Govt. Polytechnic, Nanakpur

WATER SUPPLY & WASTE WATER ENGG.

SEMESTER:-4TH

By:- Dr. Rajeev kumar

SYLLABUS

❑WATER SUPPLY

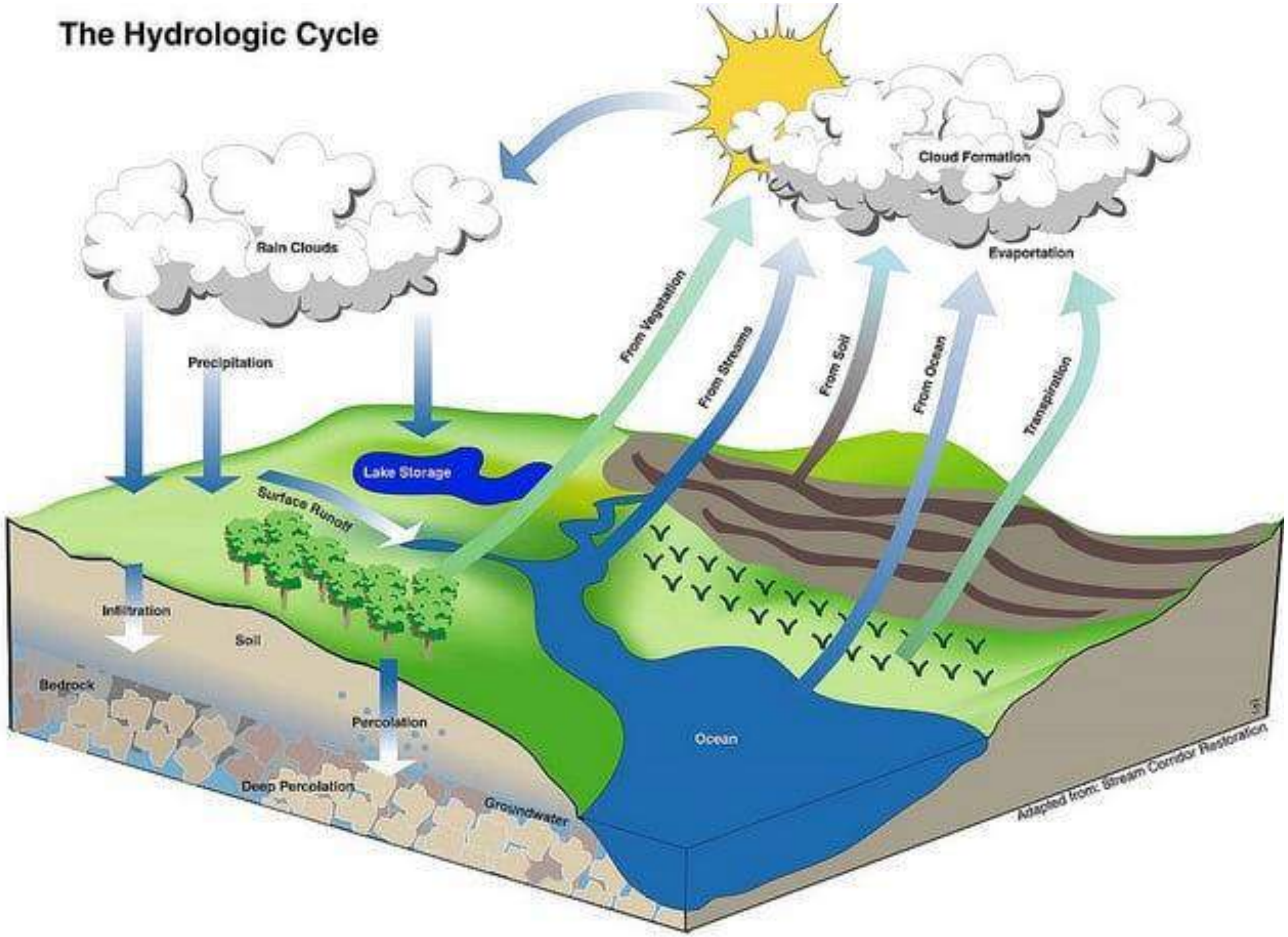
- ❖INTRODUCTION…
- ❖QUANTITY OF WATER…
- ❖QUALITY OF WATER…
- ❖WATER TREATMENT…
- ❖CONVEYANCE OF WATER…
- ❖LAYING OUT PIPES…
- ❖BUILDING WATER SUPPLY…

❑WASTE WATER ENGG

- ❖INTRODUCTION…
- ❖SEWERAGE SYSTEM…
- ❖LAYING AND CONSTRUCTION OF SEWER…
- ❖SEWAGE CHARACTERSTICS…
- ❖NATURAL METHOD OF SEWAGE DISPOSAL…
- ❖SEWAGE TREATMENT…
- ❖BUILDING DRAINAGE…

1.introduction

HYDROGEN CYCLE



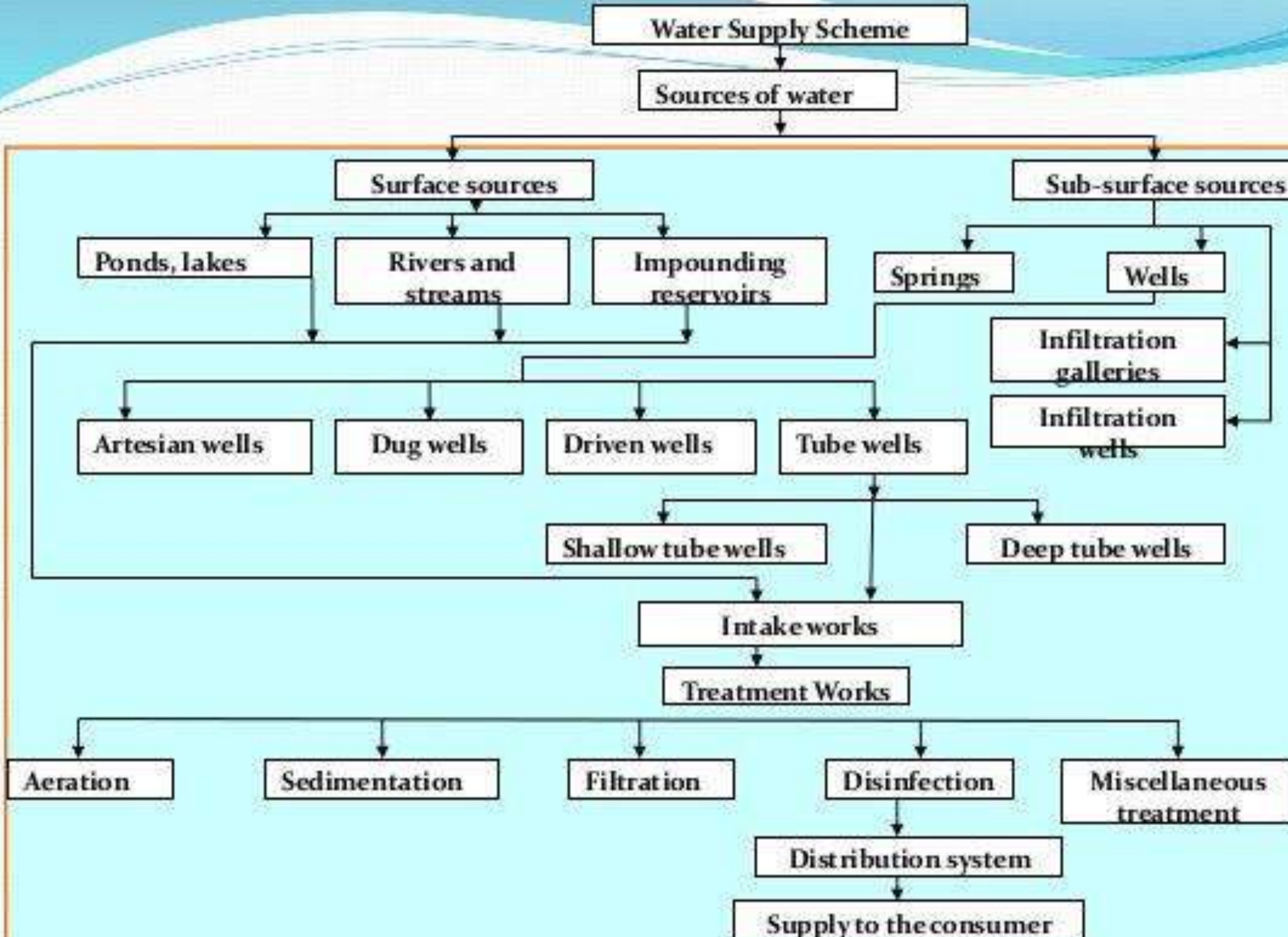


Fig 1 Schematic diagram of typical water supply scheme

2. QUANTITY OF WATER

- DOMESTIC WATER DEMAND
- COMMERCIAL WATER DEMAND
- INDUSTRIAL DEMAND
- FIRE DEMAND
- LOSES AND WASTE
- DEMAND FOE PUBLIC USE

