DOTE TAMILNADU
Directorate of Technical Education
Government of Tamil Nadu

CIVIL ENGINEERING DRAWING - II

DIPLOMA IN CIVIL ENGINEERING

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Untouchability is a sin

Untouchability is a crime

Untouchability is a inhuman

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PREFACE

We are in much happiest occasion to present CIVIL ENGINEERING DRAWING - II book for Diploma in Civil Engineering under Directorate of Technical Education, Tamil Nadu. An attempt has been made in this text learning material to meet the requirements and standards of M-Scheme curriculum of Civil Engineering Drawing -II of Fifth Semester Diploma in Civil Engineering prescribed by DOTE.

It is important to every Civil Engineer to have knowledge of public health engineering drawings, bridge drawings and structural drawings. This book deals about public health engineering drawings in first part, bridge drawings in second part and structural engineering drawings in the third part.

It is hoped that with the content exposed in this text, the readers and learners will be able to understand and pursue further in their studies. This book is written in simple and easily understandable manner.

The convener, authors and reviewer are very much grateful to the Commissioner of Technical Education Chennai for his deep involvement and encouragement in preparing this syllabus based learning material. Thanks are due to officials of DOTE, Chennai for their timely help whenever needed. Further suggestions and fair criticisms are welcome for fine tuning in future

CONVENER, AUTHORS and REVIEWER

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11. Doubly reinforced Continuous beam with two spans

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13. Dog-legged staircase

14. Lintel cum Sunshade

15. R.C.C Column with square Isolated footing

1. INFILTRATION GALLERY (WITH ONE INFILTRATION WELL ONE STRAIGHT GALLERY PIPE, ONEINSPECTION WELL AND ONE JACK WELL)

If a perennial river is running nearer to the town, the infiltration gallery is one of the cheapest sources of water supply for a town. The water from Infiltration Gallery does not require any treatment except chlorination.

The infiltration gallery consists of infiltration well, inspection well and jackwell.

Infiltration Well

Infiltration wells are shallow wells which are constructed in series along the banks of the rivers. The water will be collected into the wells by seeping through their bottom. The wells are covered at top and open at bottom so water can be easily entered through its bottom. The sides of the wells are constructed by brick masonry with open joints. The water which received through the filtration well is very pure. Sandy beds are placed at the bottom of the tank. So that the suspended impurities and inorganic impurities get filtered.

Inspection Well

Inspection wells are also called man holes. For inspection purpose man holes are provided. Inspection wells are provided at an interval of 30m to 50m.

Jack Well

The infiltration wells are connected by porous pipes to a collecting sump known as jack well. The water thus collected through the infiltration wells flows by gravity into the jack well. Then the water from the jack well is pumped to the purification plant for further treatment.

The following particulars of an infiltration gallery are.

River bed level	- + 100.000m
River bank level	- + 104.50m
Inner diameter of infiltration well	- 4m
Outer diameter of infiltration well	= 4.80m
Number of infiltration well	= 1
Maximum flood level (MFL)	= 103.0m
Lowest summer water level (LSWL)	= + 98.20m
Invert level of stone water pipe	- + 94.00
Diameter of stone water pipe	- 0.40m
Length of gallery pipe	- 50m
Width of gallery	- 1.80m
Cover Slab Thickness	- 100mm

Filter media

Layer of filter media adjacent to the pipe 200mm
Next two layers are of 100mm each
Inner diameter of jack well with pump house = 6m
Outer diameter of jack well = 6.90m
Inner diameter of inspection well = 3.00m
Outer diameter of inspection well = 3.60m

Assume any data suitably if required.

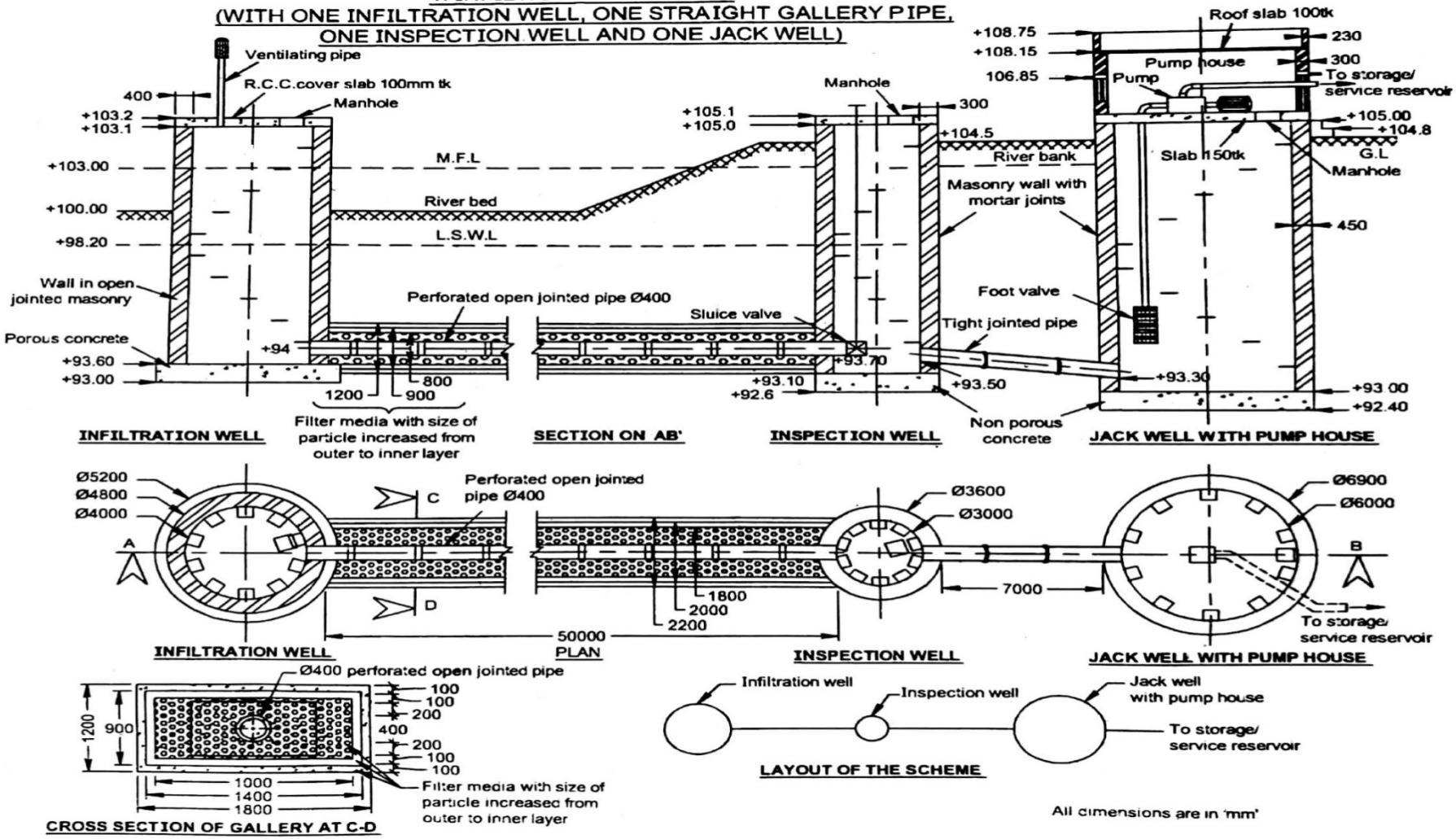
Draw the following views to a suitable scale

1. General layout of the scheme showing infiltration well, infiltration galleries, inspection wells, jack well and pump house. (Not to scale).
2. Longitudinal section of infiltration well, one straight gallery, one inspection well and one jack well.
3. Sectional plan of infiltration well, gallery, inspection well and jack well.
4. Cross sectional details of infiltration gallery.

Assumptions

1. Diameter of infiltration well - 2m to 6m
2. Diameter of inspection well 2m to 3m
3. The gallery should be laid at a minimum depth of 2m below the lowest summer water level.
4. Diameter of gallery pipe 300mm to 450mm.
5. Rate of infiltration for wells and galleries = 4500 to 6000 lit/m^2/day.

1. INFILTRATION GALLERY
(WITH ONE INFILTRATION WELL, ONE STRAIGHT GALLERY PIPE, ONE INSPECTION WELL AND ONE JACK WELL)



2. RAPID SAND FILTER

Filtration is the process of removing bacteria, colour, taste, odour, iron, manganese from water. The efficiency of rapid sand filter is 55% more than the slow sand filter. It removes 95% of bacterial impurities. Its rate of filtration is 4000 - 5000 liters / m^2 / hours.

The components of rapid sand filter are

1. Enclosure tank
2. Bases materials
3. Filter media
4. Wash water trough
5. Air compressor

Enclosure tank

It is a rectangular water tight tank constructed either of masonry or concrete generally the length of tank is 6m to 9m.

Filter media

Filter mediais provided to a depth of 600mm to 900mm using a sand of effective size 0.35 to 0.6.

Base materials

Here gravel is used as a base material and is placed on the top of the under drainage system. This depth varies from 450mm to 600mm.

Under drainage system

Area of cross section of main drain or manifold should be greater than twice the area of cross section of lateral drain. The laterals are provided approximately at a rate of 150mm c/c to 300mm c/c. Diameter of perforations in the laterals should be between 6mm and 12mm and the spacing of perforations varies from 80mm to 200mm.

Wash water trough

The troughs are placed at a distance of 1.5m to 2m edge to edge. The bottom of the trough is about 450mm to 750mm above the sand bed. The dirty water coming from the filter bed is collected and removed.

Air compressor

The agitation of sand grains during washing of filter is carried by compressed air. Compressed air is passed at the rate of 60 - 80 mm^3/ minute / m^2 of filter area for 4 minutes. By this process sand gets purified and can be reused.

The following particulars of rapid sand filters are given below.

Size of filter unit	- 8000 x 5000mm
Size of inlet chamber	- 5000 x 1000mm
Depth of filtration tank	- 3500mm
Depth of Filtration Chamber	- 2600 mm
Thickness of Filter media	- 1350 mm
Wall thickness at top	-450mm
Wall thickness of bottom	- 600mm
Thickness of foundation	-450mm
Diameter of main drain	- 380mm
Diameter of laterals	-80mm @ 300mm c/c
Diameter of air laterals	-70mm @300mmc/c
Diameter of air pipe	-150mm

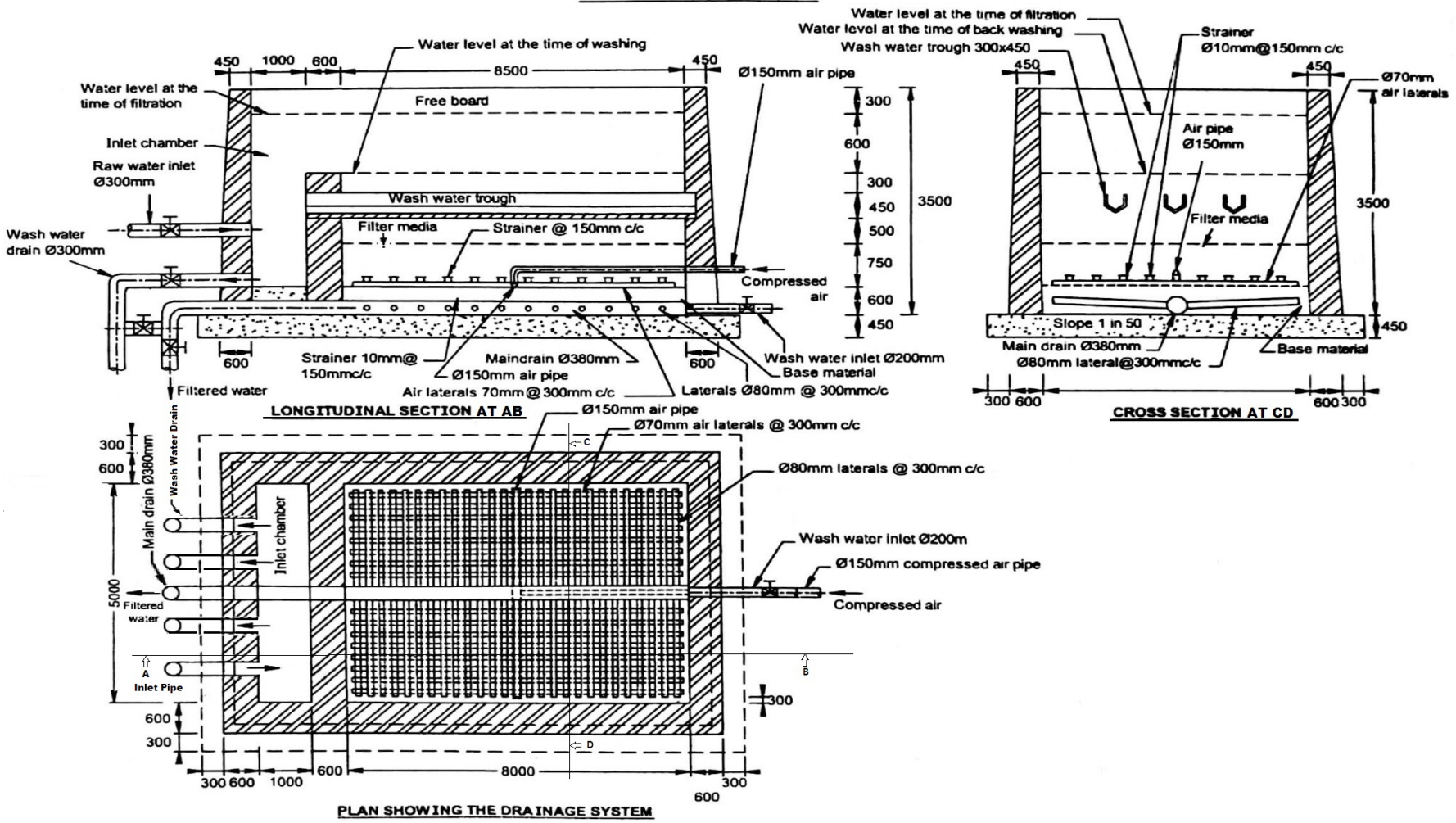
Slope of lateral - 1 in 50
Diameter of inlet pipe - 300mm
Diameter of wash water drain pipe- 300mm
Number of wash water drain pipe- 3 Nos
Size of wash water trough- 300mm x 450mm
Free board - 300mm
Diameter of wash water inlet-200mm

Assume any other data suitably if required.

Draw the following views to a suitable scale

1. Plan of the filter unit
2. Longitudinal section of the filter unit.
3. Cross section of filter unit.

2. RAPID SAND FILTER



3. a) SEPTIC TANK WITH DISPERSION TRENCH

Septic tank is a type of sedimentation tank. It is a water tight tank in which sewage is retained for sufficient time to permit sedimentation is called a septic tank. It is a rectangular tank whose length is 2 to 4 times more than the breadth. Free board of 0.3 to 0.45m is provided. 'T' shaped outlet pipe is provide to a depth of 150mm below the liquid level.

Baffle wall is provided at 1/5 length of the tank from the inlet pipe. The floor is provided with all sides sloping towards one point to facilitate de-sludging operation. R.C.C cover slab with man hole is provided on the top of the tank.

Ventilation is provided with vent pipe.The vent pipe is made of PVC of 50 to 100mm diameter and 3m height. It prevents foul smell and birds for nesting.

It can be disposed-off on land by

1. Disposal by soak pit
2. Disposal by absorption (or) dispersion trenches

1. Disposal by soak pit

Soak pit is also called seepage pitwhere space is restricted as in towns. Soak pit may be used particularly in areas where rainfall is not heavy. No underground drinking water supply line should be situated within a radius of at least 60m from a disposal site or soak pit. The pit is laid with brick or concrete blocks with dry joints which should be packed with clean coarse aggregate. The lining above the inlet level should be finished with cement mortar 1:3 to form a masonry ring to support the R.C.C covers.

2. Disposal by Dispersion trench

They are also called soakage trenches. The effluent is discharged through open jointed pipes placed in trenches. Trenches should be 0.5 to 1m deep and 0.3m to 1m wide excavated to a slight gradient. It should be provided with 150mm to 250mm of washed gravel or crushed stone. The open jointed pipes shall be made of unglazed earthen ware or concrete, have a minimum internal diameter of 75mm to 100mm. The dispersion trench should not be longer than 30m and placed should not closer than 1.8m.

Following are the particulars of a septic tank with dispersion trench.

