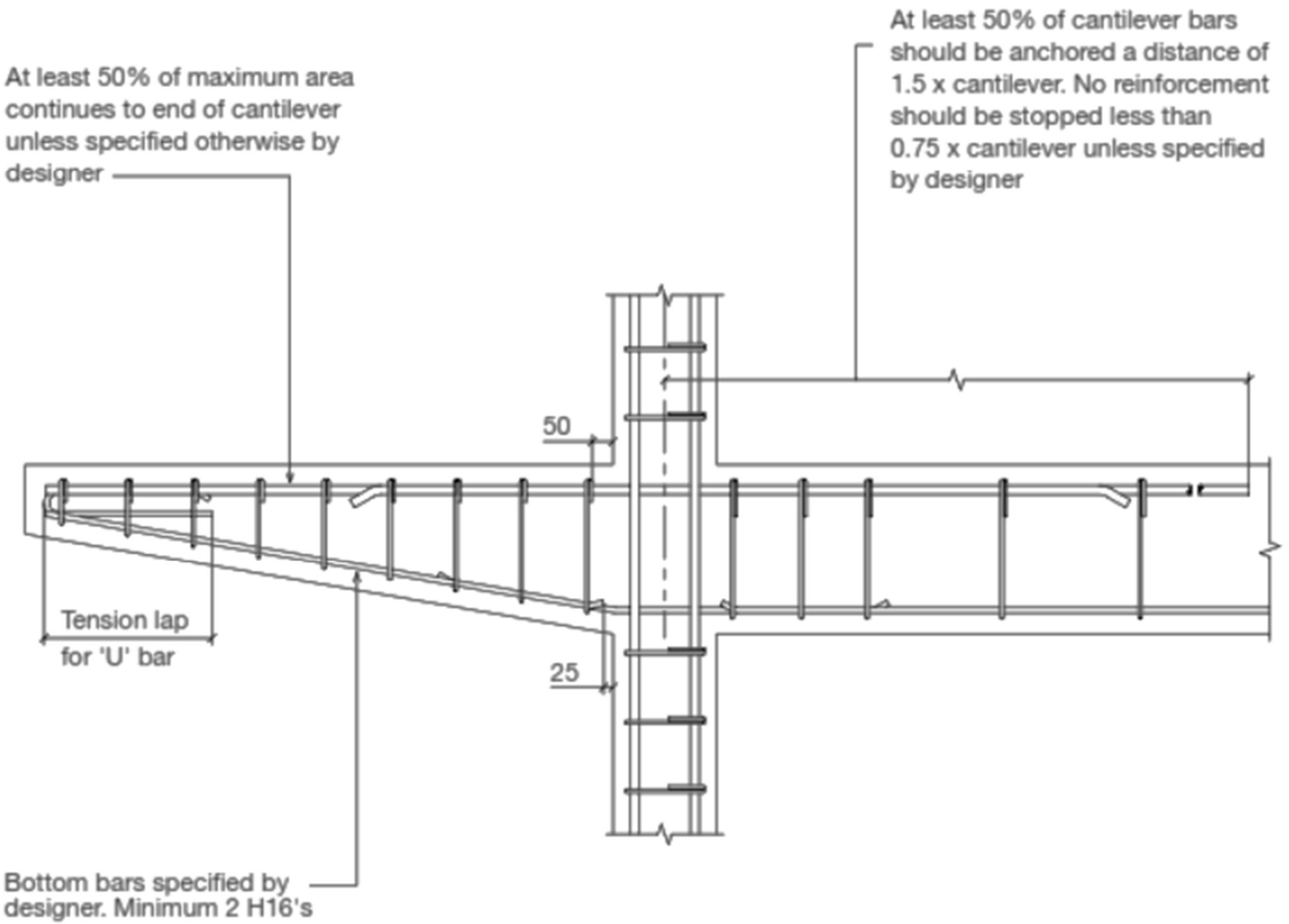
Negative moment reinforcement in a continuous, restrained, or cantilever member, or in any member of a rigid frame, shall be anchored in or through the supporting member by embedment length, hooks, or mechanical anchorage.



Anchorage of reinforcement into support

Issues in beams detailing

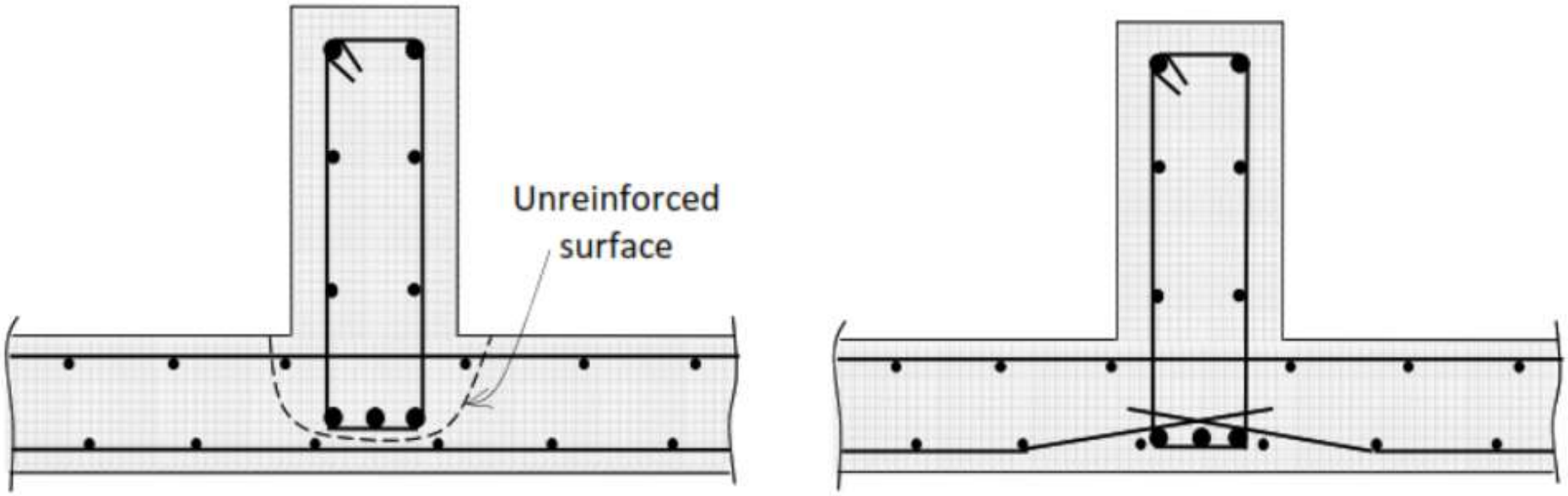
Typical Detailing - Cantilever Beam



Issues in beams detailing

Inverted beam (Slab supported by upturned beam)

