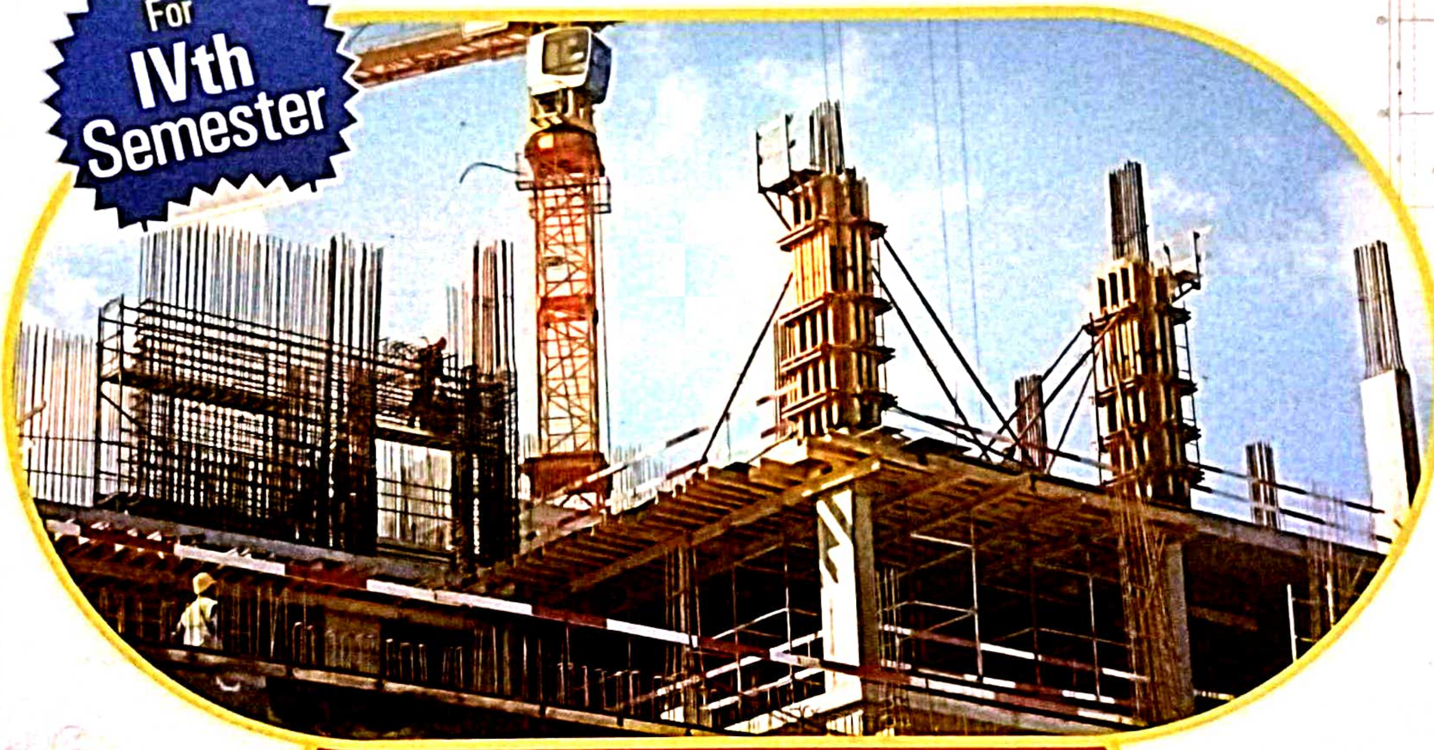
Sarthak

According to the Latest Syllabus
Approved by **U. P. B. T. E** under **N. S. Q. F.**

Reinforced Cement Concrete
RCC Drawing

For
IVth
Semester



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According to New **N.S.Q.F.** Syllabus
Approved by UPBTE

REINFORCED CEMENT CONCRETE (RCC) DRAWING

(For the students of IVth semester or IInd year of three year diploma course in Civil Engineering, special in Rurel Engg. EPC and Water Power Resource Management)

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REINFORCED CEMENT CONCRETE (RCC) DRAWING

Preface

The book has been written as per the new syllabus of BTEUP under NSQF scheme. The ook is covering 4 chapters and initial 3 chapters are only for reading the chapters to enhance nowledge and last fourth chapter includes the drawing sheets, which the students have to epare all drawings on drawing sheets for doing its in regular practice.

Though the students will have been reading the RCC book as subject of theory multaneously, however reading of RCC book and regular practice on drawing sheet is must to ass the exam.

The reinforcement bars are of grade Fe-250 as mild steel where at ends hooks are provided U bend or 180° bend which includes extra length 9ϕ for one hook and 18ϕ for two bends at oth end.

For the steel higher grade as Fe-415, 500 and Fe-550, HYSD bars have been used and bend done at 90° usually for vertical height 4ϕ, 6ϕ, 8ϕ and 12ϕ. Some time if deveopment length is uite enough then no bend is provided only single length is cut and placed.

The extra length for bent up bars for one bent up have been kept $0.27D$, $0.5D$ and $0.6D$ as xtra for 30°, 45° and 60° angle respectively. For stirrups, 2 leg stirrups have been used where xtra length has been taken as 24ϕ for both bends at 135°.

Practice on Auto CAD Software will be done by individual students by their own effort. or which it has not seemed good to include the same in this book. For this students should ownload the software and practice accordingly by following the procedure therein. Some iscellaneous drawing sheets of reinforcement have been addended in this book at the end.

Beside this bar bending schedule has been also included in this book for the extra nowledge of students. It is expected from the students that they will be engaged in preparing rawing throughout the semester and get good marks in this subject. At last I convey motion of hanks for the publishers JPNP Meerut for giving me such an opportunity for writing the book n this subject.

Syllabus

REINFORCED CEMENT CONCRETE (RCC) DRAWING

RATIONALE

Diploma holders in Civil Engineering are required to supervise the construction of RC structures. Thus one should be able to read and interpret drawings of RC structures. The competence to read and interpret structural drawings is best learnt by being able to draw these drawings. Hence there is a need to have a subject devoted to preparation of structural drawings.

LEARNING OUTCOMES

After undergoing the subject, the students will be able to :

- Draw the reinforcement details for various structural elements from the given data
- Calculate reinforcement details from the given drawings
- Draw bar bending schedule from drawing
- Read and interpret R.C.C. drawings

DETAILED CONTENTS

1. RC Drawing :

Reinforcement details from the given data for the following structural elements with bar bending schedules

(i) General instruction and rules, Drawing 1- lap, joint, development drawing :length, rings, hook etc.

2. RC Slabs

One way slab, Two way slab and Cantilever Slab.

3. Beams

Singly and doubly reinforced rectangular beams and Cantilever beam (All beams with vertical stirrups), T Beam, Tapered Beam.

Columns and Footings

Square, Rectangular and Circular Columns with lateral ties and their isolated sloped column footings, column and beam junction.

Portal Frame

Three bay two storey RC portal frame with blow up of column beam junctions.

(i) Drawing of cantilever retaining wall showing details of all the members and reinforcement.

(ii) Drawing of Intze type water tank showing details of all the members and reinforcement.

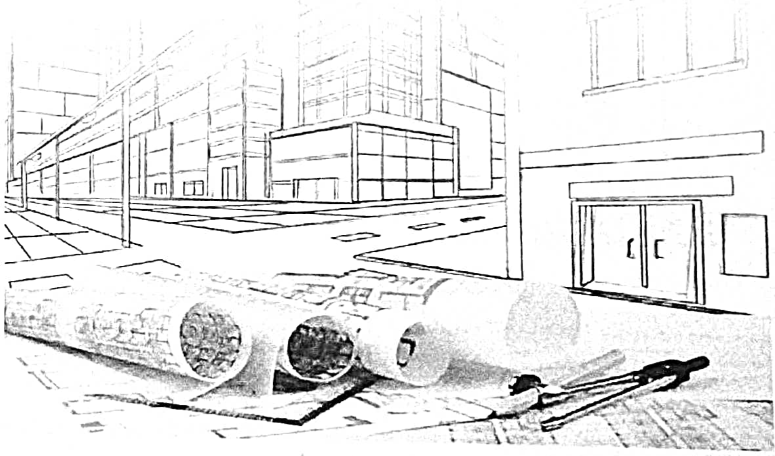
Draw at least one sheet using AutoCAD software

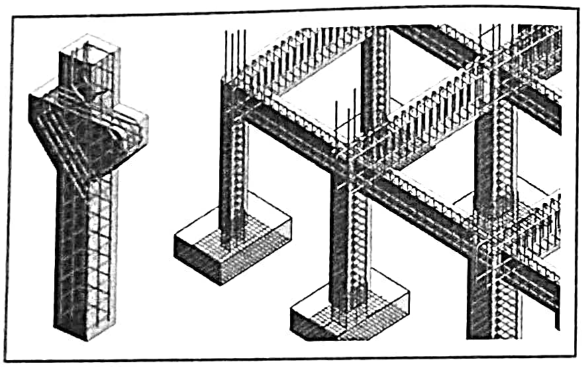
MEANS OF ASSESSMENT

- Assignments and quiz/class tests
- Mid-term and end-term written tests
- Software installation and operation
- Drawing sheets
- Report writing
- Viva-voce

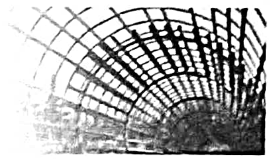
Contents

S.No.	*Chapters*	*Pages*
1.	Introduction	1-17
2.	Slab	18-24
3.	Beam	25-38
4.	Sheet	39-66
5.	Miscellaneous Drawing Sheets	67-108





REINFORCED CEMENT CONCRETE (RCC) DRAWING



1 INTRODUCTION

1.1. Reinforced Cement Concrete

Reinforced cement concrete (R.C.C.) is the combination of ordinary concrete with the reinforcement to increase its compressive and tensile strength to a great texture.

Concrete is a versatile material for modern construction which is prepared by mixing well-proportioned quantities of cement, sand, crushed rock or gravel and water.

1.2. Uses

It has been used from foundations to the roof tops of buildings, and in the construction of highways and roads traffic.

Also hydro power tunnels,

Irrigation canals, drains and

All other building structures like dams, retaining walls, over head tanks, bunkers and silos etc.

1.3. Purpose of of Reinforcement in Concrete

As we know that, concrete has a very high compressive strength, but it is low in tensile strength.

Thus, when only the compressive loads are acting on the concrete surface, then there is no need of using reinforcement in it. But where tensile forces are also involved, as, in, beams and slabs, there is a high risk of its failure when plain concrete is being used.

Steel has a very high tensile strength, and also have good compressive strength. Hence, when two materials (steel and concrete) are combined together, a material of construction is obtained that is capable of with standing all the three types of forces like to act upon a structure *i.e.*, compressive loads, tensile to stresses and shear forces.

Such a material is known as reinforced cement concrete. The concrete surrounds the reinforcement bars with a perfect bond so as no slip between both could be possible.

Concrete is basically alkaline in nature and this prevents rusting of the steel.

The bend or 'grip' between the steel and concrete is established easily.

The coefficient of thermal expansion of concrete is almost identical with that of steel. This prevents the risk of cracking due to expansion at different rates.

1.4. Advantages of RCC

Reinforced cement concrete has following advantages :

1. Structures made of reinforced cement concrete are durable.
2. It has high compressive strength (due to concrete) and high tensile strength (due to reinforcement).
3. It is resistant to fire and other climate changes.
4. Easily available almost any where in the world.
5. It can be moulded in any form or shape.
6. Repairing cost is almost minimum.
7. It is more economical as compared to other materials.
8. It can be used in any part of structure *i.e.*, from foundation to top roofing.
9. Too much expertise is not required for working on it, normal skilled labour can do it.
10. It can be casted in any shape as can be seen in RCC over head tanks. Circular slab. Folding type stair case folded roof and bunkers too.

1.5. Grade of Concrete

Concrete is graded or designed on the basis of its compressive strength. As per IS Code 456 2000 concrete is graded into fifteen types : The grades after M 35 are designed by mix design process.

S. No.	Group	Designation	Characteristic compressive strength, fck (N/mm^2)
1.	Ordinary concrete	M-10	10
		M 15	15
		M 20	20
2.	Standard concrete	M 25	25
		M 30	30
		M 35	35
		M 40	40
		M 45	45
		M 50	50
		M 55	55 The "M" letter refers to the mix and the number represent the compressive strength of concrete in N/mm^2
3.	High strength concrete	M 60	60
		M 65	65
		M 70	70
		M 7	75
		M 80	80

The various grades of concete as per their use are listed further :

1. For R.C.C. work—not lower than M 20
2. For post tensioned work—M 35 and above.
3. For pre tensioned prestressed concrete—M 40 and above.

1.6. Material used in R.C.C.

R.C.C. consists of concrete and reinforcing material. Strength of an R.C.C. section is depends on the kind of concrete and reinforced used.

Grade of concrete : Concrete is graded on the basic of its compressive strength. As per I.S. 456 : 2000, concrete is graded into 15 categories.

(a) Ordinary concrete : M-10, M-15, M-20

(b) Standard concrete : M-25, M-30, M-35, M-40, M-45 M-50, M-55

(c) High strength concrete : M-60, M-65, M-70, M-75, M-80

Here, M = Mix

1 Number] = Characteristic compressive strength, f_{ck} (N/mm^2)

f_{ck} = Characteristic strength of cube size 150 mm × 150 mm × 150 mm of respective grade passed in strength by 95% samples often after 28 days curing.

The grades of OPC cement :

(a) 33 grade (b) 43 grade (c) 53 grade

Here the grade number indicates the minimum compressive strength of cement sand mortar cubes in N/mm^2 at 28 days curing by the cube size 3″ × 3″ × 3″ or 5000 mm^2 arm area.

1.7. Steel Reinforcement

Size and grades of steel are according to I.S. 456 : 2000

Rebars—Respresented by reinforcing bars.

1.7.1 Size of bars

Nominal dia of steel bars available in India from 6 mm to 50 mm but mostly, steel bars in dia used between 8 mm to 32 mm.

So basically, steel bars are of two types based on their surface :

1. Plain bars 2. deformed bars

1.7.2 Grade of steel

Represented by yield strength of steel.

- Specified yeild strength may be treated as characteristic strength fy.
- [Expressed in N/mm^2]

1.7.2.1 Mild steel (Fe-250)

Commonly used in several or ordinary structures because of their low strength. Now these bars are not in value.

1.7.2.2 HYSD [High yield strength deformed bars]

- Fe-415
- Fe-500

See fig. 1.1 for stress and strain for bars of Fe-500, Fe-415 and Fe-250.

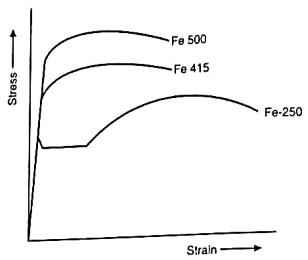


Fig. 1.1

- Fe-415 D, Fe-500 D, Fe-550 D and Fe-550 D has been resently introduced in [IS-1786-2000] D-represent high ductility

1.7.2.3 TMT bars [Thermo mechanically treated]

Inner core-soft and ductile

Outer core-very high and has more tensile strength

See fig. 1.2 for TMT.

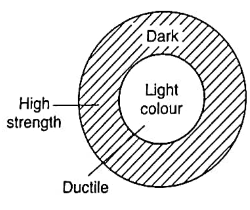


Fig. 1.2

HYSD Bars are as per IS : 1786-1985 made of steel which are provided with logs, ribs, projection or deformation on their surface and are produced in form of cold twisted deformed bars.

These bars are extensively used for reinforcement purposes in a construction.

Due to ribs or projections on their surface, these steel bars have minimum slippage with in concrete and increase the bond between two materials.

Deformed bars can be used without end hooks.

Cold twisted deformed (Ribbed or for steel bars) bars are recommended as best quality steel bars for construction work by structural Engineers (see fig. 1.3).

1.8. Characteristic Strength of Steel

Characteristic strength means yield strength whose value below should not be more than 5% of the test results are expected to fall or 95% result should pass.

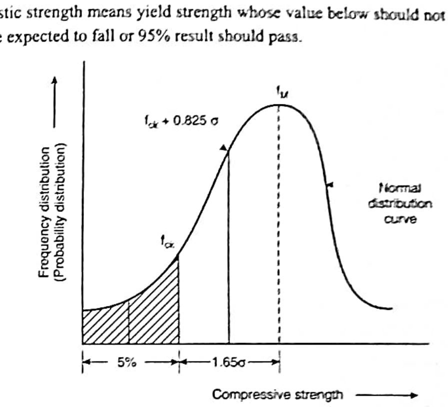


Fig. 1.3

As per I.S. : 456-2000, the characteristic strength of steel is equal to the minimum yield stress or 0.2% proof stress.

Tyeps of steel	Grade	Yield stress/0.2% proof stress or characteristic strength (N/mm^2)
1. Mild steel	Fe-250	250
2. High strength Deformed steel (HYSD)	Fe-415 (Tor 40) Fe-500 (Tor 50) Fe-550 (Tor 55)	415 500 550
3. TMT or CBS bars	Fe 500	500

1.8.1 Minimum dia of steel bars

1. Beam — 12 mm
2. colum — 12 mm
3. Slab — 10 mm
4. Lintel — 10 mm
5. R.C.C. wall — 10 mm

Weight of steel sections commonly used in building work

Bars	Weight kg/m for round bars plain or ribbed tor	Length (m) pertone	Weight kg/m For square bars
Dia (mm)			
5	0.154	6494	0.196
6	0.22	4505	0.28
8	0.39	2332	0.50
10	0.62	1621	0.78
12	0.89	1125	1.13
16	1.58	829	2.01
18	1.99	500	not manufactured
20	2.47	405	3.14
25	3.85	260	4.91
32	6.31	159	8.04

Components of concrete mix for per cubic metre

Concrete proportion [CLF.A : C.A]	Water cement ratio	Water Qvantity of water per bag (litre)	Cement Numbers (In begs)	Cement Weight (In kg)	Aggregale Fine (litre)	Aggregale Coarse (In litre)
M 7.5 (1:4:8)	0.95	47.5	3.3	165	462	924
M 10 (1:3:6)	0.75	37.5	4.3	215	452	904
M 15 (1:2:4)	0.55	27.5	6.2	310	310	868
M 20 ($1:\frac{1}{2}:3$)	0.42	21	7.9	395	395	828
M 25 (1:1:2)	0.30	15	11.2	560	192	784

1.9. Classification of Concrete

These are divided into two categories

1. Nominal mix concrete
2. Design mix concrete

1. Nominal mix concrete : Nominal mix is generally adopted for small scale constructions. In this type of mix, the mix ratios and concrete constituent proportions are prefixed and specified M20, (1:1.5:3), the quantity of cement, sand and aggregate is batched in volume as per the fixed ratio 1:1.5:3.

From the concrete table till M25 grade as 1 : 1 : 2 the concrete proportions are called as nominal mix concrete.

Concrete grade	Vol. of gross aggregate for per bag cement	Vol. of fine nad coarss agg. B	Quantity of water for per bag of cement
M-20 (1:1.5:3)	250 kg	generally 1:2	30 ltr.
M-15 (1:2:4)	330 kg	varies limits	32 ltr
M-10 (1:3:6)	480 kg	$1:1\frac{1}{2}$ to $1:2\frac{1}{2}$	34 ltr.
M-7.5 (1:4:8)	625 kg		45 ltr.
M-5 (1:5:10)	800 kg		60 ltr

2. Design mix concrete : Design mix concrete is adopted for high rise constructions. In this type of mix, the ratios are decided by an Engineer after analysing the properties of individual Ingredients of concrete.

Cement is tested for fineness and specific gravity in the lab while deciding the design mix ratio. Also aggregates tested for grading zones and then by calculations ratio of cement, coarse sand and aggregate with water are decided.

There is no pre-fixed ratio and ingredients are batched in weight. From the concrete grade table, concrete grades more than M 25 falls in design Mix.

In simple ; design mix refers to the ratios which are decided by the Engineer after testing and analysing.

Mix	Cement in kilograms				Dry sand av. Cu.m	Aggregate graded (av.) 12 to 25 mm Cu.m
	Machine mixing		Hand mixing			
	Gravel	Broken/stone	Gravel/single	Braken/stone		
1:1:2	550	580	570	600	0.40	0.80
$1:1\frac{1}{2}:2$	370	390	380	400	0.42	0.84
1:2:3	360	380	370	390	0.54	0.81
1:2:4	290	310	300	320	0.45	0.90
$1:2\frac{1}{2}:5$	250	270	260	280	0.46	0.92
1:3:6	190	210	200	220	0.46	0.94
1:4:8	140	160	150	170	0.47	0.94

Note : The 50 kg cement bag has volume 34.72 or 35 litre, and density is 1440 kg/m^3. The weight per m^3 of rapid hardening cement remains 1200 kg/cu.m.

1.10. Bends and Hooks in the Reinforcement

(a) Bends : The anchorage value of a standard bend shall be taken as 4 times of the diameter of the bar for each 45° bend subject to a maximum of 16 times of the diameter of the bar.

(b) Hooks : The anchorage value of a standard U-type hook shall be equal to 16 times of the diameter of the bar. The anchorage values of standard hooks and bends for different bar diameters have shown in the table. The anchorage value of a standard 90° bend is 8 times of the diameter. See fig. 1.4.

(a) Extra length of hook = 4ϕ + length of curve from a to c that is 5ϕ

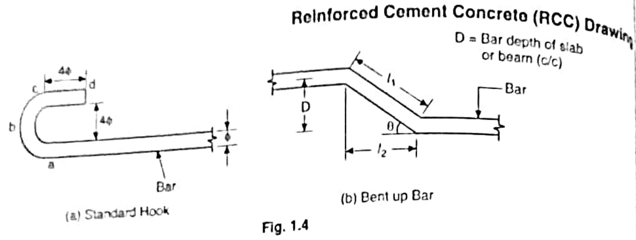


Fig. 1.4

$= 4\phi + 5\phi = 9\phi$

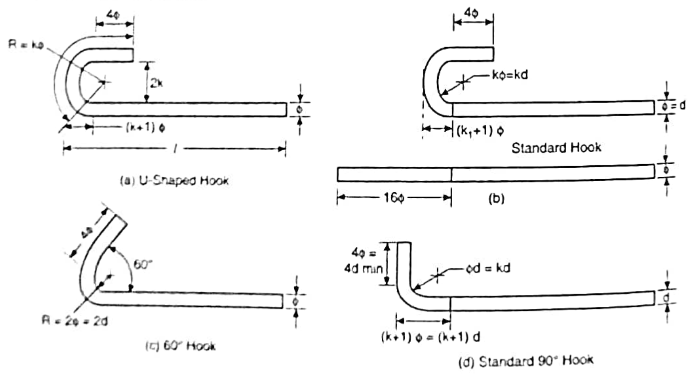
(b) Additional length $\dfrac{D}{\sin\theta} - \dfrac{D}{\tan\theta}$

Here : $\dfrac{D}{l_2} = \tan\theta$ and $\dfrac{D}{l_1} = \sin\theta$

θ (= 30°, 45° and 60° respectively), we get-different valus of extra length, as given below :

S. No.	θ°	$\dfrac{D}{\sin\theta}$	$\dfrac{D}{\tan\theta}$	Additional length of bent up bar
1.	30°	$\dfrac{D}{0.5}$	$\dfrac{D}{0.5733}$	0.27*D* for one bent up
2.	45°	$\dfrac{D}{0.707}$	$\dfrac{D}{1.0}$	0.414 D = 0.42 D for one bent up (0.42 D is generally the value that is adopted)
3.	60°	$\dfrac{D}{0.866}$	$\dfrac{D}{1.732}$	0.577 D = 0.58 D for one bent up (0.58 D is usually adopted)

See fig. 1.4 and 1.5 for Hooks :



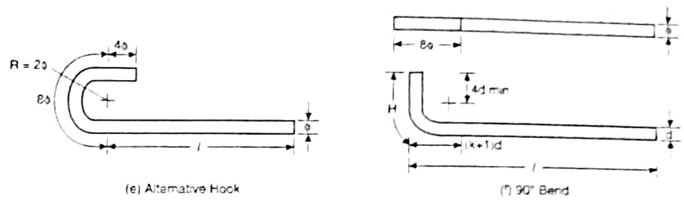


Fig. 1.5 : Different types of Hooks

1.11. Anchorage

In case of space limitation, hooks or bends in the reinforcement can be used as an anchorage.

If the bends started after the centre of support, the anchorage length should be at least 4φ but not greater than 12φ.

If the hook started before *d*/2 from the face of support, the anchorage length be 8φ but not greater than 24φ.

Note : For mild steel bars minimum *r* = 2φ

For high yield SD bars minimum = 3φ or 4φ for sizes 25 mm and above (see fig. 1.6)

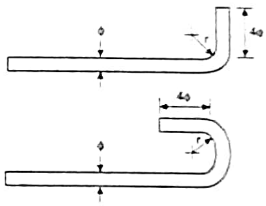


Fig. 1.6

Beams

At the end support, the proper ancorage of the tensile bar must extend a length equal to one of the following :

1. 12 times the bar size beyond the centre line of the support.

12 times the bar size plus (+) *d*/2 from the face of support.

(see fig. 1.7).

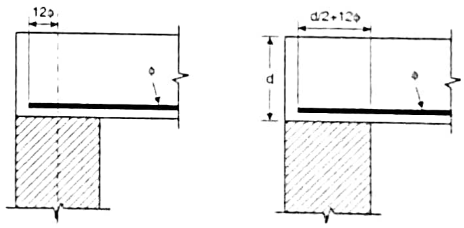
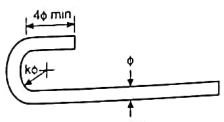


Fig. 1.7

(a) Bars in Tension (IS 456) : See fig. 1.7.



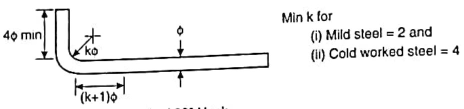


Fig. 1.7

The salient points are :

- Deformed bars may not need at end ancorages if the development length (L_d) required is satisfied.
- Hooks should normally be provided for plain bars in tension.
- The anchorage value of standard bend shall be considered as 4 times the diamter of the bar for each 45° bend subject to a maximum value of 16 times the diameter o bar.
- The anchorage value of standard U-type hook shall be 16 times the dia of bar.

(b) Bars in compression (IS 456)

Here the salient points are :

- The anchorage length of straight compression bar shall be equal to its development length.
- Development length shall be included the projected length of hooks, bends and straight length beyond bends, if provided. See fig. 1.8.

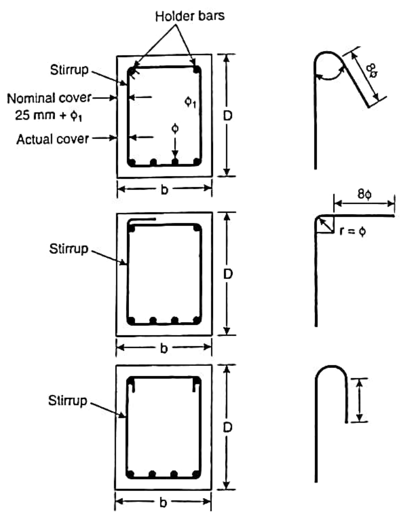


Fig. 1.8 : Anchorage of stirrups

The salient points are : Inclined bars in tension zone will have the development length equal to that of bars in tension and this length shall be measured from the end of sloping or inclined portion of the bar.