Septic Tank

Cleaning Interval	- 2 years
Length of tank	- 10.50m
Breath of tank	- 3.00m
Width of walls	- 300mm
Foundation concrete in CC 1:4:8	- 200mm

Wearing coat is provided at a slope of 1 in 20 above the foundation concrete

Depth of liquid	- 1.20m
Free board	- 0.40m
Distance of baffle wall from inlet end	- 2.0m
Height of 50mm thick baffle wall	- 750mm
Distance of partition baffle wall from inlet	- 7.0m
Height of 50mm thick partition baffle wall	- 1500mm
Outlet Chamber	- 1000x1000x550 mm

Dispersion trench

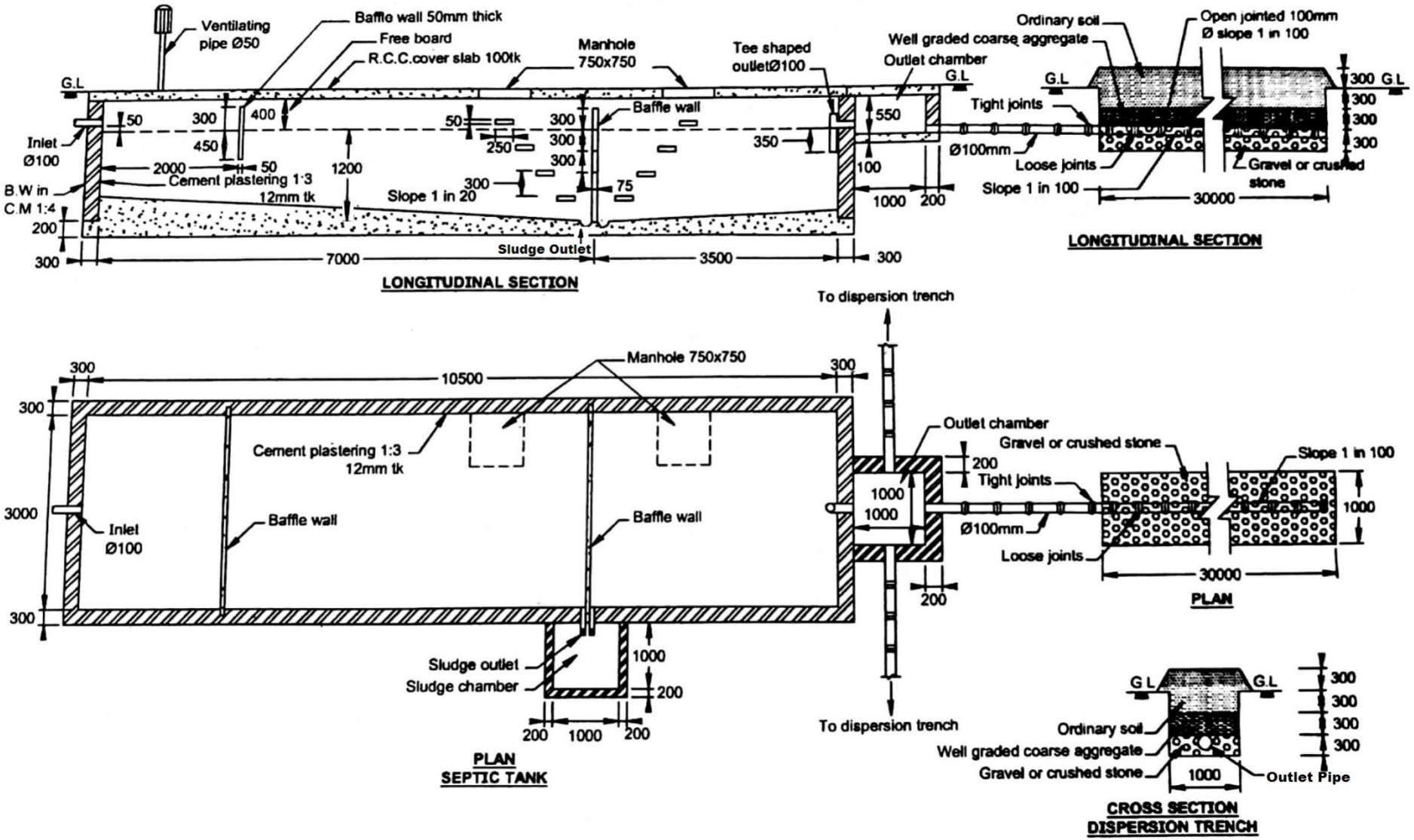
Number of trenches	- 3Nos
Length of trench	- 30m
Width of trench	- 1m
Slope of pipe	- 1 in 100
Depth below ground level	- 0.9m
Diameter of inlet and outlet pipes	- 100mmφ

Any more data required may be assumed suitably.

Draw the following views with suitable scale

1. Sectional plan of septic tank and dispersion trench.
2. Longitudinal section of septic tank and dispersion trench.
3. Cross section of dispersion trench.

3.(a) SEPTIC TANK WITH DISPERSION TRENCH



3. b) SEPTIC TANK WITH SOAK PIT

Following are the particulars of a septic tank with soak pit.

Septic tank

Length of tank = 3.0m
Breadth of tank = 1.50m
Depth of liquid = 1.80m
Free board = 0.3m

Distance of baffle wall from inlet end = 450mm
Tank walls of B.W in C.M 1:3 300mm thick
Diameter if inlet and outlet = 100mm
Precast R.C.C cover slab = 100mm thick
Diameter of ventilating pipe = 50mm
Size of distribution chamber = 750mm x 750mm
Size of manhole = 750mm x 750mm
Foundation concrete in CC 1:4:8 = 200mm
Wearing coat is provided at a slope of 1 in 20
Distribution Chamber = 750x750x400mm

Soak pit

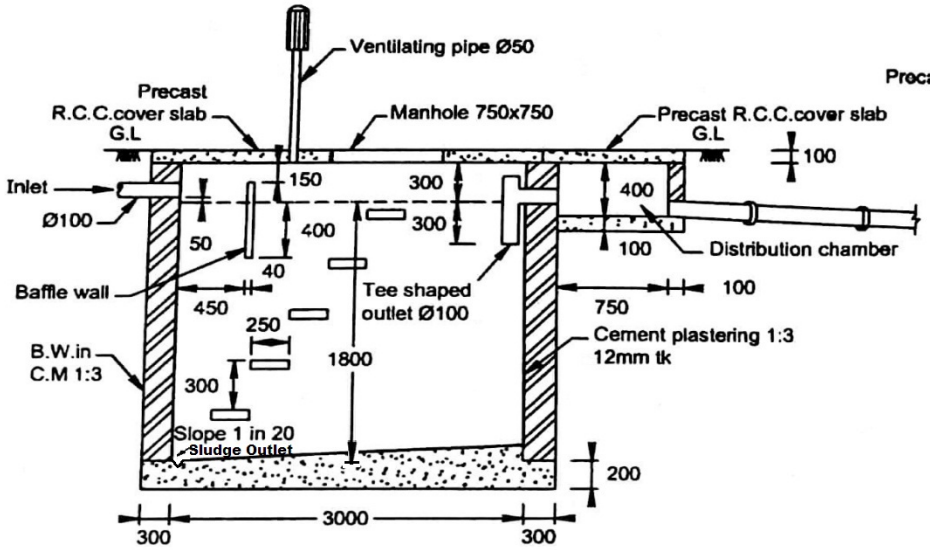
Inner diameter - 1.5m
Depth below invert level of inlet pipe - 2m
B.W in Cm 1:5 dry open joint below inlet pipe - 200mm
Depth below ground level - 2.6m
Cover slab in CC 1:2:4 - 100mm
B.W in Cm 1:5 above inlet pipe with plastering - 200mm

Any more data required may be assumed suitably.

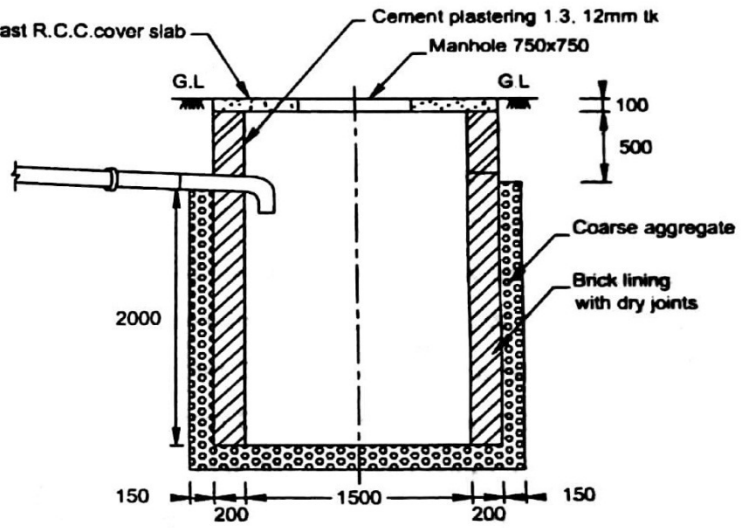
Draw the following views to a suitable scale

1. Sectional plan of septic tank
2. Longitudinal section of septic tank

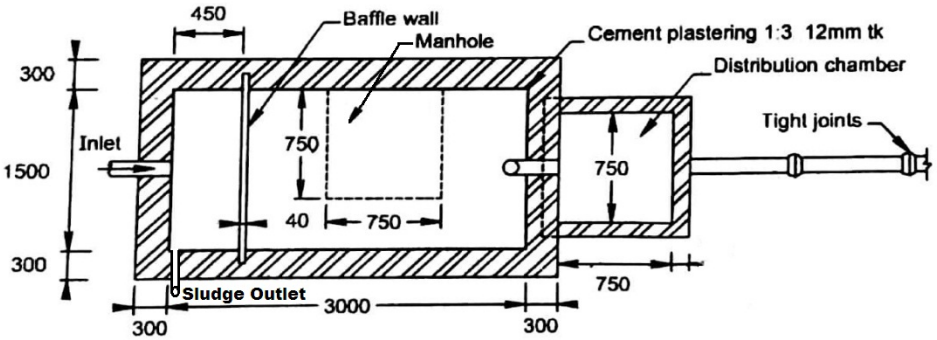
3.(b) SEPTIC TANK WITH SOAK PIT



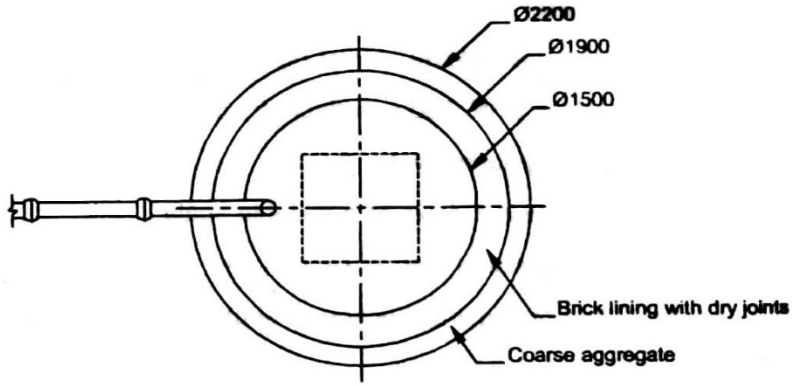
LONGITUDINAL SECTION



LONGITUDINAL SECTION



PLAN
SEPTIC TANK



PLAN
SOAK PIT

4. BIO-GAS PLANT (FLOATING TYPE)

Bio gas is obtained by anaerobic fermentation of organic materials. Bio gas is used for cooking and lighting. The Bio-gas plant consists of the following parts.

1. Inlet tank
2. Digester
3. Outlet tank
4. Gas holder

Inlet tank

In this tank, the raw cowdung is mixed with water and then allowed to pass through an inlet pipe into the digester.

Digester

The digester is a deep well, connected by inlet and outlet pipes.

Gas holder

A mild steel gas - storage drum, inverted over the slurry goes up and down around a guide pipe corresponding to the accumulation of gas.

The following are the particulars of a floating type bio-gas plant.

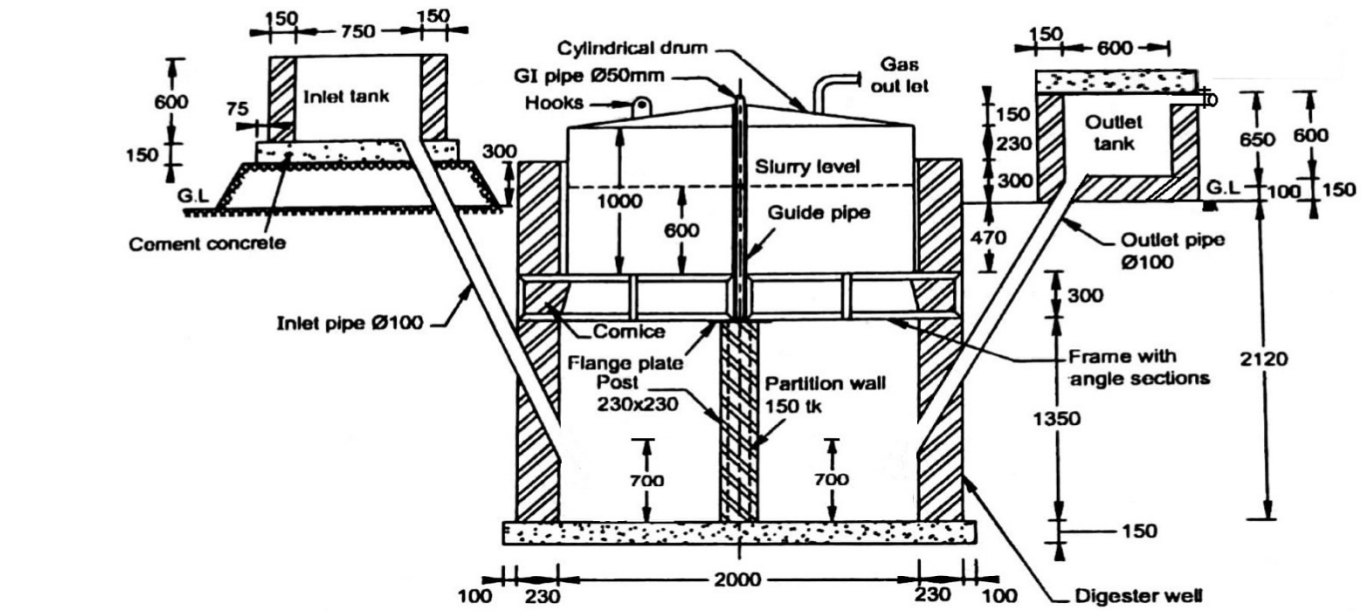
1. Dia of cylindrical drum - 1900mm
2. Height of drum - 1000mm
3. Dia of digester well - 2000mm
4. Height of digester well from foundation of cornice- 1350mm
5. Height of inlet and outlet at the digester well - 700mm
6. Thickness of foundation concrete for digester well- 150mm
7. Thickness of brick wall in C.M 1:4 - 230mm
8. Thickness of partition wall - 150mm
9. Size of brick pillar at the centre - 230mm x 230mm
10. Size of cornice - 75mm x 300mm
11. Size of inlet tank -750 x 750 x 600mm
12. Size of outlet tank -600 x 600 x 600mm
13. Diameter of inlet and outlet pipe - 100mmφ

Any more data required may be assumed suitably.

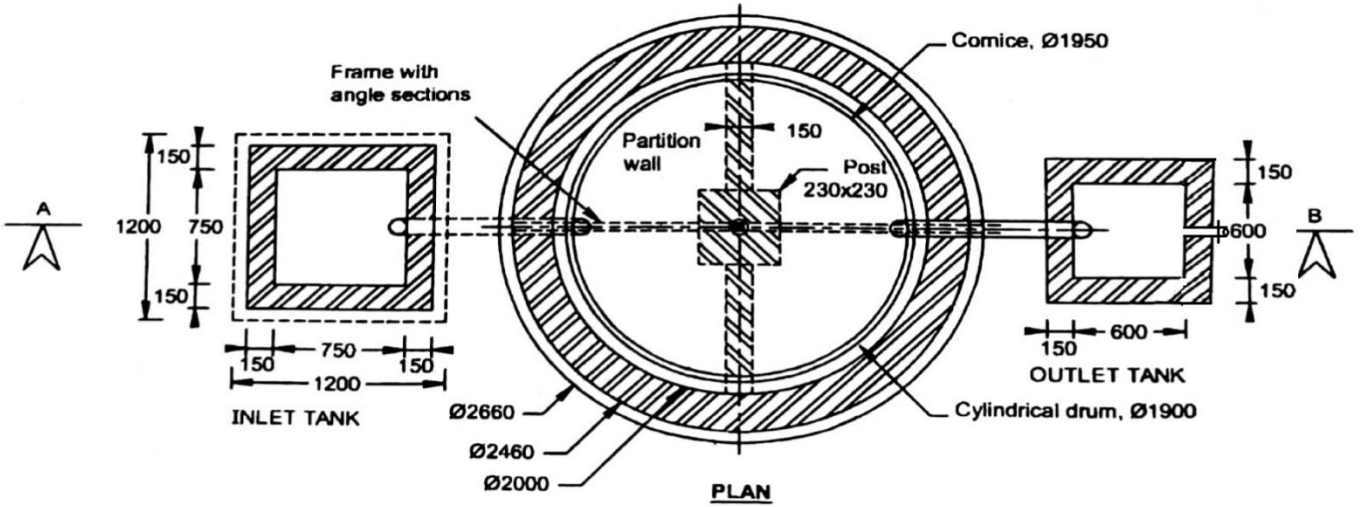
Draw the following views to a suitable scale.