Reaction from the slab must be carried in tension up to the top of the inverted beam.

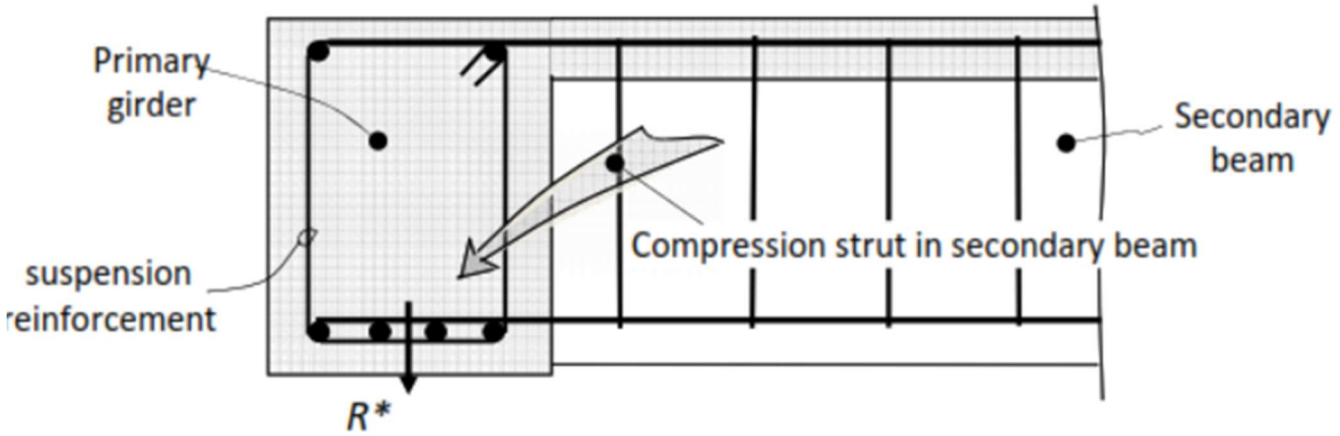


(a) Incorrect detail

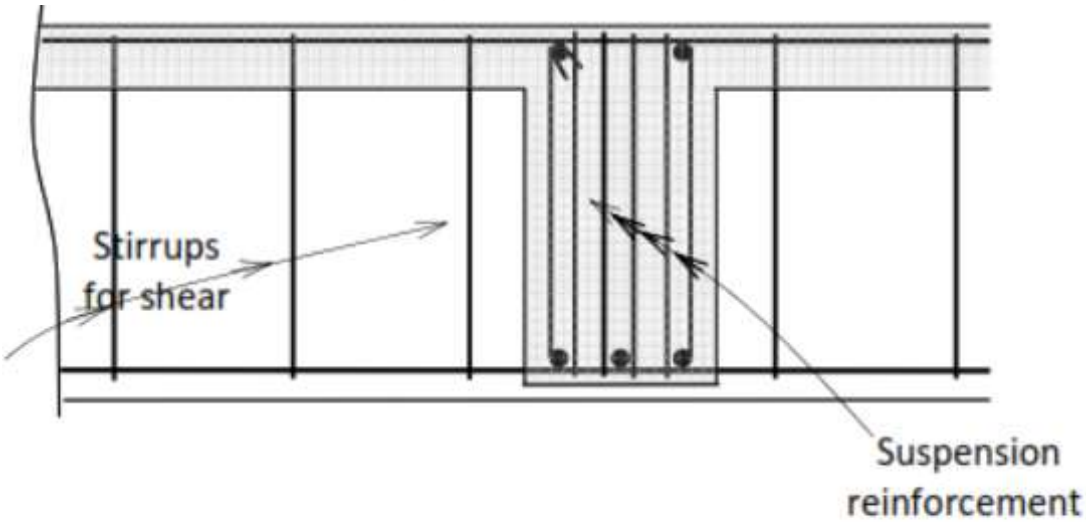
(b) Correct detail

Issues in beams detailing