Domestic use…

The details of the domestic consumption are

a) Drinking ------ 5 litres

b) Cooking ------ 5 litres

c) Bathing ------ 55 litres

d) Clothes washing ------20 litres

e) Utensils washing ------10 litres

f) House washing ------ 10 litres

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135 litres/day/capita

Public utility

The requirements of water for public utility shall be taken as...

Sl.No.	Purpose Water	Requirements
1	Public parks	1.4 litres/m2/day
2	Street washing	1.0-1.5 litres/m2/day
3	Sewer cleaning	4.5 litres/head/day

For various purposes..

Water Consumption for Various Purposes

	Types of Consumption	Normal Range (lit/capita/day)	Average	%
1	Domestic Consumption	65-300	160	35
2	Industrial and Commercial Demand	45-450	135	30
3	Public Uses including Fire Demand	20-90	45	10
4	Losses and Waste	45-150	62	25

Per capita demand

The total yearly consumption of water of a water supply Scheme divided by the population of that area and the num Of days in a year…

$$\text{Per capita demand} = \frac{\text{total consumption of water}}{\text{Population} * 365}$$

3.Quality of water

Water quality

Water quality is the physical, chemical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water.

Importance of testing

Water quality testing is important because it identifies contaminants and prevents water-borne diseases.

Necessity…….

1.Controlling operation
2.Purity determination
3.Amount of impurities
4.Type of impurities
5.Quality determination
6.Deciding various purification stages

METHODS…

❑Physical test…

- ❖Temperature test
- ❖Color test
- ❖Turbidity test
- ❖Odour test
- ❖Specific conductivity test

❑Chemical test…

- ❖Total solid test
- ❖Chloride test
- ❖Chlorine test
- ❖Lead test
- ❖Arsenic test
- ❖Ph value test
- ❖Fluorine test
- ❖Iron and manganese test
- ❖Copper test
- ❖Dissolved gases test
- ❖Calcium and sodium test

4.Water treatment

INTRODUCTION

- Water treatment is **the process of removing contaminants from wastewater and household water**.
- It **includes physical, chemical, and biological processes** to remove physical, chemical and biological contaminants.
- Its **objective** is to **produce an environmentally safe fluid** waste stream and a solid **waste suitable for disposal or reuse** .

Steps.

- Screening
- Plain sedimentation
- Sedimentation with coagulation
- Filtration
- Disinfection
- Aeration

1.Screening

A protective device provided T

Exclude large size particle

called screening…

Types..

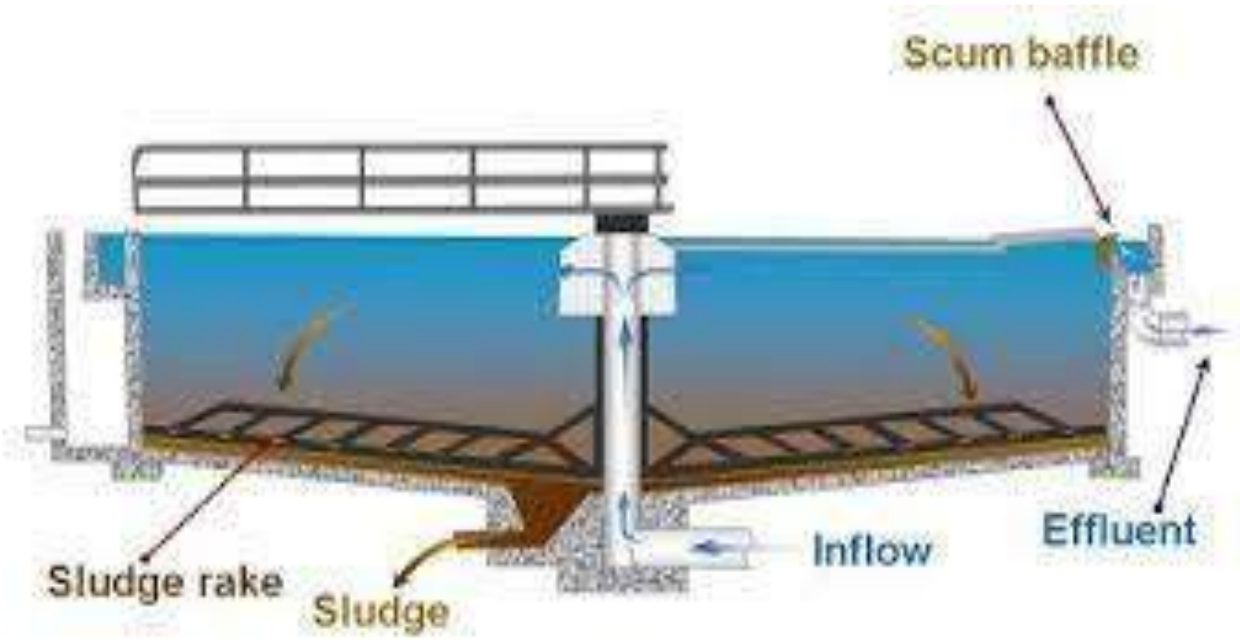
1.Coarse screening 2.Fine screening

❑. Sedimentation

The process by which suspended particles Removed form water under effect of Gravity Called sedimentation.

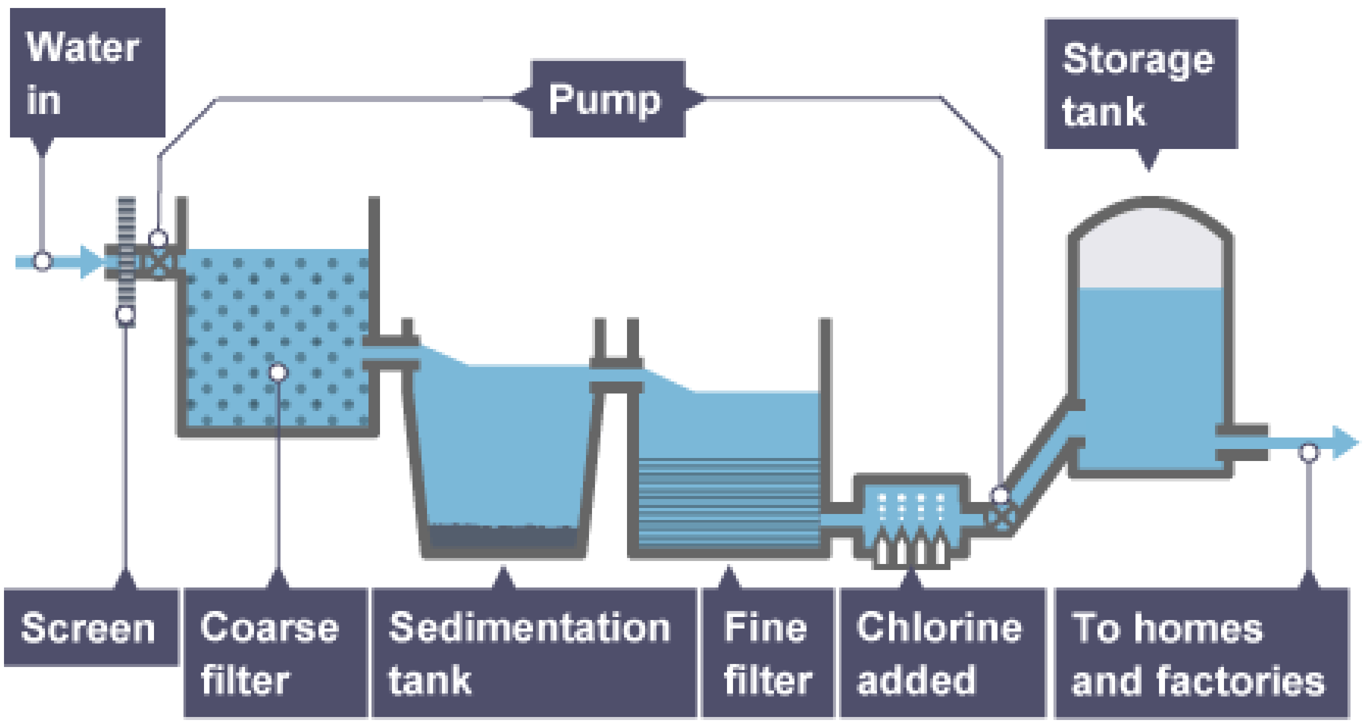
Types..