1. Top plan
2. Sectional elevation

4. BIO GAS PLANT (FLOATING TYPE)



SECTIONAL ELEVATION ON 'A-B'



PLAN

5. TWO SPAN PIPE CULVERT

Pipe culverts are provided when discharge of stream is small. Usually one or more pipes of diameter not less than 300mm are provided side by side. These pipes may be of cement concrete, cast iron or steel. Pipe culvert should be provided with suitable concrete bedding at bottom. The gradient of the pipe should not be less than 1 in 1000. A minimum clearance of 150mm is maintained between the H.F.L and the crowns of the pipe. An earth cushion of minimum depth of 450mm should be provided at the top of pipes. R.C.C Hume pipes are commonly used.

The specifications for a two span pipe culvert are given below.

Hydraulic Particulars

Road and stream

Width of road	- 5000mm
Bed level of stream	- + 20.00
Road level	- + 22.10
Water level	- + 21.80
Thickness of W.B.M road	- 250mm

Pipes

Number of pipes	- 2 Nos
Diameter of concrete Hume pipe	- 1000mm
c/c distance of pipes	- 1600mm
Type of joint	- Collar joint in C.M 1:2
Width of concrete seating for pipes at top	- 3300mm
Width of concrete seating for pipes at bottom	- 2700mm
Thickness of concrete seating for pipes	- 500mm

Retaining wall

Top level	- +22.20m
Bottom level	- + 19.20m
Top width	- 500mm
Bottom width	- 1200mm
Front face vertical	
Width of foundation concrete	- 1600mm
Thickness of foundation concrete	- 300mm

Parapet

Length - 4100mm
Thickness - 400mm
Height - 600mm
Coping - 100mmtk

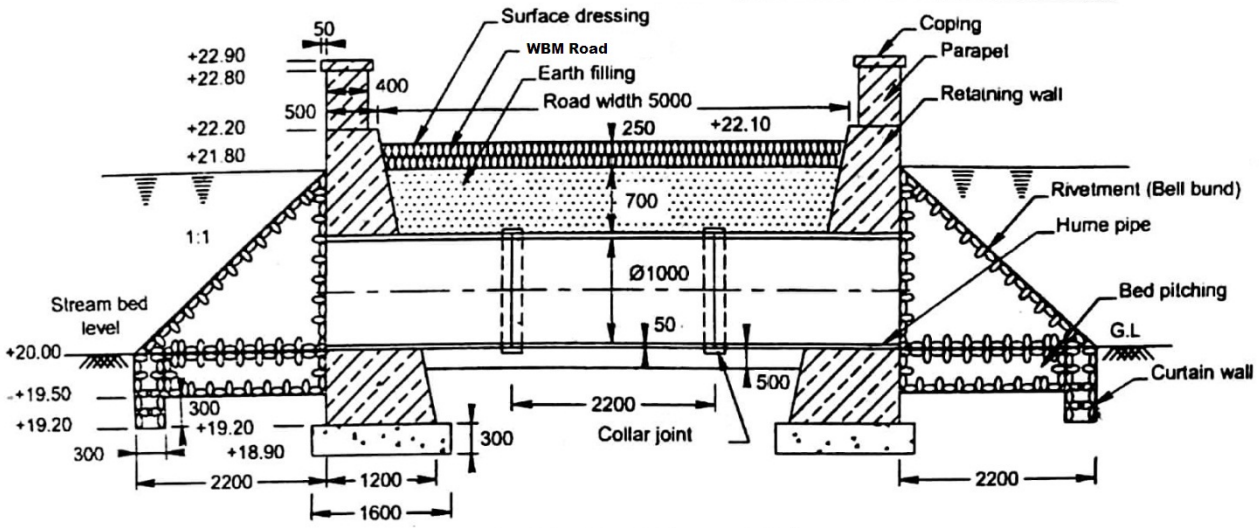
Earth filling

Earth filling above the pipe - 700mm
Thickness of surface dressing - 10mm

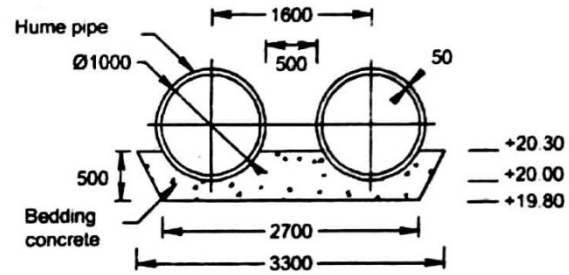
Draw the following views of the pipe culvert

1. Half plant at top and half plan at foundation.
2. Longitudinal section
3. Front elevation
4. Section showing bedding details of the pipe

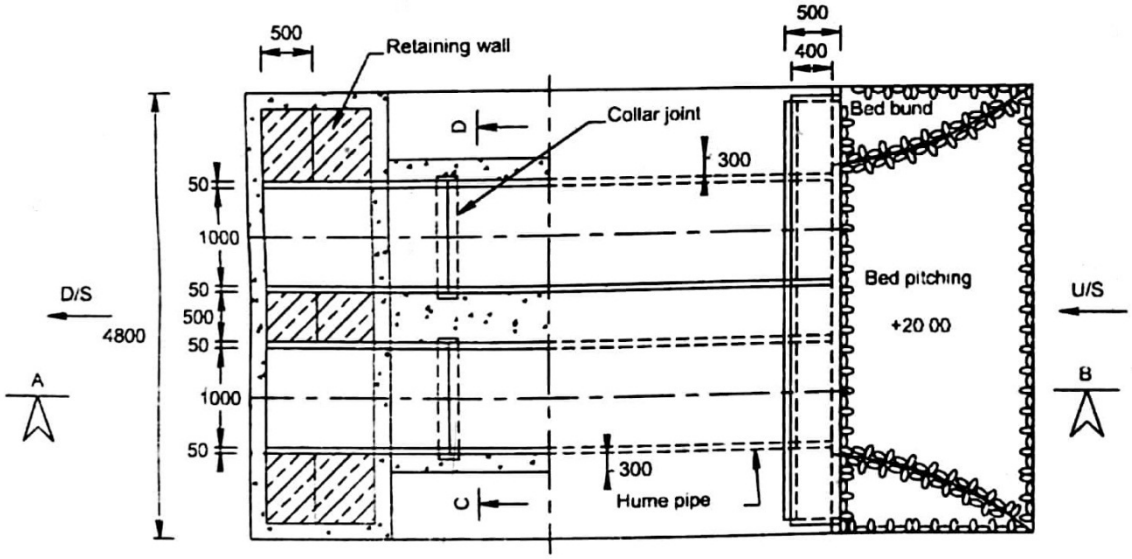
5. TWO SPAN PIPE CULVERT



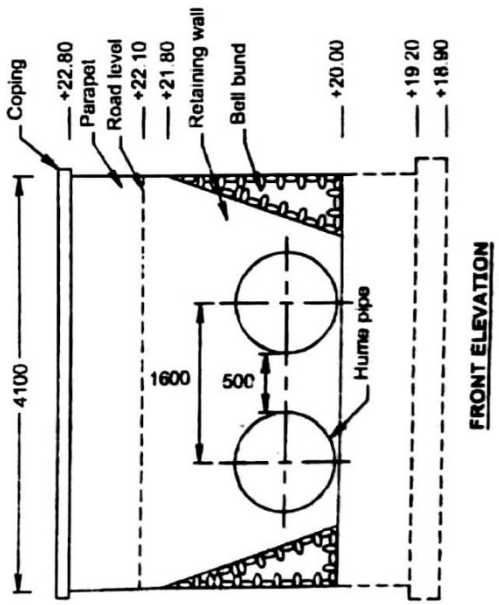
LONGITUDINAL SECTION AT 'AB'



SECTION AT CD SHOWING BEDDING DETAILS OF PIPE



HALF PLAN AT TOP AND HALF AT FOUNDATION



FRONT ELEVATION

6. TWO SPAN TEE BEAM BRIDGE WITH SQUARE RETURNS

These types of bridges are constructed when the width of the drain is to be crossed by a road is wider. It consists of 'Tee' beams supported on piers and abutments.

Abutment

Abutments are provided with wing walls.The wing walls are constructed on both sides of abutments to protect the earthen banks. The wing walls may be of straight, splayed or return. The depth of foundation is based on the scour depth. Cut water and ease water shall be provided for piers and abutments.

Piers

The intermediate supports of abridge super structure are known as piers. The pier end of upstream side is called cut water and on the downstream side is known as ease water. The R.C.C piers are normally rectangular in cross section.

Approach road

The approach road width is reduced at the point of crossing. Road kerbs are provided at the end of the deck slab. IRC recommends that a minimum straight length of 15m on either side of a bridge has to be provided. Suitable handrails and parapet are provided at the bridge. The width of approach should be equal to the width of bridge.

Following are the particulars of a two span 'T' Beam bridge with square returns.

Hydraulic particulars

Drain

Bed level of canal	- + 50.00
Full supply level (F.S.L)	- + 51.30
Bed width of canal	- 6600mm
Top level of Road	- + 52.50
Clear width of road way	- 4000mm
Top width of approach road way	- 5000mm
Top of foundation for all walls	- + 49.70
Bottom level of foundation for all walls	- + 49.40
Offset of foundation concrete	- 200mm
Top of parapet	- + 53.35
Top of kerb	- + 52.65
Size of kerb	- 300 x 150mm

Abutment

Top width	- 600mm
Bottom width	- 1200mm
Water face vertical	
Length of abutment	- 5700mm
Size of bed block	- 600 x 600 x 150mm
Width of foundation concrete	- 1600mm
Thickness of foundation concrete	- 300mm

Pier

Top and bottom width	- 600mm
Length of pier	- 5700mm

Return wall in C.R masonry C.M 1:5

Length of return wall	- 3500mm
Top width	- 600mm
Bottom width	- 1200mm
Front face vertical	

Tee Beam

Size of beam	- 150 x 300mm
Thickness of R.C.C deck slab	- 200mm

Parapet

Thickness of parapet	- 300mm
Size of parapet pillars	- 300mm x 700mm
Spacing of parapet pillars	- 2500mm

Provide 25mmφ G.I pipe for hand rails

Length of rough stone revetment on both side U/s and D/s 2000mm

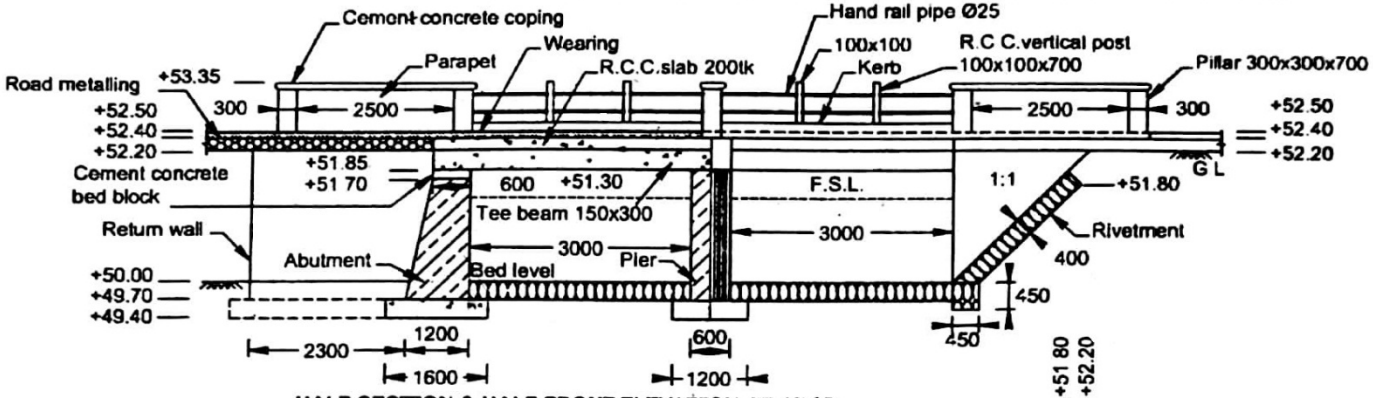
Thickness of revetment	- 400mm
Size of RCC post	- 100x100x700mm

Assume any other data required suitably

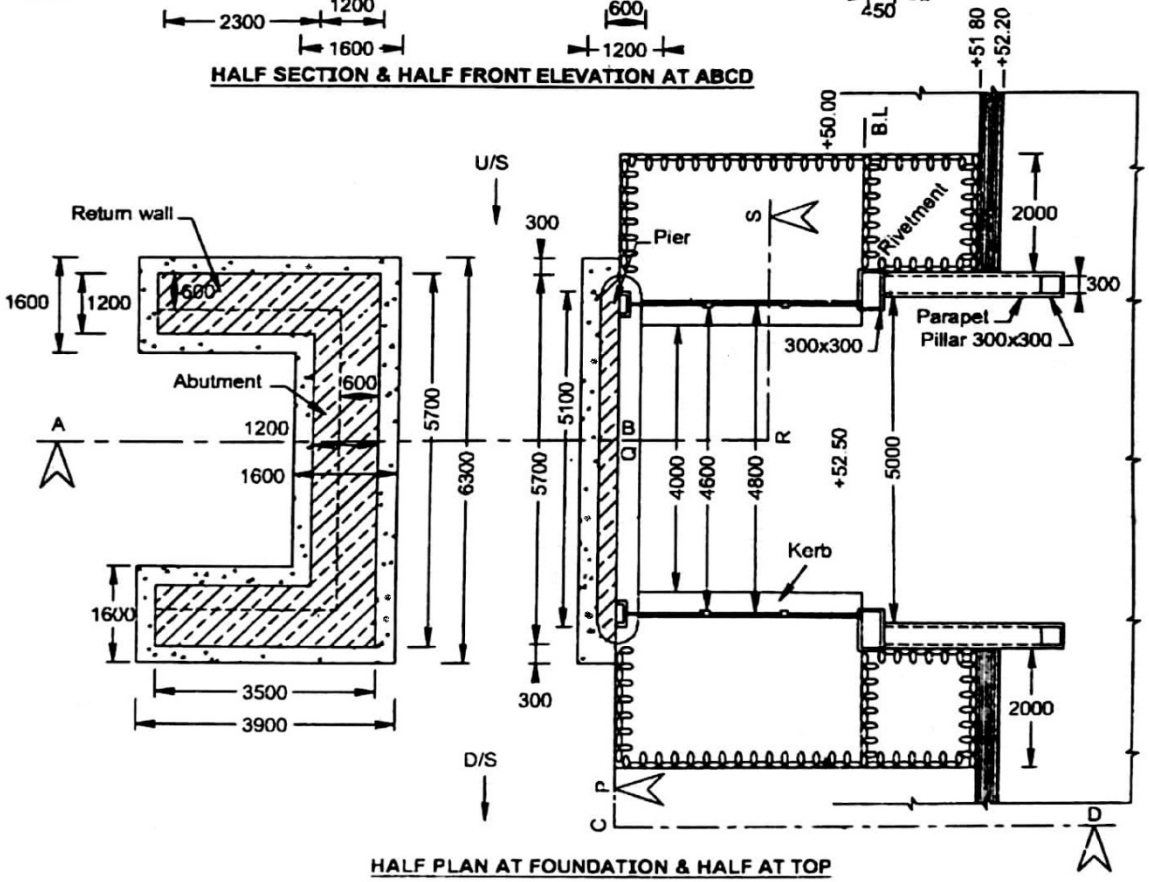
Draw the following views to a suitable scale

1. Half plan at foundation and half plan at top
2. Longitudinal sectional elevation
3. Cross section

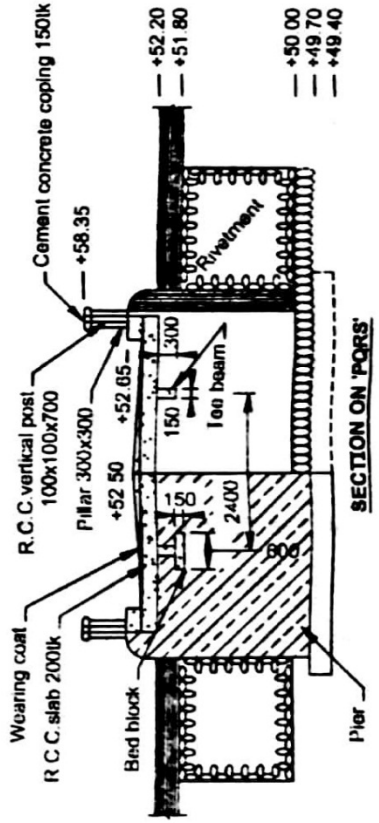
6. TWO SPAN TEE BEAM BRIDGE WITH SQUARE RETURNS



HALF SECTION & HALF FRONT ELEVATION AT ABCD



HALF PLAN AT FOUNDATION & HALF AT TOP



SECTION ON 'PQRS'

7) SIMPLY SUPPORTED ONE WAY SLAB

When the slab is supported on two opposite sides alone by walls or beams is said to be one way slab. When Ly/Lx ratio is greater than 2, one way slabs are provided.