Beam-to-beam connection



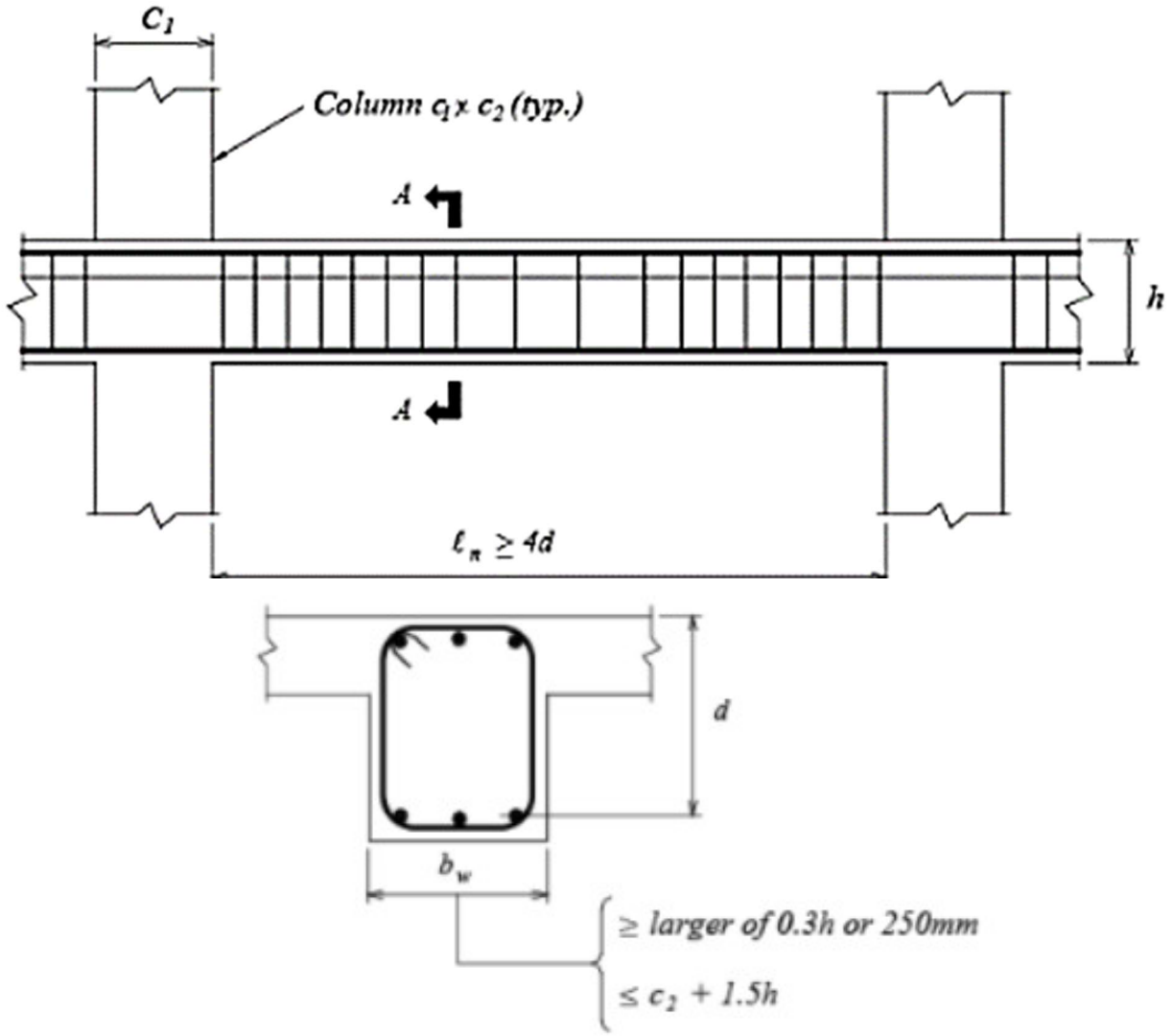
(a) Section



(b) Primary girder - Elevation

Typical Detailing – (lateral loads)

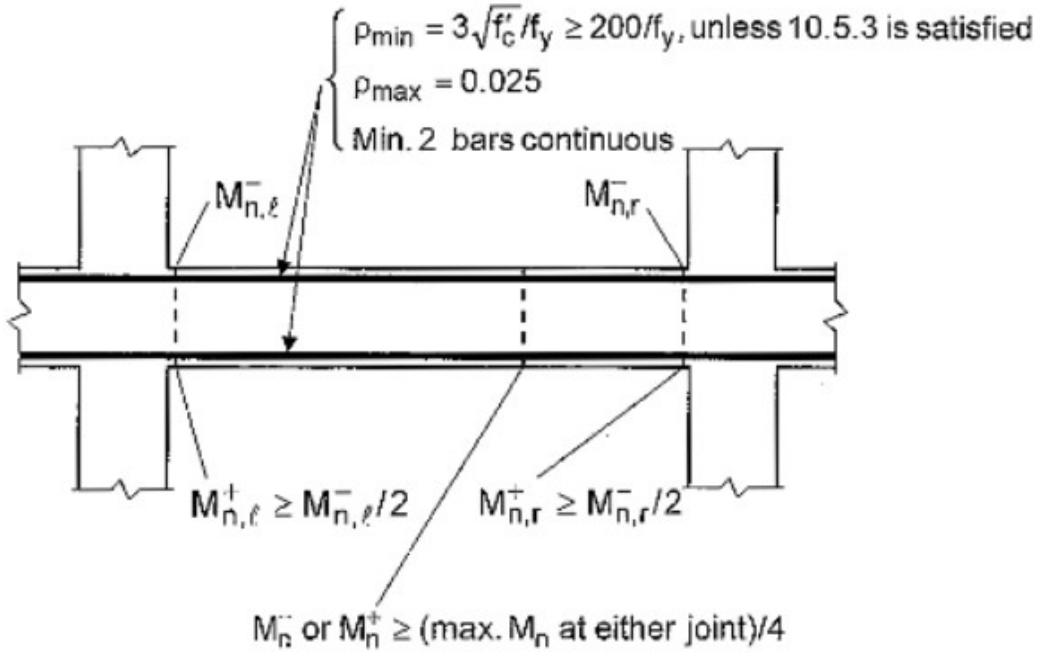
Fundamental detailing provisions of beams in higher SDCs (D-E)