- Plain sedimentation.
- Sedimentation with co-agulation



Chlorination

Chlorination is one of many methods that can be used to disinfect water. This method was first used over a century ago, and is still used today. It is a chemical disinfection method that uses various types of chlorine or chlorine-containing substances for the oxidation and disinfection of what will be the potable water source



5.Conveyance of water

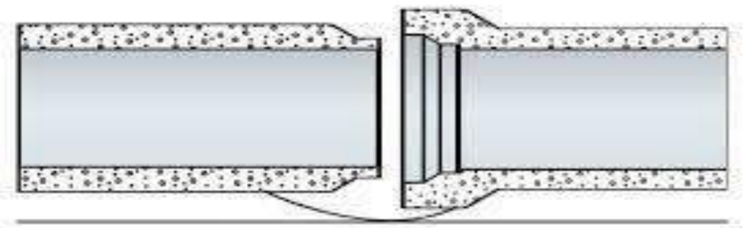
The pipes of different material are used in conveyance of w
Some of them are…..

- oCopper lead pipe oCast iron pipe oGalvanized pipe oSteel pipe
- oP.V.C. Pipes
- oAsbestos cement pipe oConcrete pipe

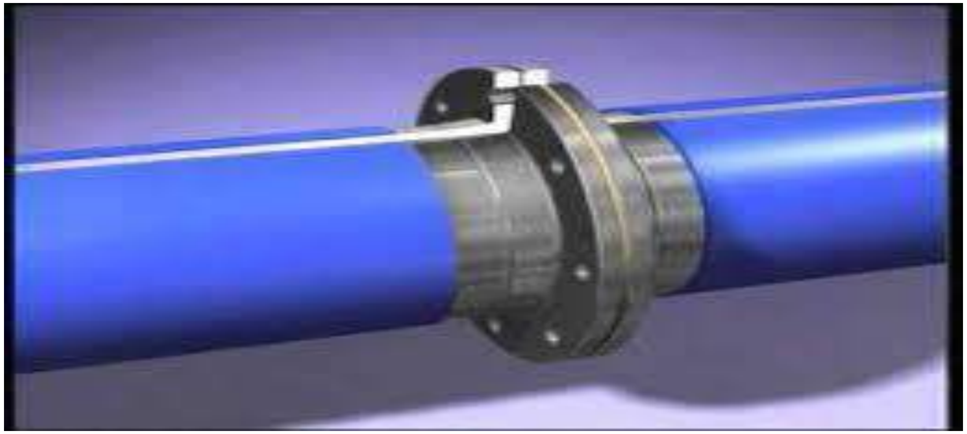
Copper pipe

Joints in pipe..

1.Socket joint



2.Flanged joint



3.Expansion joint

4.Screwed joint

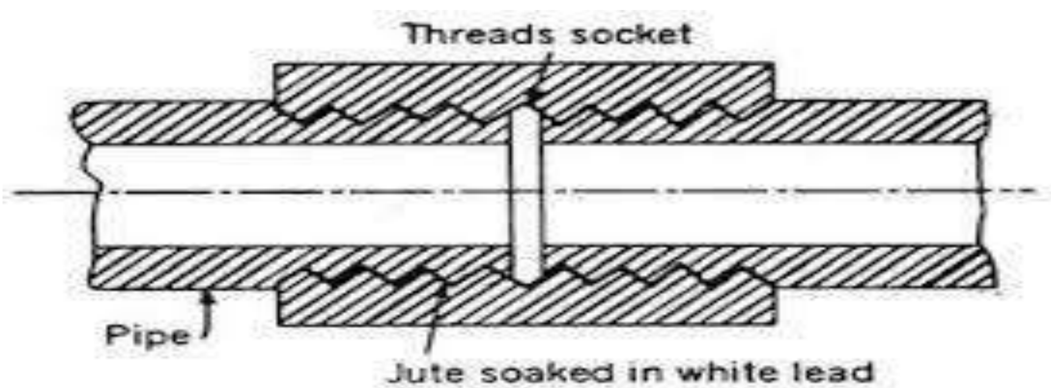


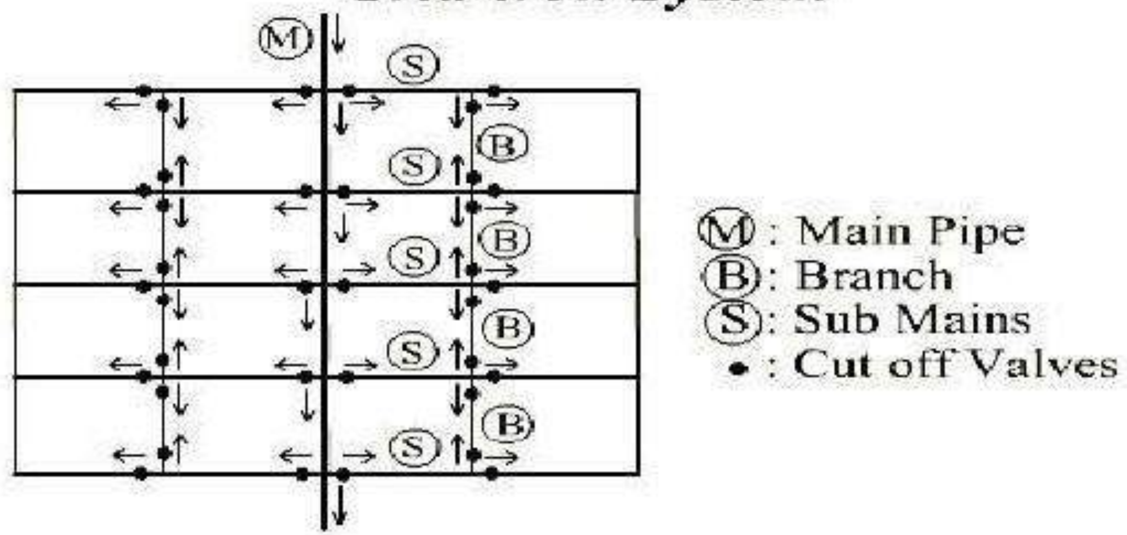
Fig. 7.19. Screwed Joint.