The load on the way slab is transferred to the two supports only, hence the main reinforcement is provided along the shorter span direction 50% of the main reinforcements are bend to the top for length of 0.1 ***l*** from the face of the support.

The bars in longer direction of the slab are called distribution or transverse steel. Distributors are placed in the upper layer and tied with the main steel bars to keep them in correct position during concreting.

Problem

The following are the particulars of a simply supported one way roof slab.

Size of room	= 3.10 m x 7m
Clear span	= 3.10m
Width of supporting walls	= 230 mm
Total thickness of slab	= 120 mm
Clear cover	=15 mm
Main reinforcement	= 10mm dia Fe 415 Bars
	@140 mm c/c
Distributors	=8mm dia Fe 415 Bars
	@ 250 mm c/c

50% of main Reinforcement can be bent up 0.1 from the face of the support.

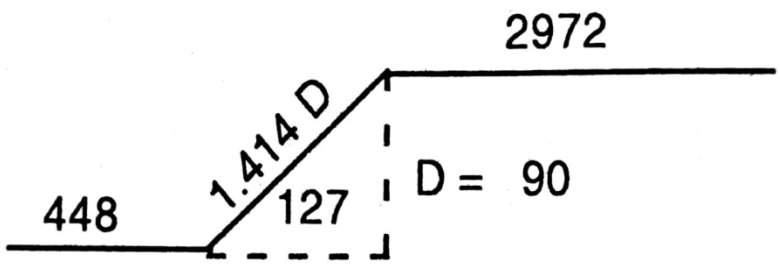
Cover: For tensile, compressive, shear or any other reinforcement in Slabs, minimum cover shall not be less then 15mm, and the side Cover 25 mm.

Anchorage and curtailment of reinforcement may be adopted with standard values. Assume any other data required suitably.

Draw to a suitable scale

1. Plan at bottom showing reinforcement arrangements.
2. Plan at top showing reinforcement arrangements.
3. Cross section of the slab showing reinforcement details.
4. Prepare bar bending schedule for 1m width to slab

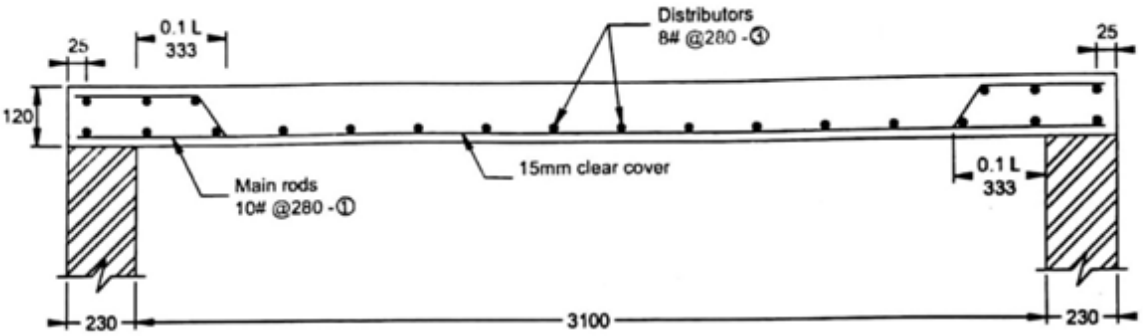
CRANK LENGTH CALCULATION



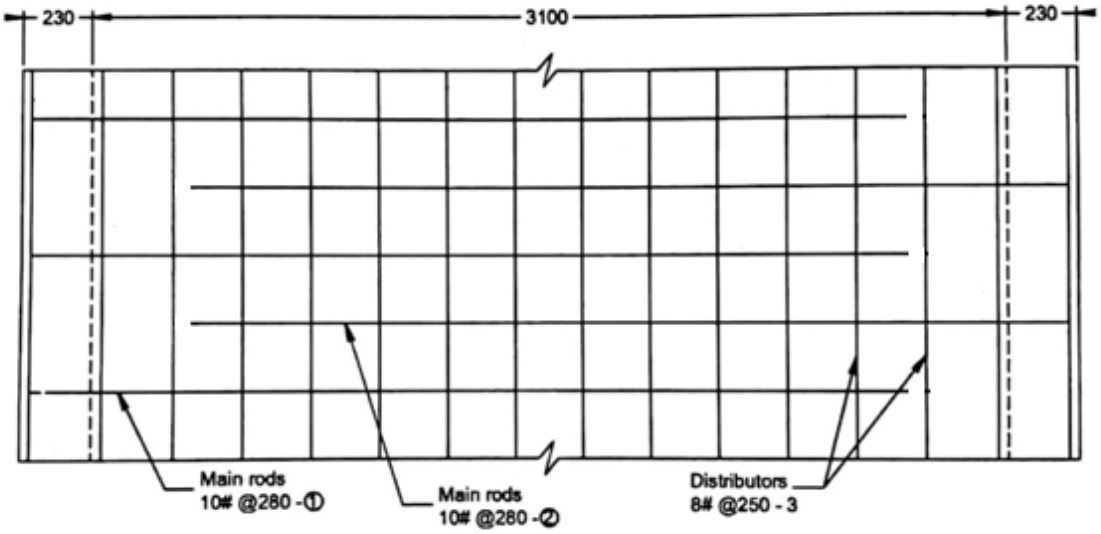
1.414 X D =1.414 x 90 =127.26

Where D = Depth of slab – top @ Bottom cover

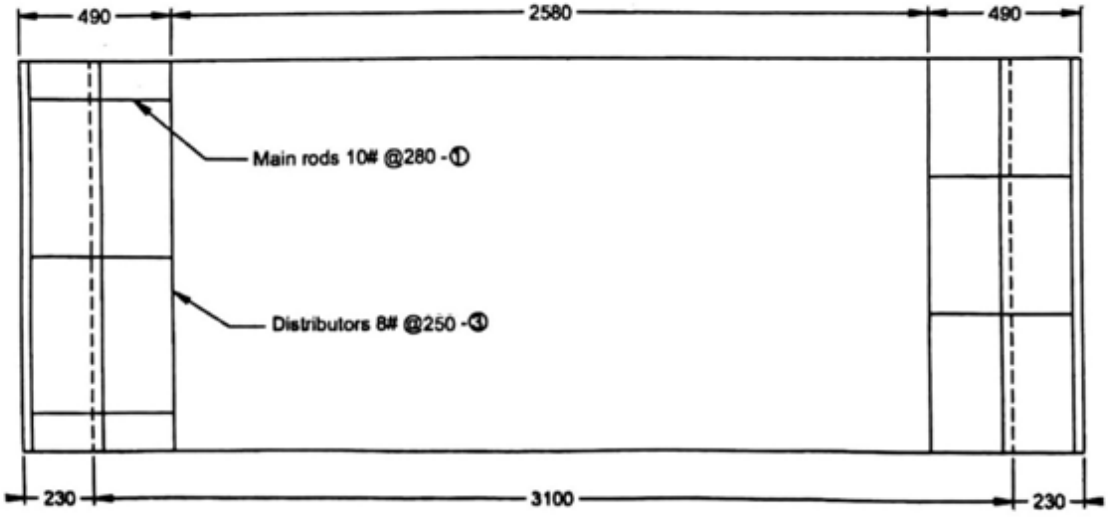
D = 120 – (2 x 15) = 90



CROSS SECTION



PLAN SHOWING THE BOTTOM RE INFORCEMENT

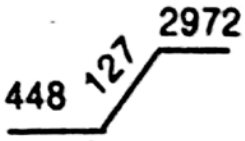
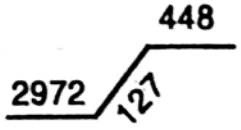
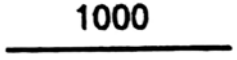
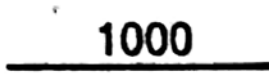


PLAN SHOWING THE TOP RE INFORCEMENT

SIMPLY SUPPORTED ONE WAY SLAB

All dimensions are in mm

BAR BENDING SCHEDULE

Type No.	Size	Shape	Length In m	Number	Weight/Unit length in N/m	Total weight in 'N'	Remarks
1.	10#		3.547	$\frac{1000}{280} = 3.70$	6.2	81.36	Main Reinforcement
2.	10#		3.547	$\frac{1000}{280} = 3.70$	6.2	81.36	Main Reinforcement
3.	8#		1.000	$\frac{3510}{250} + 1 = 15.04$	4.0	60.00	Distributors
4.	8#		1.000	$\left[\frac{448}{250} + 1\right] \times 2$ =5.58≈ 6	4.0	24.00	Supporting main bar
					Total weights	246.72	
Add 5% extra for wastage in cutting & others						12.34 N	
Total quantity of steel required						259.06 N	Say 260 N

8) SIMPLY SUPPORT TWO WAY SLAB (CORNERSNOT HELD DOWN)

A slab is called 'two way slab' when the load on it is distributed in both directions to all its four supports. Two way slabs are provided whenly/lx ratio is less than 2 [Ly/Lx< 2].

Since two way slabs deflect in both directions the tension reinforcement (main reinforcement) is provided in bothshorter span and longer span.

50% of the reinforcement are curtailed or cranked at 0.1 Lx and 0.1 Ly for shorter and longer direction respectively. Remaining 50% of the reinforcements should be extended in to the supports.

Problem

The following are the particulars of a simply supported two way slab in which corners are not held down.

Size of the room	=	4.50 x 6.10 m
Width of support	=	300 mm
Thickness of slab	=	150 mm
Clear cover	=	15 mm
Edge cover	=	25 mm

Reinforcement details:

Reinforcement along shorter span	= 10 mm Fe 415 @ 200 mm C/C
Reinforcementalong longer span	=10 mm Fe 415 @ 220 mm C/C
Distributors in both directions	= 8 mmFe 415 @ 290 mm

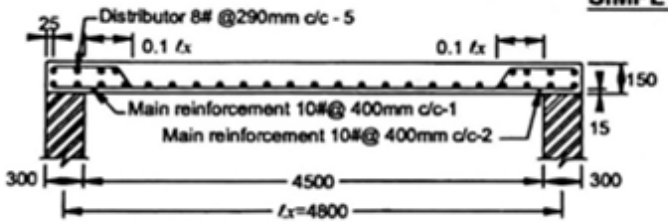
Anchorage and curtailment of reinforcement may be adopted with standard values and any more data required may be assumed suitably.

Draw the following views to a suitable scale

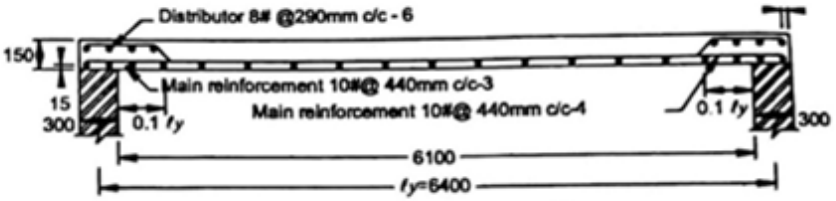
1. Plan at bottom showing reinforcement arrangements.

2. Plan at top showing reinforcement arrangements.
3. Cross section of the slab showing reinforcement details.
4. Prepare bar bending schedule for 1m width of slab.

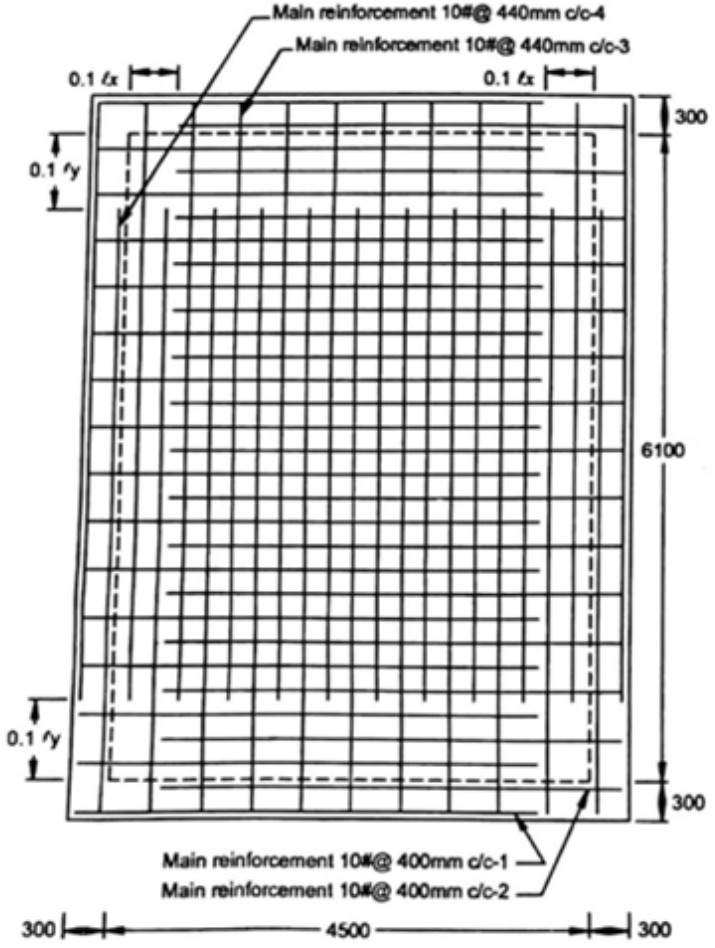
SIMPLY SUPPORTED TWO WAY SLAB



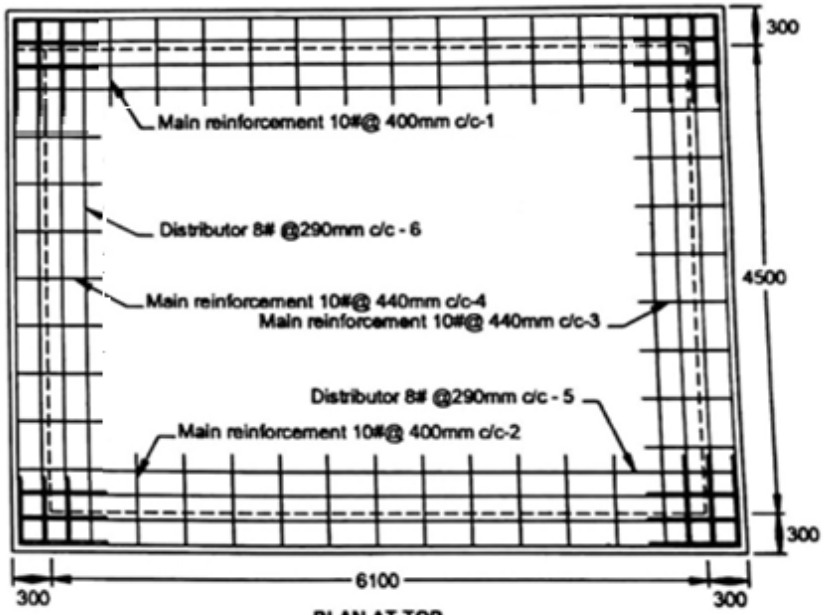
SECTION ALONG SHORTER SPAN



SECTION ALONG LONGER SPAN

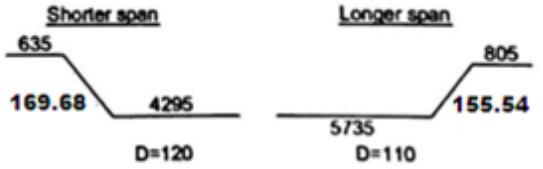


PLAN AT BOTTOM

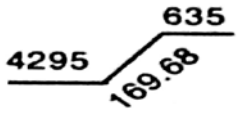
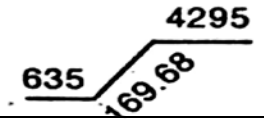
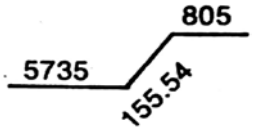
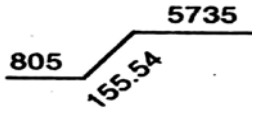
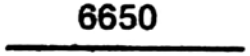


PLAN AT TOP

CRANK LENGTH



BAR BENDING SCHEDULE

Type No.	Size	Shape	Length In m	Number	Weight/Unit length in N/m	Total weight in 'N'	Remarks
1.	10#		5.100	$\frac{6650}{400} + 1 = 17.6$ (say 18)	6.2	569.16	Main Reinforcement along shorter span
2.	10#		5.100	$\frac{6650}{400} = 16.6$ (say 17)	6.2	537.54	Main Reinforcement along shorter span
3.	10#		6.696	$\frac{5050}{440} + 1 = 12.47$ (say 12)	6.2	498.18	Main reinforcement along longer span
4.	10#		6.696	$\frac{5050}{440} = 11.47$ (say 11)	6.2	456.66	Main reinforcement along longer span
5.	8#		6.650	$\frac{635}{290} + 1 = 3010$ (say 3+3 = 6)	4.0	159.60	Distributor along longer span
6.	8#		5.050	$\frac{805}{290} + 1 = 3.7$ (say 4) 4+4 = 8	4.0	161.60	Distributor along shorter span
					Total weights	2382.74	
					Add 5% for wastage in cutting, bending overlapping etc	119.13	
						2501.87 N	

9) RESTRAINED TWO WAY SLAB

In restrained two way slabs, the corners are restrained and not allowed to lift away from the supports. If this is done, torsion is induced at corners and the slab be suitably reinforced for torsion.