Inclined bars in compression zone will have the development length equal to that of bars in tension and this length shall be measured from the mid-depth of beam.

For stirrups, transverse ties and other secondary reinforcement, complete development length and anchorage are considered to be satisfied if prepared as shown in figure (shear)

1.12. Developement Length

L_d is called development length. It is the minimum length of bar which must be embedded in concrete beyond any section to develop its full strength (see fig. 1.9).

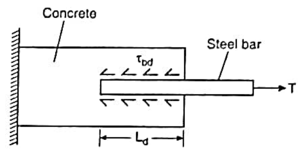


Fig 1.9

According to IS 456 : 2000

$$L_d = \frac{\phi \sigma_{st}}{4\tau_{bd}}$$

Where,

ϕ = Nominal diameter of bar

σ_{st} = Stress in bar at the section considered at design load, and

τ_{bd} = Design bond stress dependent on grades of concrete

The permissible bond stress τ_{bd} depends upon the grade of concrete and type of steel. The value of permissible bond stress are given in the table.

Permissible bond stress for plain bars and deformed bars in tension

Grade of concrete	τ_{bd} for plain bars (N/mm^2)	τ_{bd} for deformed bars (N/mm^2)
M 20	0.6	0.96
M 20	0.8	1.28
M 25	0.9	1.44
M 30	1.0	1.6
M 35	1.1	1.76
M 40 and above	1.2	1.92

M 45	1.3	2.08
M 50	1.4	2.74

For Example : Assume grade of concrete. M 30, yield strength of steel 250 N/mm^2 applying value in the formula :

$$\Rightarrow \quad \text{Lap length} = \frac{\phi \times 140}{4 \times 1.0} = 35\phi$$

Here 'ϕ' is the diameter of steel bar

Imp → For flexure tension lap length	Direct tension lap length	In compressive lap length
L_d or 30ϕ (Which ever is greater)	L_d or 30ϕ which ever is greater	L_d or 24D which ever is greater

Development length for signle bar

Type of steel bar	Fy N/mm^2	L_d in tension (mm)			L_d in compression (mm)		
		M-15	M-20	M-25	M-15	M-20	M-25
Fe-250, Plain bar	250	55ϕ	46ϕ	39ϕ	44ϕ	37ϕ	31ϕ
Detormed bare F-415	415	56ϕ	47ϕ	40ϕ	45ϕ	38ϕ	32ϕ
	500	69ϕ	58ϕ	49ϕ	54ϕ	46ϕ	39ϕ

Example 1. Prepare a bar bending schedule/schedule of bars for the below figure 1.10.

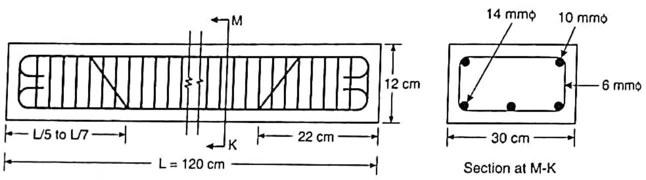


Fig. 1.10

14 mmφ— 2 Bars straight

14 mmφ— 1 Bar bent up.

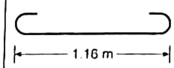
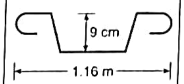
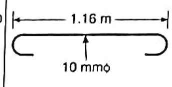
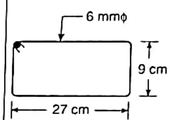
10 mmφ— 2 Bar anchor at top ends

[6 mmφt.vo ledged stirrups @ 10 cm c/c spacing throughout the length.]

Ends clear cover = 2 cm either side

Lintel size = 1.2 m ×03 m × 0.12 m

Top-Bottom-sides-eff. cover = 1.5 cm

S. No.	Desc. of bar	Shape of bar	No	*L*	*l*	*w*	Total *W*	Remark
1.	14 mm φ main straight bar		2	1.16 + 2×9 ×0.014 = 1.412 m	2.82 m	1.21 kg/m	3.41 kg	
2.	14 mm φ bent up bar		1	1.16+18 ×0.014 + 0.09 = 1.502 m	1.502 m	1.21 kg/m	1.82 kg	
3.	10 mm φ Anchor bars		2	1.16 + 18 ×0.01 = 1.34 m	2.68 m	0.62 kg/m	1.66 kg	
4.	6 mm φ two ley stirrups @ 10 cm c/c		13	2× 0.27 + ×0.09 + 24 × 0.006 = 0.864 m	11.232 m	0.22 kg/m	2.47 kg	Nos = $\frac{116}{10}+1$ = 11.6+1 = 12.6=13
						Total	9.36 kg	

Example 2. Draw B.B.S. for bars of given below figure 1.11.

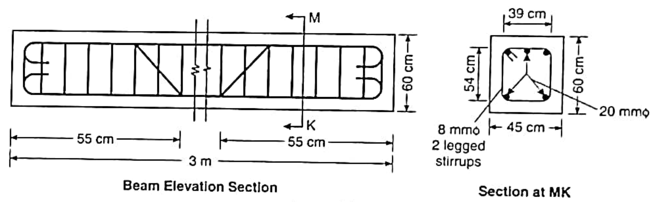


Fig. 1.11

(i) 12 mm φ Anchor bars—2

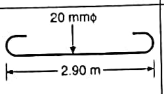
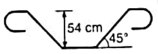
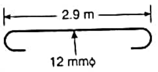
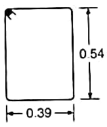
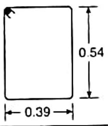
(ii) 20 mm φ bent up bar—01

(iii) 8 mm φ two leg stirrups 11 cm c/c 55 cm distance at bith side.

(iv) 8 mm φ two leg stirrups 18 cm c/c for mide dutic

(v) Ends clear cover = 5 cm

(vi) TOP-BOTTOM-SIDE Effective cover = 3 cm

S. No.	Desc. of bar	Shape of bar	N	l	L	wt kg/m	W	Remark
1.	20 mmϕ main straight bars		2	2.9 + 18 × 0.02 = 3.26 m	6.52 m	2.47	16.10 kg	
2.	20 mmϕ main bentup bar		1	2.9+18×0.0 2 +0.54	3.79 m	2.47	9.36 kg	
3.	12 mmϕ Anchor bar		2	3.9+18 × 0.012 = 3.116 m	6.232 m	0.89	5.54 kg	
4.	8 mmϕ two ledged stirrups@ 11 cm		12	2×054 + 2×039+24 × 0.008 = 2.052 m	24.624	0.39	9.6 kg	$\frac{55}{11}+1=6$ 6×2=12
5.	8 mmϕ 2 ledged stirrups @ 18 cm c/c 180 cm		9	2.052 m	18.468	0.39	7.2 kg	$\frac{180}{18}-$ 1=9
						Total	47.8 kg	

Example 3. Prepare bar bending schedule for below figure 1.12 of slab size = 6 m × 3.3 m × 0.15 m, top bottom eff cover = 12 mm, ends clear cover = 15 mm, 12 mm ϕ temp. bar 3-3 number at both ends, use Fe 250 mild steel.

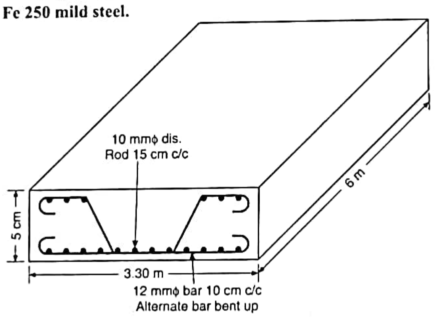
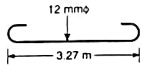
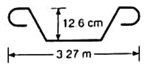
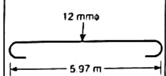
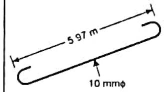


Fig. 1.12

S. No.	Desc. of bar	Shape of bar	N	l	Total L	w	Total W	Remark
1.	12mmϕ main straight bar		31	3.27 + 18 ×0.012 = 3.486 m	108.066 m	0.89	96.18 kg	Nos = 600 − 3 = 597 $\frac{597}{20}+1$ =30.85 = 31
2.	12 mmϕ Bentup bar		30	3.486+ 0.126 = 3.612 m	108.36 m	0.89	96.44 kg	15 cm − 2.4 cm = 12.6 cm
3.	12 mmϕ temp. bar		6	5.97 + 18 ×0.012 = 6.186 m	37.116 m	0.89	33.03 kg	
4.	10 mmϕ dist bar 15 cm c/c		23	5.97 + 18 × 0.01 = 6.15 m	141.45 m	0.62	87.70 kg	60−3= 597 cm = 5.97 m $\frac{327}{1}+1=21.8$ + 1 = 22.8 = 230

Example 4. Prepare B.B.S. for below figure 1.13. Effective Bottom cover 40 mm, clear end cover = 50 mm, Bottom size 2.40 × 2.40 m effective cover on colum = 40 mm.

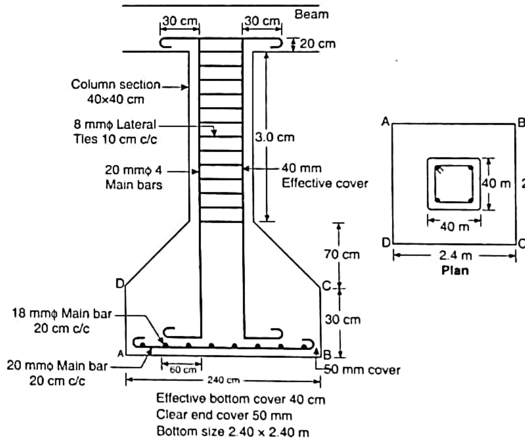
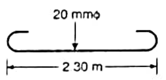
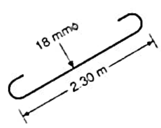
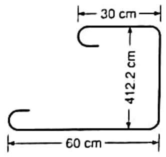
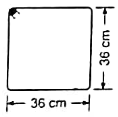


Fig. 1.13

S. No.	Desc. of bar	Shape of bar	N	l	Total L	w	Total W	Remark
1.	20 mm φ 20 cm c/c main (Bars)		13	2.3+1 8 × 0.02 = 2.66 m	34.586 m	2.47	85.41 kg	$\frac{230}{20}+1$ = 12.5 =13
2.	18 mm φ 20 cm c/c distribution bars		13	2.3 + 18 × 0018 = 2.624 m	34.112 m	2.00	68.22 kg	
3.	20 mm φ main vertical bars		4	5.022 + 18 × 0.02 = 5.382 m	21.53 m	2.47	53.18 kg	60+30 −7.8 + 70 + 300+ 20 + 30 = 502.2 cm
4.	8 mm φ 10 cm/cc lateral bars @ 15 cm c/c		33	0.36 × 4 + 24 × 0.008 = 1.44 +	53.856 m	0.39	21.00 kg	$\frac{320}{10}+1$

1.13. Types in Shear Reinforcement

These types of shear reinforcement are used :

1. Vertical stirrups
2. Bent-up bars
3. Inclined stirrups.

1. 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 6 mm to 16 mm. The free end of the stirrups are anchored in the compression zone of the beam to the anchor bars of the compressive reinforcement. See fig. 1.14.

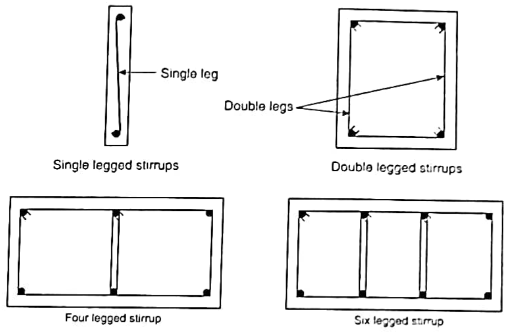


Fig. 1.14

2. Bent up bars along with vertical stirrups : Some longitudinal bars in a beam can be bent up near the support. These bent up bars resist diagonal tension. These bars are usually bent up at 45° normally. This system is used for heavier shear force. See fig. 1.15.

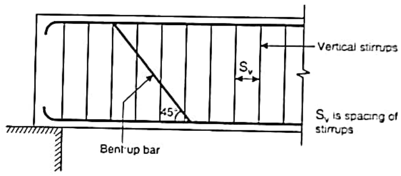


Fig. 1.15

3. Inclined stirrups : Inclined stirrups are also provided generally at 45° for resisting diagonal tension. They are provided throughout the length of the beam. See fig. 1.16.

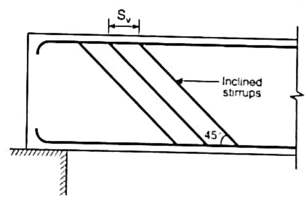
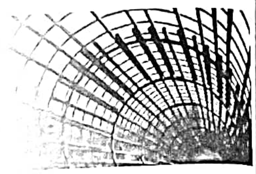


Fig. 1.16



2 SLAB

2.1. Introduction

Slab is two dimensional element, used in all type of structures. The thickness of slab remain very small as compared to its length and width. Slabs are classified on the basis of $\frac{l_y}{l_x}$ ratio.

l_y = length of longer span

l_x = length of shorter span.

Slabs are of following types :

1. One way slab
2. Two way slab

2.2. One Way Slab

One way slabs are those slab in which the $\frac{l_y}{l_x}$ ratio is greater than 2. The one way slab is analysed by assuming it to be a beam of 1 m width means $\frac{l_y}{l_x} > 2$. See fig. 2.1. Say room size 3 × 6.5 m 4 × 8.3, 2 × 4.5 m and 4 × 8.5 m will have independent slab of one way type. This type of slab is deflected at shorter span.

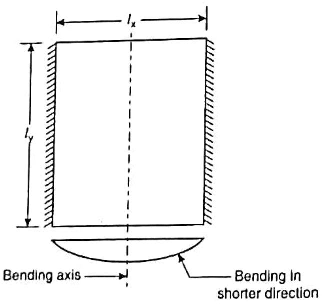


Fig. 2.1 : One way Slab

2.1.2. Two way slab

The slab which is supported on all the four walls and having $\frac{l_y}{l_x}$ ratio as less than or equal to 2, is called two-way slab. See fig. 2.2.

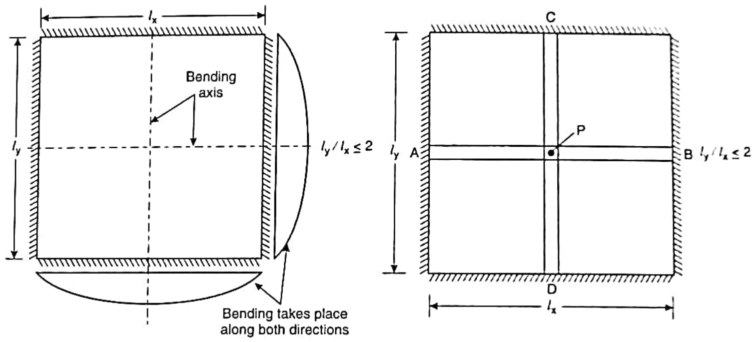


Fig. 2.2 : Two way Slab

2.2. Difference between one-way and two way slab

S. No.	One-way slab	Two-way slab
1.	$\frac{l_y}{l_x} > 2.0$	$\frac{l_y}{l_x} \le 2.0$
2.	Te bending takes place only in one direction. [shorter span]	Bending take place in both direction.
3.	Required more depth.	Less dept is required.
4.	Main steel reinforcement is provided along shorter span.	Main steel reinforcement is provided along both the span.
5.	Less economical	More economical.
6.	Thickness is more	Thickness is less.
7.	Amount is steel riquired is more	Amount of required steel is less

2.3. I.S. 456 : 2000 Recommendations or Design of Slabs

2.3.1. Effective span : (a) For simply supported

1. Centre to centre of supports
2. Clear distance between the supports + effective depth] which ever is small

(b) For continious slab

Where the depth of support is less than $\frac{1}{12}$ of the clear span, the effective span should be taken as given in (a) for simply supported slab.

2.3.2. Deflection control

For slabs the vertical deflection limits are specified by maximum l/d ratio :

(a) For spans upto 10 m

Slab	l/d Ratio
Cantilever	7
Simply supported	20
Continuous	26

(b) For slab greater than 10 m, the above value may be multiplied by 10/span, except for cantilever, for which exact deflection calculations should be made.

(c) For two-way slabs of small spans (upto 3.5 m) with mild steel reinforcement, the shorter span to overall depth ratio may be assumed to satisfy the deflection limits for loading class upto 3000 N/m^2.

Simply supported : 35

continuous slab : 40

For high deformed bars ⟶ given value multiplied by 0.8

2.3.3. Steel Reinforcement

(a) Minimum reinforcement : In slab : for M.S bars → reinforcement should not be less than 0.15% of the total cross-sectional area. In case of high strength deformed bars it should be 0.12% of *bd*.

(b) Maximum diameter : Maximum diameter of the reinforcing bar in a slab should not exceed $\frac{1}{8}$th of the total thickness of the slab.

(c) Spacing :

1. Minimum distance : (i) Minimum horizontal distance between two parallel main bars shall not be less than.

- the diameter of bar
- 5 mm more than the nominal maximum size of coarse aggregate used in concrete.

(ii) Vertical distance between two layers of main reinforcement shall not be more than

- 15 mm or
- $\frac{2}{3}$rd of nominal maximum size of aggregate
- Maximum size of bar

2. Maximum distance :

(i) The spacing of main steel in a slab should not exceed :

- 3*d* or
- 300 mm

(ii) Spacing of bars to act as distribution steel shall not exceed :

- 5*d* or
- 450 mm

(d) Cover : Nominal cover to be provided in a slab is 20 mm.

(e) Bent-up-bars : Generally alternate bars are bent-up at a distance of 0.15 l or $\frac{l}{7}$ from the centre supports. See fig. 2.3.

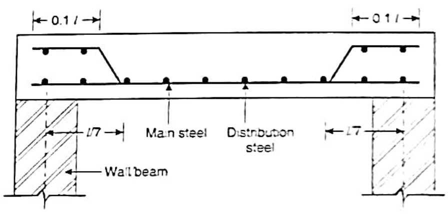


Fig. 2.3

The bar available at the upper face should be more than $\frac{l}{10}$ (0.1 l) from the centre of support.

Cantilever slab

The points to be considered in design of one way cantilever slab are following :

1. The effective span of cantilever slab is equal to the unsupported or projecting length of slab.
2. The clear depth at fixed end is maximum and is assumed to be about $\frac{\text{span}}{10}$ to $\frac{\text{span}}{12}$.
3. The depth required at the free end is minimum and is kept $\frac{1}{2}$ to $\frac{1}{3}$ of the depth at fixed end.
4. The main reinforcement is provided at the top and is to be curtailed at appropriate point.

Example 1. Draw a sectional plan and sectional elevation of a simply supported one way slab with the following data.

size of room = 4.5 × 8.5 m

end cover = 20 mm

thickness of slab = 150 mm

wall thickness = 300 mm

bearing of wall = 200 mm

Reinforcement :

Main bars = 12 mmφ @ 150mm c/c, alternate bars bent up.

Distribution steel = 8 mmφ @ 200mm c/c.

S. No.	Type of bar	Shape of bar	Dia of bar	No. of bar	Length (m)	Weight (kg/m)	Weight (kg)
1	Main bars						
	(i) Straight		12	30	4.86	0.89	129.76
	(ii) Bent up bars		12	29	4.94	0.89	127.5
2.	Distribution bars		8	33	8.86	0.39	114.02
						Total (W)	= 371.28
						5% wastage	= 18.56

389.844

= 390 kg

Calculation for length of Bar :

(i) Length of straight bars (main) = 4500 + 200 + 200 − 2 × 20

= 4860 mm = **4.86 m**

Total no. of mainbars $= \frac{8500+200}{150} + 1 = 58 + 1 = 59$ bar

Straight bars = 30

(ii) Length of bent up bars = length of straight bar + 2 × 0.42 H

$H = 150 - 2\times20 - 12 = 98$ mm = **0.098 m**

Length of bent up bar = 4.86 + 2 × 0.42 × 0.098 = **4.94 m**

No of bent up bars = **29**

(iii) Length of distribution bars = 8500 + 200 + 200 − 2 × 20

= 8860 mm or **8.86 m**

No. of distribution bars at bottom $= \frac{4500+200}{200} + 1$

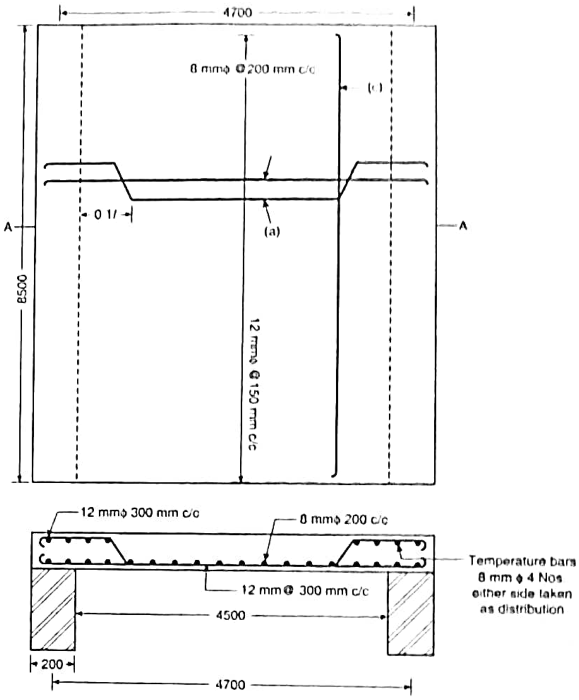
= 23.5 + 2 = 24.5 ≈ 25 bars

Providing 4 distribution bars at the top bars on each side

Total no. of distribution bars = 25 + 4 + 4 = **33 bars**

Note → Use HYSD bars clear cover = 20 mm

See fig. 2.4 :



Section A-A (Along short span)

Fig. 2.4 : Section AA (Along Short Span)

Example 2. Draw a bar bending schedule for a cantilever slab to act as a balcony projection 1.5 m with the following data :

thickness at free end = 80 mm

thickness at fixed end = 150 mm

Main bars = 12φ @ 150 mm c/c (HYSD bars)

Distribution steel = 8 mm φ @ 200 mm c/c

Supporting beam = 300 × 500 mm size

Main bars = 3 – 20ϕ,
Anchor bars = 2 – 12ϕ
Stirrups = 8ϕ@ 200 mm c/c
Width of slab = 2.5 m

Also prepare the bar bending schedule.

Sol. Bar bending schedule for slab

S. No.	Type of bar	Shape of bar	Dia of bar (mm)	No of bars	Length (m)	Weight (kg/m)	Weight (kg)
1.	Main bar		12	18	2.02	0.89	32.36
2.	Distribution bar		8	9	2.46	0.39	8.64
						Total	≈ 41 kg

Adding 5% wastage = 41 × 0.05 = 2.05 kg
total weight = 41 + 2.05 = 43.05 kg

Calculations : Assuming cover = 20 mm, $L_d = 45\phi$, for main bars

$$L_d = 45 \times 12 = 540 \text{ mm}$$

$$\text{No. of main bars} = \frac{2500}{150} + 1 = 17.7 \approx 18$$

$$\text{No. of distribution bars} = \frac{1500}{200} + 1 = 8.5 \approx 9$$

$$\text{Length of main bar} = 1500 - 20 + 540 = 2020 \text{ mm} \approx 2.02 \text{ m}$$

$$\text{Length of distribution steel} = 2500 - 2 \times 20 = 2460 \approx 2.46 \text{ m}$$

See fig. 2.5 :

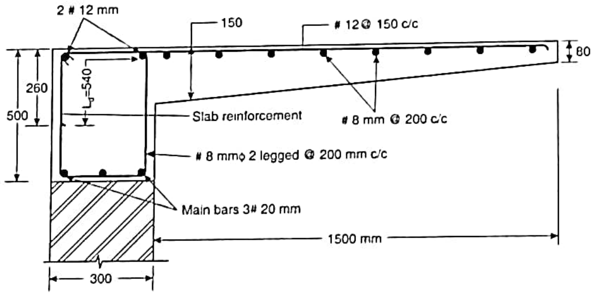
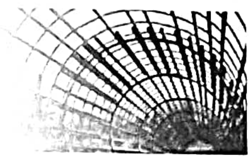


Fig. 2.5 : Section of Slab Showing details of Reintorecment



3

BEAM

3.1. Introduction

A beam is a structured element that primarily resists loads applied vertically to the beam's axis. Its mode of deflection is due to bending. Total effect of all the forces acting on the beam produced shear force and bending moments within the beam, that in turn induce internal stresses, strains and deflections in the beam. See fig. 3.1.

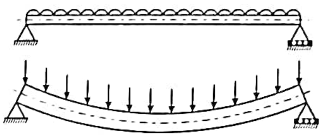


Fig. 3.1 : A statically determinate Beam, Bending (sagging) Under the Uniformly distributed load.

Beams are characterized by their manner of support, profile on (shape of cross-section) equilibrium conditions, length, and their material.

3.2. RCC Beams

Types of beam in construction

1. Singly reinforced beam
2. Doubly reinforced beam

See fig. 3.2 :

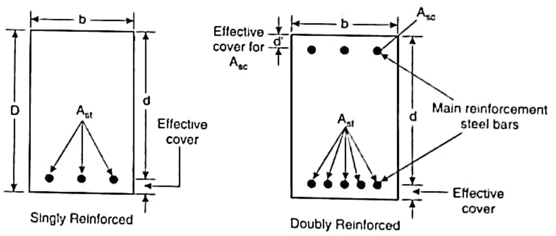


Fig. 3.2

3.3. Types of Loading on Beams

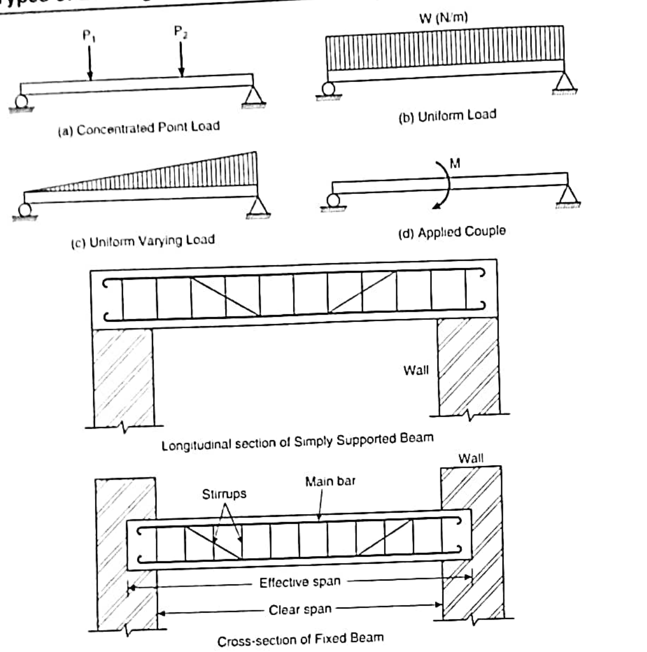


Fig. 3.3

3.4. Design Procedure of R.CC Beams

Singly reinforced beam designed by these steps :

1. Effective span
2. Loads

3.4.1.