Layout of water distribution

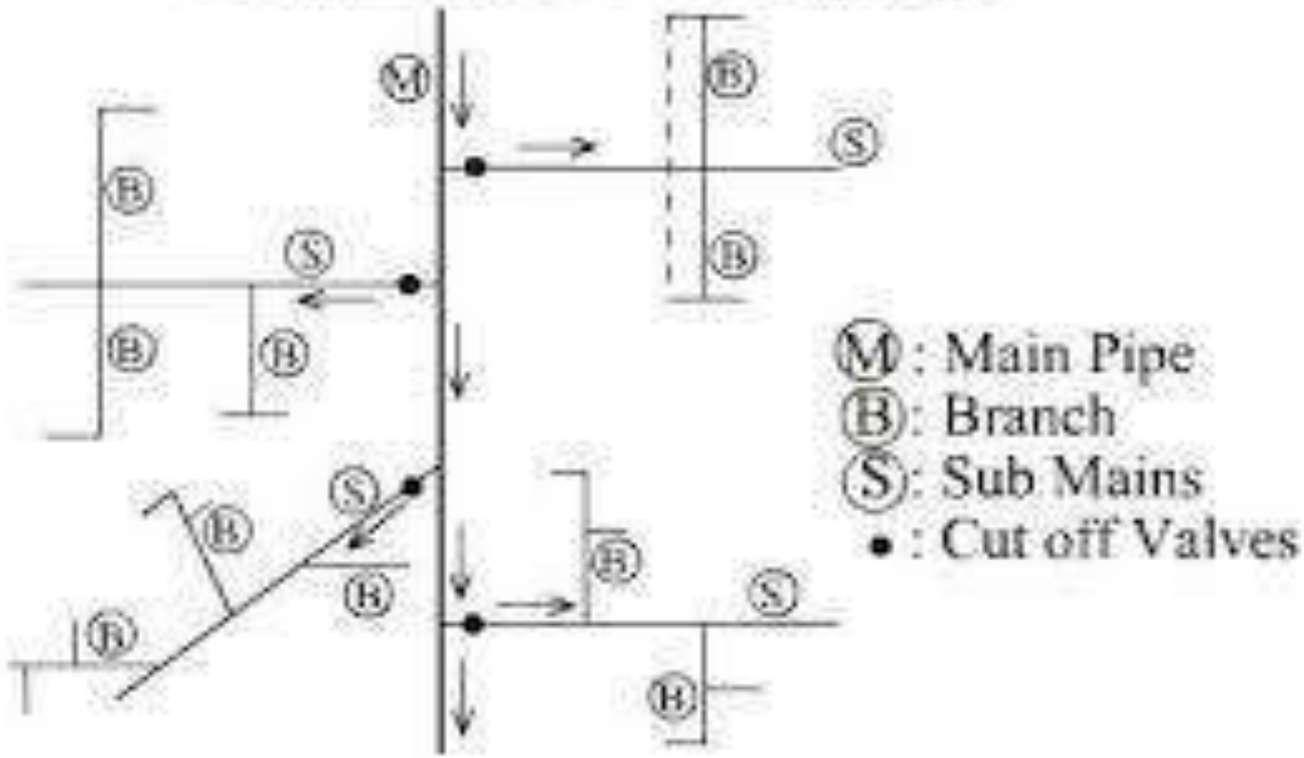
Grid Iron System...

❖ It is suitable for cities with rectangular layout, where the water mains and branches are laid in rectangles.

Grid-iron System



Dead End or Tree System



6.Laying of pipes

- There are nine steps of laying out pipes

1)General planning of area
2)Setting out alignment
3)Excavation of trench
4)Bedding of trench
5)Lowering of pipes
6)Laying of pipes
7)Jointing of pipes
8)Testing of pipe lines
9)Back filling

Excavation of trench

Bedding of trench

7.Building water supply

The different types of fittings used in a building for installing water Supply plumbing are called as water supply fixtures.

Various type of fixtures are…

- Ferrule
- Goose neck
- Stop cock
- Service pipe
- Bib cock
- Stop tap
- Storage tank

Goose neck

Bib cock

Bends in pipes

Part :-2
Waster water Engineering

8.Introduction to sanitation

The used water or anything else like solid or semi solid whicjh is throw Finally in one form to the other is called waste…….

❑Classification …

✓Dry waste
✓Semi solid or semi liquid
✓Liquid waste

❑In our research, we've come up with five frequently mentioned sanitation tips to prevent foodborne illnesses in food service and retail businesses. They are:

❖Proper personal hygiene, including frequent hand and arm washing and covering cuts;
❖Proper cleaning and sanitizing of all food contact surfaces and utensils;
❖Proper cleaning and sanitizing of food equipment;
❖Good basic housekeeping and maintenance; and
❖Food storage for the proper time and at safe temperatures.

SANITARY DESIGN DAIRY CHECKLIST

- **PRINCIPLE #1 - MICROBIOLIGICALLY CLEANABLE**
- **PRINCIPLE #2 - MADE OF COMPATIBLE MATERIALS**
- **PRINCIPLE #3 - ACCESSIBLE FOR INSPECTION, MAINTENANCE, & CLEANING/SANITATION**
- **PRINCIPLE #4 - NO LIQUID COLLECTION**
- **PRINCIPLE #5 - HOLLOW AREAS HERMETICALLY SEALED**
- **PRINCIPLE #6 - NO NICHES**
- **PRINCIPLE #7 - SANITARY OPERATIONAL PERFORMANCE**
- **PRINCIPLE #8 - HYGIENIC DESIGN OF MAINTENANCE ENCLOSURES**
- **PRINCIPLE #9 - HYGIENIC COMPATIBILITY WITH OTHER SYSTEMS**
- **PRINCIPLE #10 - VALIDATED CLEANING & SANITIZING PROTOCOLS**

commercial food sanitation

Difference between water conservancy and water carriage system

SEWERAGE SYSTEMS:

CONSERVENCY SYSTEM	WATER CARRIAGE SYSTEM
Very cheap in initial cost.	It involves high initial cost.
Due to foul smells from the latrines, they are to be constructed away from living room so building cannot be constructed as compact units.	As there is no foul smell latrines remain clean and neat and hence are constructed with rooms, therefore buildings may be compact.
The aesthetic appearance of the city cannot be improved	Good aesthetic appearance of city can be obtained.
For burial of excremental matter large area is required.	Less area is required as compared to conservancy system.
Excreta is not removed immediately hence its decomposition starts before removal,	Excreta are removed immediately with water, no problem of foul smell or hygienic trouble.
This system is fully depended on human agency .In case of strike by the sweepers; there is danger of insanitary conditions in	As no human agency is involved in this system ,there is no such problem as in case of conservancy system

9.Sewerage system

Sewers are the underground pipes which are used for carrying the sewage
To the disposal point outside the town…..

Classification of sewerage..