Slabs are considered as divided in each direction into middle strip and edge strips. The middle strip being $3/4^{th}$ of the width and each edge strip $1/8^{th}$ of the width. Reinforcement in edge strip parallel to the edge, shall comply with the minimum reinforcement requirements and the requirements for tension.

Torsion reinforcement shall be provided at any corner where the slab is simply supported on both edges meeting at that corner. It shall consist of top and bottom reinforcement, each layer of bars placed parallel to the sides of the slab and extending from the edges to a minimum distance of $1/5^{th}$ the shorter span.

Problem

The following are the details of a simply supported slab of a reading room of dimension 5m x7m which is discontinuous along all of its four edges. The corners of the slab are prevented from lifting.

Width of support	=300mm
Thickness of slab	=150mm
Clear cover of reinforcement	=15mm

Reinforcement details

In middle strip

Rft. along shorter span = 10mm dia Fe 415 bars @100mm c/c

Rft. along longer span = 10mm dia Fe415bars @ 150mm c/c

Edge strip

10mm Fe415 bars @ 150 mmc/c along both spans.

Torsion reinforcement

Both at top and bottom8mmdia Fe 415 bars @ 100mm c/c in both directions forming a mesh.

Use standard anchorage and curtailment of reinforcement may be adopted with standard values.

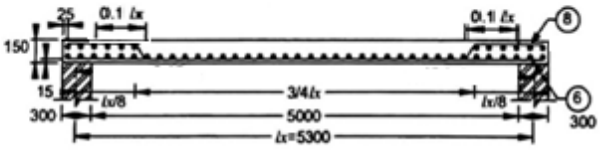
Assume any other data required suitably.

Draw the following views to a suitable scale.

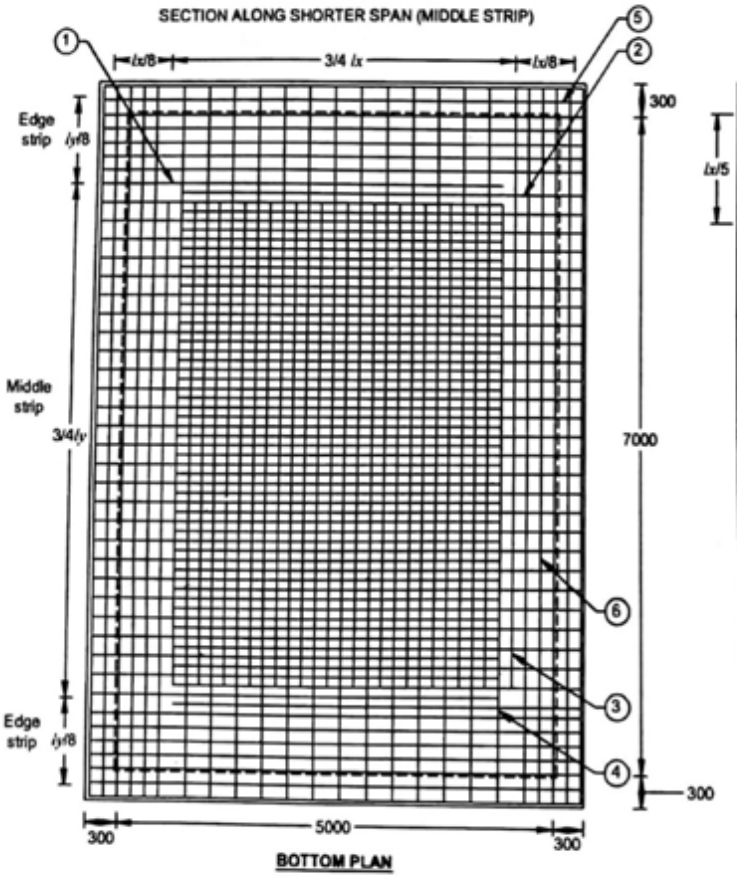
1. Plan showing the arrangement of reinforcement at bottom.
2. The plan showing arrangement of reinforcement at top.
3. The cross section along shorter span middle strip.
4. The cross section along longer span middle strip.
5. Prepare a bar bending schedule.

RESTRAINED TWO WAY SLAB

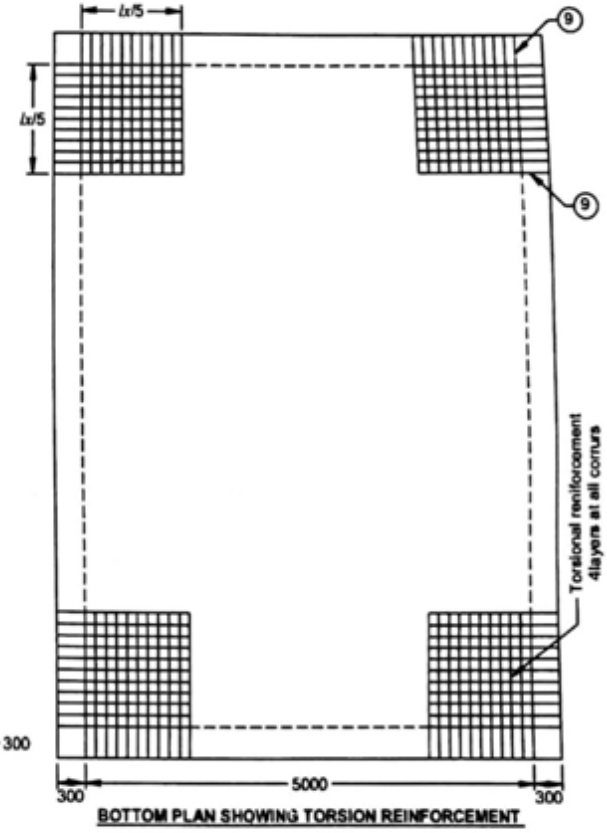
1. Mainreinforcement along shorter span 10# @ 200mm c/c
2. Mainreinforcement along shorter span 10# @ 200mm c/c
3. Mainreinforcement along longer span 10# @ 300mm c/c
4. Mainreinforcement along longer span 10# @ 300mm c/c
5. Reinforcement along shorter span edge strip 10# @ 150mm c/c
6. Reinforcement along longer span edge strip 10# @ 150mm c/c
7. Distributor at top along shorter span 10# @ 150mm c/c
8. Distributor at top along longer span 10# @ 150mm c/c
9. Torsion reinforcement 8# @ 100mm c/c



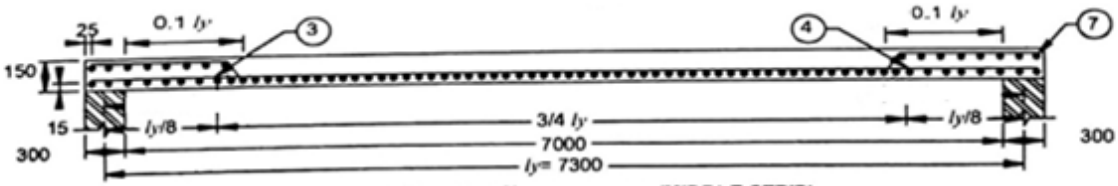
SECTION ALONG SHORTER SPAN (MIDDLE STRIP)



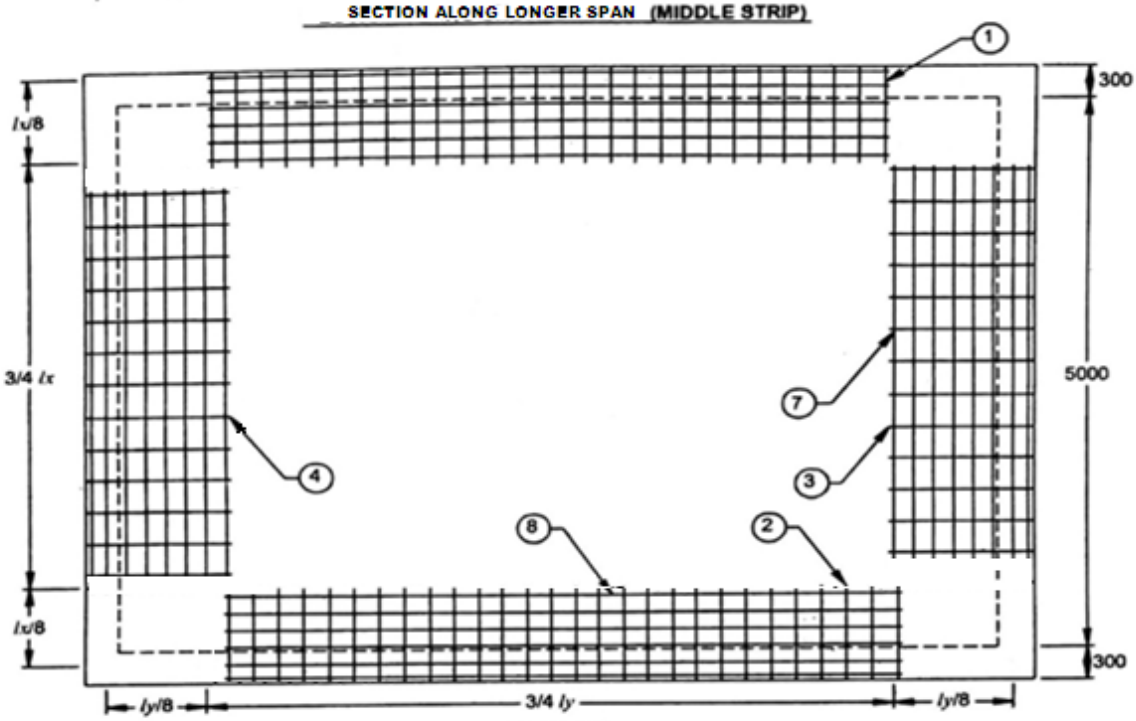
BOTTOM PLAN



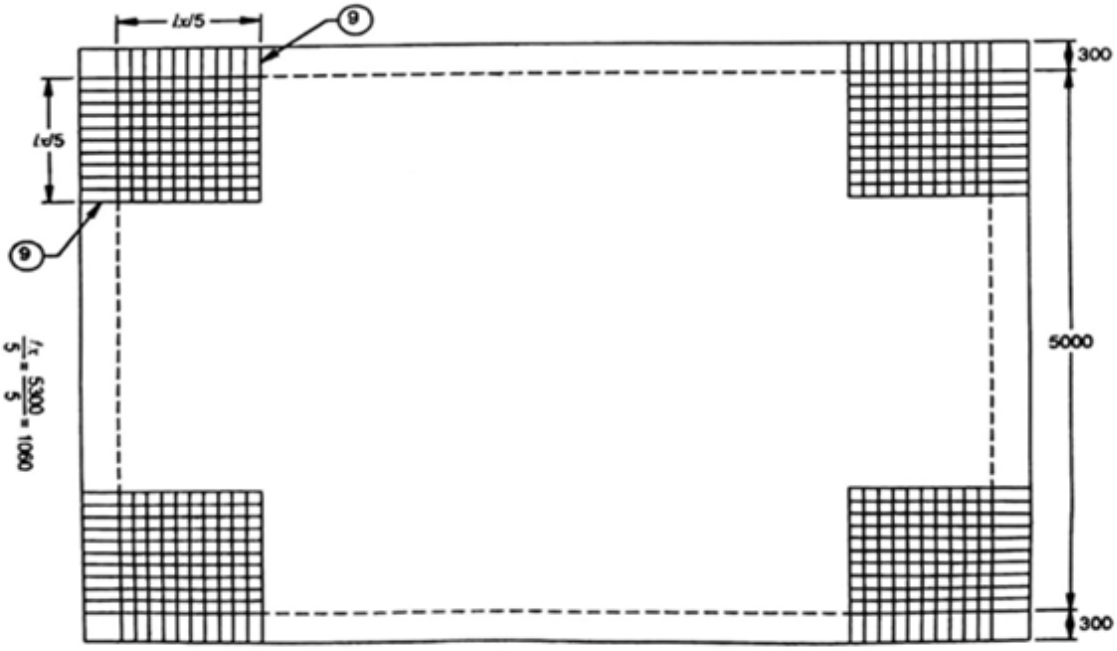
BOTTOM PLAN SHOWING TORSION REINFORCEMENT



SECTION ALONG LONGER SPAN (MIDDLE STRIP)

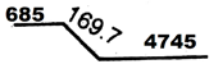
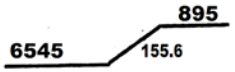
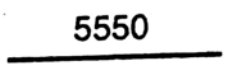
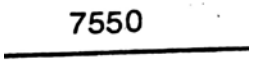
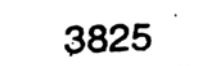
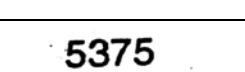


TOP PLAN



TOP PLAN SHOWING TORSION REINFORCEMENT

BAR BENDING SCHEDULE

Type No.	Size Grade	Shape Dimension	Length In m	Number	Weight/Unit length in N/m	Total weight in 'N'	Remarks
1.	10#		5.60	$\frac{5475}{200} = 27.4$ say 28	6.17	987.27	Main Reinforcement along shorter span (middle strip)
2.	10#		5.60	$\frac{5475}{200} = 27.4$ say 28	6.17	987.27	Main Reinforcement along shorter span (middle strip)
3.	10#		7.60	$\frac{3975}{300} = 13.25$ Say 14	6.17	656.11	Main Reinforcement along longer span (middle strip)
4.	10#		7.60	$\frac{3975}{300} = 13.25$ Say 14	6.17	656.11	Main Reinforcement along longer span (middle strip)
5.	10#		5.550	$\frac{912.5}{150} = 6.08$ 6+6 = 12	6.17	410.92	Reinforcement along shorter span (edge strip)
6.	10#		7.550	$\frac{662.5}{150} = 4.42$ 5+5 = 10	6.17	465.84	Reinforcement along longer span (edge strip)
7.	10#		3.825	$\frac{895}{150} + 1 = 6.97$ 7+7 = 14	6.17	330.40	Distributor at top along shorter span.
8.	10#		5.375	$\frac{685}{150} + 1 = 5.57$ 6+6 = 12	6.17	397.96	Distributor at top along longer span.

9.	8#	1335	1..335	$\frac{1060}{100} + 1 = 11.60$ Say 12 12+12 = 24	3.95	126.55	Torsion reinforcement
					Total weights	5018.44 N	
INCL 5%EXTRA 5269.34							
Say 5270 N							

10. SINGLY REINFORCED SIMPLY SUPPORTED BEAM

A singly reinforced simply supported beam is a structural member supported on bearing walls or columns and subjected to roof or floor loads and reinforced on the tension side only.