1. Effective span : (a) For beam & slab

(i) Clear span + effective depth $l = L + d$

(ii) Clear span + width $l = L + b$ Which ever is less.

(b) For contilever beam

Efective span = length of overhanging + effective depth/2

(c) For continious beam

(i) If width $\geq \frac{\text{clear span}}{12}$, take effective span according to (a)

(ii) If width of support is greater than $\frac{1}{12}$ of the clear span or 600 mm which ever is less when,

(i) One end is fixed and other is continious

Effective span = clear span

(ii) If one end is simply supported and other is continious

$$\left.\begin{array}{l}\text{Effective span} = \text{clear span} + \dfrac{\text{Effective depth}}{2} \\ \text{or} \\ \text{Clear span} + \dfrac{\text{Width of last column}}{2}\end{array}\right\} \text{Which ever is less}$$

(iv) For roller of roller bearing

Effective span = Distance between the centre of bearing.

2. Control of deflection : For beams, the vertical deflection limits may be assumed to be satisfied if the span to depth ratios are not greater than the following :

Same as slab

Point (2.3.2)

3. Reinforcement

(a) Minimum reinforcement : The minimum area of tension steel shall not be less than that given by following

$$\frac{A_s}{bd} = \frac{0.85}{f_y}$$

Where,

A_s = Minimum area of tension steel

b = Breath of beam of width of the web of T-beam

d = Effective depth

f_y = Characteristic strength of reinforcement in N/mm^2

(b) Maximum reinforcement : The maximum area of tension reinforcement shall not be exceed 0.04bD.

(c) Side force reinforcement : For beam exceeding the depth of 750 mm. Side face reinforcement is provided to insure lateral stability as well as confinement to increase the ductility of the beam member. Moreover, this additional side reinforcement which is not included in load sharing mechanism also helps in dissipation of additional forces.

As per I.S. 456 : 2000, guidelines for the provision of side face reinforcement in beams in which web thickness is greater than 750 mm, mould be provided. See fig. 3.4.

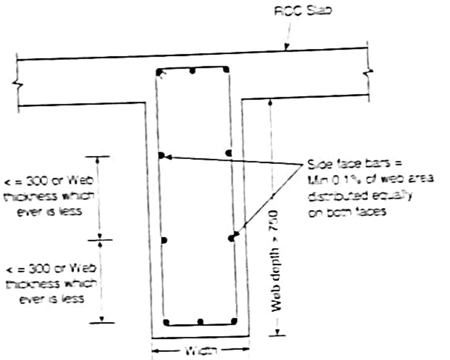


Fig. 3.4 : Details of side face reinforcement in beams exceeding 750 mm depth as per IS (456 : 2000)

(d) Spacing of reinforcement bars

(i) Horizontal space : The horizontal distance between two parallel main bars shall not be less than the greatest of the following :

- Diameter of the bar if the bars are placed at the same distance.
- Diameter of the larger bar if the diameter of bar are unequal.
- 5 mm more than the nominal maximum size of coarse aggregate.

(ii) Vertical space : Minimum vertical distance between the bars shall be greater of following

- 15 mm
- $\frac{2}{3}$ rd of nominal maximum size of aggregate.
- Maximum diameter of bar.

(e) Nominal cover of reinforcement

It shall not be less than the diameter of bars in any case The nominal cover is provided in R.C.C Design for following reasons.

(a) To protect the reinforcement against corrosion.

(b) Provide cover against fire.

(c) To develop the sufficient bond strength along the surface area of the steel bar.

Nominal cover to meet durability requirements

Exposure condition	Nominal cover (mm) not less than
Mild	20
Moderate	30
Severe	45
Very severe	50
Extreme	75

2. Loads :

(A) Dead load :

(a) Depth of beam :

$$\text{For light load} = \frac{\text{Span}}{15} \text{ to } \frac{\text{Span}}{20}$$

$$\text{For medium load} = \frac{\text{Span}}{10} \text{ to } \frac{\text{Span}}{20}$$

$$\text{For heavy load} = \frac{\text{Span}}{5} \text{ to } \frac{\text{Span}}{10}$$

(b) Width of beam : $\frac{1}{3}$ to $\frac{2}{3}$ of depth

(B) Live load = For residential buildings flats, Hospitals, wards and hostels = Min-2 kN/m^2

(c) Total load on beam per meter length

Total load = Dead load + Live load

3. Maximum bending moment

For $\quad \text{U.D.L. B.M.} = \frac{wl^2}{8}$ kg-m

$$= \frac{wl^2}{8} \times 10^4 \text{ N-mm} \qquad [10 \text{ N} = 1 \text{ kg}]$$

w = U.D.L. kg/m

l = effective span in meter

4. (i) Natural axis = $\quad x = \frac{m\sigma_{cbc} \times d}{m\sigma_{cbc} + \sigma_{st}}$

$x = 0.394d$

$m = 13$

$\sigma_{cbc} = 7 \text{ N/mm}^2$

$\sigma_{st} = 140 \text{ N/mm}^2 \qquad z = 1 - \frac{x}{3}$

(ii) Lever Arm $= 0.869\,d$

(iii) Moment of resistance = $M_r = 1.2\,bd^2$

5. Effective depth

$$d = \sqrt{\frac{M_r}{1.2b}}$$

6. Reinforcement steel :

$$\text{Area of tensile steel} = A_{st} = \frac{M_r}{\sigma_{st} \times z}$$

7. Checks = (a) Minimum tensile reinforcement

$$A_{st} < A_0$$

$$A_0 = \frac{0.85bd}{f_y}$$

(b) Shear reinforcement :

(i) Maximum shear force = $V = \frac{w \times L}{2}$ (c = clear span)

(ii) Nominal shear force $\tau_v = \frac{V}{bd}$

(iii) % of tensile steel in section = $p_t = \frac{100 \times A_{st}}{bd}$

(iv) Find τ_c on the basing p_t

(v) Compare τ_v and τ_c with $\tau_{c\,max}$

(vi) $\frac{\tau_c}{2} > \tau_v$, no shear

$\frac{\tau_c}{2} = \tau_v$ or $\tau_v = \tau_c$ (Minimum shear be provided in the form of stirrups)

$\tau_v > \tau_c < \tau_{c\,max}$

Shear reinforcement in the form of bent up bars and stirrups shall be provided.

(c) Development length :

$$Ld \le \frac{1.3M_1}{V} + L_0$$

$Ld = \frac{\phi\sigma_{st}}{4\tau_{bd}}$, $L_0 = 12\phi$ and whichever is greater.

Here, Ld = Development length

L_0 = Anchorage length

$M_1 = \left(\frac{A_{st}}{2} \times \sigma_{st} \times Z\right)$. As 50% bars have been bent up

Example 1. Draw *l*-section, and cross section of a simply supported rectangular beam with the following data :

Clear span = 4 m

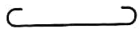
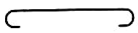
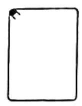
Bearing on walls = 200 mm

Overall depth of beam = 400 mm

Width hof beam = 220 mm

Main reinforcement = 6-12 mmϕ bars, 2 bars bent up at $l/7$ from the centre of support, stirrups = 6 mm ϕ at 200 mm c c

Anchor bars = 2-10 mm ϕ diameter bars.

S. No.	Types of Bar	Shope of bar	Dia of bar	No. of bars	Length one bar (m)	Weight (kg/m) = 7850 × Area of bar (m^2)	Total weight (kg) = col (5 × 6 × 7 × 8)
1	Main bars						
	(i) straight bar		12	3	4.144	0.89	11.06
	(ii) Bent up bars		12	2	4.426	0.89	7.87
2	Hanger bars		10	2	4.144	0.62	5.14
3	Stirrups		6	20	1.176	0.22	5.17
						Total	= 29.24 kg

Adding 5% wastage = 1.462 kg

Total weight = 30.702

= **31 kg**

Calculation of bar bending schedule :

Totel length of beam = Clear span + 2 × bearing

= 4 + 2 × 0.2 = 4.4 m

(i) Length of straight bars = Total length of beam — 2 × End cover + 2 × 9ϕ

= 4.4 − 2 × 0.02 + 2 × 9 × 0.012 = 4.144 m

(ii) Length of bent up bar = length of straight bar + 2 × 0.42 H

$H = D - 2 \times$ end cover $- 2 \times$ dia of stirrups − dia of main bar

= 400 − 2 × 20 − 2 × 6 − 12 = 336 m or 0.336 m

Length of bent up bar = 4.144 + 2 × 0.42 × 0.336

= 4.42 m

(iii) No. of stirrups = $\frac{c/c \text{ of bearing}}{\text{spacing}} + 1 = \left|\frac{4000 + 200}{200}\right| + 1$

= 22 bars

(iv) Length of one straight bar $= 2(L + B) + 24 \times d$

$L = 400 - 2 \times 20 - 2 \times 6 = 348$ mm

$B = 220 - 2 \times 20 - 2 \times 6 = 168$ mm

$= 2(348 + 168) + 24 \times 6$

$= 1176$ mm

$=$ **1.176 m**

See fig. 3.5

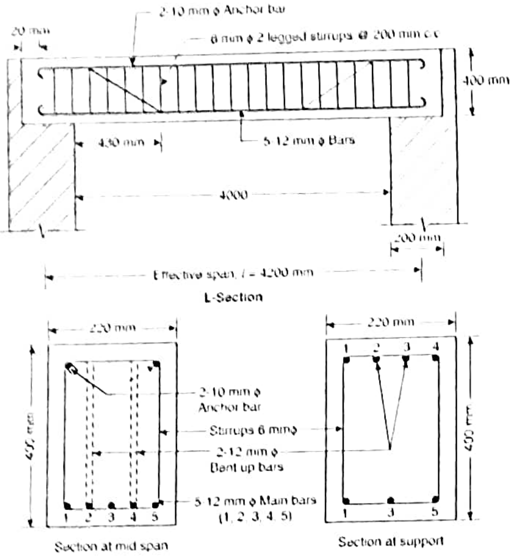


Fig. 3.5

Notes = Mild steel bars are used

clear cover = 20 mm

End cover = 20 mm

Stirrups are hooked around the main bars for a length of 12ϕ

All dimension are in mm unless specified

Example 2. Draw a *l*-section, a cross-section at the mid span, and a cross-section near the support of a simply supported douly reinforced beam from the following data :

size of beam = 350 × 450

clear span = 4.2 m

Bearing of wall = 200 mm

Thickness of wall = 300 mm

Main reinforcement HYSD = Tensile-3 bars 20 mmϕ, one bar bent up *l* / 7, comprsive 2 bars 16 mmϕ, stirrups = 8 mmϕ 2 legged @ 200 mm c/c

Sol. Bar bending schedule

S. No.	Types of Bar	Shope of bar	Dia of bar (mm)	No. of bars	Length one bar (m)	Weight (kg/m) = 7850 × Area of bar (m^2)	Total weight (kg) = col. (5 × 6 × 7 × 8)
1.	Main tensile bar						
	(i) straight bar		20	2	4.56	2.46	22.43
	(ii) Bent up bars		20	1	4.85	2.46	11.93
2	Compressive bars		16	2	4.56	1.58	14.40
3	Stirrups		8	25	1.568	0.39	15.28
						Total	64.04
						Assume 5% wastage	3.202
						Total Weight	= 67.242

Calculation of bar bending schedule :

Assumed end cover = 20 mm

Clear cover = 20 mm

Total length of beam = clear span + 2 × Bearings

$= 4.2 + 2 \times 0.2 = 4.6$ m

Assuming no hook at the end of bars since they are HYSD bars

(i) Length of straight bar = Total length of beam − 2 × end cover

$= 4.6 - 2 \times 0.02 =$ **4.56 m**

(ii) Length of bent-up bars = length of straight bar + 2 × 0.42 H

$H = D - 2 \times$ End cover $- 2 \times$ dia of stirrups − dia of main bar

$= 420 - 2 \times 20 - 2 \times 8 - 20 = 344$ mm $=$ **0.344 m**

(iii) Stirrups No. of stirrups $= \dfrac{\text{c/c bearing}}{\text{spacing}} + 1 = \dfrac{4200+200}{200} = 22$

Length of one straight bar $= 2(A+E) + 24 \times$ Dia of stirrups bar

$A = D - 2 \times$ Clear cover $- 2 \times$ Dia of stirrups

$A = 450 - 2\times 20 - 2\times 8 = 394$ **mm**

$E = b - 2 \times$ clear cover $- 2 \times$ dia of stirrups

$350 - 2\times 20 - 2\times 8 = 294$ mm

Length of one stirrups bar $= 2(394 + 294) + 24 \times 8$

$= 1568$ mm $=$ **1.568 m**

Note : HYSD bars have used

clear cover = 20 mm

See fig. 3.6 :

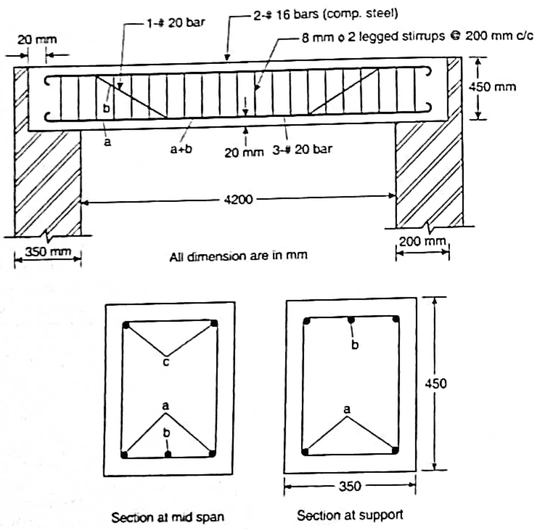


Fig. 3.6

Example 3. Drax *I*-section, *x*-section and bar bending schedule of a rectangular singly supported beam with the following data :

(i) Clear span = 4.5 m

(ii) Width of beam = 220 mm

(iii) Overall depth of beam = 300 mm

(iv) Bearing width in support = 200 mm

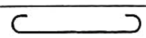
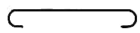
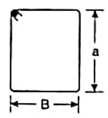
(v) Main reinforcement = 5 No. 12 mmφ with 2 bars bent up at $\frac{L}{7}$ from the centre support

(vi) Anchor/Hanger bars = 2 Nos-10 mmφ

(vii) Stirrups = 6 mmφ@ 220 mm c/c

(viii) Materials = Mild Steel M-20 grade conc.

(ix) Cover = 25 mm

S. No.	Types of Bar	Shope of bar	Dia of bar	No. of bars	Length one bar	Weight (kg/m)	Total weight
1.	Tensile straight		12	3	5.16	0.89	13.772
2.	Crank or bent up bar		12	2	5.37	0.89	9.558
3.	Hanger bars		10	2	5.16	0.62	6.39
4.	Stirrups		6	17	1.0	0.22	3.74
						Total	= 3346

5% wastage 1.673

35.133

Total = **35 kg**

Calculation

Total length of beam = Clear span + 2 × bearings

$4.5 + 2 \times 0.2 = 4.9$ m

(i) Length of straight bar = total length of beam + Hook length— 2 × End cover

$= 4900 + 26 \times 12 - 2 \times 25 = 5162$ mm

(ii) Length of bent up bars = length of straight bar + 2 × 0.42 × depth bend

$= 5162 + 2 \times 0.42 \times 250 = 5372$ mm

(iii) Length of hanger bar = length of straight bar = 5162 = 5200 mm

(d) Stirrups = No of stirrups = length of bar (end to end) ÷ c/c distance of stirrups

$$= \frac{4500 + 200}{200} + 1 = 24.5 = 25 \text{ bars}$$

Length of stirrups = 2(A + B) + 24φ of stirrups

$A = (D - 2 \times \text{clear cover} - 2 \times \text{dia of stirrups})$

$= 300 - 2 \times 25 - 2 \times 6 = 238$ mm

$B = b - 2 \times \text{clear cover} - 2 \times \text{dia of stirrup}$

$= 220 - 2 \times 25 - 2 \times 6 = 158$ mm

Length of one stirrup = 2(238 + 158) + 24 × φ stirrups

= 2(238 + 158) + 24 × 6

792 + 144 = 936 mm = 1000 mm

See fig. 3.7

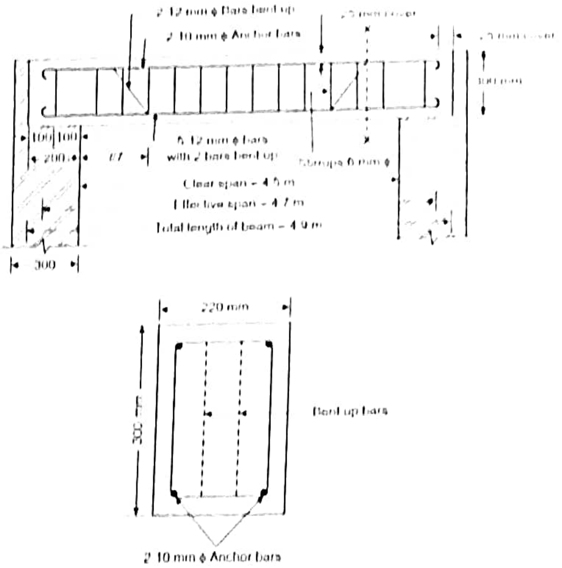


Fig. 3.7

Example 4.

1. Clear span = 3.5 m
2. Width of beam = 250 mm
3. Overall depth of beam = 300 mm
4. Main reinforcement = 5 Nos 18 mm φ bar with 2 bars bent up at 900 mm from inside of each end support
5. Hanger bars = 2 Nos 12 mm φ
6. Stirrups = 6 mm φ at 200 mm c/c
7. Cover = 25 mm

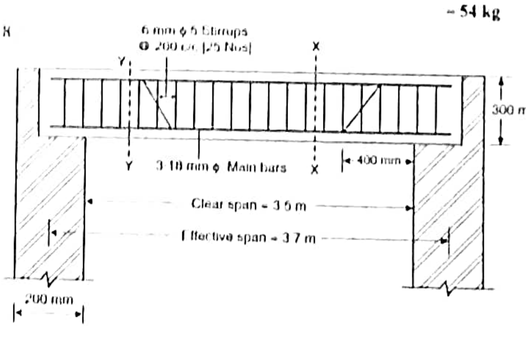
S. No.	Type of bar	Shape of bar	Dia of bar	No. of bar	Length of bar	Weight (kg/m)	Total Weight
1	Main tensile straight bar		18	3	3.85	2.0	23.1
2	Bent up bars		18	2	4.06	2.0	16.24
3	Anchor bars		12	2	3.85	0.89	6.85
4	Stirrups		6	25	0.8	0.22	4.4
						Total	50.59

Add 5% wastage = 2.529

= 53.1195

= 54 kg

See fig. 3.8



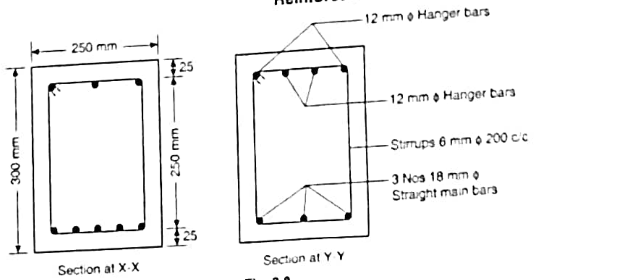


Fig. 3.8

Calculation of B.B.S.

Total length of beam = clear span + 2 × bearing

= 3500 + 2 × 200

= 3900 mm = 3.9 m

(i) Bottom straight bar = total length of beam — 2 × End cover

= 3900 − 2 × 25 = 3850 mm

(b) Length of bent up bar = Length of straight bar + (0.42 × depgth of bend)

= 3850 + 2 × 0.42 × 250

= **4060 mm**

(ii) Length of hanger bar = Length of straight bar = **3850 mm**

(iii) Stirrups = No. of stirrups = $\frac{3500 + 200}{200} + 1 = 18.5 = $ **19 Bars**

Length of stirrups = $2(A + E) + 24\phi$ stirrups

A = 300 − 2 × clear cover − 2 × dia of stirrup)

= 300 − 2 × 25 − 2 × 6 = **238 mm**

E = (b − 2 × clear cover − 2 × dia of stirrups)

= 250 − 2 × 25 − 2 × 6 = **188 mm**

Length of stirrups = $2|A + E| + 24 \times \phi$ of stirrups

= 2|238 + 188| + 24 × 6

614 + 144 = **758 mm = 800 mm**

4 SHEET

Sheet 1

1. Lap length of bars : Over lapping of two bars in order to safely transfer the load from one bar to another is known as lap length. If both bars have same diameter then lap length is kept 50ϕ. See fig. 1

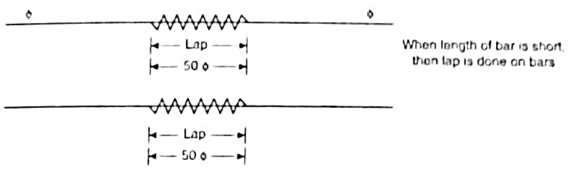


Fig. 4.1

Usually reinforcement bars have length 40 feet. If column or beam has height or length say 65' then lapping in bars will be done

(a) For flexure tension means bending tension lap = Ld or 30ϕ which ever is greater

(b) For direct tensions, lap = 2 × Ld or 30ϕ which ever is greater.

(c) Lap should not be less than 15ϕ or 200 mm.

(d) Lap length in compression be Ld in compression should not *i.e.*, less than 24ϕ.

(e) If bars have different diameter then minimum diameter of bar will be consider.

(f) For 1:2:4 cement concrete, mild steel plain bar lap length with hook = 58ϕ − 18ϕ = 40ϕ. See fig. 4.2 and 4.3.

Fig. 4.2

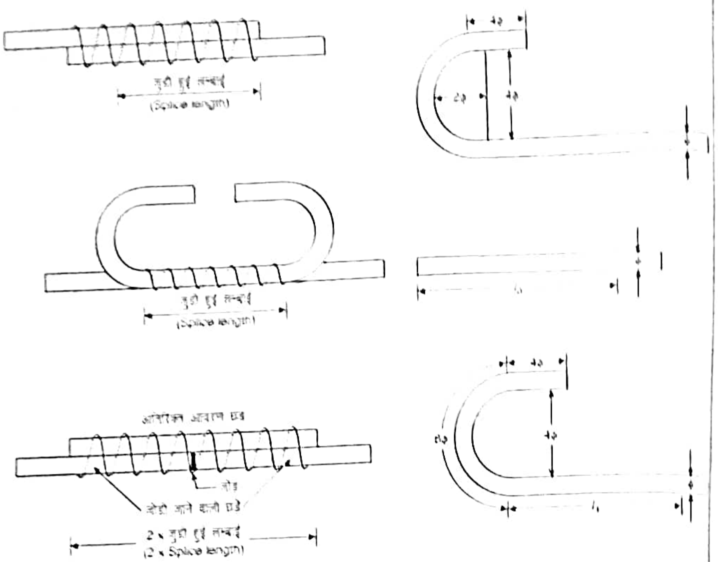


Fig. 4.3

$$Ld = \text{Development length}$$

$$= \frac{\phi \sigma_{st}}{4\tau_{bd}} = \frac{\phi \times 140}{4 \times 06} = 58\phi \text{ in tensioon}$$

$$Ld = \text{Development length mm comp}$$

$$= \frac{\phi \times \sigma_{sc}}{5 \times \tau_{bd}} = \frac{\phi \times 130}{5 \times 06} = 43\phi \text{ in compression}$$

σ_{st} = stess of steel in tension = 140 N mm^2 for Fe 250

σ_{sc} = stess of steel in compression = 130 N mm^2 for Fe 250

(g) Lap length of M-20 grade concrete

In column = 45φ

In Beans = 60φ

In slabs = 60φ

If φ = 16 mm. Then for column = 45 × 16 = **720 mm**

(h) As per IS code 456-2000, over lapping should not be less than 150 mm and lapping should be avoided for tensions zone.

(i) Development length is provided to transfer the load from steel to concrete. This Ld is known also as anchorage length. See fig. 4.4

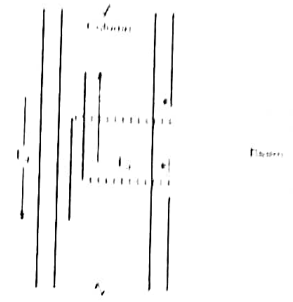


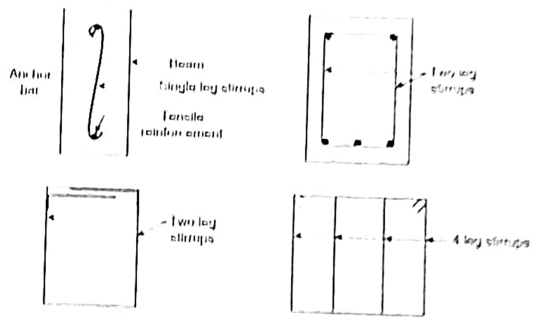
Fig. 4.4

$$Ld = \frac{\phi \times \sigma_{st}}{4\tau_{bd}} = \frac{\phi \times 140}{4 \times 06} = 58\phi \text{ for plain bars of Fe 250}$$

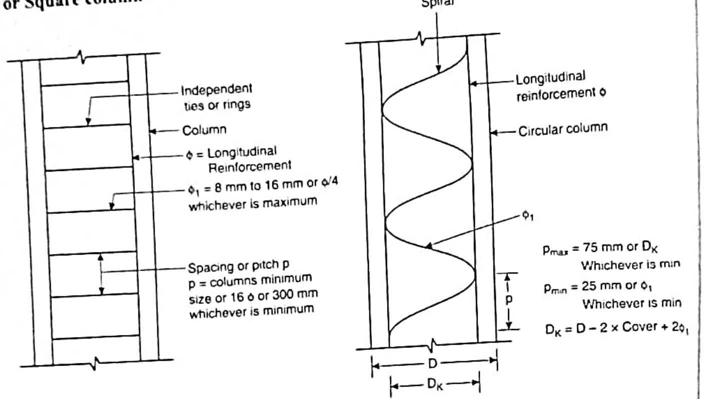
τ_{bd} = bond stess

$$Ld = \frac{0.87 f_y \times \phi}{4\tau_{bd}} = \frac{0.87 \times 250 \times \phi}{4 \times 10} = 55\phi \quad \text{(For ribbed steel of Fe 250)}$$

2. Rings : These are known as stirrups. See fig 4.5. Usually used in beams. Rings in the form of independent ties or helical are used in columns.



For Square column



Square Column

Circular Column

Fig. 4.5

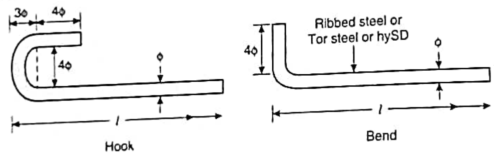
$p_{min} = 25$ mm or 3ϕ, which ever is min.