- ✓Separate system
- ✓Combined system
- ✓Partially separate system

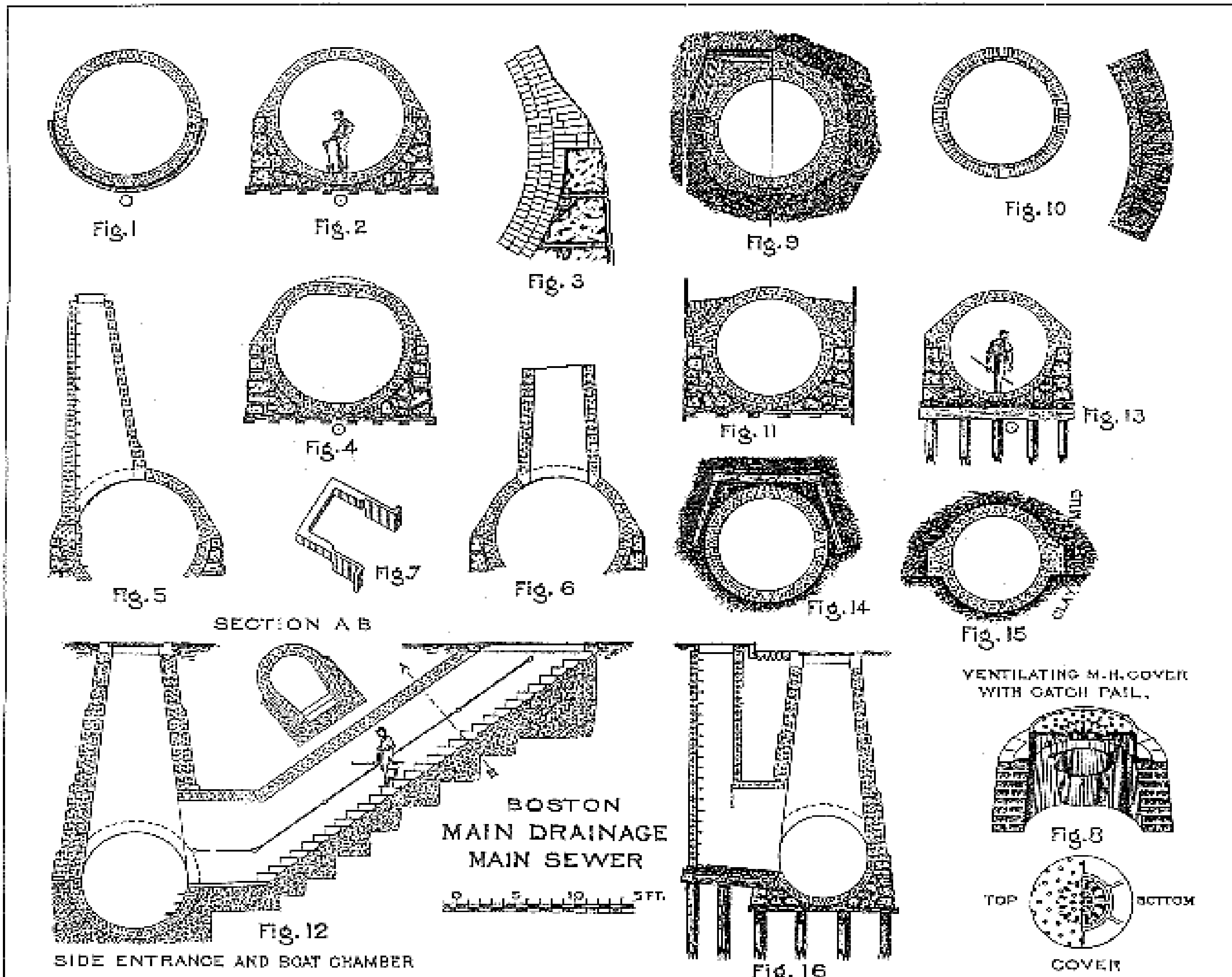
❑The pipes are made
with diff material..

- ▪Cast iron
- ▪Concrete sewers
- ▪Stone ware
- ▪Asbestos cement
- ▪Masonry
- ▪Plastic

Underground Sewerage pipes

Different shape sewers

Plate VI



10.Laying and Cons. Of Sewer

- Stages of construction and laying of sewers

- Setting out alignment of sewer
- Excavation of trench
- Setting the gradient
- preparation of bedding
- Handling of sewer
- Testing of sewer
- Backfilling of trench

Excavation of trench

Procedure…

Sand Bedding

Installation of Pipe and Sensor

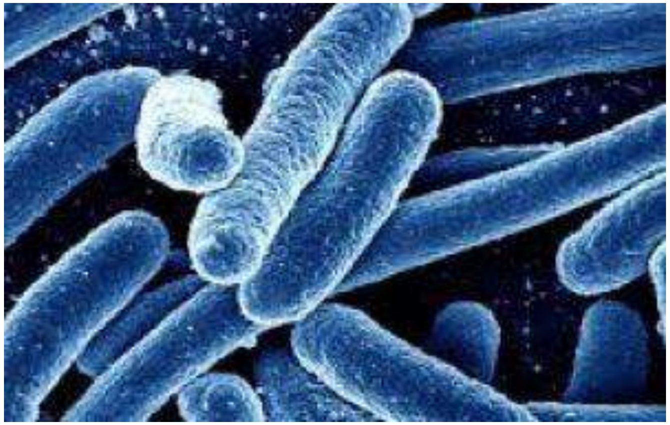
3 Layer Sand Backfill
and Compaction

2 Layer In-Situ Soil Backfill
and Compaction

11.Sewarage characteristics

❑Composition of sewage…

- ➢Floating matter like wrappers, match sticks, leaf etc.
- ➢Mineral matter like sand,gravels,dust etc.
- ➢Vegetable and animal matter like hydrocarbon,oil,fatty acid etc.
- ➢Gases like ammonia hydrogen sulphide,methane etc.
- ➢Biological life like bacteria