Problem

The following are the details of a singly reinforced simply supported fixed beam.

1. Size of beam =300 x 450 mm
2. Clear span =4000 mm
3. Width of support =300 mm
4. Clear cover to rft = 25 mm
5. Reinforcement details:

Main reinforcement (tensile)	= 16 mmdia Fe 415 bars - 5 Nos
Hanger rods	=12 mmdia Fe 415 bars- 2 Nos
Stirrups	= 8mm dia 2 legged Fe415 steel @ 160 mm c/c

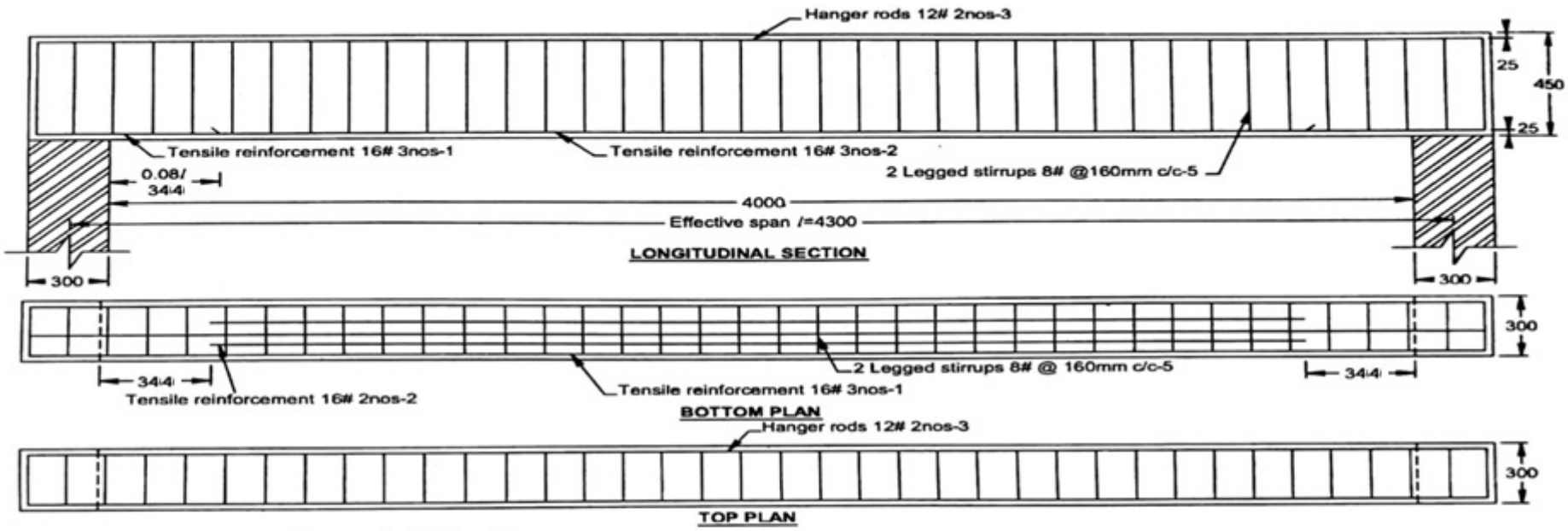
Anchorage and curtailment of reinforcement may be adopted with standard values.

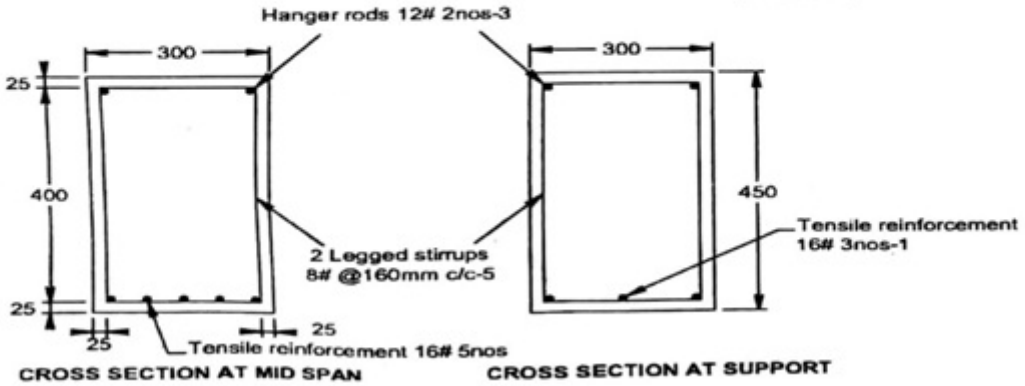
Assume any other data required suitably.

Draw the following views to a suitable scale.

1. Longitudinal section of the beam showing reinforcement details.
2. Top and bottom plan showing arrangement of reinforcement details.
3. Cross sectional view of the beam at mid span and at supports.
4. Prepare a bar bending schedule.

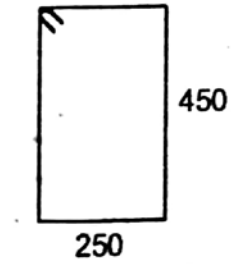
SINGLY REINFORCED SIMPLY SUPPORTED BEAM





Ld from table : 8
For
Bar in tension
Grade of concrete - M20
Bar type - 16mm deformed bar
fy = 415N/mm²
then Ld= 750 mm

BAR BENDING SCHEDULE

Type No.	Size Grade	Shape Dimension	Length In m	Number	Weight/Unit length in N/m	Total weight in 'N'	Remarks
1.	16#	4550	4.550	3	15.78	215.39	Tensile reinforcement
2.	16#	3312	3.312	2	15.78	104.53	Tensile reinforcement (Curtailed)
3.	12#	4550	4.550	2	8.88	80.80	Hanger rods
4.	8#	 (250 + 450) 2 + 20d 1400 + (20 x 8) = 1560	1.560	$\frac{4550}{150} + 1 = 31.33$	3.95	193.05	Stirrups
					Total weights	593.77	
Add 5% of above total weight for wastage						29.69	
						623.46 N Say 624 N	

11) DOUBLY REINFORCEMENT BEAM

Doubly reinforced beams are reinforced both on the tension and compression zones. If the depth of beam is restricted for any reasons, it becomes necessary section by providing reinforcements on the compression side.

Curtailment of main reinforcement is made for a length of 0.08l from the support on either side.

Problem

The following are the details of a doubly reinforced beam.

1. Clear span =4000 mm
2. Width of support =300 mm
3. Size of beam =300 x 500 mm

Reinforcement details

MID SPAN

Tensile reinforcement	=4 Nos16mmdia Fe415 steel
Compressive reinforcement	=2Nos16mmdia Fe 415 steel

AT SUPPORT

Tension	= 3 Nos #16mm, Fe415
Compression	= 2 Nos #16mm, Fe415
Shear reinforcement	=8mmdia Fe 415bars 2 leggedstirrups at 160 mm c/c up to a distance of 800mm from the edge of the support on both sides. Beyond this point use these shear stirrups @ 300 mm c/c.

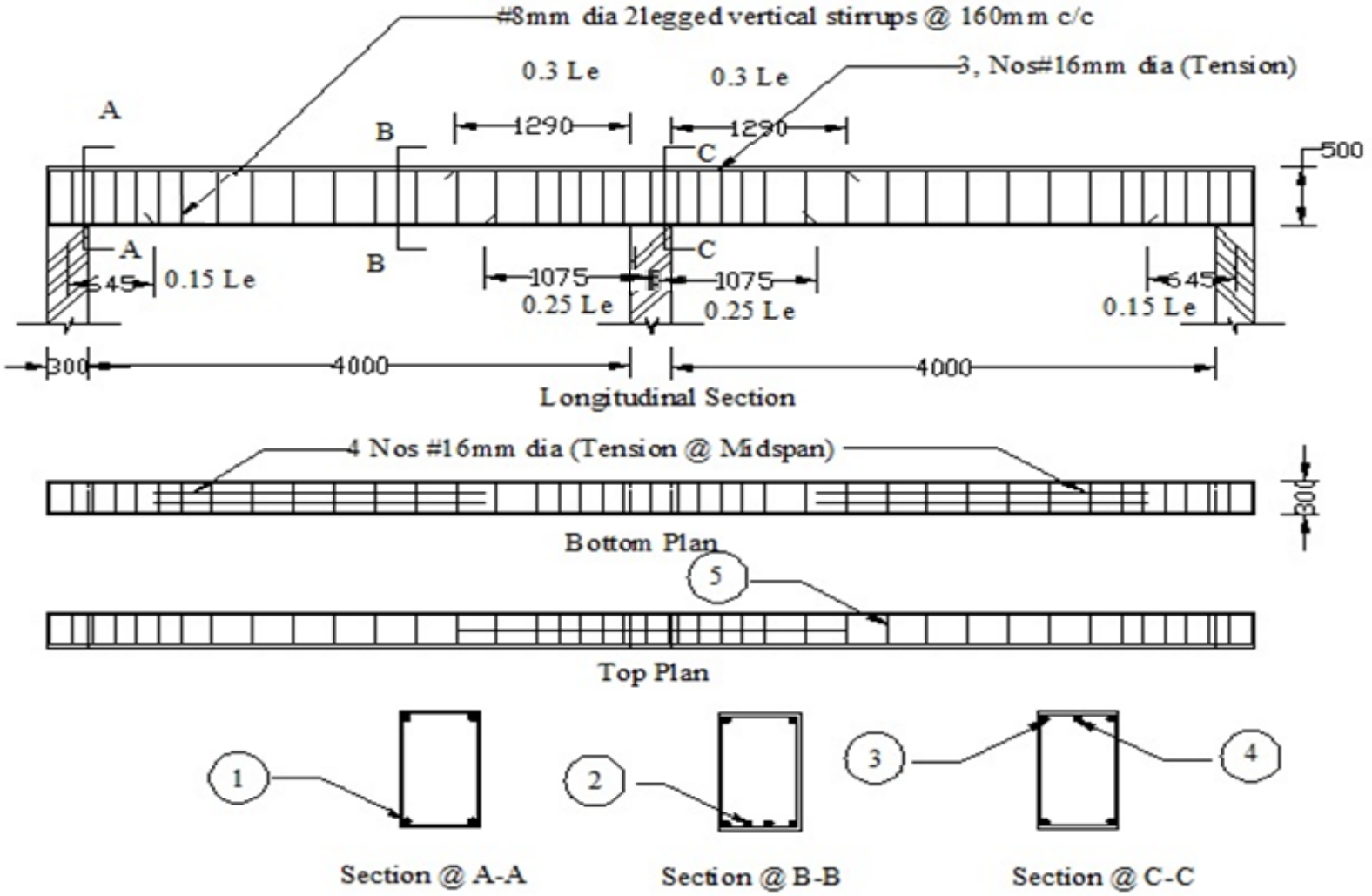
Anchorage and curtailment of reinforcement may be adopted with standard values.

Assume any other data required suitably.

Draw the views to a suitable scale

1. The longitudinal section of the beam.
2. The c/s of the beam at mid span.
3. The cross section of the beam at support.
4. The top and bottom plan of reinforcement.
5. Prepare the bar bending schedule for the beam.

DOUBLY REINFORCED CONTINUOUS BEAM



BAR BENDING SCHEDULE

Type No.	Size Grade	Shape Dimension	Length In m	Number	Weight/Unit length in N/m	Total weight in 'N'	Remarks
1.	16#	8850	8.850	2	15.78	279.06	Tensile reinforcement
2.	16#	**2580**	2.580	4	15.78	153.38	Tensile reinforcement (Curtailed)
3.	16#	8850 450 450	8.850	2	15.78	279.06	Compressive reinforcement
4.	16#	2880	2.880	1	15.78	45.45	Compressive reinforcement (Curtailed)
5.	8#	450 250 (250 + 450) 2 + 20d 1400 + (20 x 8) = 1560	1.560	$\frac{800}{160}+1=6$ 2x6 = 12 $\frac{2700}{300}-1=8$ 12 + 8 = 20 For two spans 20+19=39	3.95	240.32	Stirrups
					Total weights	880.19	
					Add 5% of above total weight etc	44.01	
						924.20 N Say 925N	

12. TEE BEAMS SUPPORTING CONTINUOUS SLAB

A slab having three or more supports is called a continuous slab. Slabs spanning in one direction supported at ends and also at intermediate points on beams shall be designed for maximum sagging moment (+ve bending moment) at spans and hogging moment (negative bending moment) at supports.

Tension Reinforcement is to be provided at the bottom of mid span section and at the top of support sections.

Problem

The following are the particulars of a continuous one way slab over the beams.

Size of room	= 12m x 4m
Spacing of 'T' beams	= 3m c/c
Depth of Tee beams	= 450 mm overall
Breadth of web or rib	= 250 mm
Width of support	= 250 mm
Thickness of slab	= 120 mm

Main Reinforcement in Tee beam

Main Tensile reinforcement	= 20 mmdia Fe 415 bars 5 Nos
Hanger rods	=12 mmdia Fe 415 bars 2 Nos
Shear reinforcement	=2 legged stirrups 8mmdia Fe 415 steel @250 mm c/c

Reinforcement in slab

Main reinforcement for positive moment at ends spans

= 10mmdia Fe415 bars @ 300 mm c/c

Main reinforcement for negative moment at support next end support

=10mmdia Fe415 bars @ 290 mm c/c

Main reinforcement for positive moment at interior span

=10mmdia Fe415 steel 230 mm c/c

Distribution = 8mmdia Fe415 steel 340mm c/c

Reinforcement at top at support

=16 mmdia Fe415 steel 2 Nos for a length 0.1 l

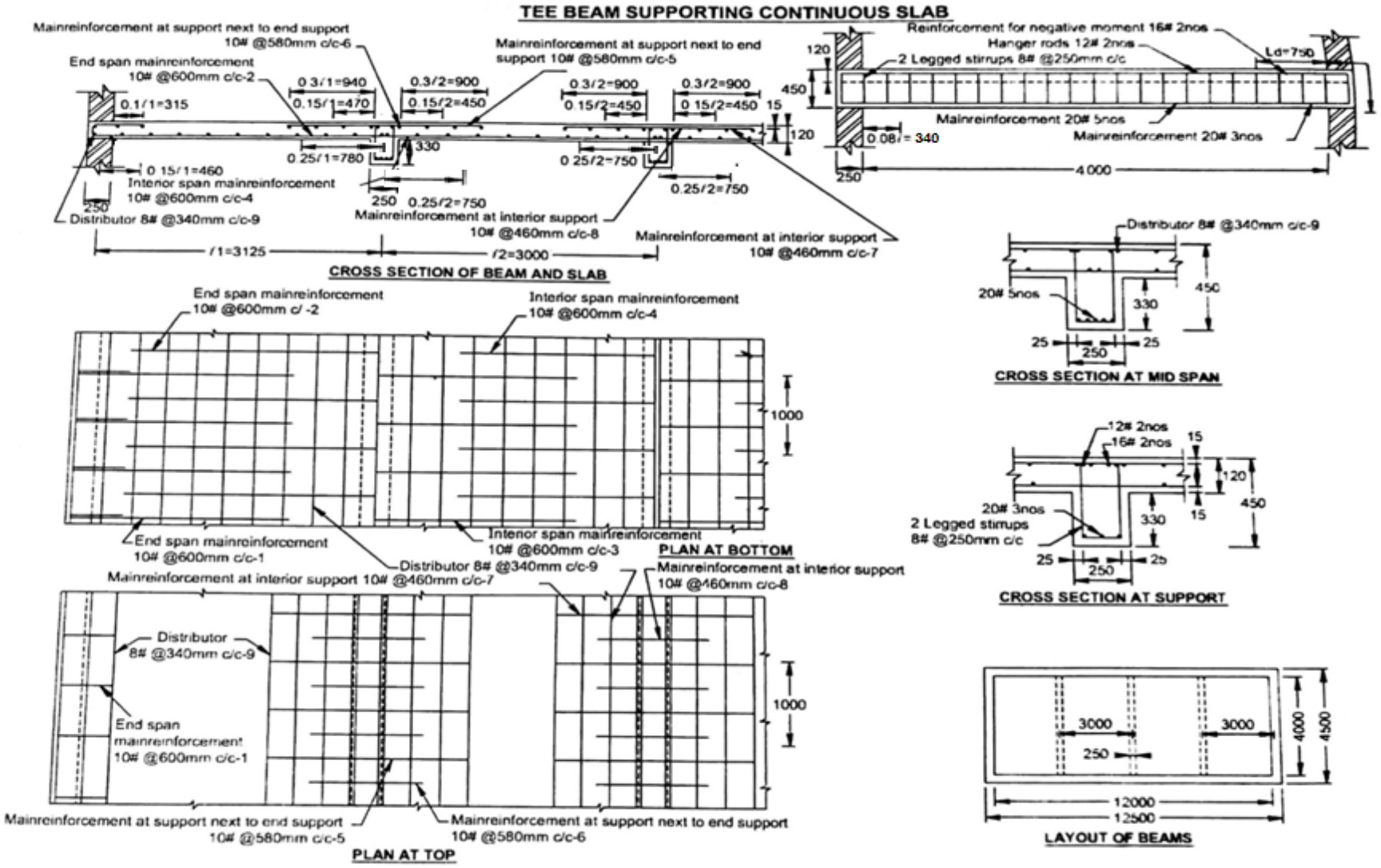
(orLd) whichever is greater.