$p_{max} = 75$ mm or $\frac{Dk}{6}$

which ever is min.

$Dk = D - 2 \times \text{cover} + 2\phi$

3. Hooks : Hooks are provided at the end of bars for plain reinforcement and bends are provided at the end of bars for ribbed bars. See fig. 4.6.



Hook

Bend

Fig. 4.6

Total length = $l + 9\phi$ for one hook

Total length = $l + 18\phi$ for two hook For plain bars with end hook.

Total length = $l + 4\phi$ or $l + 6\phi$ or $l + 8\phi$ for one bend at end for Tor steel

Total length = $l + 8\phi$ or $l + 12\phi$ or $l + 16\phi$ for both bend at the end for Tor steel

Sheet No. 2

Slab —
- One way — $\frac{L}{B} > 2 \rightarrow$ Room size $= 6.5 \times 3$ m = One way
- Two way — $\frac{L}{B} \leq 2 \rightarrow$ Room size $= 6 \times 3$ m = Two way

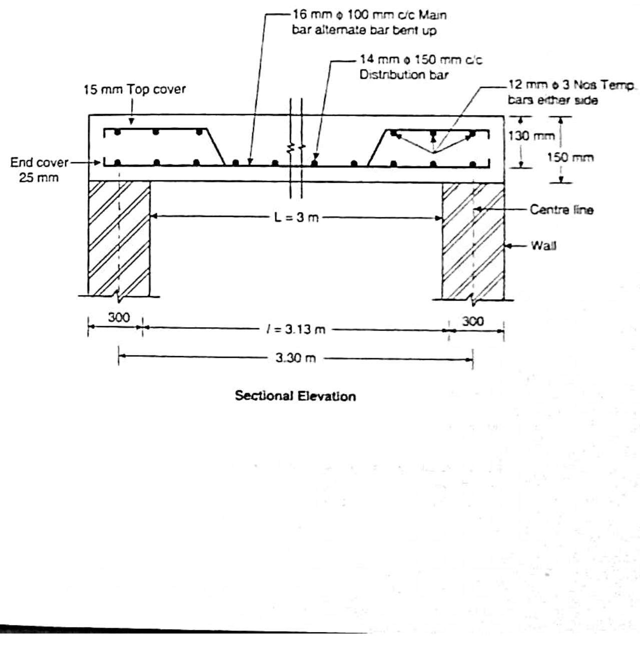
One way slab means bending will be in short direction and load of slab will be transferred to longer walls.

Two way slab means bending will be in both direction and load of slab or on slab will be transferred to all four walls. Hence two way slab bears more load than one way slab, but needs more reinforcement than one way.

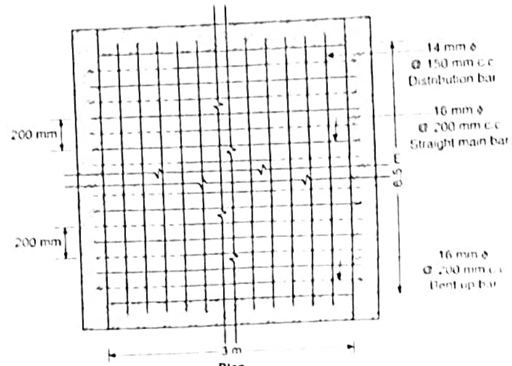
1. One way Slab

Room size 3m × 6.5 m

See fig. 4.7 :



Sectional Elevation



Plan

Fig. 4.7

2. Two way slab : Slab size 3 m × 6 m. See fig. 4.8

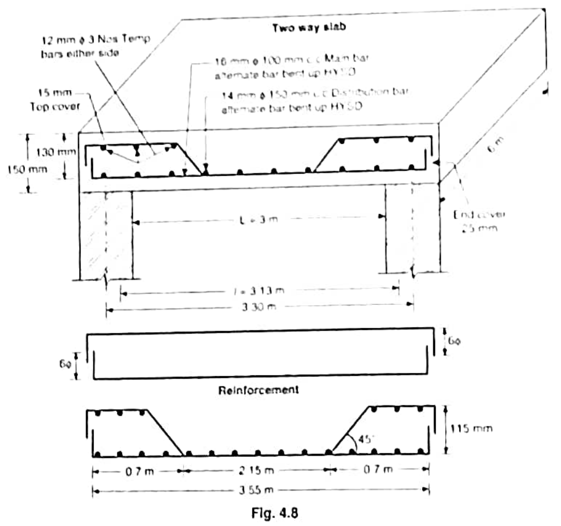


Fig. 4.8

3. Cantilever slab : A slab whose one end is fixed and another end is free. The slab fixed end is kept more deaper than free end because bending moment exist more at fixed end. Usually the slab depth at free end is usually kept $\frac{1}{3}$ of depth at fixed end. See fig. 4.9

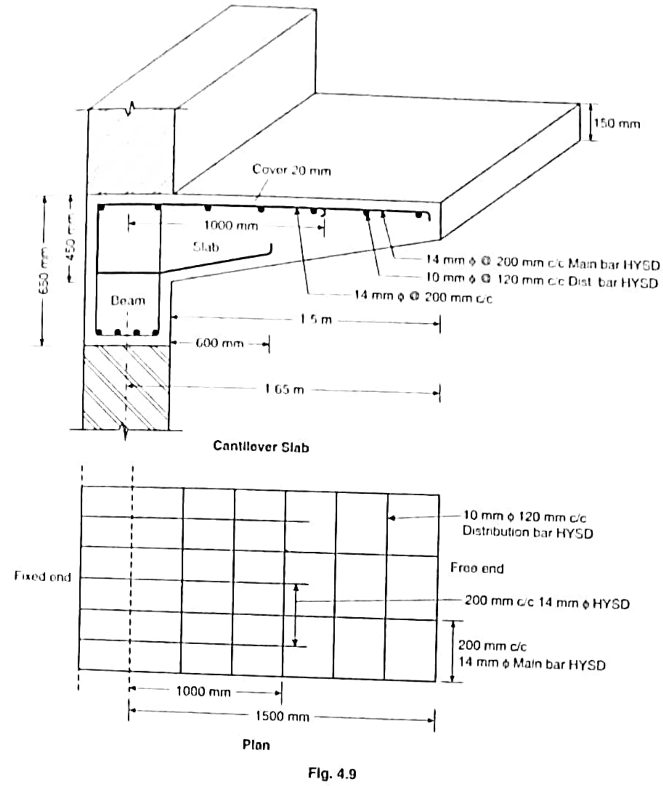


Fig. 4.9

Sheet No. 3

Beams : Beams are horizontal members on which load comes perpendicular on its axis. Due to load, bending occurs in beam.

Beams : Singly reinforced–when reinforced in tension zone.

Doubly reinforced–when reinforced in tension as well as compression zone.

Beams : Simply supported, continuous, fixed, cantilever, T-beam, inverted Tee beam and L-beam etc.

Singly RCC Beam

See fig.4.10 :

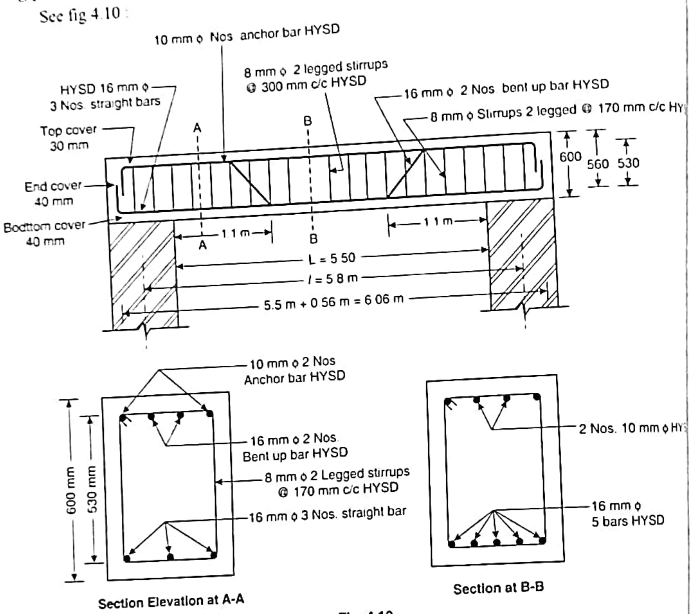
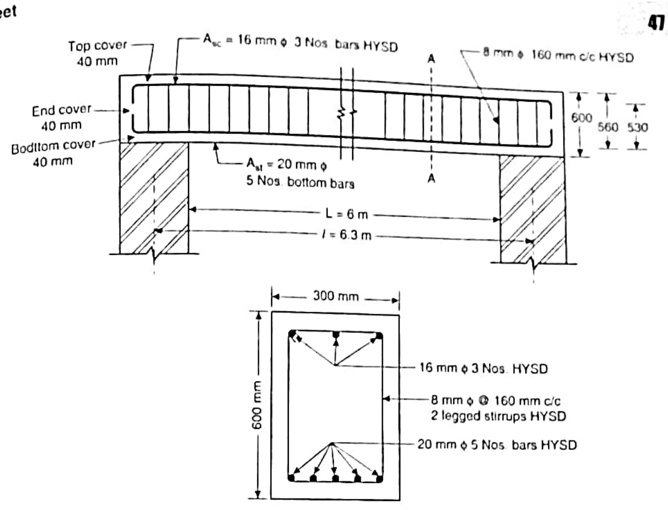


Fig. 4.10

Doubly RCC Beam

Reinforced beam is called doubly reinforced when reinforcement is used in tension as well as compression, so that the beam can bear more load and beam will not be over reinforced. See fig. 4.1



Section at A-A

Fig. 4.11

T-Beam

See fig.4.12, 4.13, 4.14 :

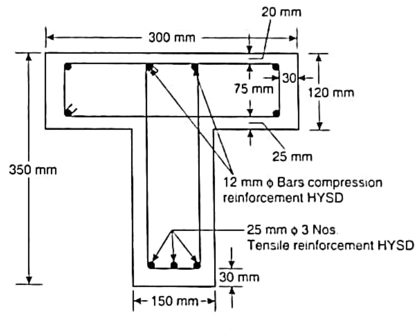


Fig. 4.12

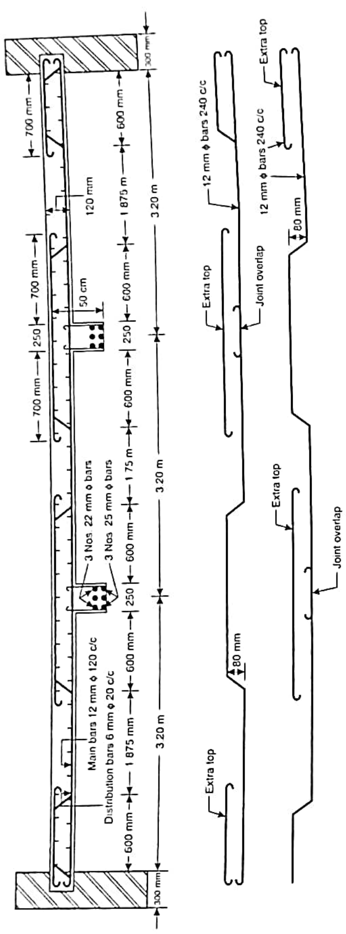


Fig. 4.13

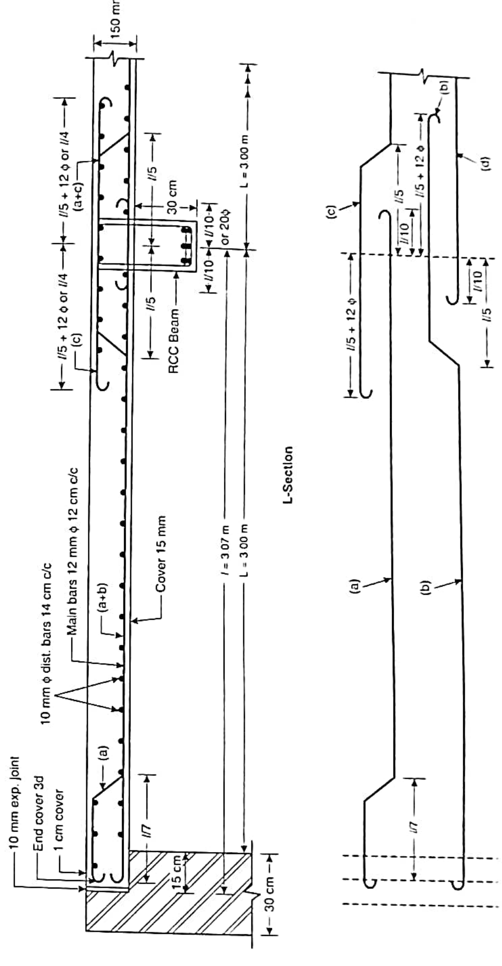


Fig. 4.14

Inverted-T-Beam used in Foundation

See fig. 4.15 :

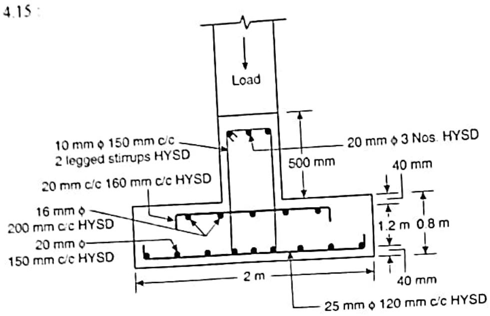


Fig. 4.15

Cantilever beam

See fig. 4.16 :

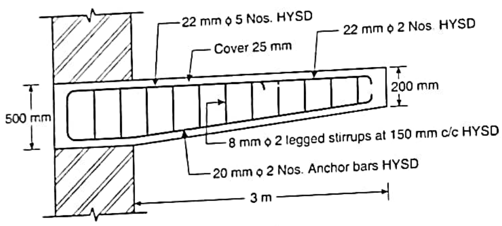


Fig. 4.16

Sheet 4

Column

RCC column is a vertical member on which the load comes along its axis either axially or eccentrically. Short and long column are constructed where short column is more load bearing and long column is less load bearing and usually fails in buckling. Longitudinal reinforcement is provided along its height and lateral reinforcement in the form of independent ties or helical ties are provided to present the longitudinal reinforcement from spreading out and to provide stength. See fig. 4.17, 4.18, 4.19, 4.20, 4.21 and 4.22.

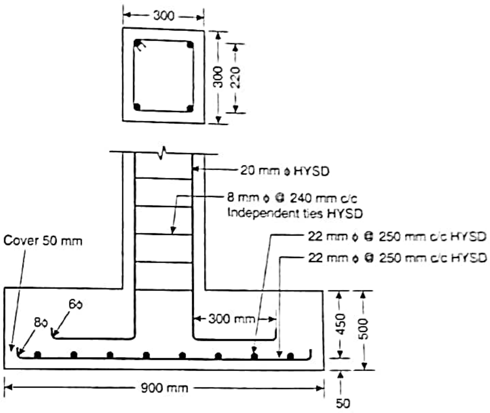


Fig. 4.17

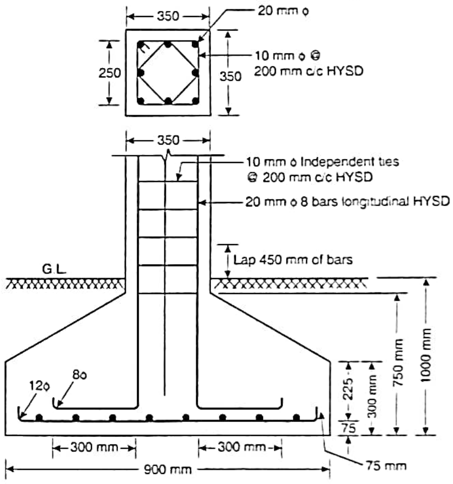


Fig. 4.18

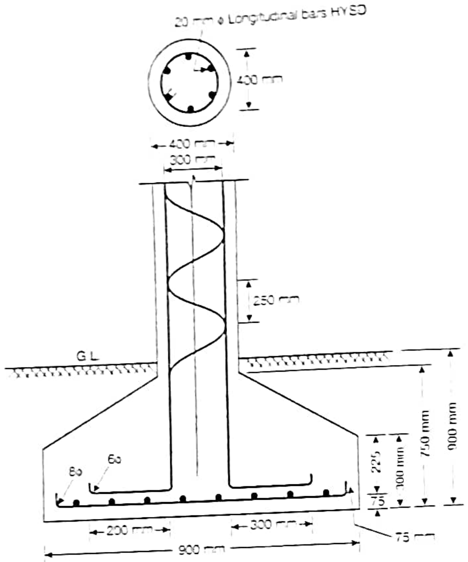


Fig. 4.19

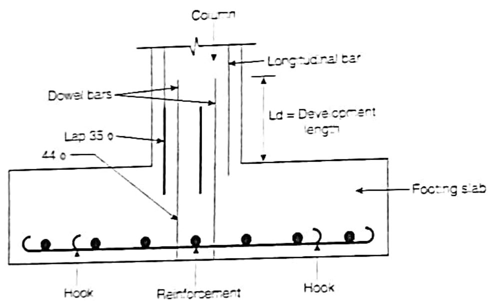


Fig. 4.20

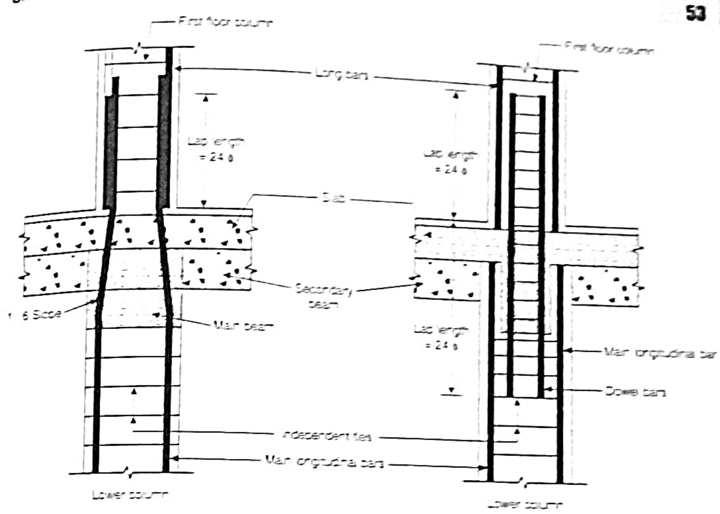
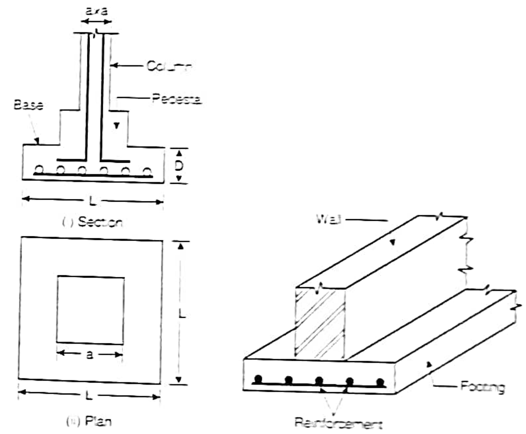


Fig. 4.21



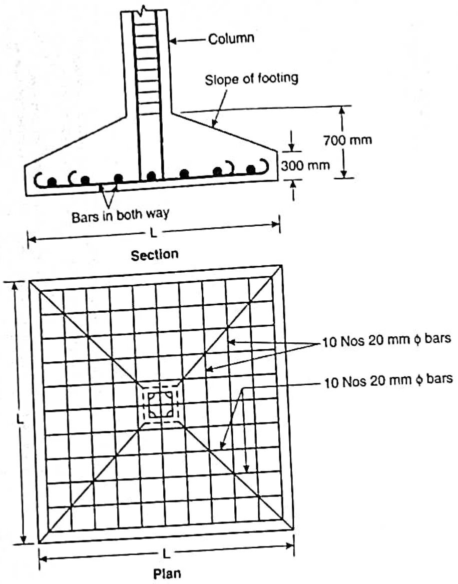


Fig. 4.22

Sheet 5

Portal frame

These frames are the main parts of structure which combines the beam and column of RCC monolithically, so that load on each may transfer from one to another without any slip. The part reinforcement of beam prolonged to meet column with proper development length/and-large length. These frames are of segment wise in layer known as storeys. See fig. 4.23, 4.24(a), 4.24(b) and 4.25.

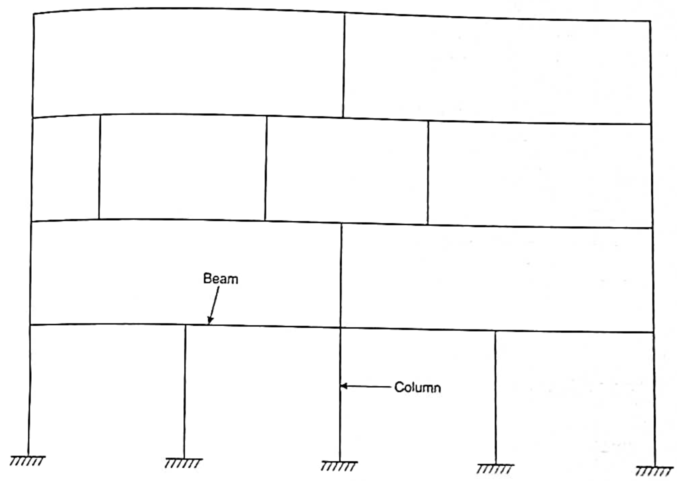
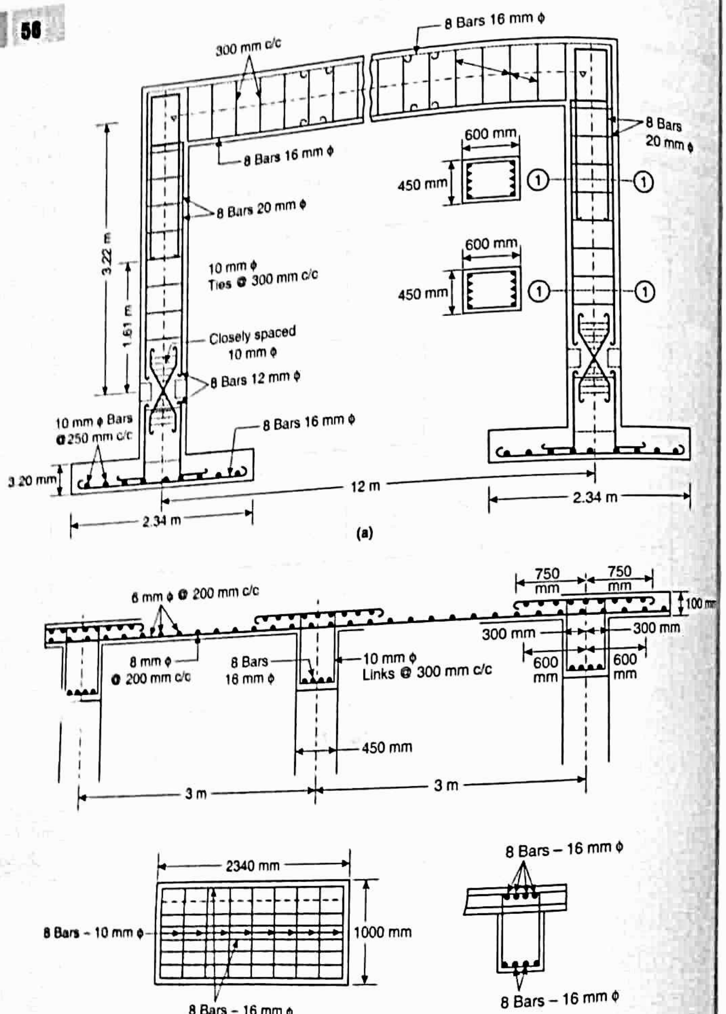


Fig. 4.23



(b)

Fig. 4.24

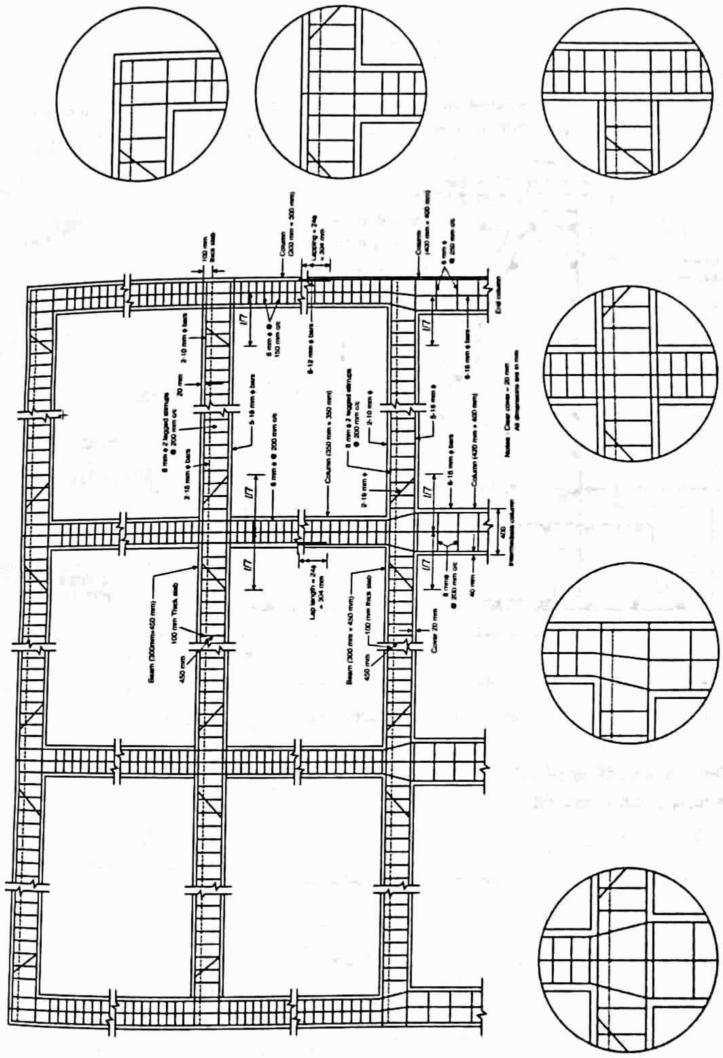


Fig. 4.25

Sheet 6

Retaining well

Retaining wall is the wall to retain the earth pressure coming laterally on this well. To keep the soil in vertical position a wall of RCC or stone or brick is made. See fig. 4.26, 4.27, 4.28 and 4.29.