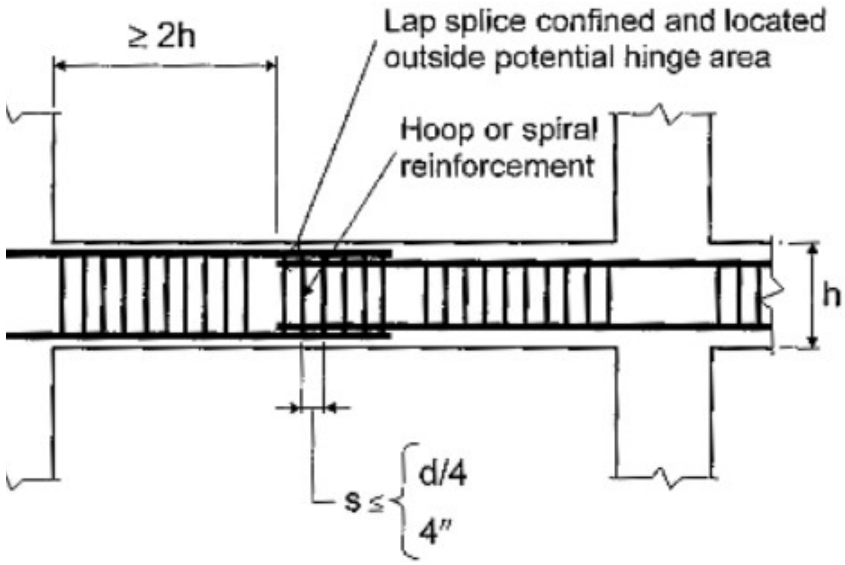
General requirement for Flexural Members of Special Moment Frames

Typical Detailing – (lateral loads)

Fundamental detailing provisions of beams in higher SDCs (D-E)



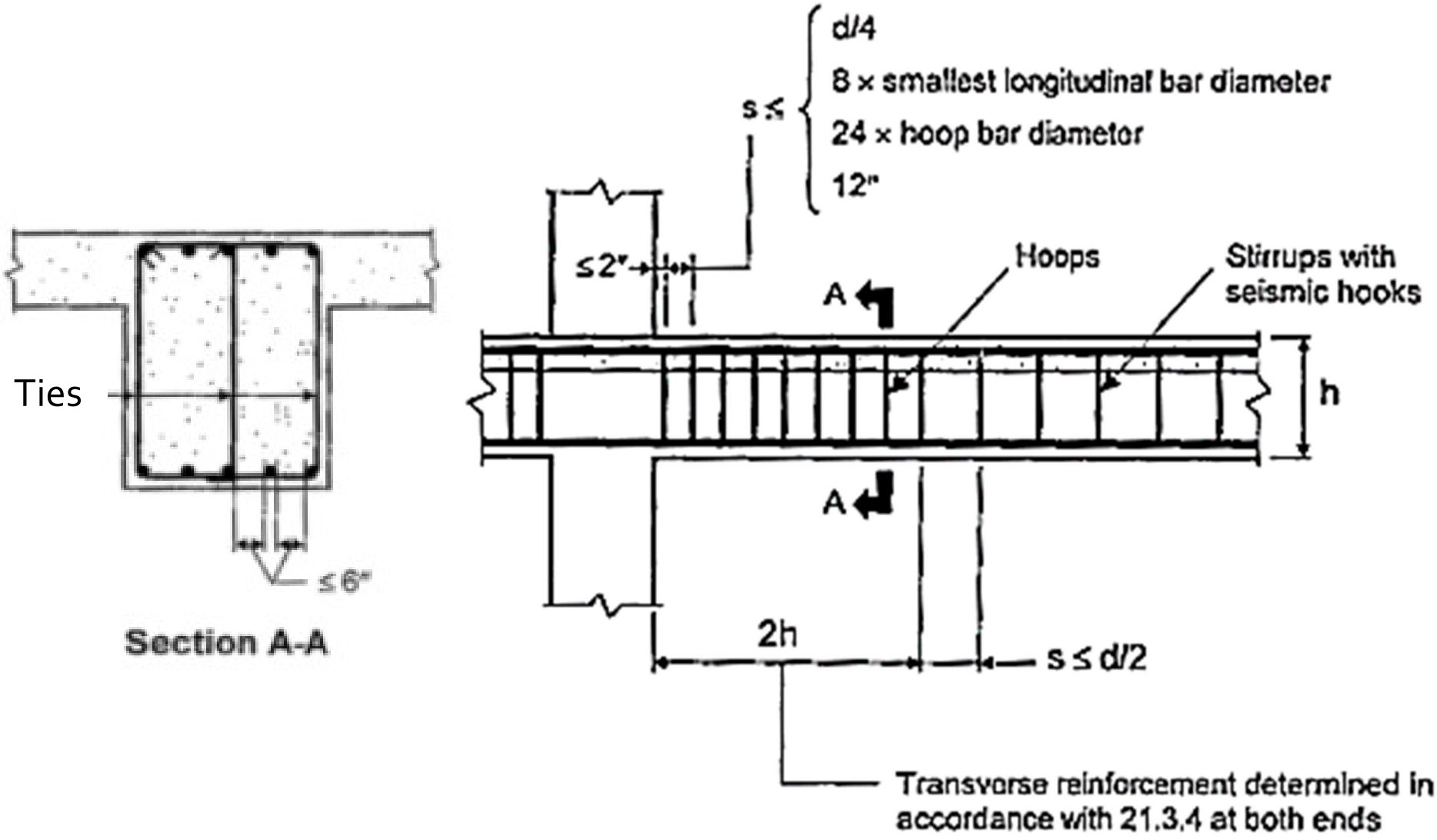
Flexural reinforcement requirement



Lap Splice Requirements

Typical Detailing – (lateral loads)