Anchorage and curtailment of reinforcement may be adopted with standard values.

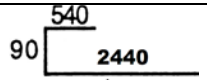
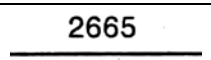
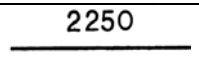
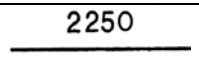
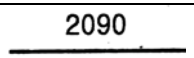
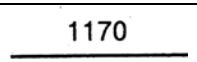
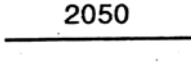
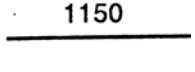
Assume any other data required suitably.

Draw the following views to a suitable scale.

1. The layout of beams
2. Plan showing reinforcement details at bottom and at top
3. The cross section of beam and slab for end span and interior span showing reinforcement details.
4. Longitudinal section of Tee beam.
5. Cross section of beam at mid span and at supports.
6. Prepare a bar bending schedule for all spans except beam portion for 1m width of slab.


TEE BEAM SUPPORTING CONTINUOUS SLAB
Mainreinforcement at support next to end support 10# @580mm c/c-6
End span mainreinforcement 10# @600mm c/c-2
Mainreinforcement at support next to end support 10# @580mm c/c-5
Reinforcement for negative moment 16# 2nos
Hanger rods 12# 2nos
2 Legged stirrups 8# @250mm c/c
Ld=750
0.1/1=315
0.3/1=940
0.15/1=470
0.3/2=900
0.15/2=450
0.3/2=900
0.15/2=450
0.3/2=900
0.15/2=450
15
120
450
120
330
0.25/1=780
0.25/2=750
0.08/= 340
Mainreinforcement 20# 5nos
Mainreinforcement 20# 3nos
0.15/1=460
Interior span mainreinforcement 10# @600mm c/c-4
250
250
0.25/2=750
0.25/2=750
4000
Distributor 8# @340mm c/c-9
Mainreinforcement at interior support 10# @460mm c/c-8
Mainreinforcement at interior support 10# @460mm c/c-7
/1=3125
/2=3000
CROSS SECTION OF BEAM AND SLAB
Distributor 8# @340mm c/c-9
20# 5nos
330
450
25
250
25
CROSS SECTION AT MID SPAN
End span mainreinforcement 10# @600mm c/ -2
Interior span mainreinforcement 10# @600mm c/c-4
1000
End span mainreinforcement 10# @600mm c/c-1
Interior span mainreinforcement 10# @600mm c/c-3
PLAN AT BOTTOM
Distributor 8# @340mm c/c-9
Mainreinforcement at interior support 10# @460mm c/c-7
Mainreinforcement at interior support 10# @460mm c/c-8
12# 2nos
16# 2nos
15
120
20# 3nos
2 Legged stirrups 8# @250mm c/c
330
15
450
25
250
25
CROSS SECTION AT SUPPORT
Distributor 8# @340mm c/c-9
End span mainreinforcement 10# @600mm c/c-1
1000
Mainreinforcement at support next to end support 10# @580mm c/c-5
Mainreinforcement at support next to end support 10# @580mm c/c-6
PLAN AT TOP
3000
3000
250
4000
4500
12000
12500
LAYOUT OF BEAMS

BAR BENDING SCHEDULE FOR TEE BEAM

Type No.	Size Grade	Shape Dimension	Length In m	No. of span	Number	Weight/ Unit length in N/m	Total weight in 'N'	Remarks
1.	10#		3.070	2	$\frac{1000}{600} = 1.67\ say\ 2$	6.17	75.77	Main reinforcement at end span
2.	10#		2.665	2	$\frac{1000}{600} = 1.67\ say\ 2$	6.17	65.77	Main reinforcement at end span
3.	10#		2.250	2	$\frac{1000}{600} = 1.67\ say\ 2$	6.17	55.53	Main reinforcement at interior span
4.	10#		2.250	2	$\frac{1000}{600} = 1.67\ say\ 2$	6.17	55.53	Main reinforcement at interior span
5.	10#		2.090	2	$\frac{1000}{580} = 1.72\ say\ 2$	6.17	51.58	Main reinforcement at next to end support
6.	10#		1.170	2	$\frac{1000}{580} = 1.72\ say\ 2$	6.17	28.88	Main reinforcement at next to end support
7.	10#		2.050	2	$\frac{1000}{460} = 2.17\ say\ 2$	6.17	50.59	Main reinforcement at interior support
8.	10#		1.150	2	$\frac{1000}{460} = 2.17\ say\ 2$	6.17	23.38	Main reinforcement at interior support

9.	8#	1000	1.000	2	$\frac{3225}{340}+1=10.48\ say\ 11$ $\frac{3000}{340}+1=9.80\ say\ 10$ $\frac{540}{340}+1=2.58\ say\ 3$ $\frac{2090}{340}+1=7.14\ say\ 8$ $\frac{2050}{340}+1=7.03\ say\ 8$	3.95	86.90	Distributor at end span
						Total weights		723.03
Adding 5% of above total weight for wastage 36.15 Total quantity of steel required 759.18 Say 760 N								

13. DOG –LEGGED STAIRCASE

Staircase is a structural form provided in building to facilitate easy vertical movements of persons from one floor to another.

Dog legged stairs are one of the different stairs adopted and in which the succeeding flight goes in the opposite direction.

The two flights are not separated with the gap and are suited where the width of room is sufficient to accommodate the width of two flights.

Problems

The following are the particulars of a dog legged staircase

Clear size of staircase room	= 5.90 x 3.40 m
Width of supporting wall	= 230 mm
Height of the floors	= 3.30 m
Width of Landing	=1600mm
Number of flight	=2 Nos
Rise of steps	=150 mm
Tread of steps	=270mm
Main reinforcement	= 10mmdia Fe415 steel
	@ 120mm c/c
Distributors	=8mmdia Fe415 steel
	@ 160 mm c/c

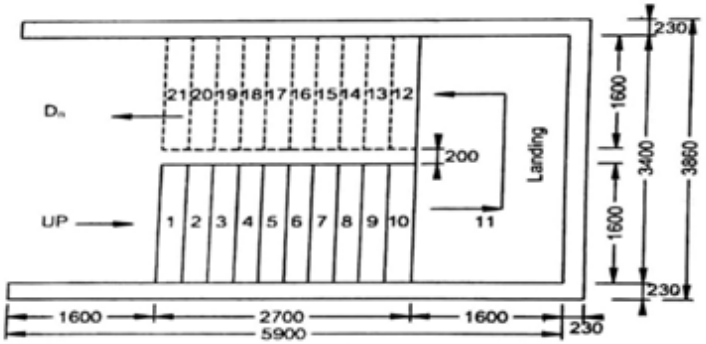
50% of the main reinforcement is provided at the bottom of landing slab and extended to the top of waist slab for a length of 0.15 *l*(or) Ld whichever is greater.

Assume any other data required suitably.

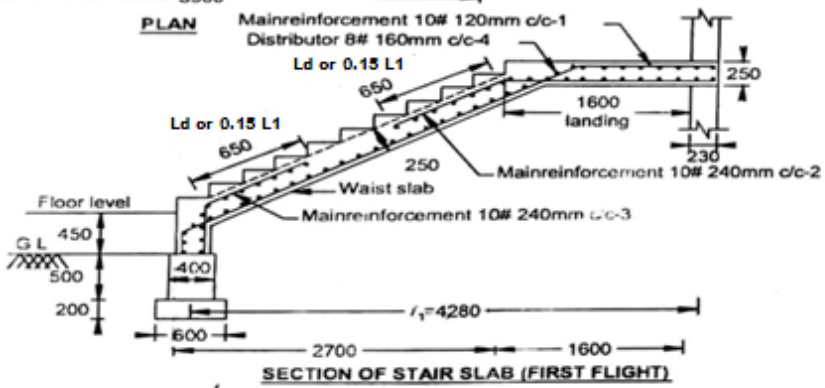
Draw the following views to a suitable scale

1. Plan and elevation of dog legged stair.
2. Section of waist slab.
3. Prepare a bar bending schedule.

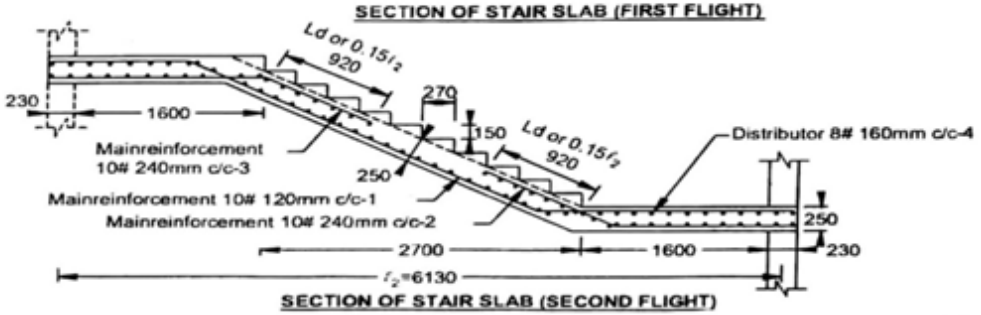
DOG LEGGED STAIRCASE



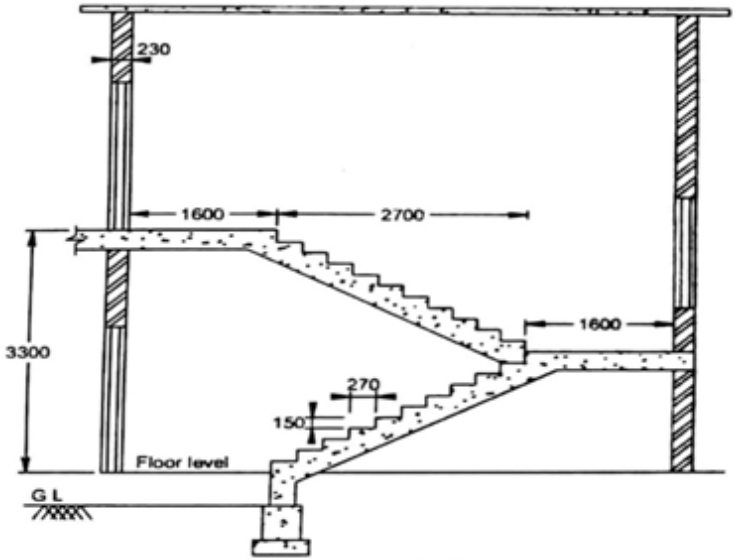
PLAN



SECTION OF STAIR SLAB (FIRST FLIGHT)

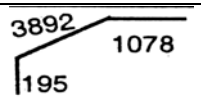
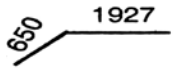
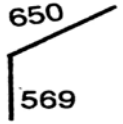
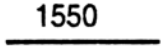


SECTION OF STAIR SLAB (SECOND FLIGHT)

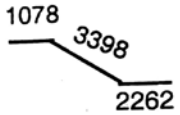
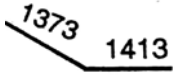
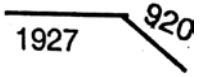
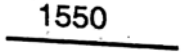


SECTIONAL ELEVATION

Bar bending schedule for First flight

Type No.	Size grade	Shape Dimension	Length in m	Number	Weight/Unit length in N/m	Total weight in 'N'	Remarks
1.	10#		5.165	$\frac{1550}{120} + 1 = 13.92\ say\ 14$	6.17	446.15	Main reinforcement
2.	10#		2.577	$\frac{1550}{240} + 1 = 7.46\ say\ 8$	6.17	127.20	Main reinforcement
3.	10#		1.219	$\frac{1550}{240} + 1 = 7.46\ say\ 8$	6.17	60.17	Main reinforcement
4.	8#		1.550	$\frac{195}{160} + 1 = 2.22\ say\ 3$ $\frac{3892}{160} = 24.33\ say\ 25$ $\frac{1078}{160} = 6.74\ say\ 7$ $\frac{650}{160} + 1 = 5.10\ say\ 6$ $\frac{1927}{160} = 12.04\ say\ 12$ $\frac{569}{160} + 1 = 4.56\ say\ 5$ $\frac{650}{160} = 4.120\ say\ 5$ Total= 63	3.95	385.72	Distributor
Total weights 1019.24							
Add 5% of above total weight for wastage during cutting, bending etc 50.96 N							
Total quantity of steel required 1070.20 N							
say 1075 N							

Bar bending schedule for Second flight

Type No.	Size grade	Shape Dimension	Length in m	Number	Weight/ Unit length in N/m	Total weight in 'N'	Remarks
1.	10#		6.738	$\frac{1550}{120}+1=13.92\ say\ 14$	6.17	582.03	Main reinforcement
2.	10#		2.786	$\frac{1550}{240}+1=7.46\ say\ 8$	6.17	137.52	Main reinforcement
3.	10#		2.847	$\frac{1550}{240}+1=7.46\ say\ 8$	6.17	140.53	Main reinforcement
4.	8#		1.550	$\frac{1078}{160}+1=7.74\ say\ 8$ $\frac{3898}{160}=24.33\ say\ 22$ $\frac{2262}{160}=14.14\ say\ 15$ $\frac{1373}{160}+1=9.58\ say\ 10$ $\frac{1413}{160}=8.83\ say\ 9$ $\frac{1927}{160}=13.04\ say\ 13$ $\frac{920}{160}=5.75\ say\ 6$ Total= 83		508.17	
Total weights1368.25N							
Add 5% of above total weight for wastage during cutting, bending etc 68.4 N							
Total quantity of steel required 1436.66 N							
Say 1440 N							

14. LINTEL CUM SUNSHADE

Lintels are horizontal structural elements provided over the openings on walls (doors, windows, ventilators etc) to carry the masonry over them. Lintel beams are designed as small rectangular beams of width always equal to the thickness of wall.

In the external openings it may be cast monolithically with sunshade. In sunshade the tension develops at top. The reinforcements of sunshade are well anchored into the lintel.

Problem

The following are the details of a lintel cm sunshade.

Clear span of lintel	=2.10m
Bearing on either side	=300 mm
Size of lintel	=300 x 200 mm
Width of support	=300 mm
Width of sunshade	=900mm
Thickness of sunshade	=70 mm @ support and 50 mm @ free end.

Reinforcement details

Main reinforcement (tension) =12mm Fe415 bars 5Nos

Hanger rods	=10mm Fe415 bars 2 Nos
Shear reinforcement	= 8mm Fe415 bars 2 legged stirrups @ 175 mm c/c

Sunshade

Main reinforcement = 10 mm Fe 415 bars @ 230 mm c/c

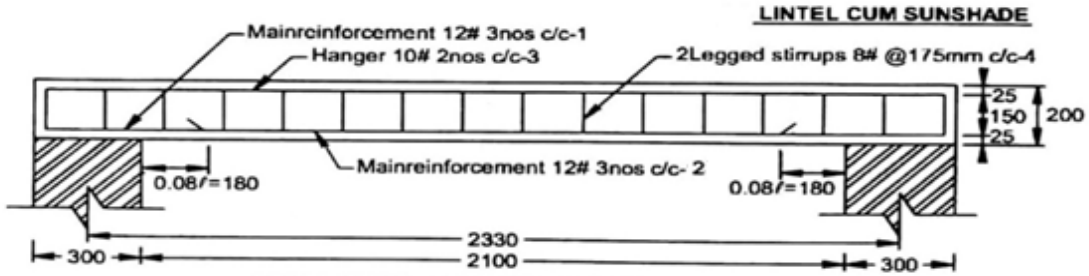
Distributor = 8 mm Fe 415 bars @ 300 mm c/c

Anchorage and curtailment of reinforcement may be adopted with standard values.