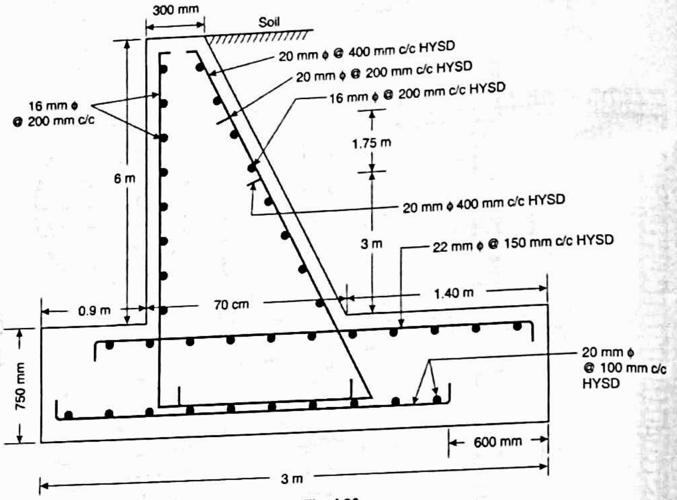


Fig. 4.26

One side were filling of soil in these is called back fill.

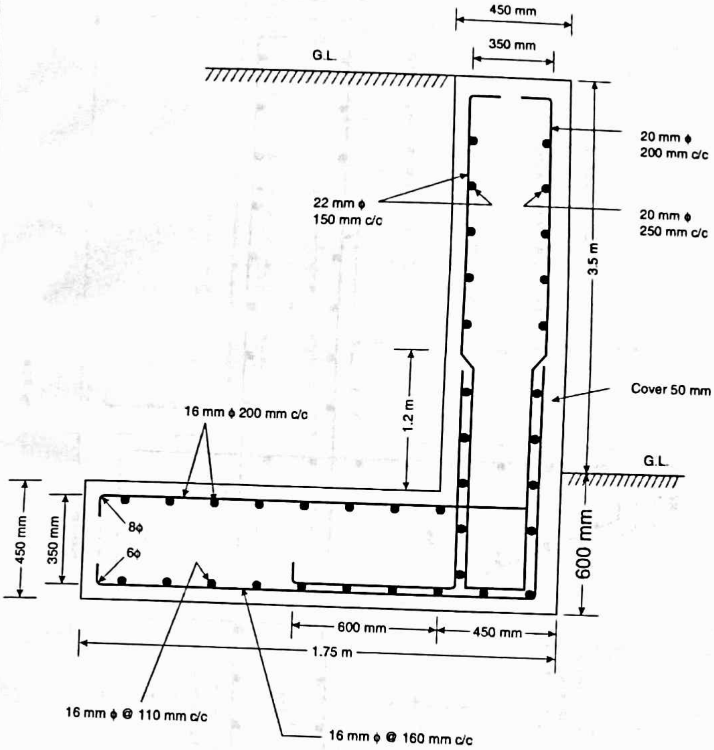


Fig. 4.27

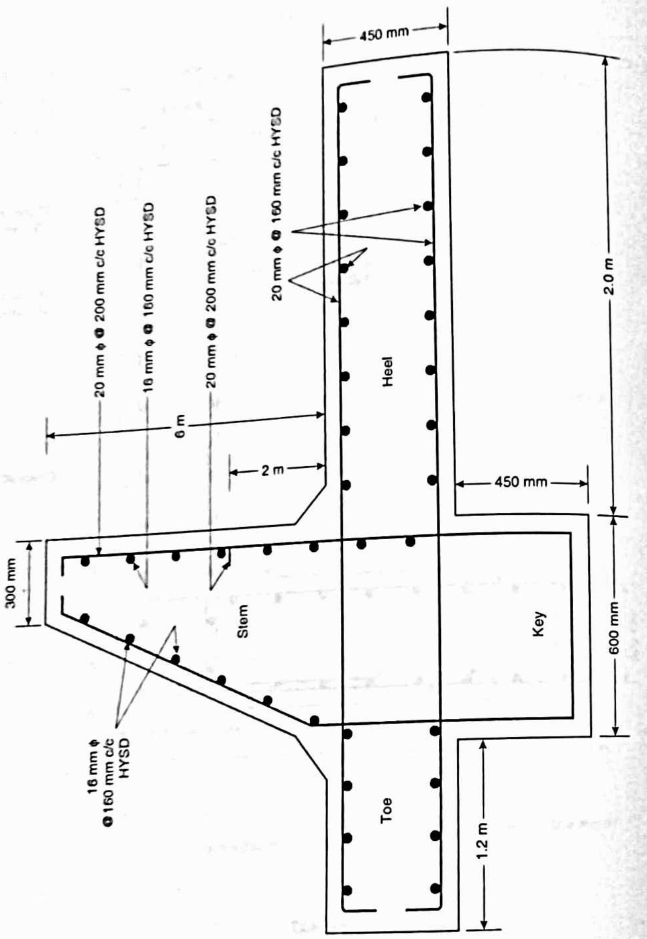


Fig. 4.28

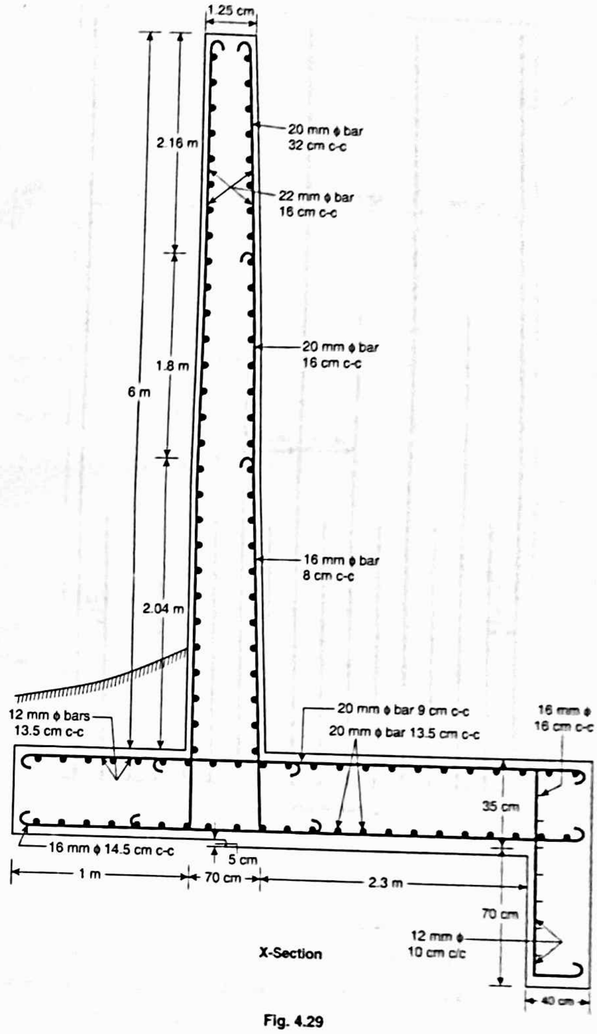
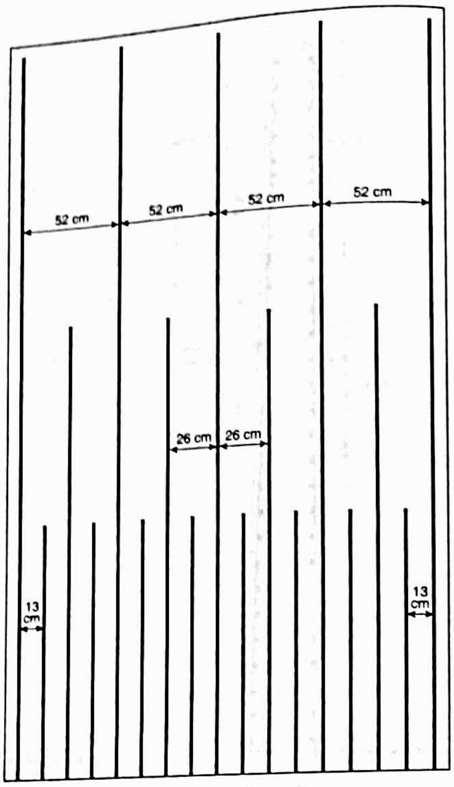


Fig. 4.29



Cantilever type retaining wall

Fig. 4.30

Sheet No. 07

Drawing of Intze Type Water Members and Reinforcement. See fig. 4.30 and 4.31.

Exercise : **Design of Intze water tank**

Name of work :

1.	Tank capacity		1000000 Ltr.	1000 m^3	1.00 mtr
2.	Height of tower from G.L.		16.00 mtr	Foundation from G.L.	0.1 kN/m^2
3.	Live load on Dome		1.50 kN/m^2	Finishes load	10 kN/m^2
4.	Intensity of wind		1.50 kN/m^2	wt of water	250 kN/m^2
5.	Number of columns		8 No.	Bearing capacity of earth	24 kN/m^2
6.	Concrete	M	20	Unit weight	24 kN/m^3
		σ_{cc}	5 N/mm^2	m	13
		σ_{cd}	7 N/mm^2	Q	0.897
6.	Steel HYDS	f_y	415	Tensile stress (Tank)	150 N/mm^2
	Resistance to cracking	σ_{ct}	1.2 N/mm^2	σ_{cb}	1.7 N/mm^2
7.	Nominal coyer		25 mm	Effective cover	40 mm
8.	Depth/dismeler Ratio	I	0.75		
	Top Dome (main/distri.)		8 mm φ	160mm c/c both way	
	Top ring Beam (B_1)		12 mm φ	8 nos.	
	two leg. stimups		8 mm φ	300 mm c/c	

Vertical watt

2 m from top	hoop ring	10 mm φ	190 mm c/c both side
4 m from top	hoop ring	16 mm φ	250 mm c/c both side
8 m from top	hoop ring	20 mm φ	190 mm c/c both side

	2 m from top	Distri. steel 10 mm ϕ	260 mm c/c both side		
	4 m from top	Distri. steel 10 mm ϕ	170 mm c/c both side		
	8 m from top	Distri. Steel 10 mm ϕ	130 mm c/c both side		
Bottom Ring Bear 1			18 Nos.		
	Main	20 mm ϕ	130 mm c/c		
	Distri. Steel	10 mm ϕ			
Conical wall			190 mm c/c		
	Main	25 mm ϕ	130 mm c/c		
	Distri. Steel	10 mm ϕ			
Bottom Spherical Dome Bottom Circular Cirder			6 Nos.		
	Main top	25 mm ϕ	110 Nos.	4	Leg. Stimups
	Vertical stirrups	12 mm ϕ			
	Main bottom	25 mmϕ	5 Nos.		
	Vertical Stimpus	10 mm ϕ	300 mm c/c	2	Leg Stimps
Columns Supporting tower			8 Nos.		
	Main	32 mmϕ	300 mm c/c		
	Lateral	10 mm ϕ			
Bracing	Main	25 mm ϕ	4 Nos. at top and bottom		
	Stirrups	10 mm ϕ	300 mm c/c	2	Let. stirrups
Circular Beam for Reft					
	Bottom	25 mm ϕ	6 Nos.		
	top	25 mm ϕ	3 Nos.		
Reft Foundetion slab					
	main	25 mm ϕ	200 mm c/c		
	Distribution	12 mmϕ	180 mm c/c		

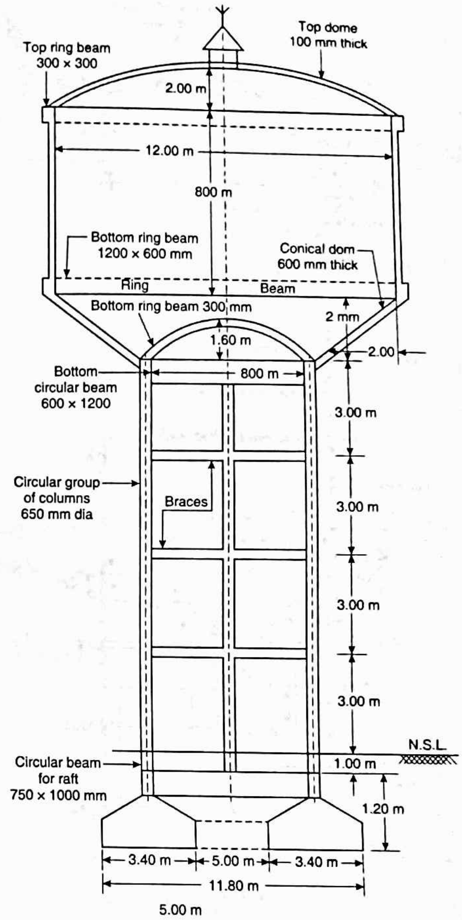


Fig. 4.31

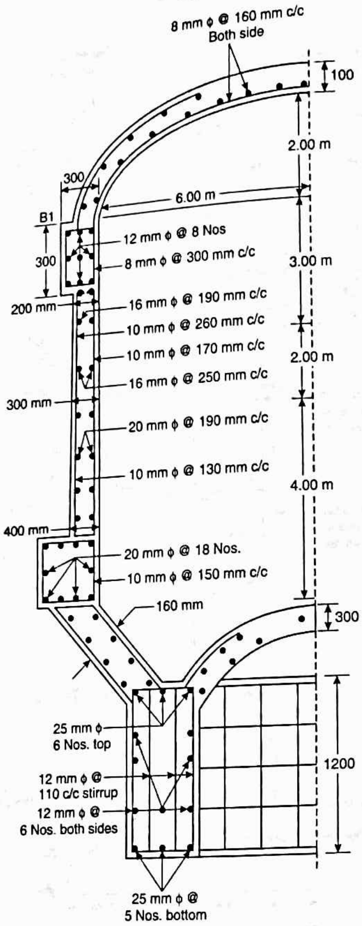


Fig. 4.32

5 MISCELLANEOUS DRAWING SHEETS

Doubly Reinforced Beam

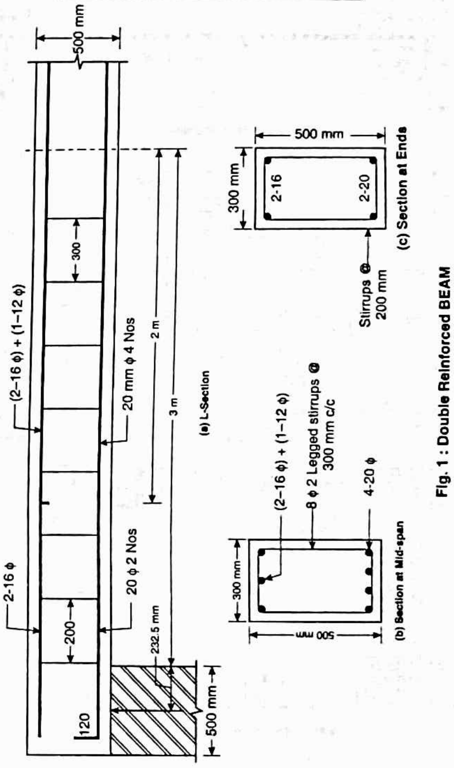


Fig. 1 : Double Reinforced BEAM

TWO WAY SLAB

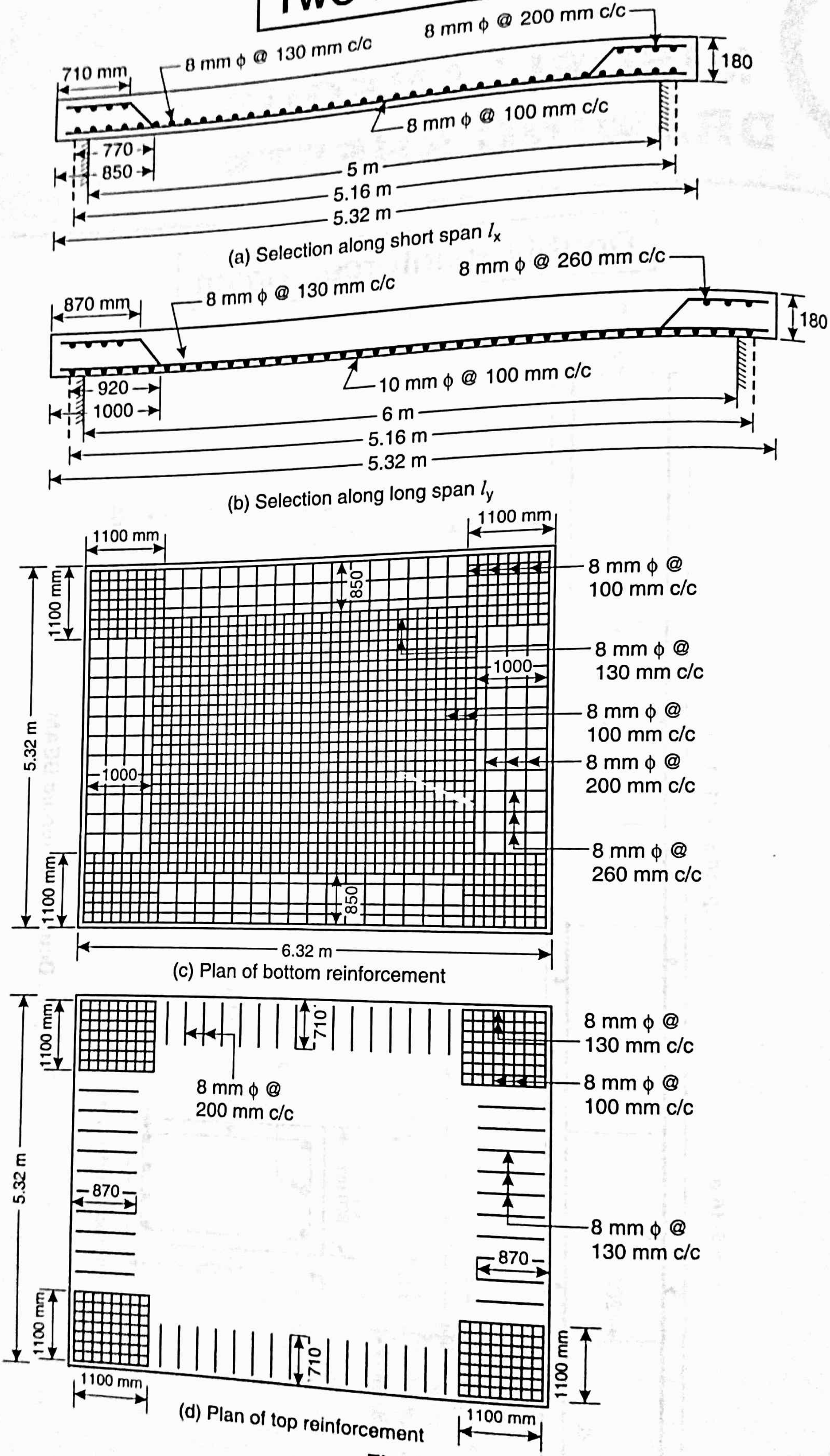


Fig. 2

Stair Case

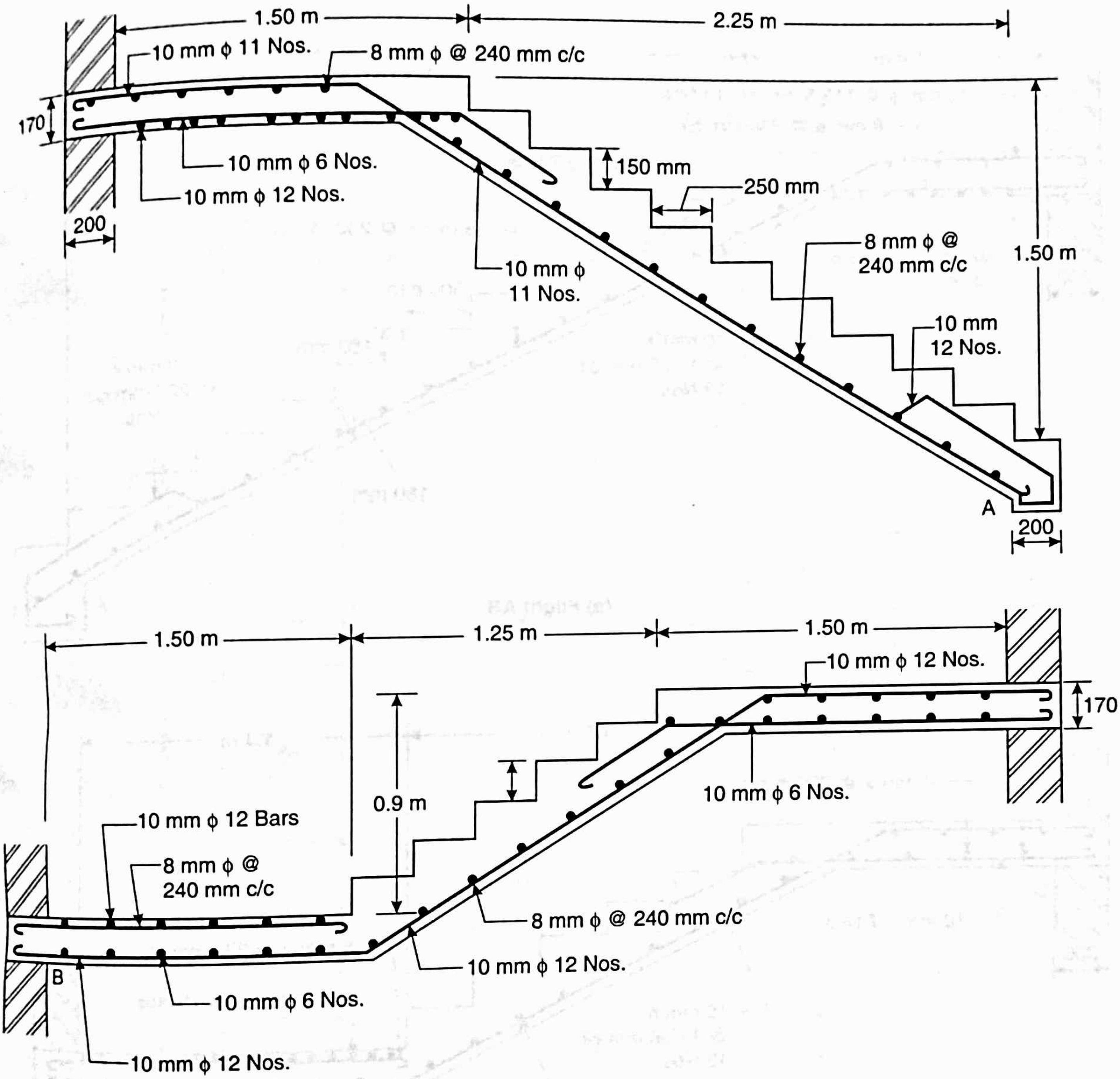
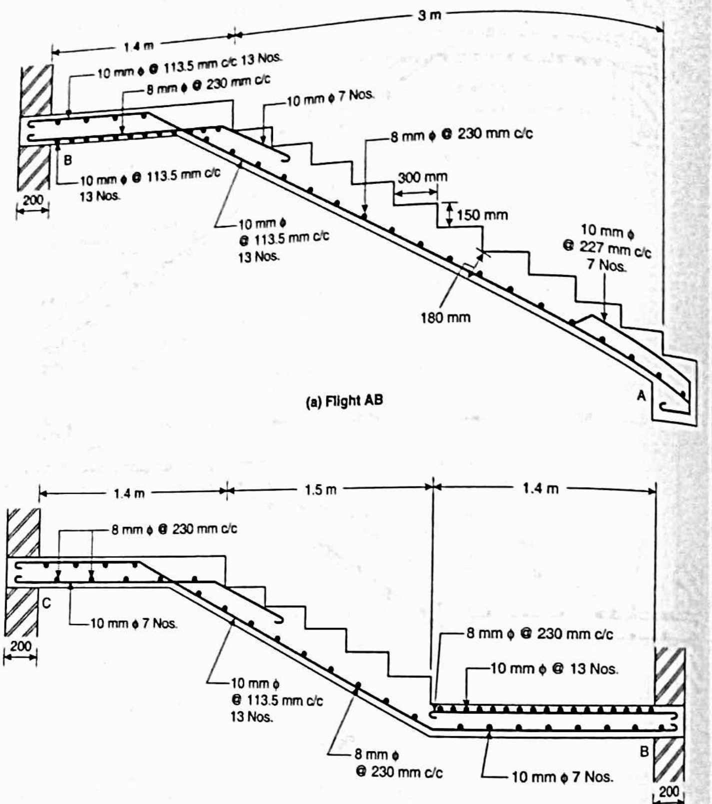