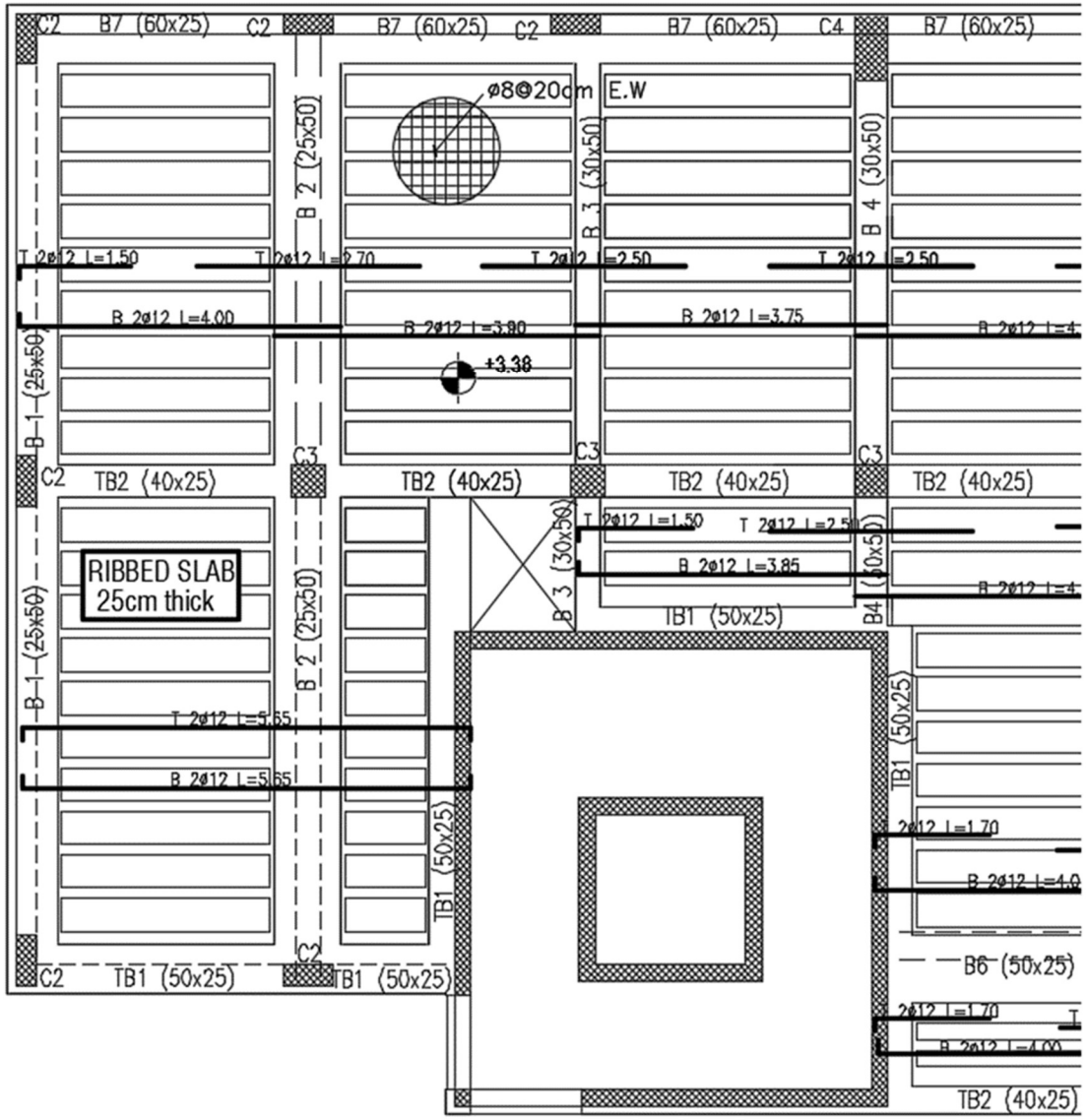
Fundamental detailing provisions of beams in higher SDCs (D-E)