Bacteria in sewage

Floating matter

Analysis of sewage

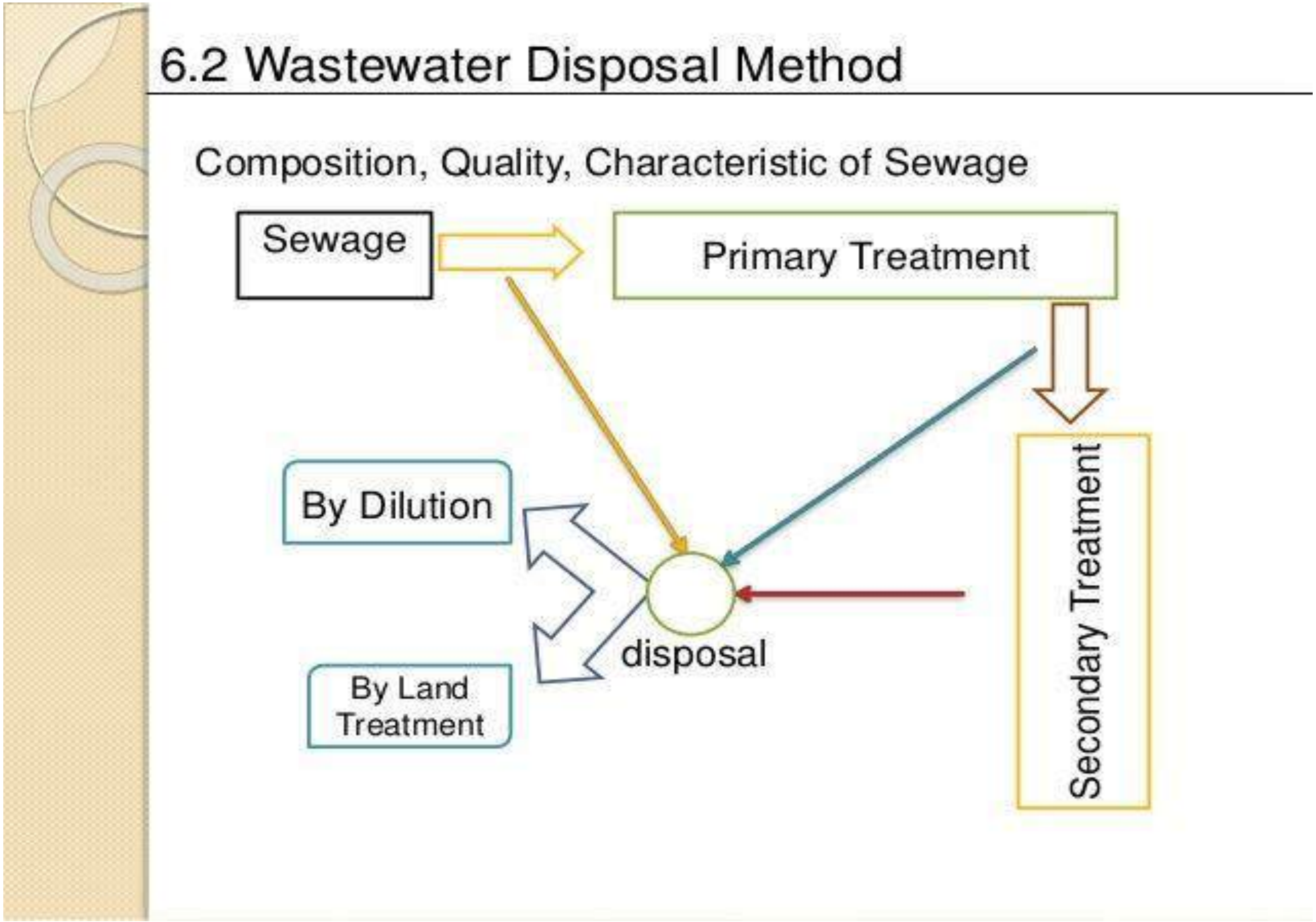
❑Physical analysis…

- ✓Turbidity test
- ✓Odour test
- ✓Temperature test
- ✓Color test

❑Chemical analysis…

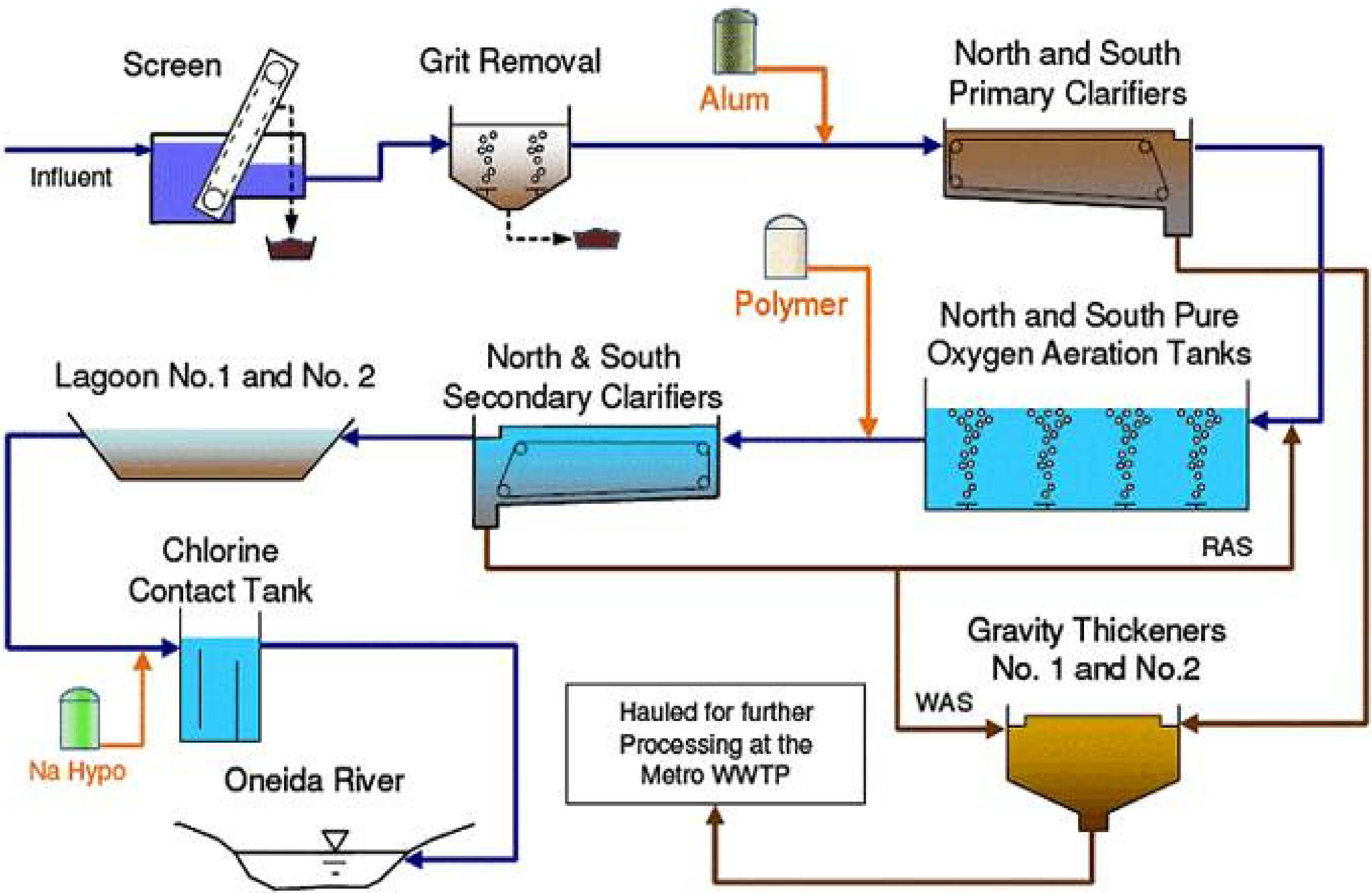
- ✓Solids
- ✓Dissolved oxygen
- ✓Bio-chemical oxygen demand
- ✓Chemical oxygen demand
- ✓Nitrogen
- ✓Chloride and sulphide
- ✓Chlorine test
- ✓Ph-value test
- ✓Oil and grease