Fig. 3

Stair Case

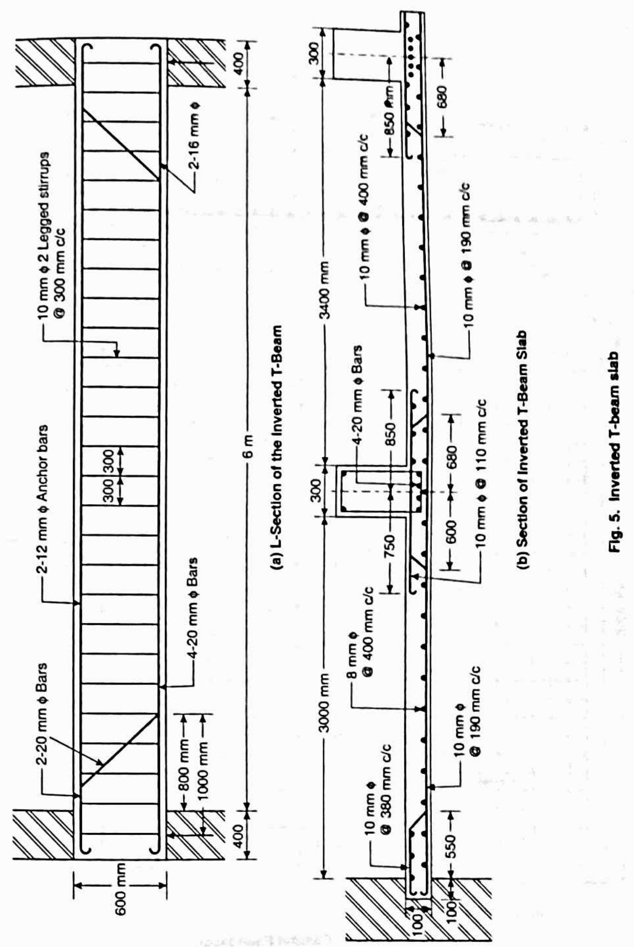


(a) Flight AB

(b) Flight BC

Fig. 4

L-Section of Inverted T-beam slab



Column Foundation

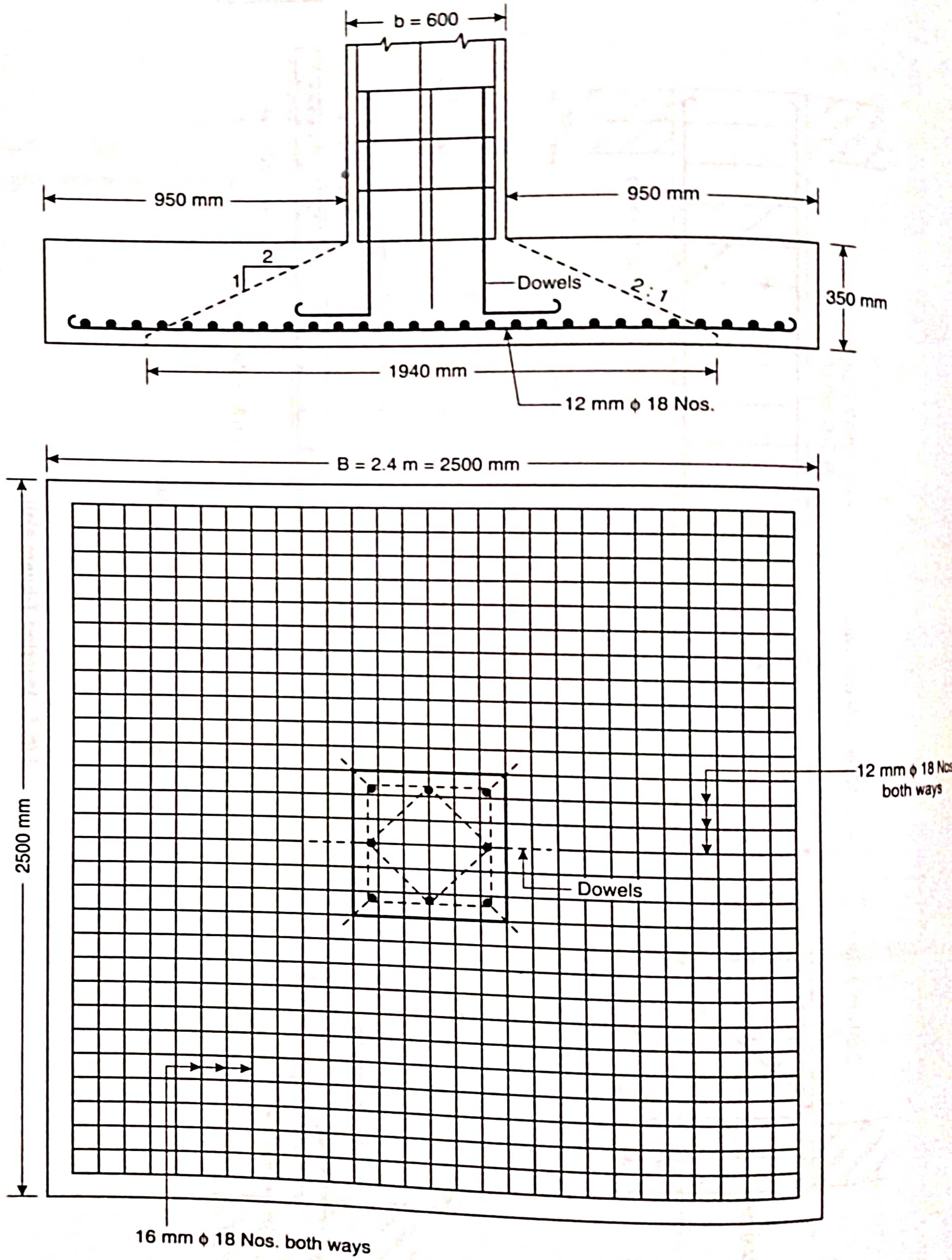


Fig. 6. Column Foundation

Circular Column Foundation

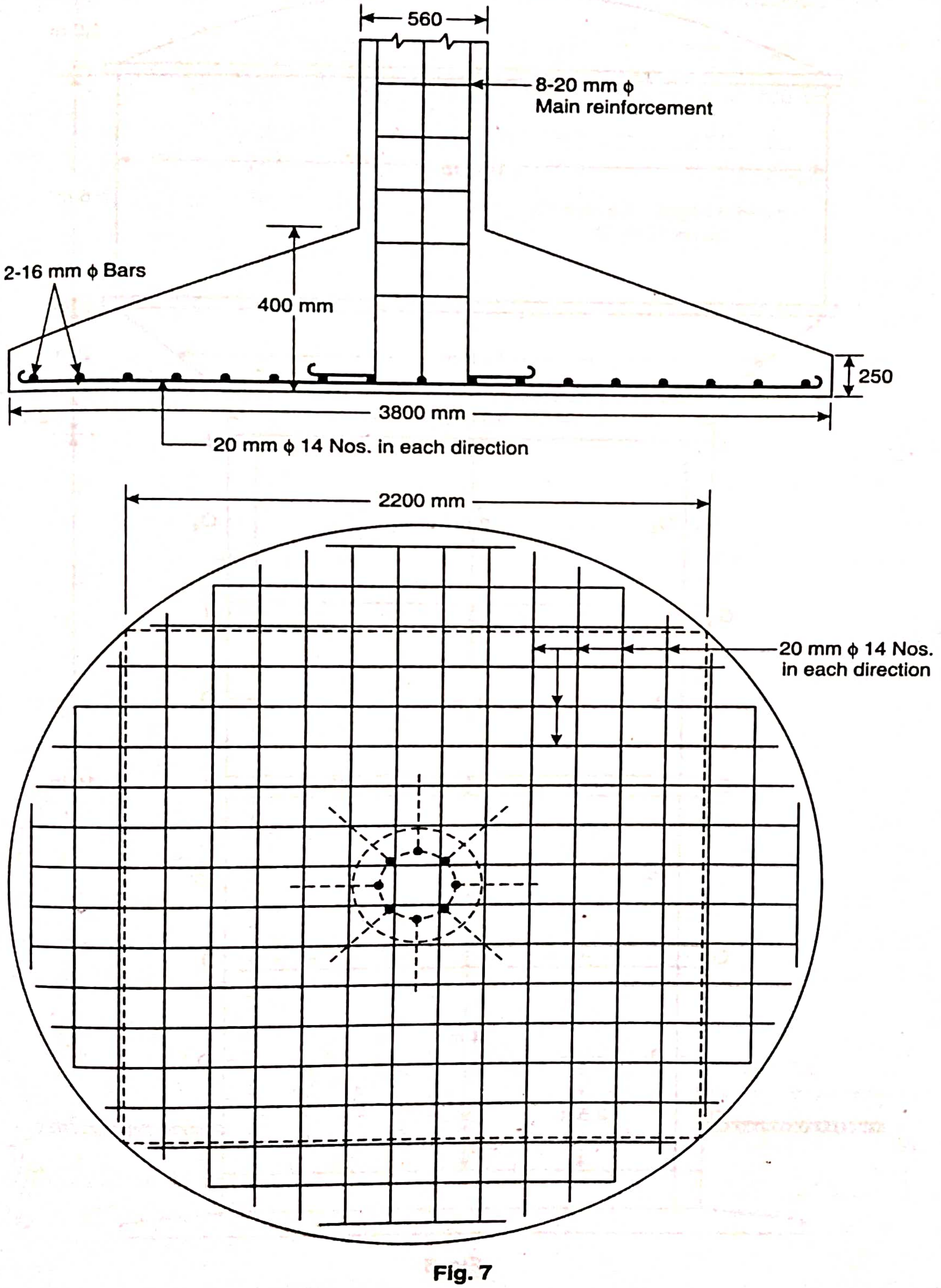


Fig. 7

RCC Over Head Tank

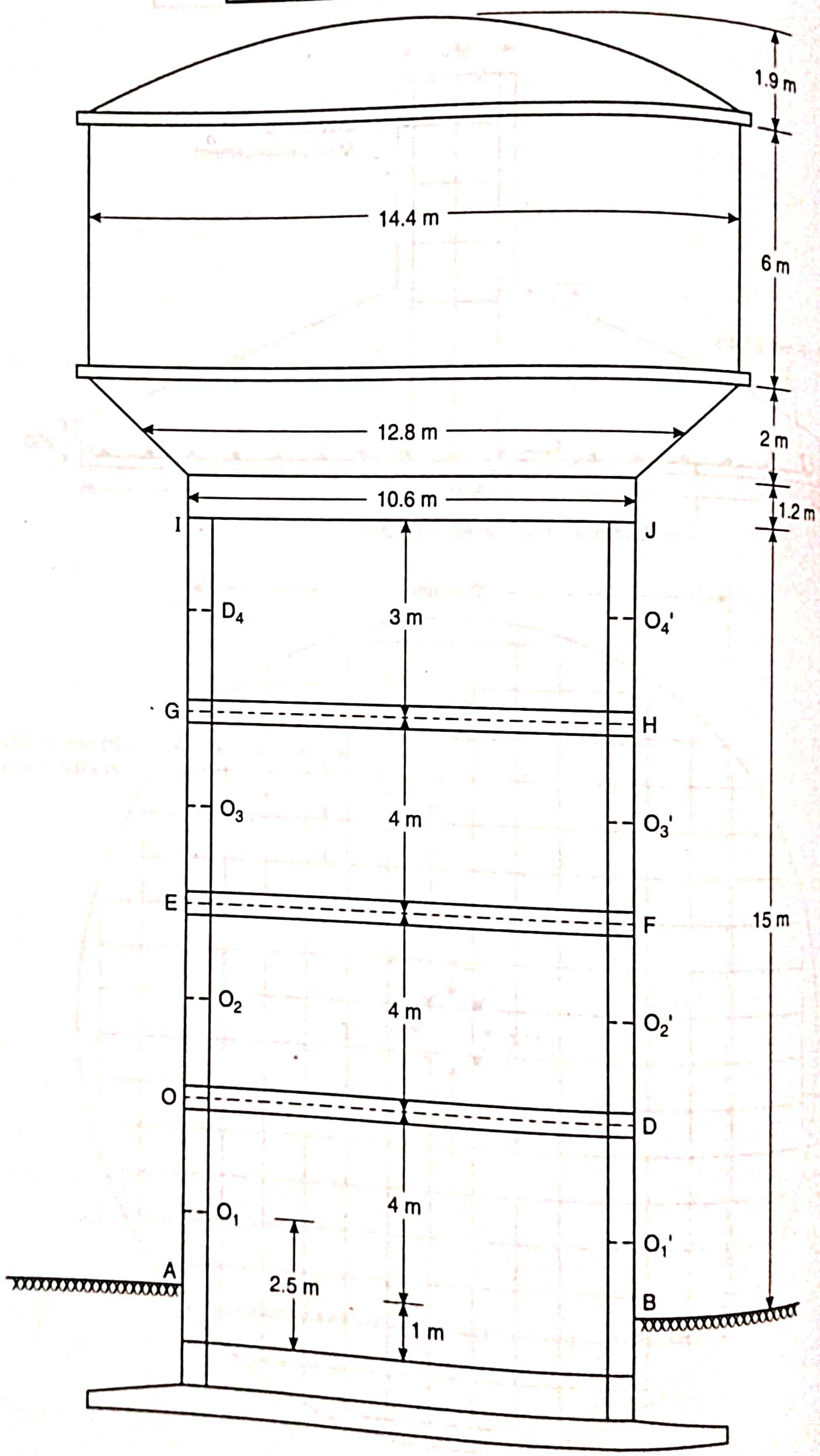


Fig. 8

Portal Frame

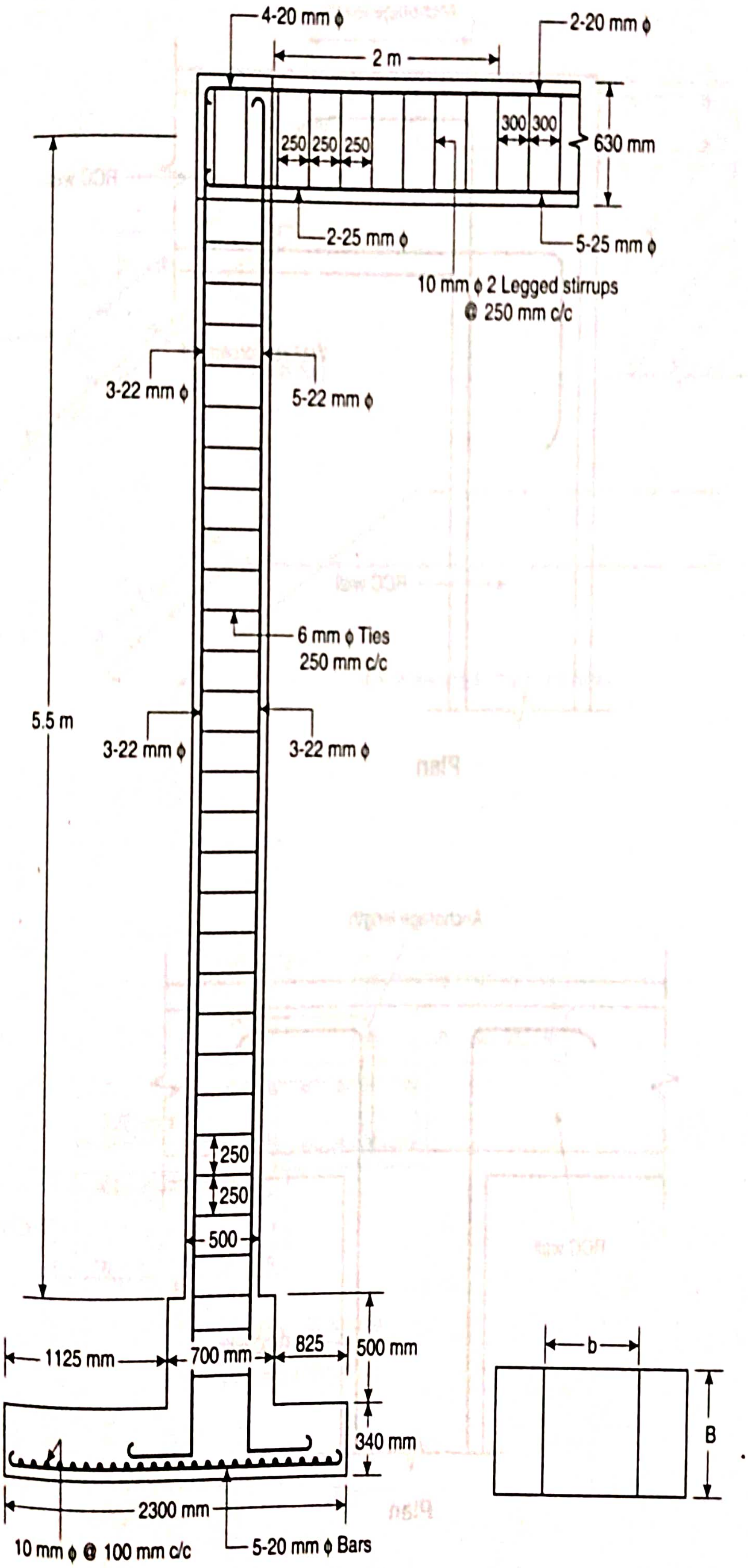
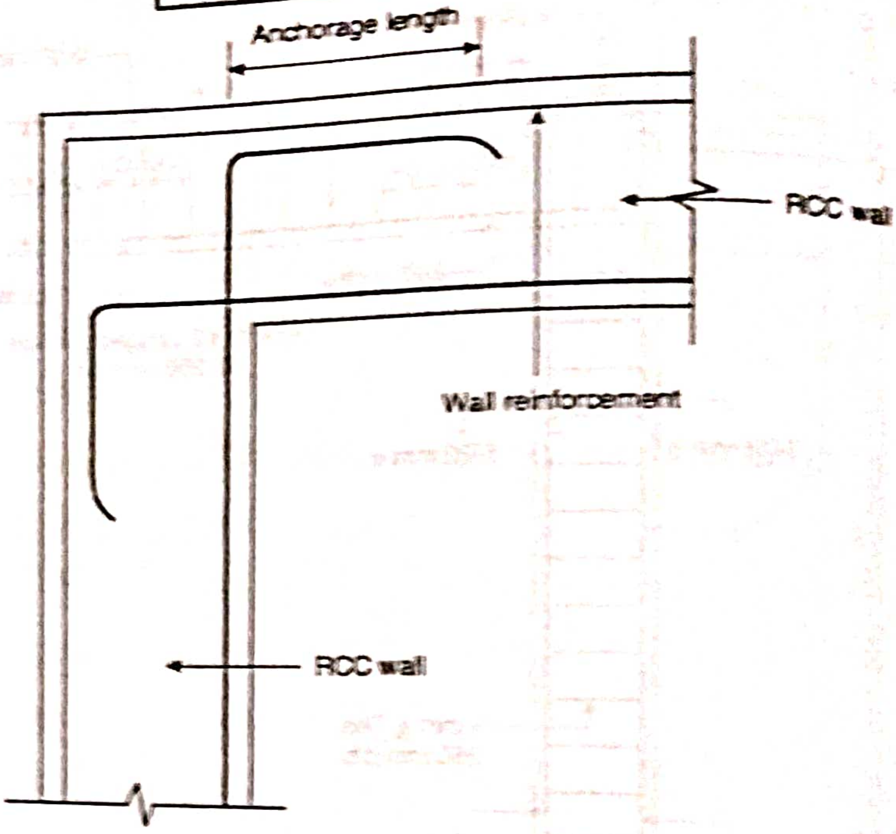
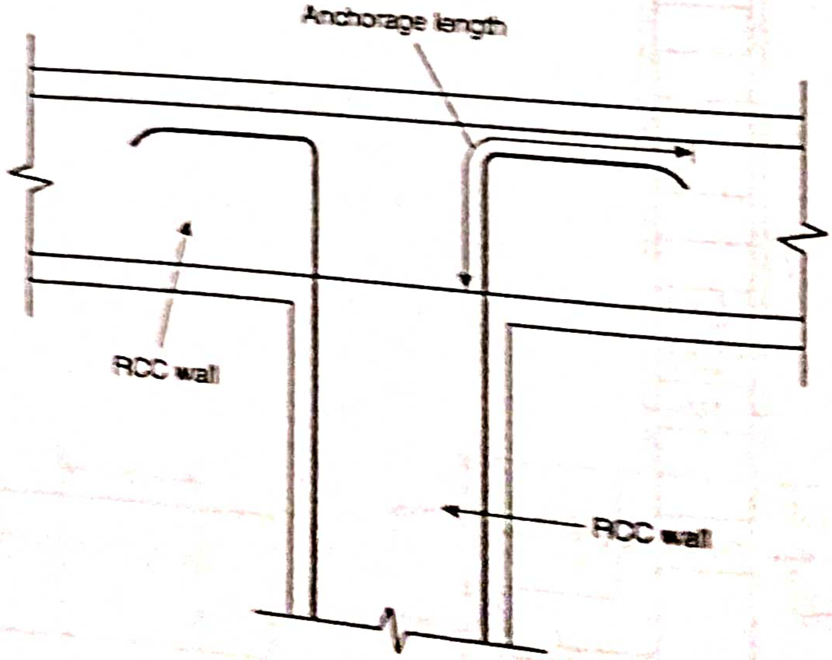


Fig. 9

Anchorage Length



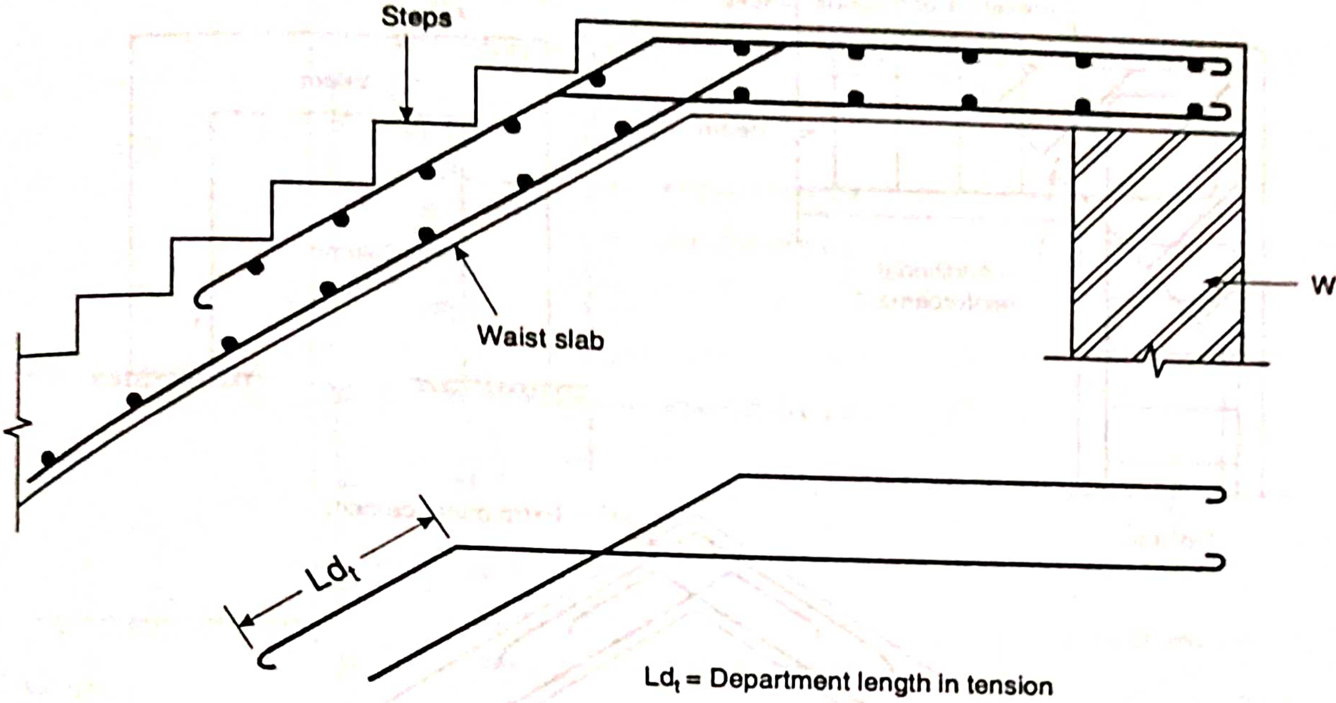
Plan



Plan

Fig. 10

Stair Case Reinforcement



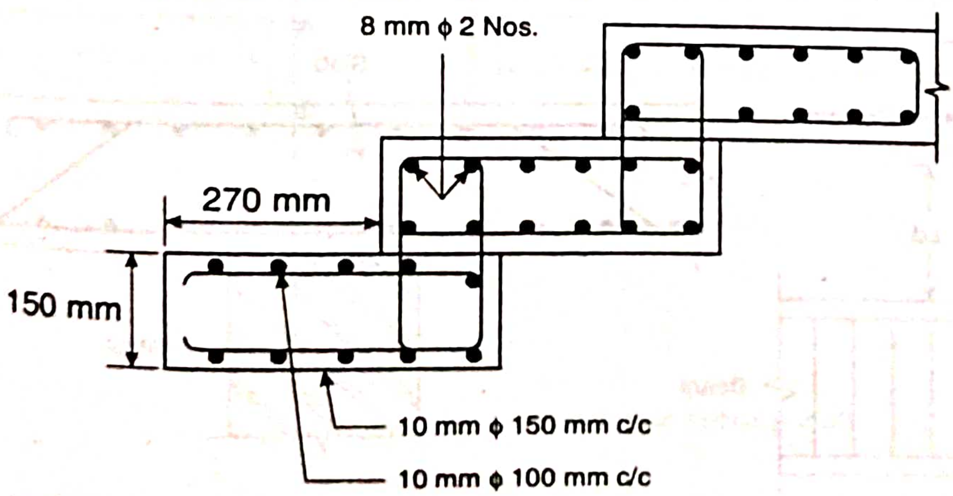
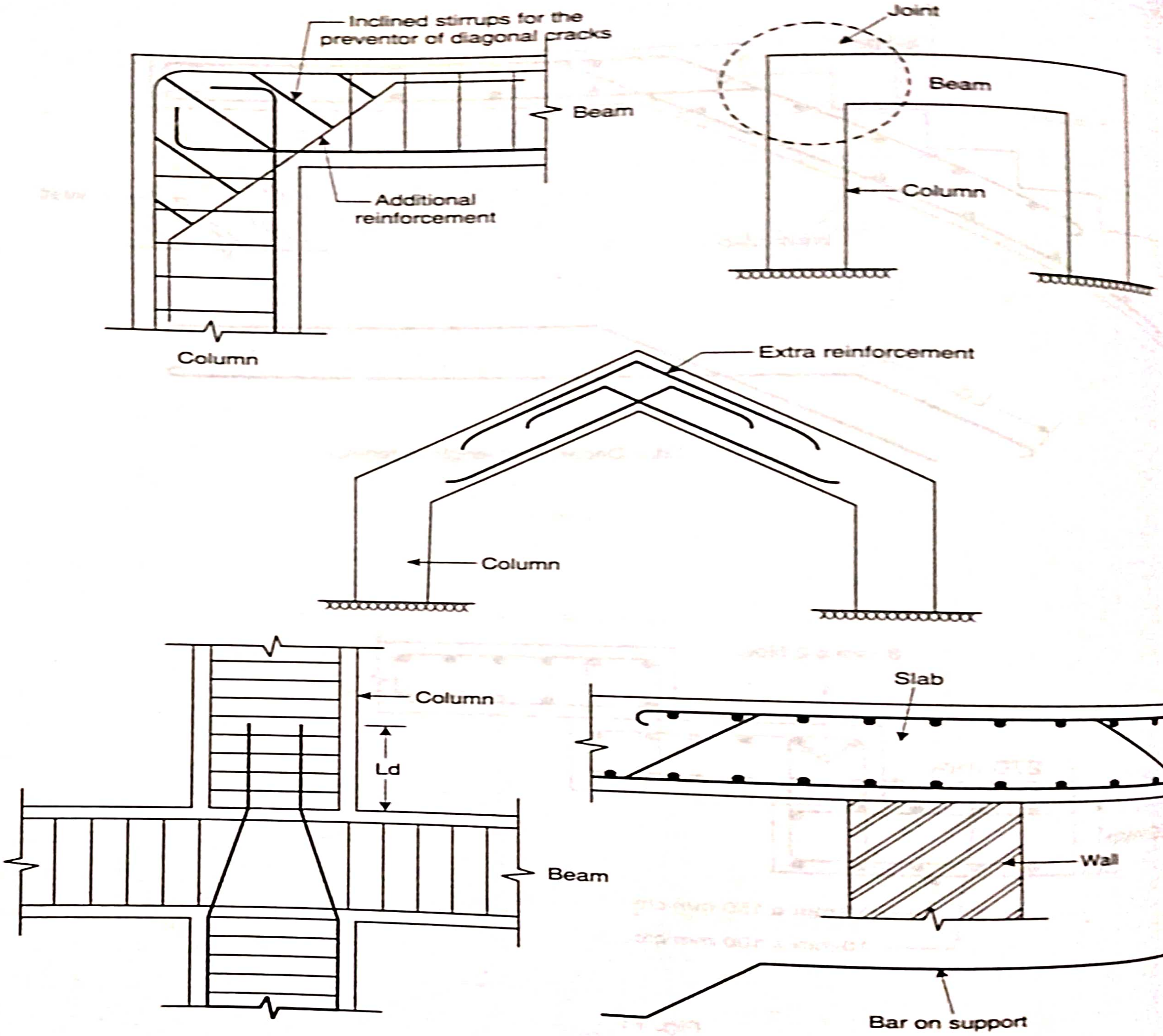