Transverse Reinforcement Requirements

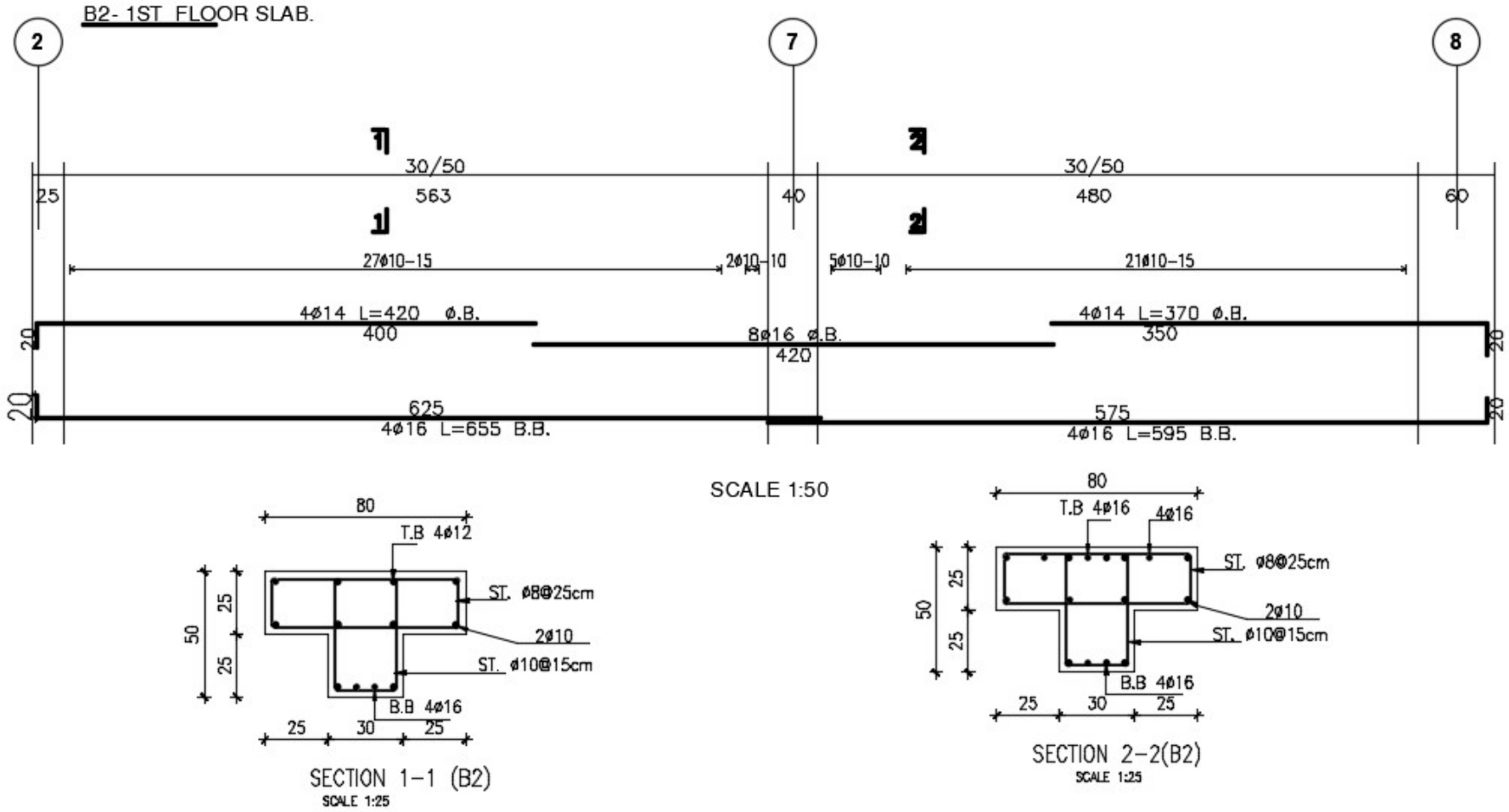
Beams Drawings

1. General arrangement Drawings. Shows the general arrangement of beams in the floor plans. Each beam is describe by a number followed by dimensions such as B2(25x50) where 25 and 50 are the width and depth of the beam in centimeters respectively.

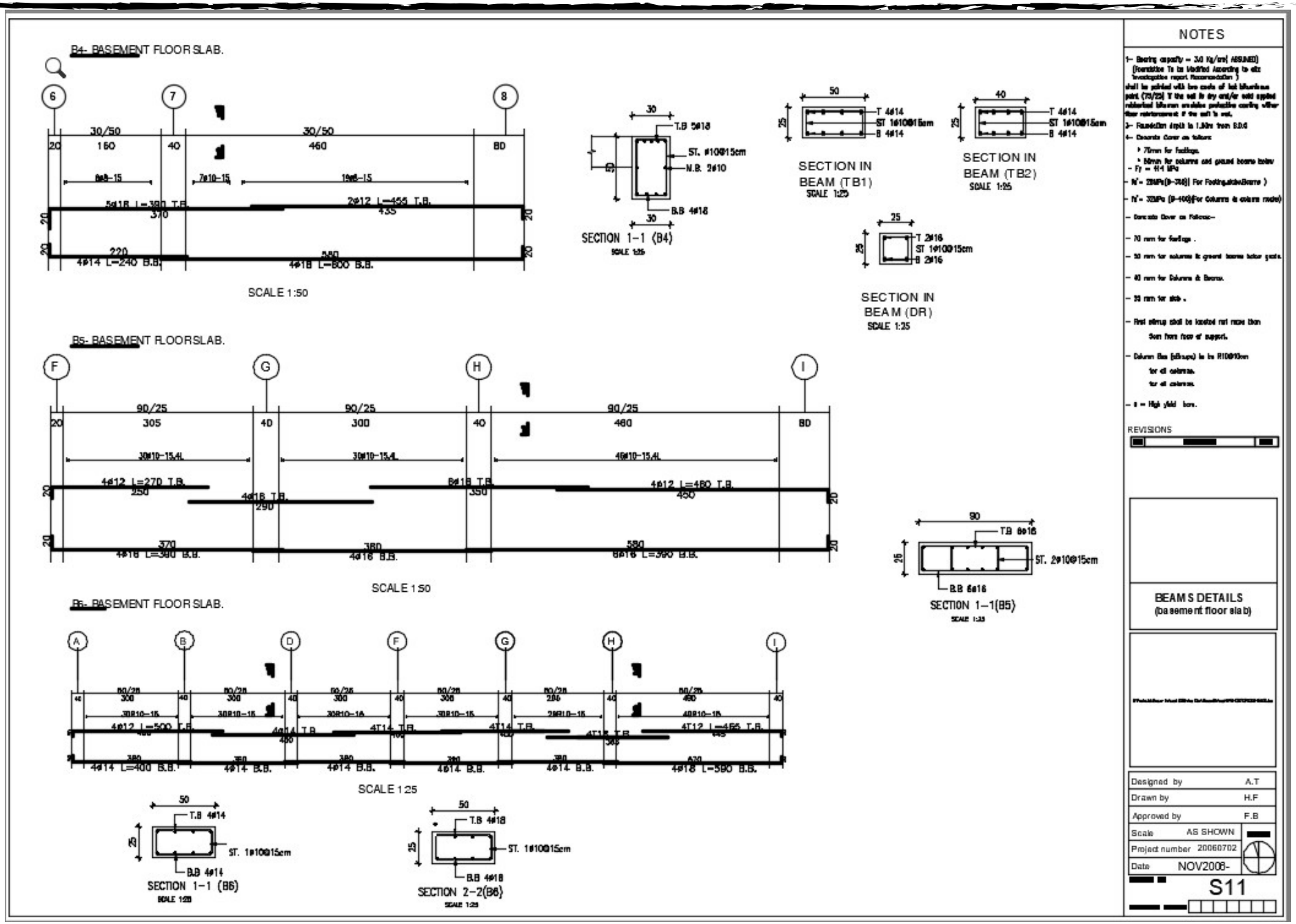


Beams Drawings

2. Beams are detailed in elevation, with sufficient cross sections to illustrate the positions of all the longitudinal bars and the shape of the stirrups. All descriptions of bars are given on the elevation and the bar marks only are repeated in the cross-sections.