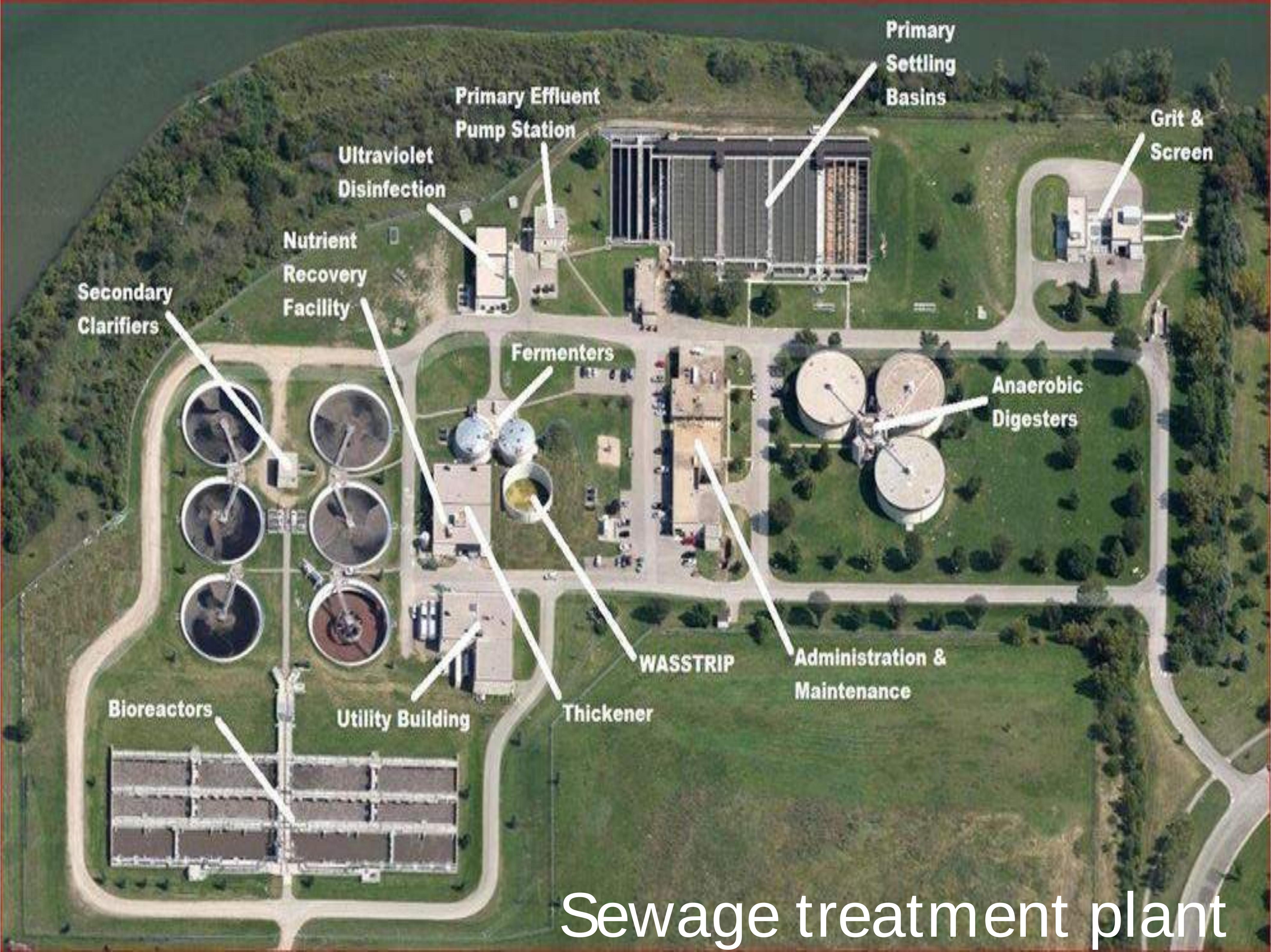
12.Natural method of sewage disposal



1.Dilution of sewage
2.Land treatment

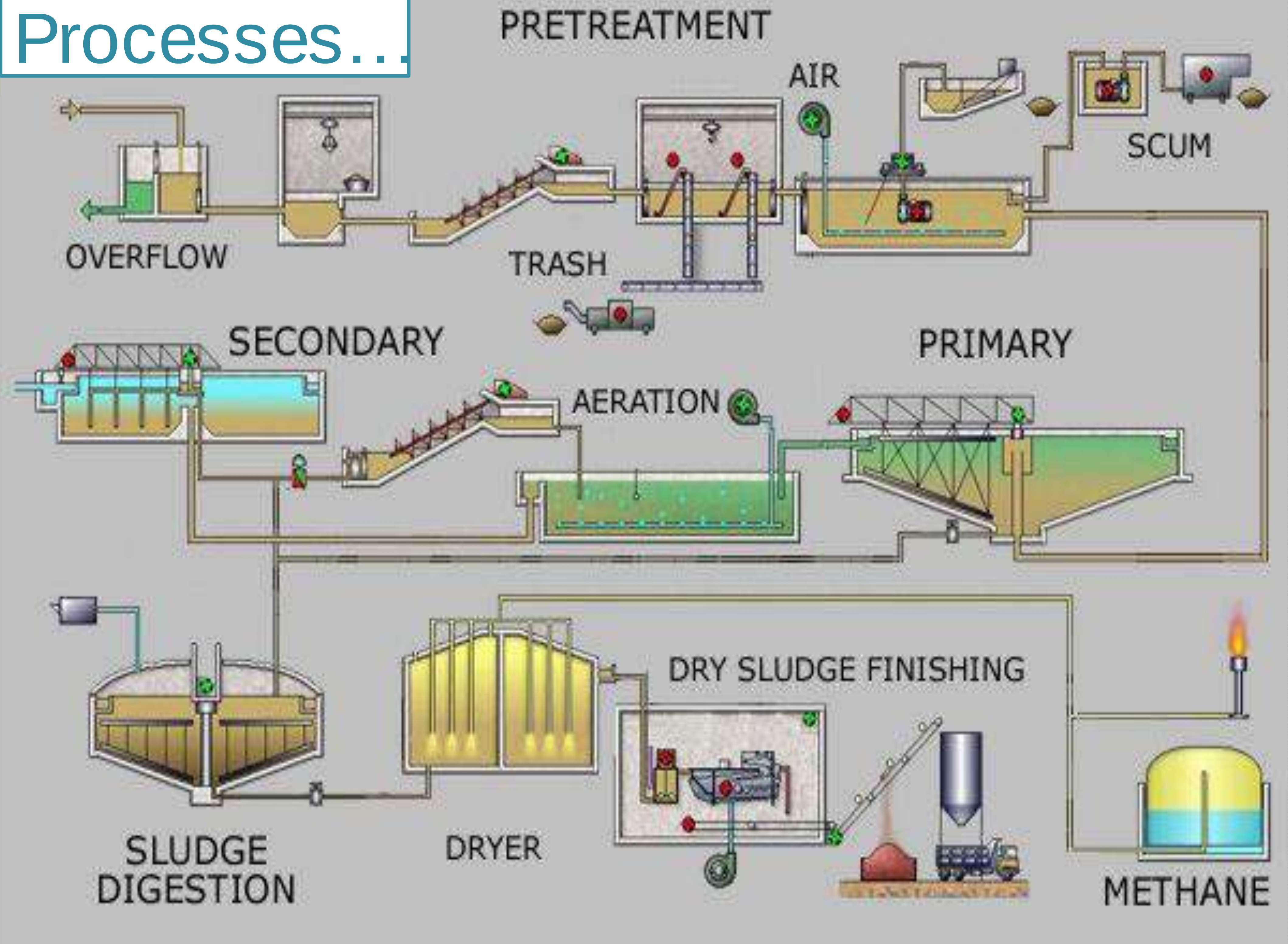
13.Sewage treatment





Sewage treatment plant

Processes…


PRETREATMENT
AIR
SCUM
OVERFLOW
TRASH
SECONDARY
PRIMARY
AERATION
DRY SLUDGE FINISHING
SLUDGE
DIGESTION
DRYER
METHANE

14.Building drainage

Different sanitary fitting and fixtures…

Wash basins

sink

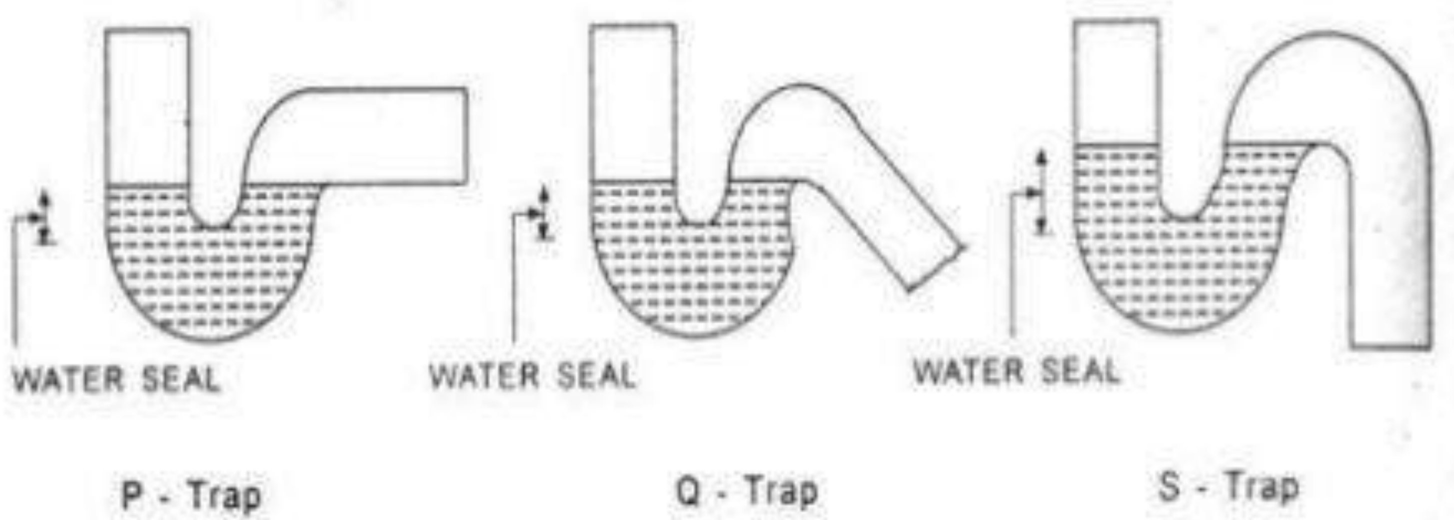
Water closet

Types Of Traps:

a. P-trap.

b. Q-trap.

c. S-trap.



Traps according to shapes

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Save

E-CONTENT

ON

WSWWE & IRR DRAWING

BY:- Dr. Rajeev Kumar

20.39. BRICK MASONRY OR STONE MASONRY SEWER

Sewers made of bricks or stones and cement mortar are called *Brick or Stone Masonry Sewers.*

Masonry sewers are constructed with wooden moulds. Wooden moulds are made according to true curves of sewer. The bricks are laid in the trough and grouted with cement mortar. After the masonry is set, the mould is taken out. Cement Mortar used should be rich in proportion so as to make sewer water tight. Internal joints should not be more than 6 mm.