Fig. 11

Beam and Column Junction



Slab Support

Fig. 12

Cantilever Retaining wall

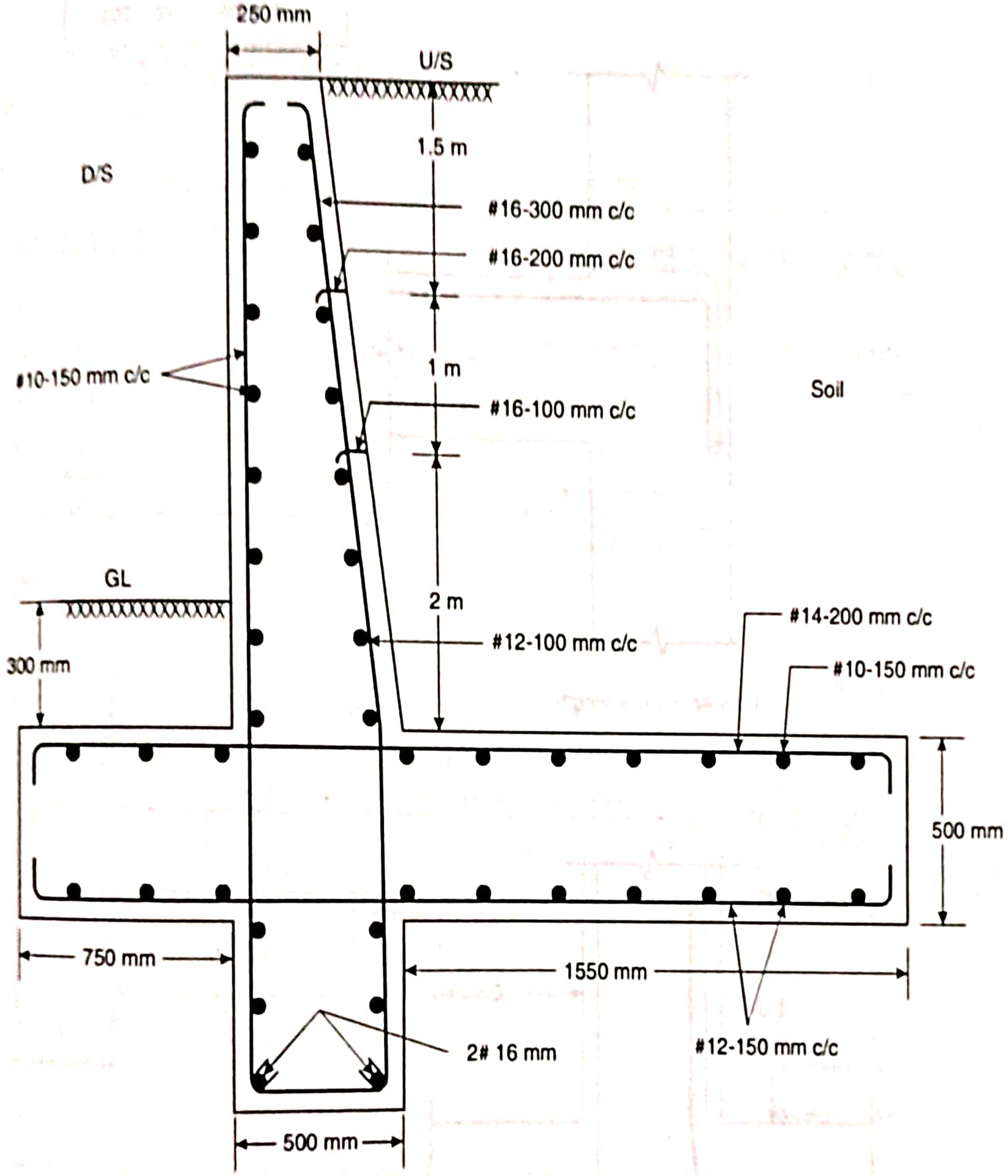
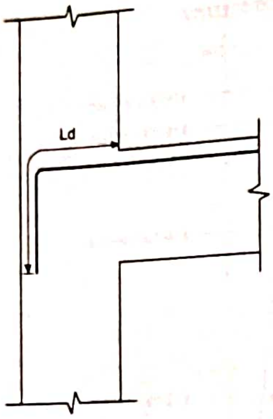
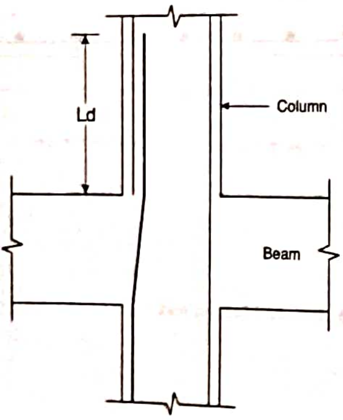


Fig. 13. Cantilever Retalng Wall

	M20	M25	M30
Ld_t =	47φ,	40φ,	38φ
Ld_c =	38φ,	32φ,	30φ



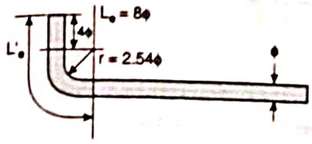
Ld = Anchorage length

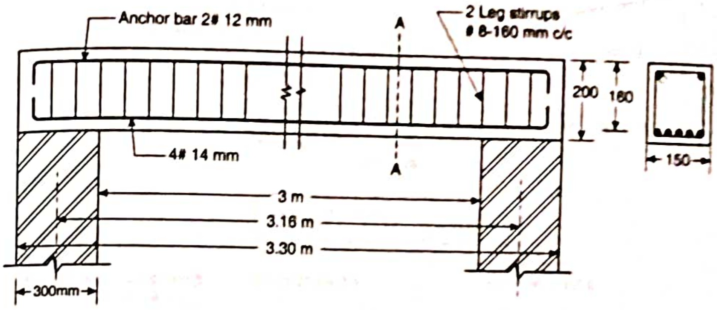


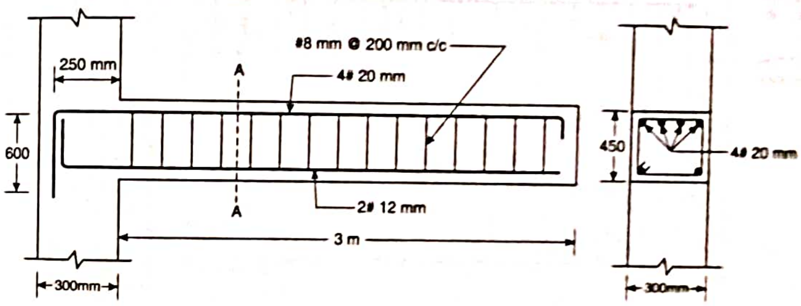
Ld = Anchorage length

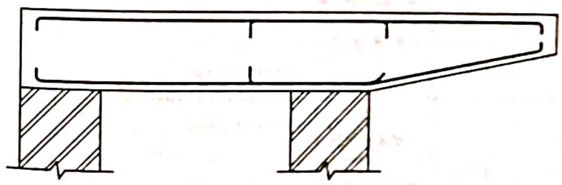
Fig. 14

Singly RCC Beam









Lapping Bars in Cantilever Beam

Fig. 15

Lintel Sunshade

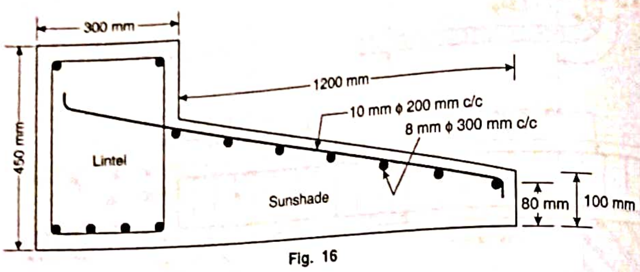


Fig. 16

Double RCC Beam

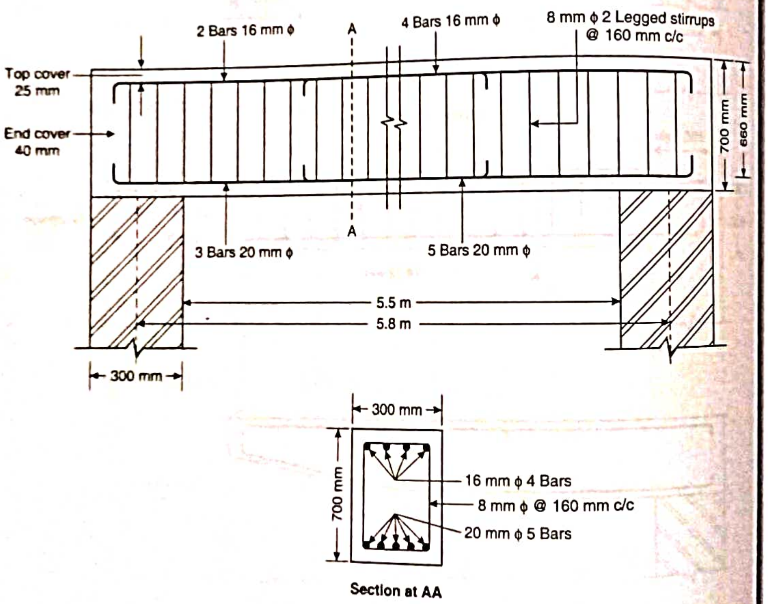


Fig. 17

Singly RCC Beam

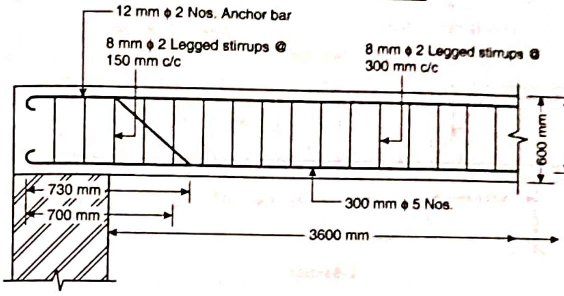


Fig. 18

RCC Slab

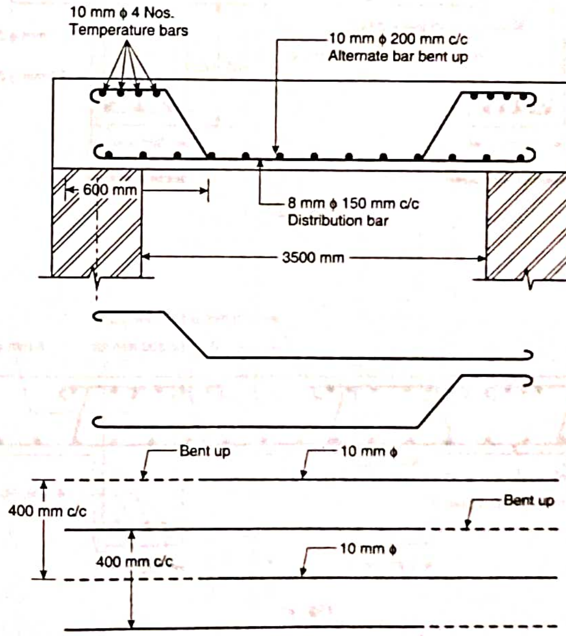
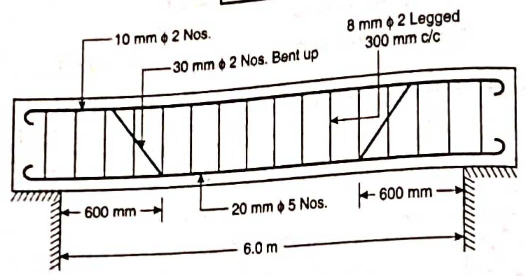
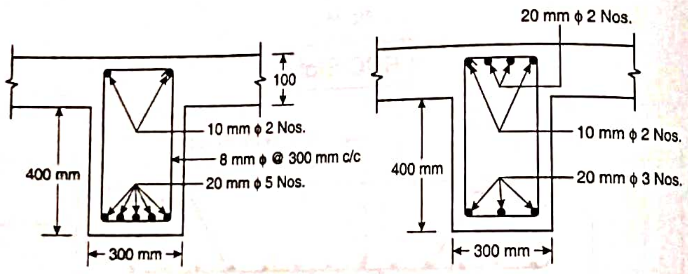


Fig. 19

T-Beam



L-Section



Section at Mid Span

Section at End

Fig. 20

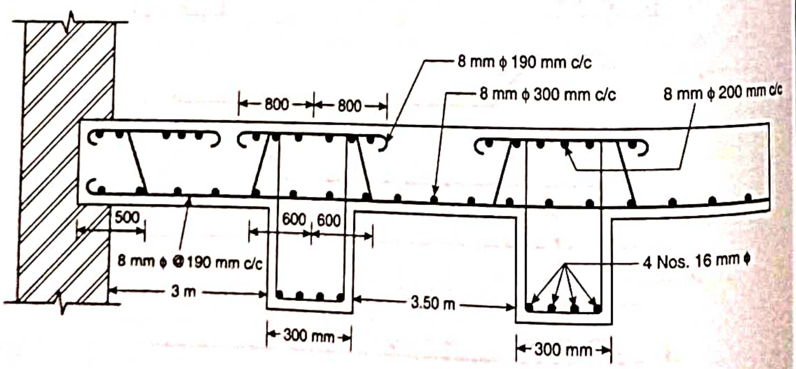
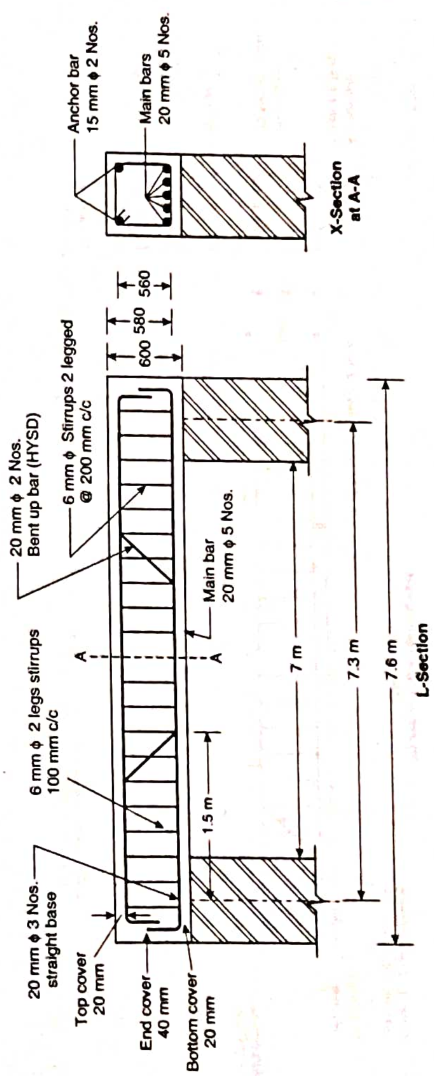


Fig. 21

Singly Reinforced Beam



L-Section

Singly Reinforced Beam

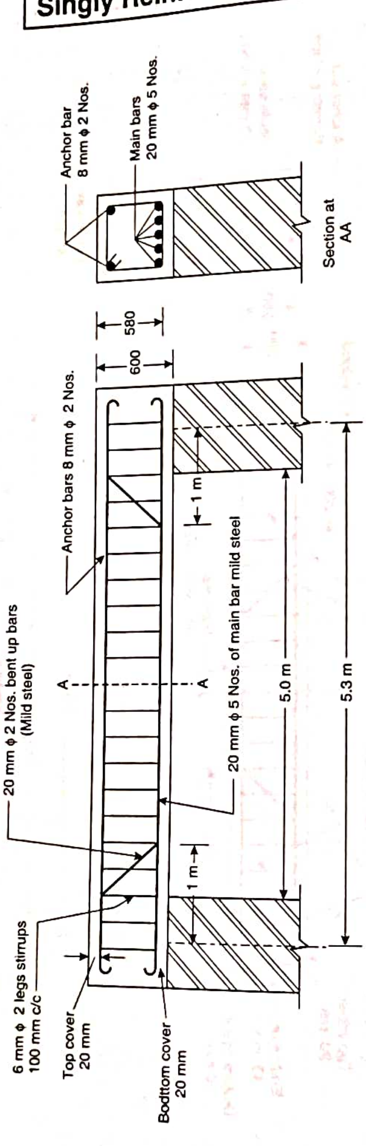


Fig. 23

Singly Reinforced Beam

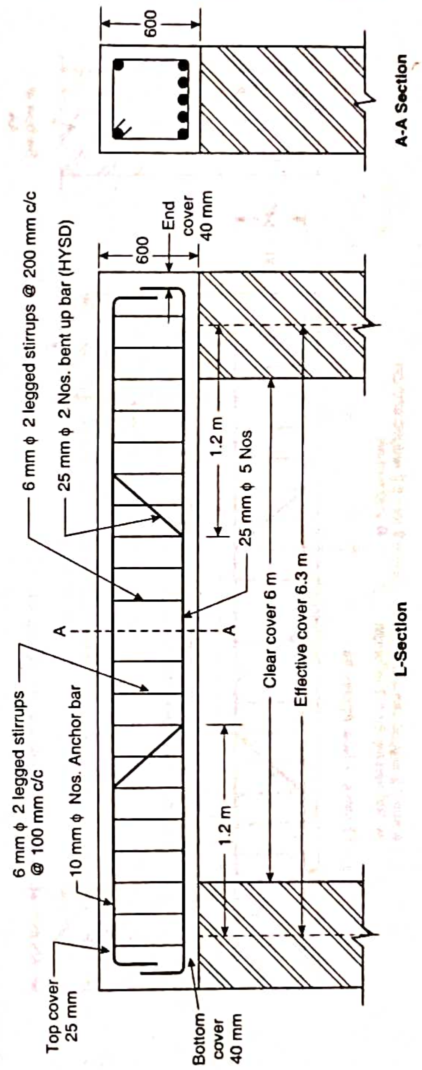


Fig. 24

Singly Reinforced Beam

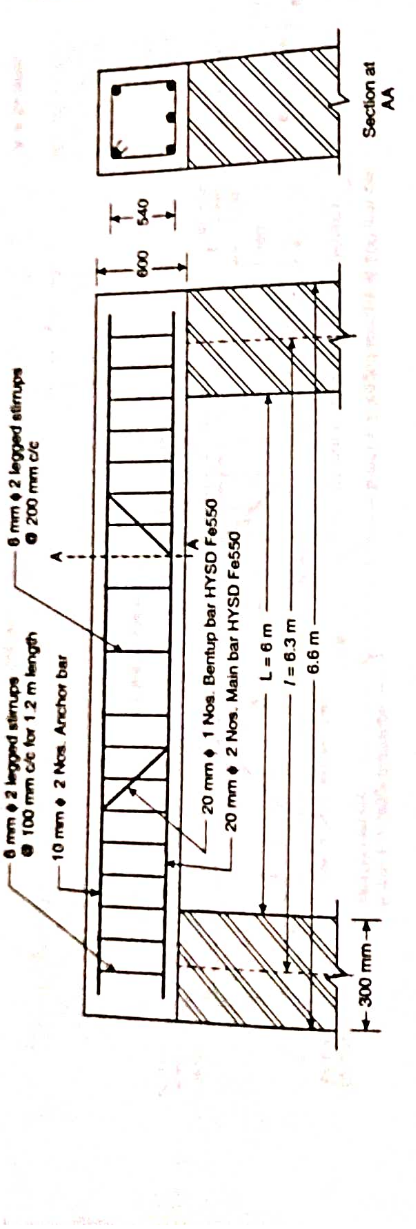


Fig. 25

Singly Reinforced Beam

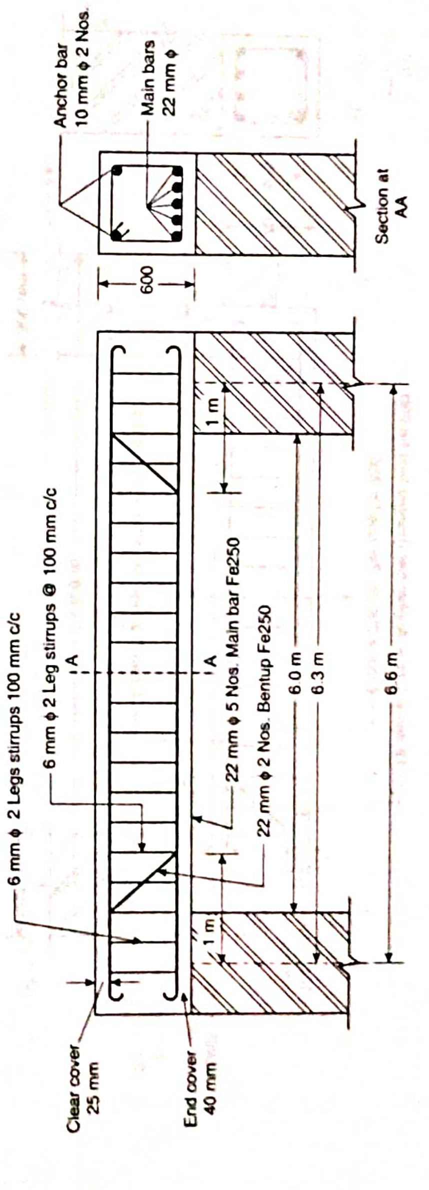


Fig. 26

Singly Reinforcement Beam

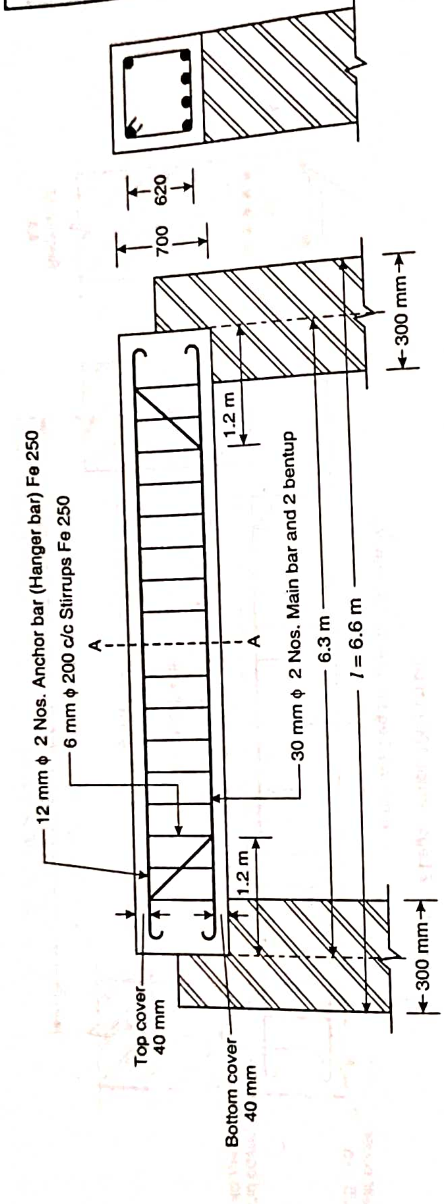
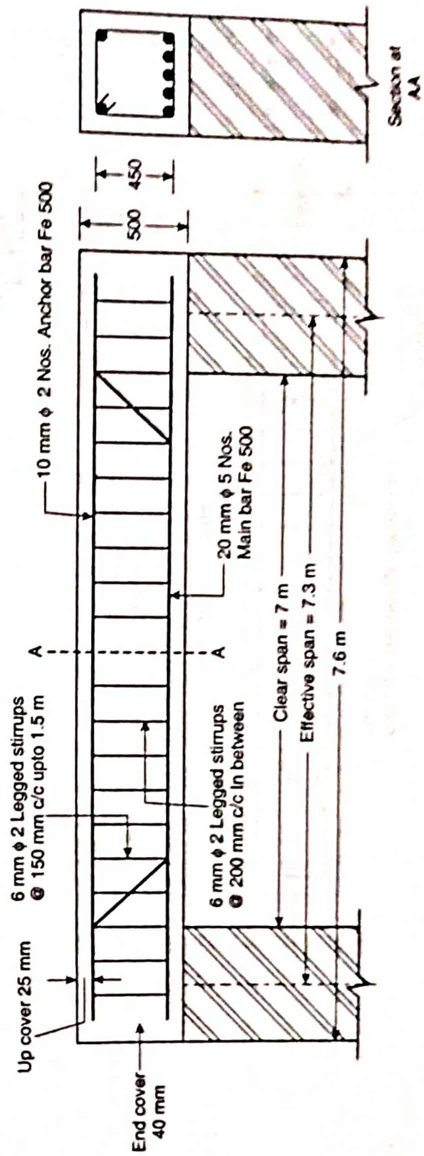


Fig. 27

Singly Reinforcement Beam



Singly Reinforcement Beam

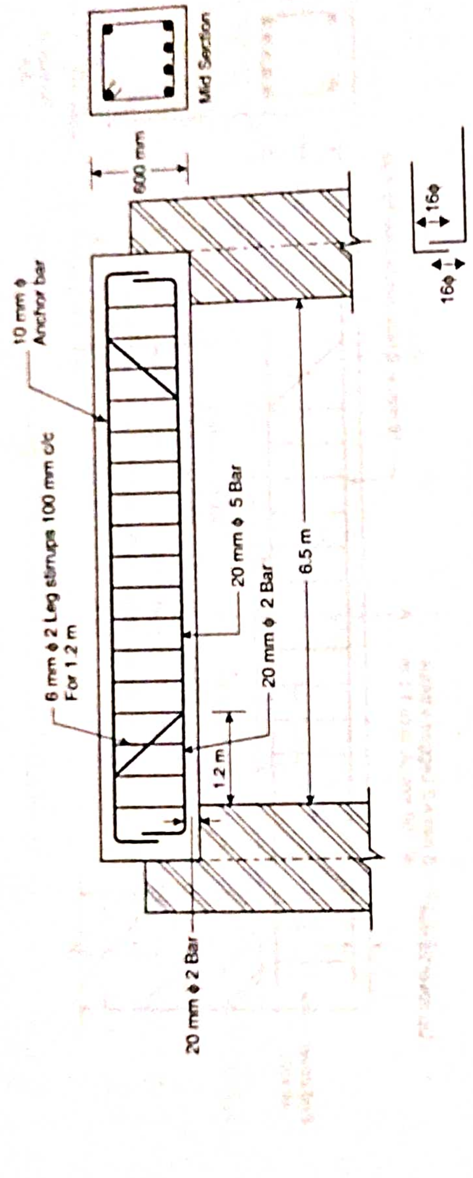
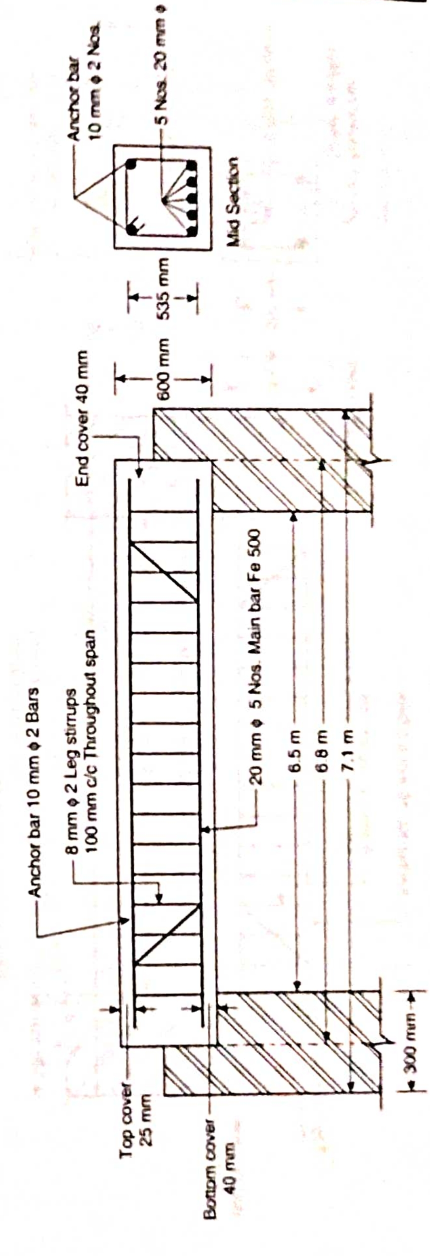