Typical drawing

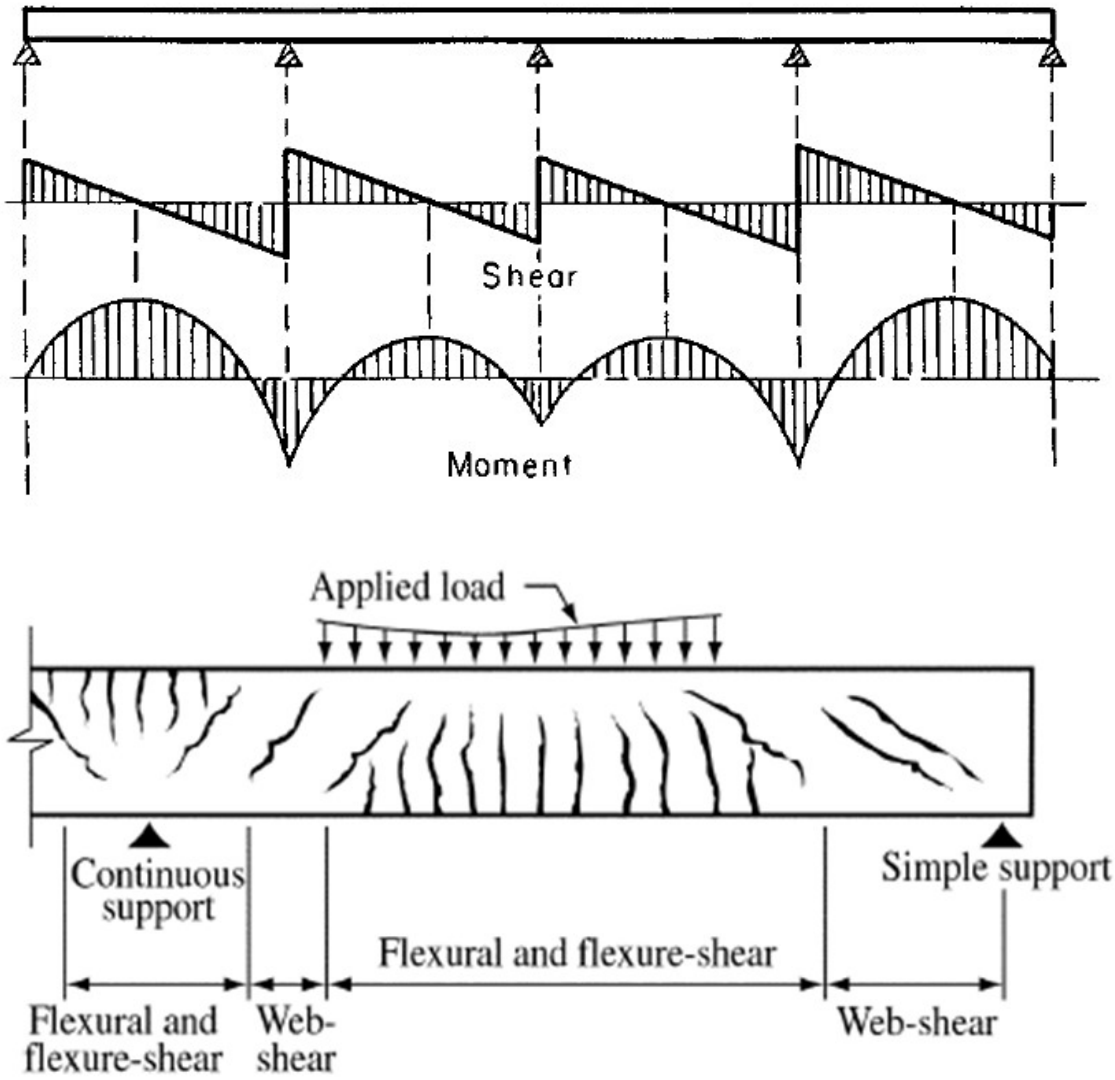


Detailing of Beams

Flexural reinforcement Detailing rules

In continuous beams the tensile zone moves to the top over the supports, as is shown in figure. Accordingly there is an increase in the amount of reinforcement at the top of the beam.

Shear stress shall be resisted by vertical stirrups.