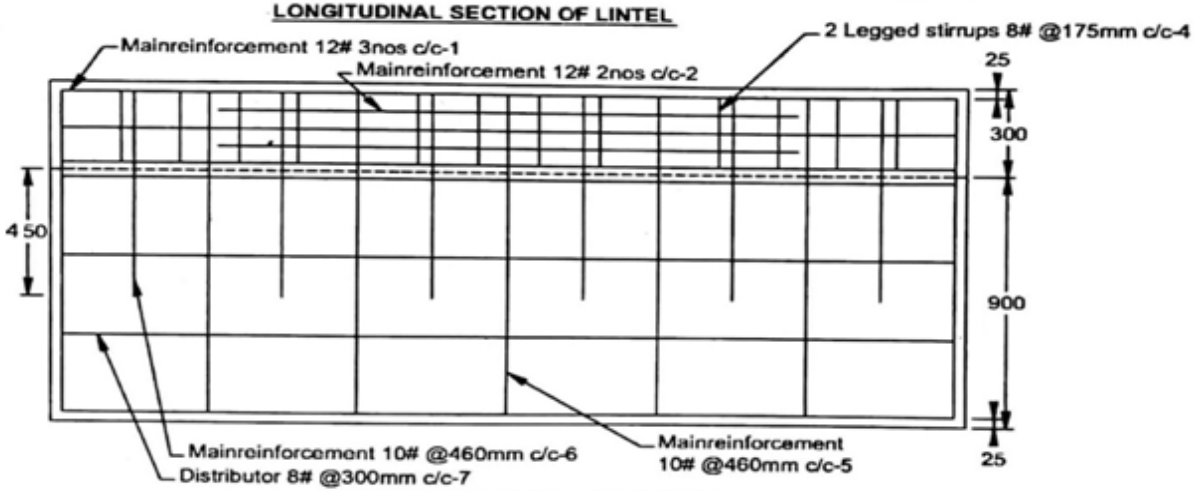
Assume any other suitable data if not given

Draw the following views to a suitable scale

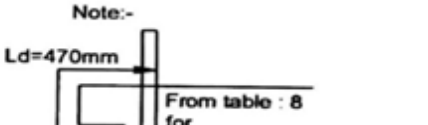
1. Longitudinal section of lintel
2. Cross section of lintel and sunshade at mid span and at support.
3. Prepare a bar bending schedule for the lintel cum sunshade.

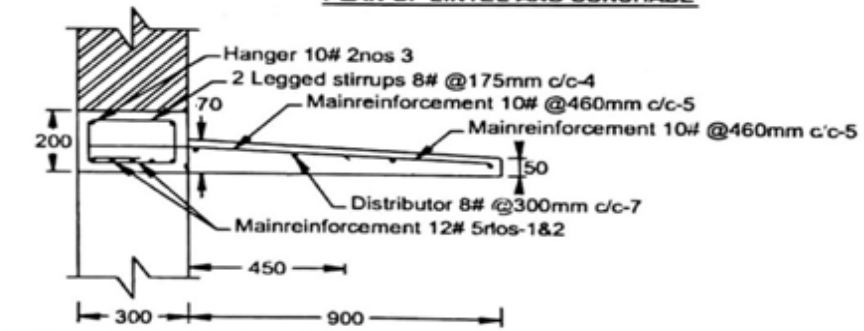


LONGITUDINAL SECTION OF LINTEL

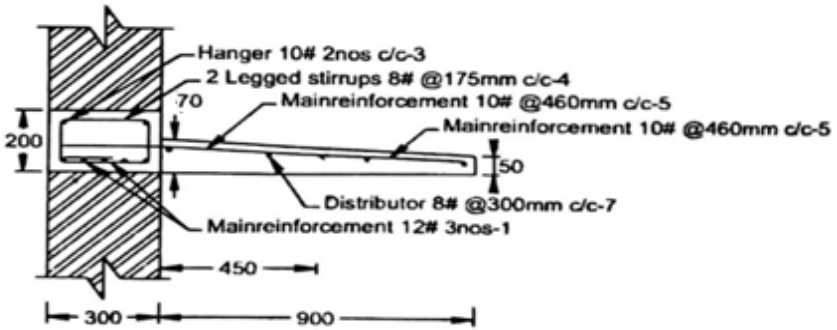


PLAN OF LINTEL AND SUNSHADE



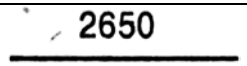
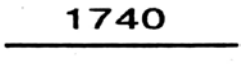
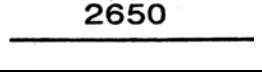
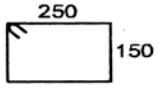
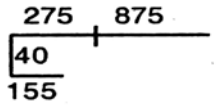
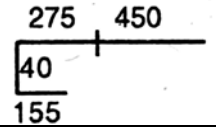


CROSS SECTION OF LINTEL AND SUNSHADE AT MID SPAN



CROSS SECTION OF LINTEL AND SUNSHADE AT SUPPORT

BAR BENDING SCHEDULE

Type No.	Size Grade	Shape Dimension	Length In m	Number	Weight/ Unit length in N/m	Total weight in 'N'	Remarks
1.	12#		2.650	3	8.88	70.59	Main reinforcement
2.	12#		1.740	2	8.88	30.90	Main reinforcement
3.	10#		2.650	2	6.17	32.70	Hanger rods
4.	8#	 (250+150)2 + 2d 800+(20x8)=960	0.960	$\frac{2250}{175}+1=15.57\ say\ 16$	3.95	60.67	Stirrups
5.	10#		1.345	$\frac{2550}{460}+1=6.54\ say\ 7$	6.17	58.09	Main reinforcement
6.	10#		0.920	$\frac{2550}{460}=5.54\ say\ 6$	6.17	34.06	Main reinforcement
7.	8#		2.650	$\frac{875}{300}+1=3.92\ say\ 4$	3.95	41.87	Distributor
Total weights						328.88	
Add 5% of above total weight etc						16.44	
						345.32 N Say 350 N	

15. R.C.C COLUMN WITH SQUARE ISOLATED FOOTING

A column is a vertical compression member provided to carry a compressive load and whose effective length exceeds three times its least laterals dimensions. Columns are used to transmit the load from super structure to foundation. Based on the shape of columns, it is classified into square, rectangular and circle.

The foundation provided for a R.C. column is called a 'Column base' or a 'Column footing'. The main function of column base is to transfer the load carried by the column safely on a larger area of the soil. Individual footings are generally square and supports a central column.

Problems

The following are the particulars of a R.C.C square column with square footing.

Column size	= 400mm x 400 mm
Clear cover	= 40 mm
Size of footing	= 2100mm x 2100 mm
Thickness of footing	= 600 mm
Bottom cover	= 50 mm
Side cover	= 75mm

Reinforcement details

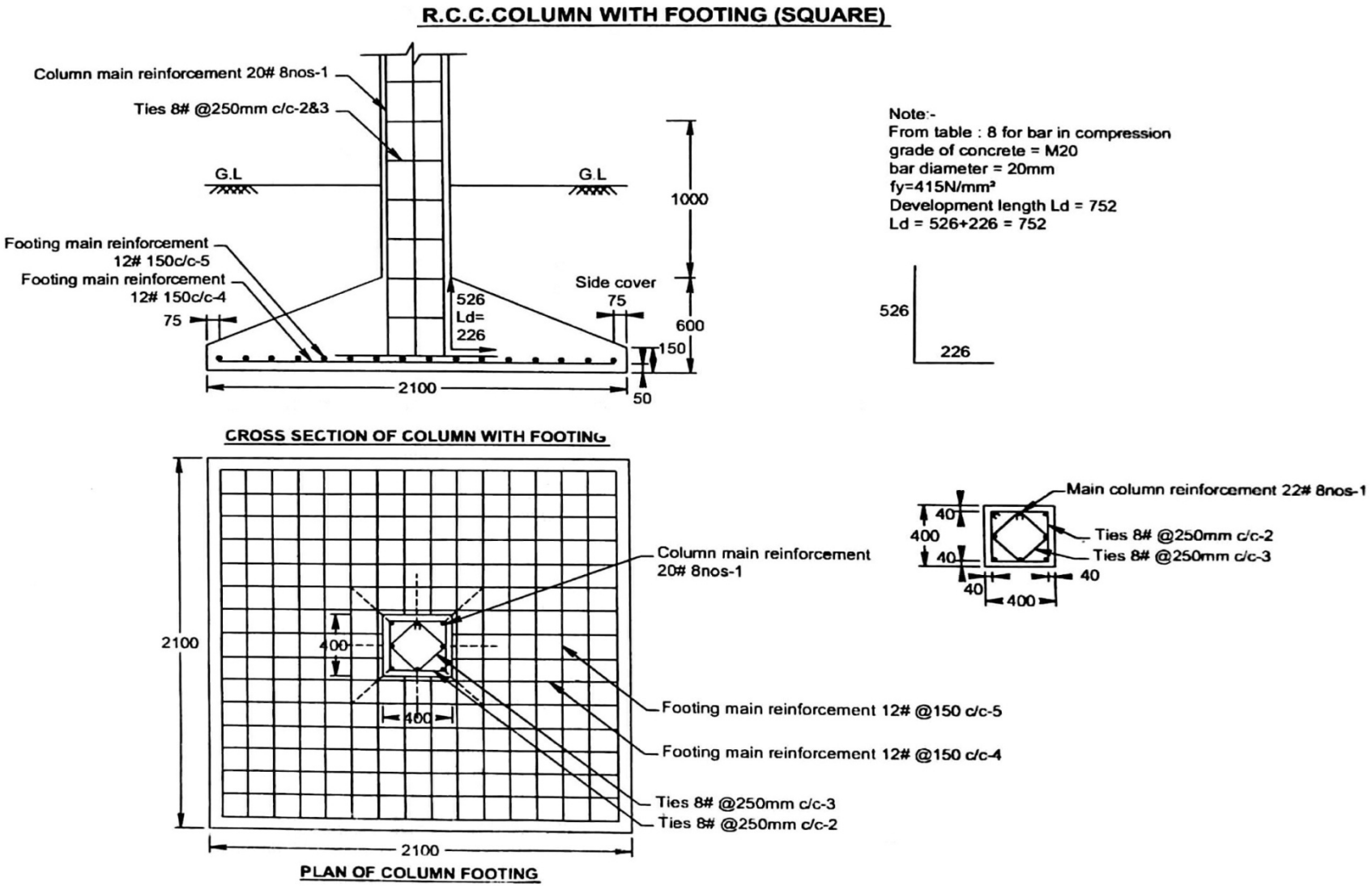
Main reinforcement	= 20 mm Fe415 bars 8Nos
Lateral ties	= 8 mm Fe415 bars @ 250 mm c/c
Footing	=12mm Fe415 bars @ 150 mm c/c

Anchorage and curtailment of reinforcement may be adopted with standard values.

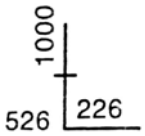
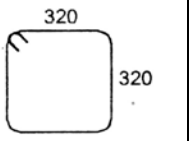
Assume any other data required suitable

Draw the following views to a suitable scale.

1. Plan column with reinforcement details
2. Sectional view of column with footing
3. Plan of footing showing reinforce details
4. Prepare a bar bending schedule for column and footing (for 1m ht of column)



BAR BENDING SCHEDULE FOR R.C.C COLUMN WITH FOOTING (SQUARE)

Type No.	Size	Shape		Length In m	Number	Weight/Unit length in N/m	Total weight in 'N'	Remarks
		Column	Footing					
1.	20#			1.752	8	24.66	345.63	Main Reinforcement
2.	8#	 (320+320)2+20d 1280+(20x8)=1440		1.440	$\frac{1526}{250} = 6.10\ say\ 6$	3.95	34.13	Lateral ties
3.	8#	 (226.3+226.3)2+20d 905.2+(20x8)=1065.2		1.065	$\frac{1526}{250} = 6.10\ say\ 6$	3.95	25.24	Lateral ties
4.	12#		1950	1.950	$\frac{1950}{150} = 13$	8.88	225.10	Main Reinforcement
5.	12#		1950	1.950	$\frac{1950}{150} = 13$	8.88	225.10	Main Reinforcement
Total weights							855.20+42.76 =897.96	
Add 5% of above total weight etc							Say 900 N	

Annexure

Development Length for fully stressed plain Bars

f_y = 250 N/mm^2 for bars up to 20 mm diameter

= 240 N/mm^2 for bars over 20 mm diameter

(Tabulated values are in millimeters)

Bar Diameter	Tension Bars for Grade of Concrete					Compression Bars for Grade of Concrete			
	M15	M20	M25	M30		M15	M20	M25	M30
1	2	3	4	5		6	7	8	9
mm									
6	326	272	233	218		261	218	186	174
8	435	363	311	290		348	290	249	232
10	544	453	388	363		435	363	311	290
12	653	544	466	435		522	435	373	348
16	870	725	621	580		696	580	497	464
18	979	816	699	653		783	653	559	522
20	1088	906	777	725		870	725	621	580
22	1148	957	820	766		919	766	656	612
25	1305	1088	932	870		1044	870	746	696
28	1462	1218	1044	974		1169	974	835	780
32	1670	1392	1193	1114		1336	1114	955	896
36	1879	1566	1342	1253		1503	1253	1074	1002

Note 1 : The development lengths given above are for a stress of 0.87 f_y in the bar.

Note 2 : It is important to note that hook should normally be provided for plain bars in tension. Threfore, the straight length required in such cases is equal to the value taken from the table minus the anchorage value of hook.

Development Length for fully stressed deformed Bars

f_y = 415 N/mm^2

(Tabulated values are in millimeters)

Bar Diameter	Tension Bars for Grade of Concrete					Compression Bars for Grade of Concrete			
	M15	M20	M25	M30		M15	M20	M25	M30
1	2	3	4	5		6	7	8	9
mm									
6	338	282	242	226		271	226	193	181
8	451	376	322	301		361	301	258	241
10	564	470	403	376		451	376	322	301
12	677	564	484	451		542	451	387	361
16	903	752	645	602		722	602	516	481
18	1015	846	725	677		812	677	580	542
20	1128	940	806	752		903	752	645	602
22	1241	1034	887	827		993	827	709	662
25	1410	1175	1007	940		1128	940	806	752
28	1580	1316	1128	1053		1264	1053	903	842
32	1805	1504	1289	1203		1444	1203	1032	963
36	2031	1693	1450	1354		1625	1354	1161	1083

Note : The development lengths given above are for a stress of 0.87 f_y in the bar.

Development Length for fully stressed deformed Bars

f_y = 500 N/mm^2 (Tabulated values are in millimeters)

Bar Diameter	Tension Bars for Grade of Concrete					Compression Bars for Grade of Concrete			
	M15	M20	M25	M30		M15	M20	M25	M30
1	2	3	4	5		6	7	8	9
mm									
6	408	340	291	272		326	272	232	218
8	544	453	388	363		435	363	312	290
10	680	566	485	453		544	453	388	363
12	816	680	583	544		653	544	466	435
16	1088	906	777	725		870	725	621	580
18	1223	1020	874	816		979	816	699	653
20	1359	1133	971	906		1088	906	727	725
22	1495	1246	1068	997		1196	997	854	798
25	1699	1416	1214	1133		1359	1133	971	906
28	1903	1586	1359	1269		1523	1269	1088	1015
32	2175	1813	1554	1450		1740	1450	1243	1160
36	2447	2039	1748	1631		1958	1631	1398	1305

Note : The development lengths given above are for a stress of 0.87 f_y in the bar.

Reinforcement characteristics – Area, Weight and Perimeter

Size	Area	Weight	Perimeter	Length per Kn		Size	Area	Weight	Perimeter	Length per Kn
1	2	3	4	5		1	2	3	4	5
mm	mm^2	(N/m)	(mm)	(m)		mm	mm^2	(N/m)	(mm)	(m)
6	28.3	2.22	18.90	450.5		22	380.1	29.8	69.1	33.6
8	50.3	3.95	25.10	253.2		25	490.9	38.54	78.5	26.0
10	78.5	6.17	31.40	162.1		28	615.7	48.30	88.0	20.7
12	113.1	8.88	57.70	112.5		32	804.2	63.13	100.5	15.9
14	153.9	12.06	44.00	82.9		36	1017.9	79.90	113.1	12.5
16	201.1	15.78	50.30	63.3		40	1256.6	98.64	125.7	10.1
18	254.5	20.00	56.50	50.0		45	1590.4	124.90	141.4	8.0
20	314.2	24.66	62.80	40.5		50	1963.5	154.10	157.1	6.5