Fig. 29

Singly Reinforcement Beam



Singly Reinforcement Beam

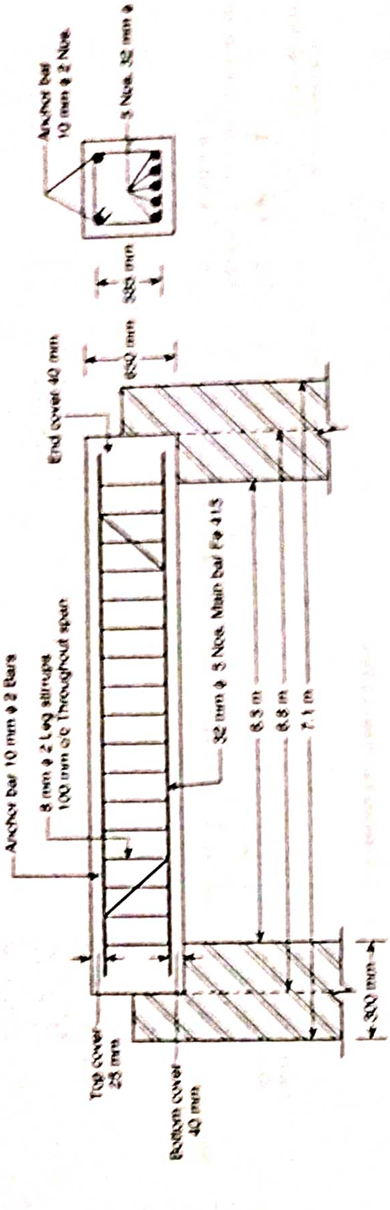


Fig. 31

Doubly Reinforced Beam

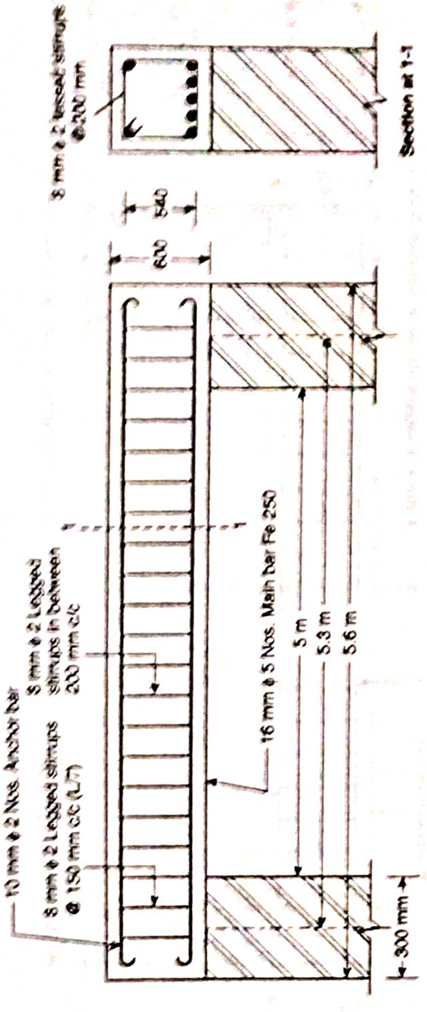


Fig 32

Doubly Reinforced Beam

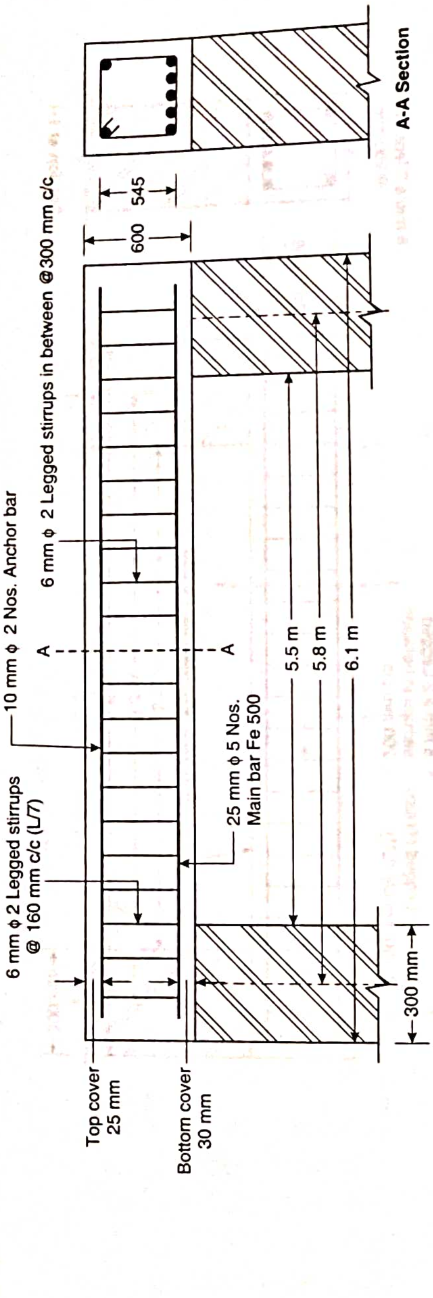


Fig. 33

Doubly Reinforcement Beam

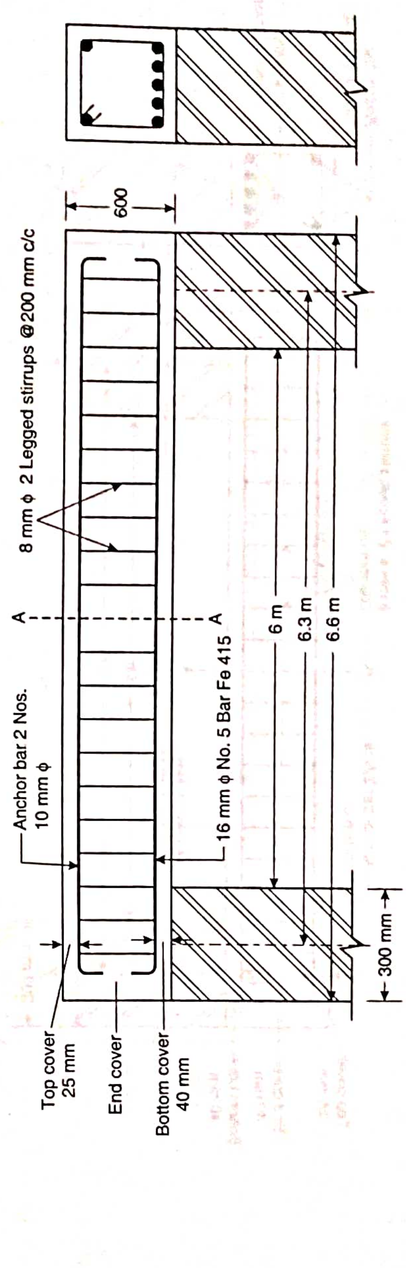


Fig. 34

Doubly Reinforced beam

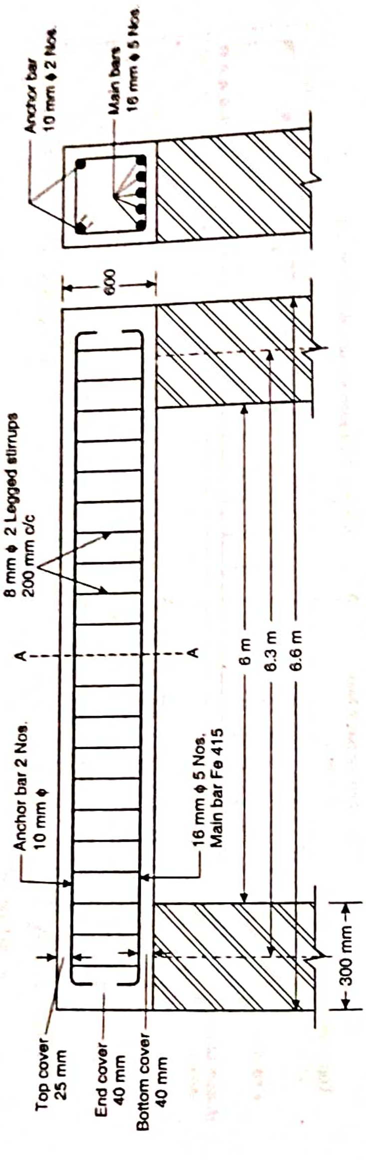
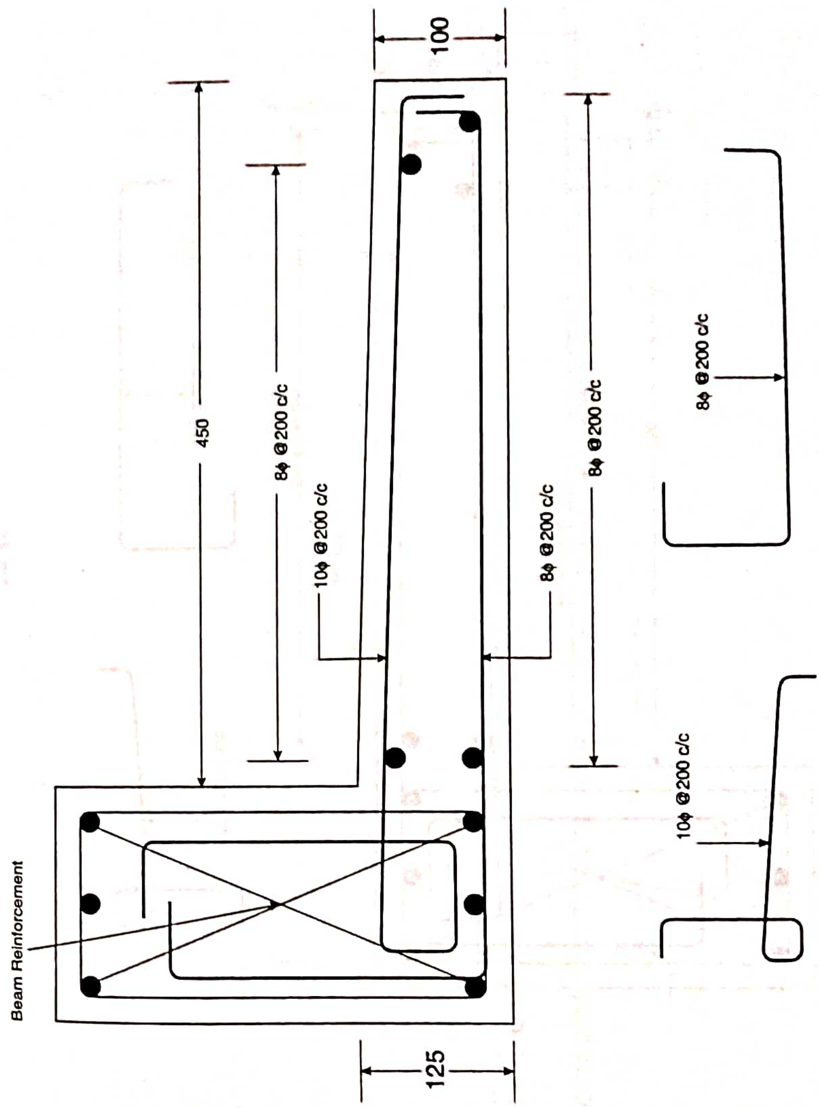


Fig. 35

Typical Sunshade Detail For 450mm Wide Sunshade



Typical Sunshade Detail For 750mm Wide Sunshade

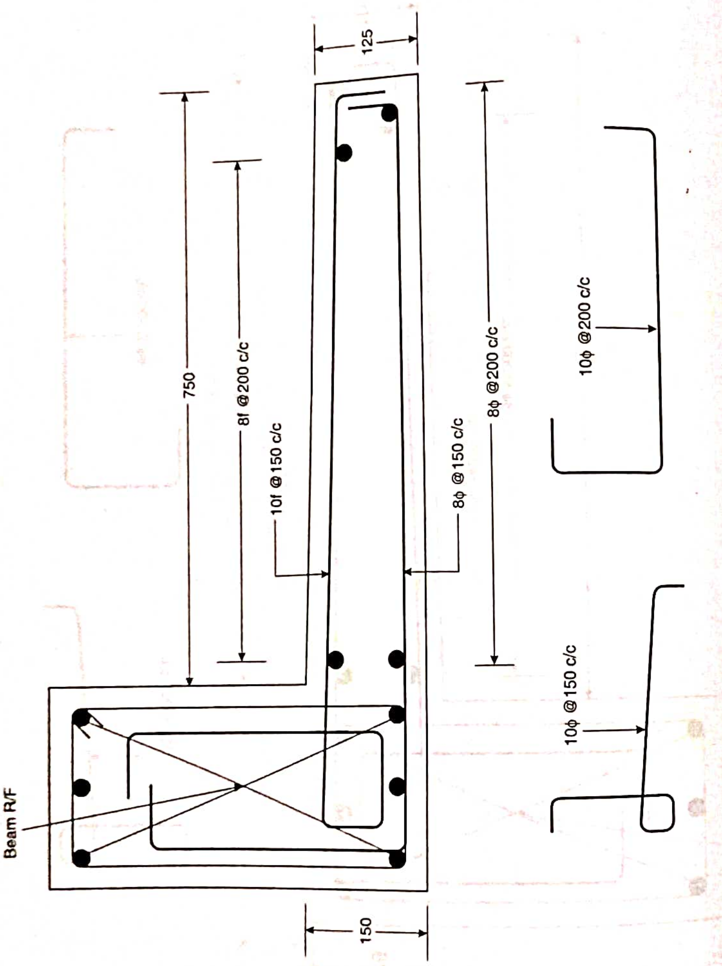


Fig. 37

Typical Detail For Splicing of Column Reinforcemen

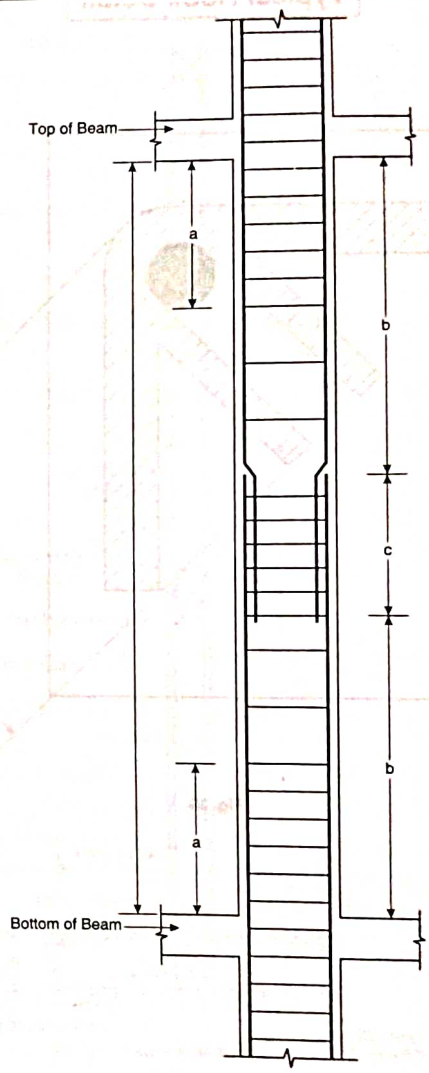


Fig. 38

Typical Hook Detail

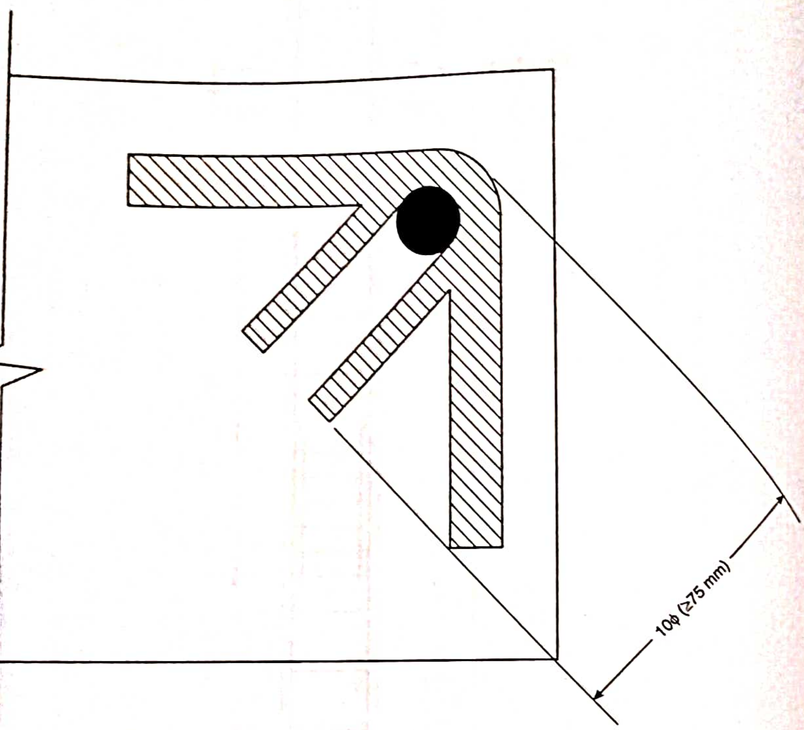
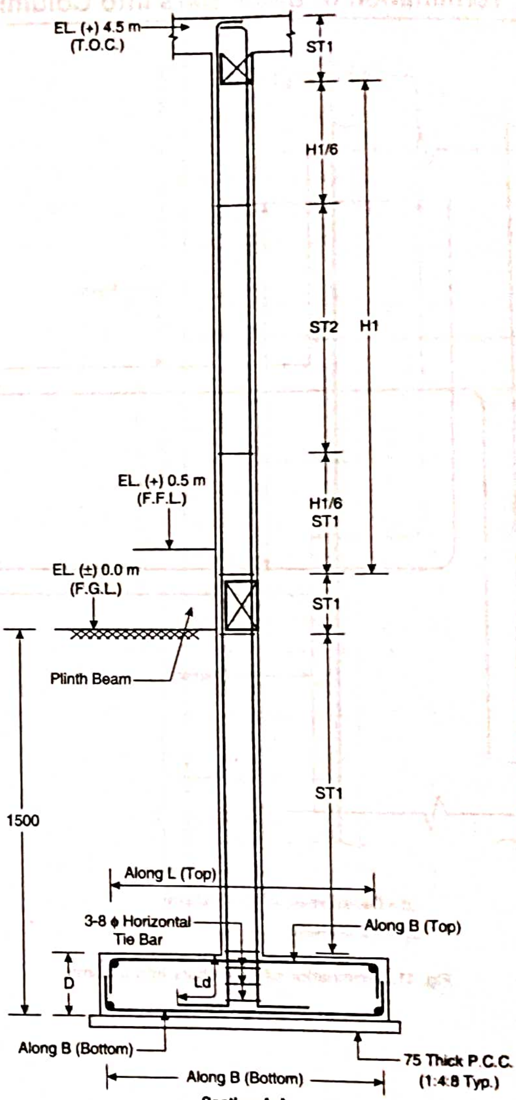


Fig. 39

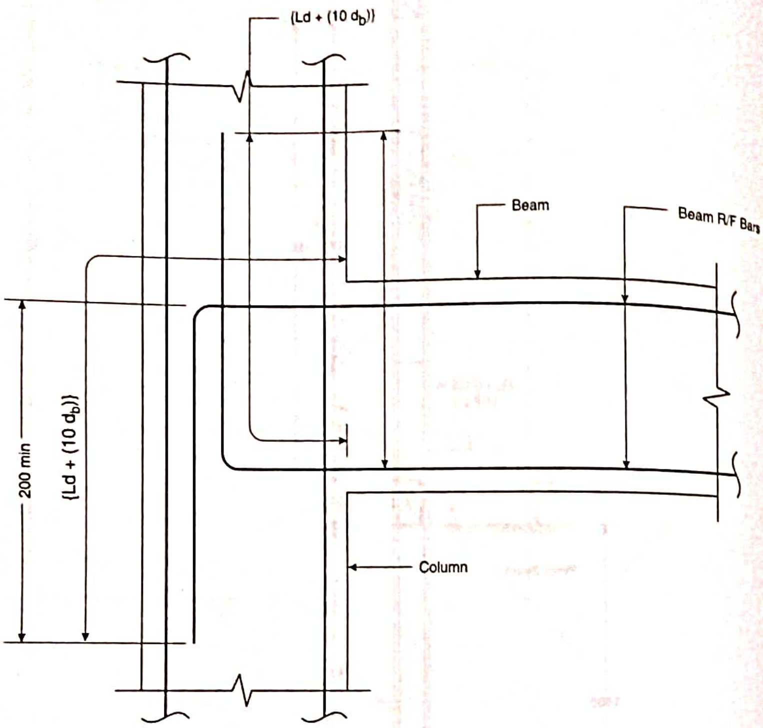
Detail of Column



Section A-A

Fig. 40

Termination of Beam Bars into Column



Ld = Development length in tension
d_b = Bar diameter

Fig. 41. Termination of Beam bars into Column

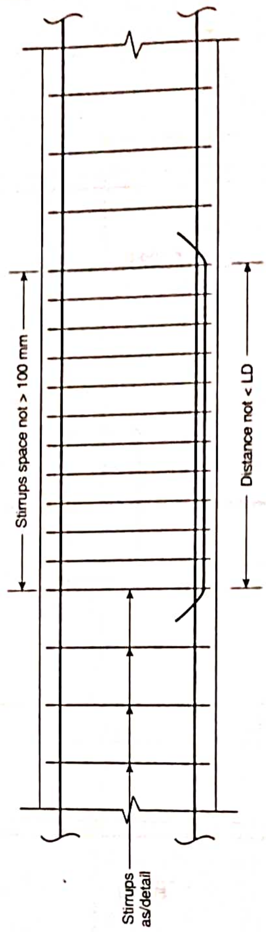


Fig. 42

Detail of Isolated Footing

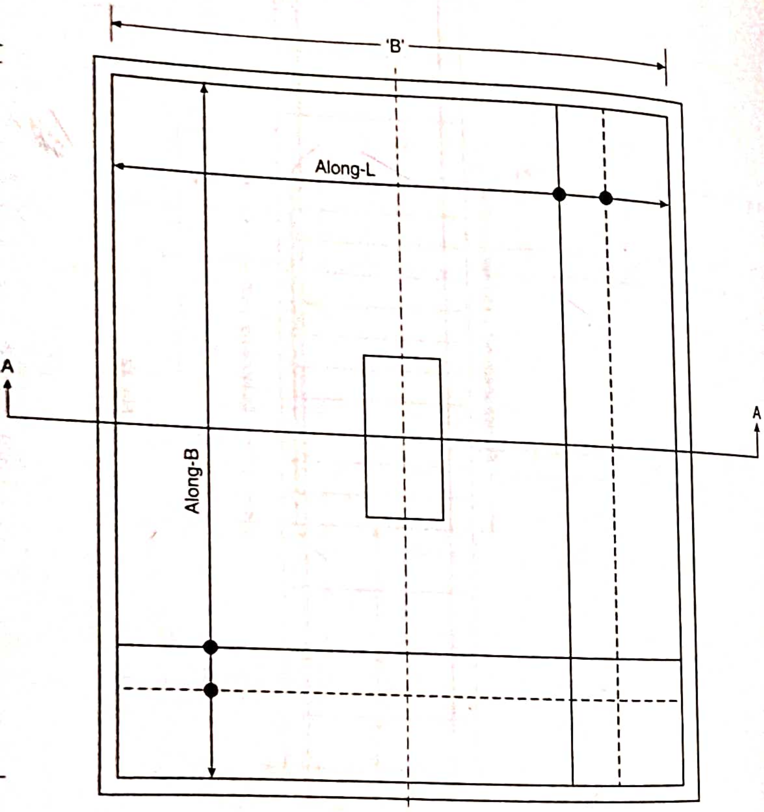
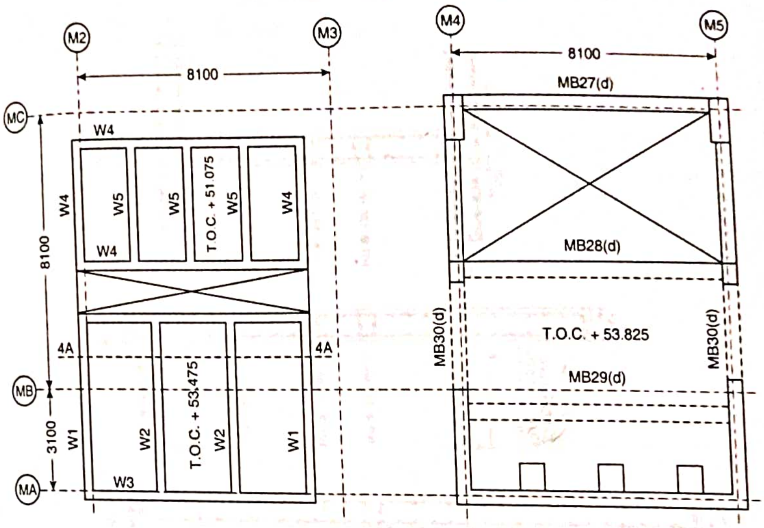


Fig. 43

OHT and Machine Room roof Plan



OHT and Machine Room Roof Plan

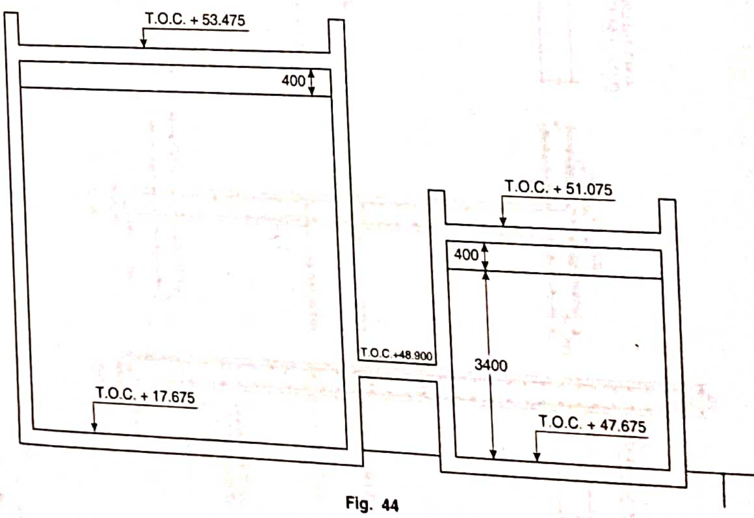


Fig. 44

Beam with RCC Wall