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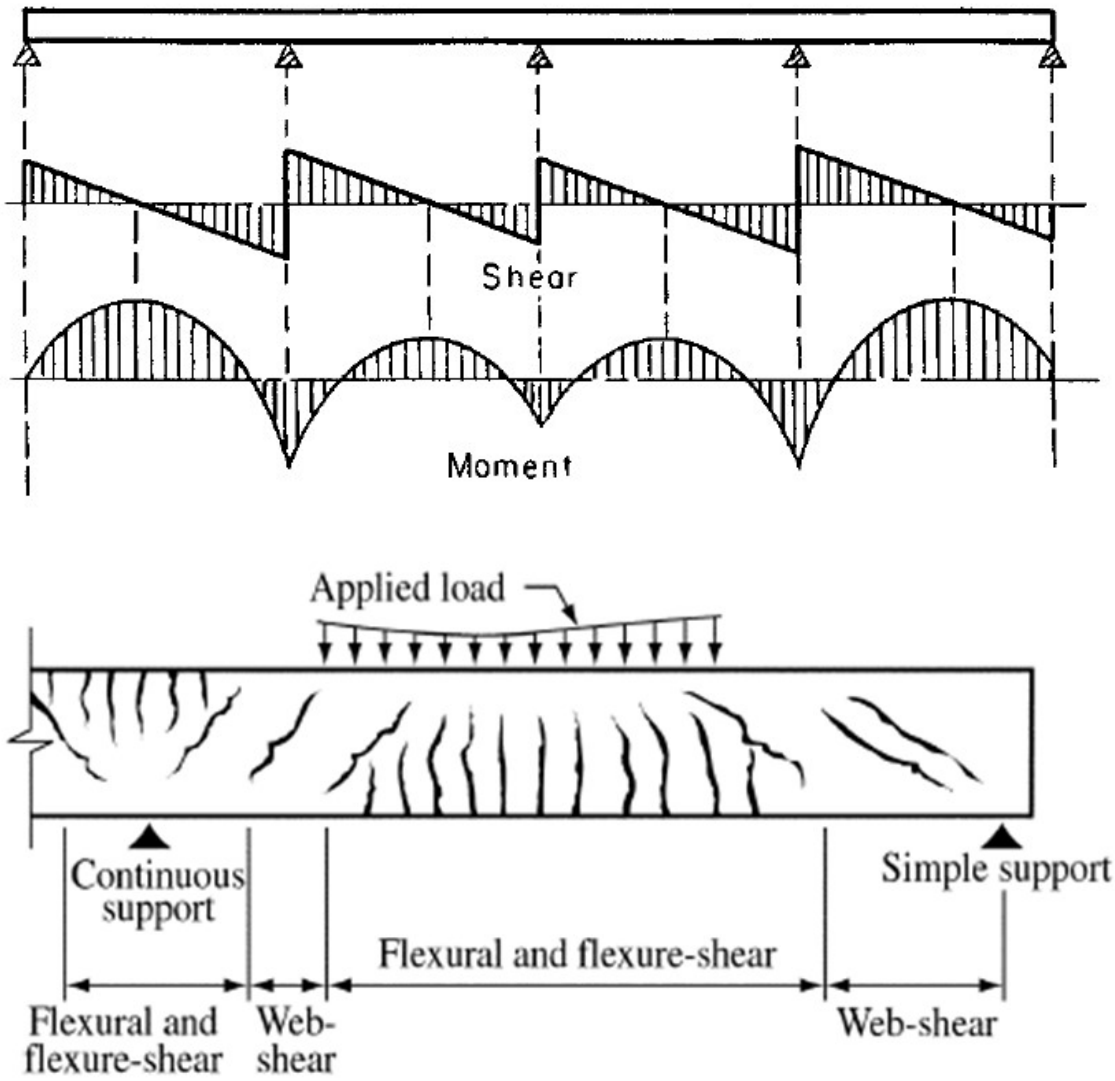
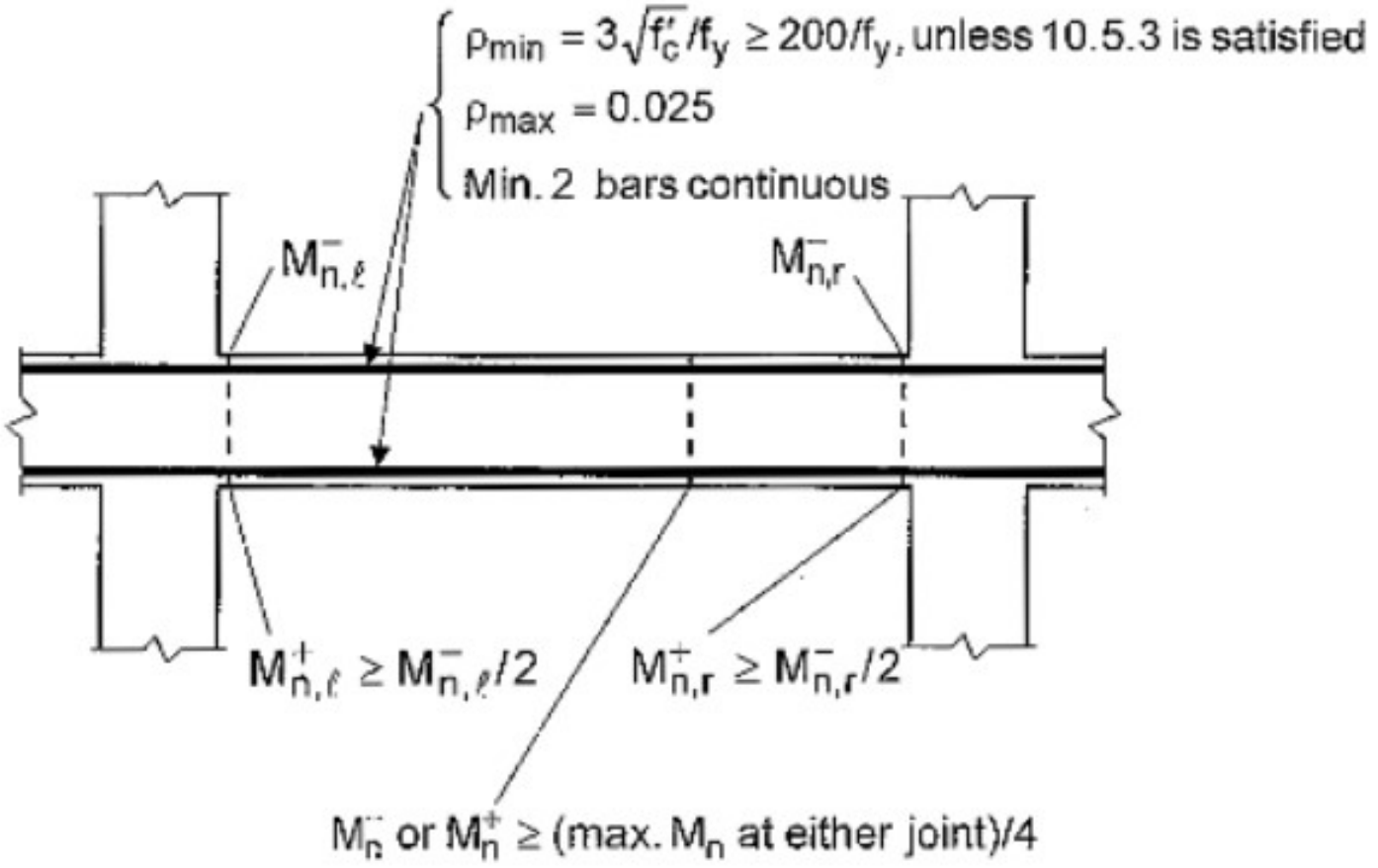


Typical Detailing – (lateral loads)

Fundamental detailing provisions of beams in higher SDCs (D-E)



Flexural reinforcement requirement