Masonry sewers are of two shapes.

(*i*) Circular sewers.

(*ii*) Ovoid or Egg shaped sewer.

1. Circular Masonry Sewer. Circular sewers are constructed with special made wedge shaped bricks. Circular sewer gives maximum hydraulic mean depth when running full or half. If the discharge is less, than its performance is very poor, then egg shaped should be used. See Fig. 20.73.

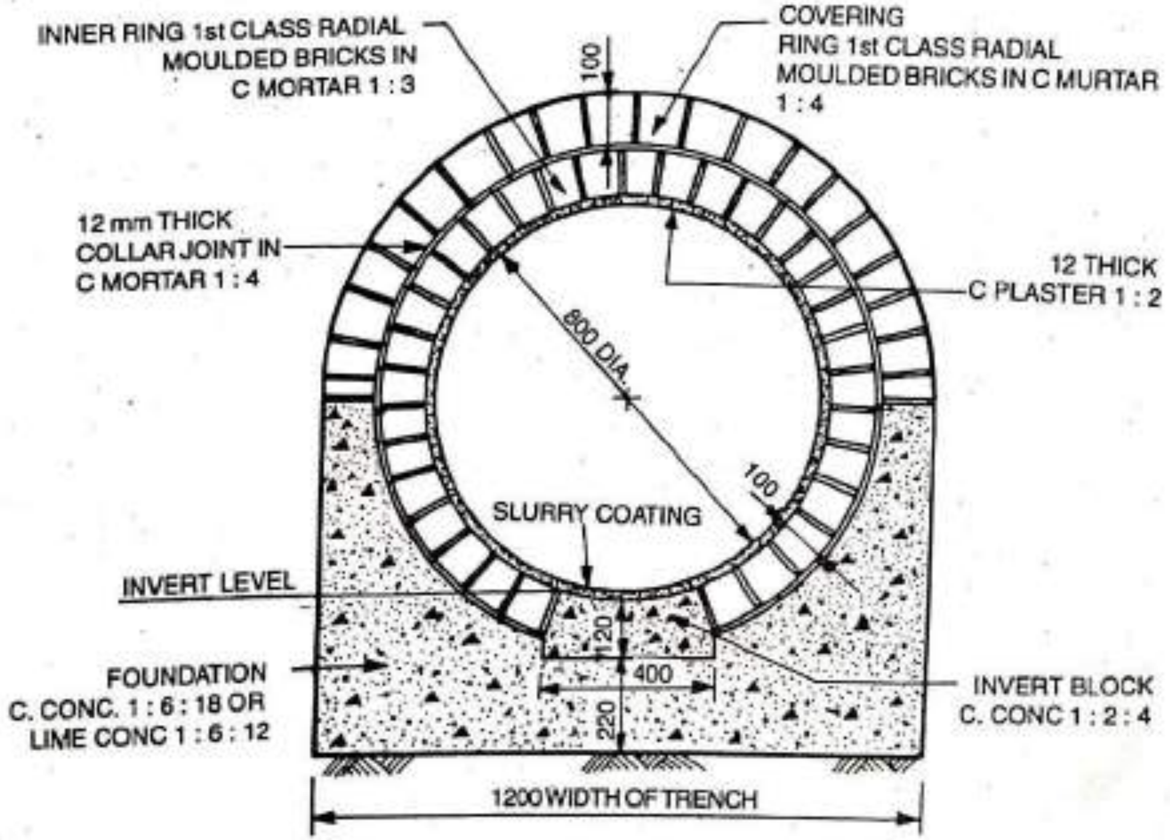


Fig. 20-73. Circular Brick Masonry Sewer.

20.40. EGG SHAPED OR OVOID SEWER

A masonry sewer having its shape like an egg is called Egg shaped or Ovoid sewer.

This sewer gives slightly higher velocity than circular sewer of the same capacity during low flow. Self cleaning velocity is developed at low discharge even. It is suitable for carrying combined flow.

There are two types of this sewer :

1. **Egg-Shaped Standard Sewer Sections.** Fig. 20-74 shows a standard egg-shaped sewer in section along with its geometrical construction. A sepecially prepared invert block of cement concrete 1 : 2 : 4 is placed.

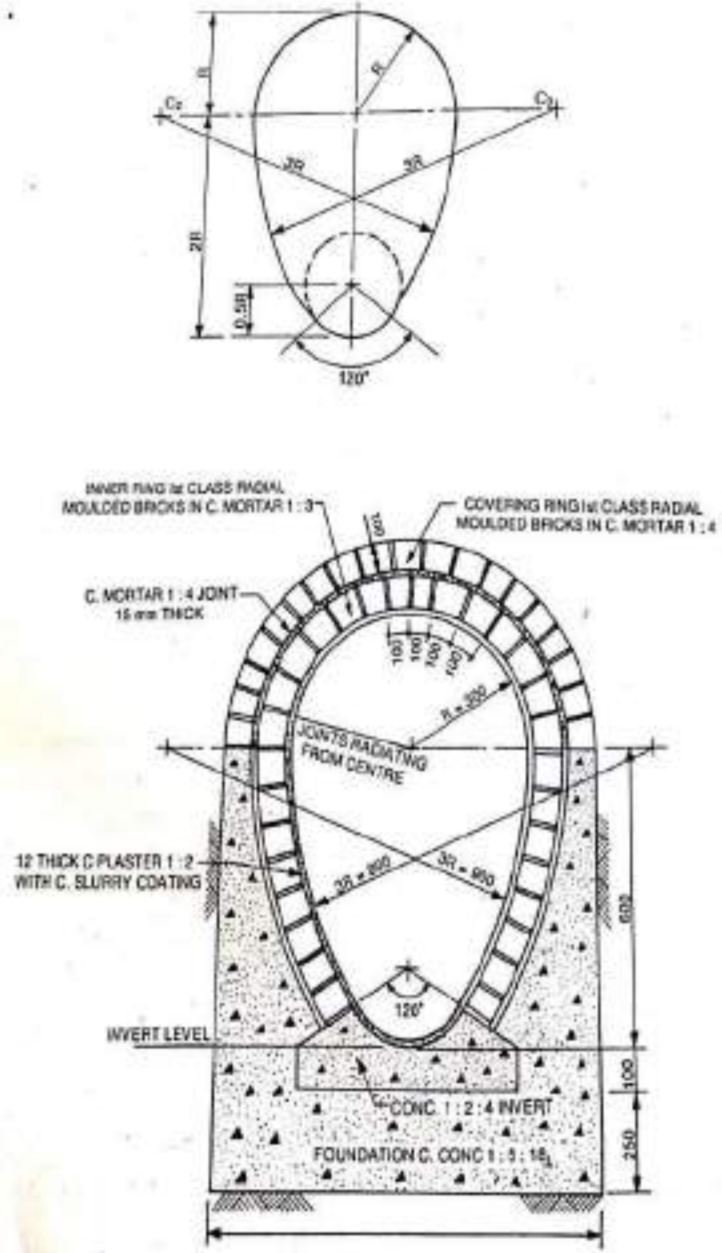


Fig. 20-74. Egg Shaped Brick Masonry Sewer.

17.2.1 Drains

Surface drains are made in circular or "V" shaped sections for easy flow of sewerage. Drains are provided with a normal gradient to create a smooth gravitational flow.

Different forms of sections are known as types. Figures 17.1 to 17.7 show type I to type VI. The following shaped drains are commonly used.

1. Semicircular drain } Type I
2. "U" shaped drain }

3. V-shaped drain Type II
4. V-shaped drain Type III } Cast-in-site
5. V-shaped drain Type IV to VI laid with c. conc. or brick blocks.

Drains are normaly laid close to the boundry of a building or side edges of a street or road, thus forming one stable edge for the drain.

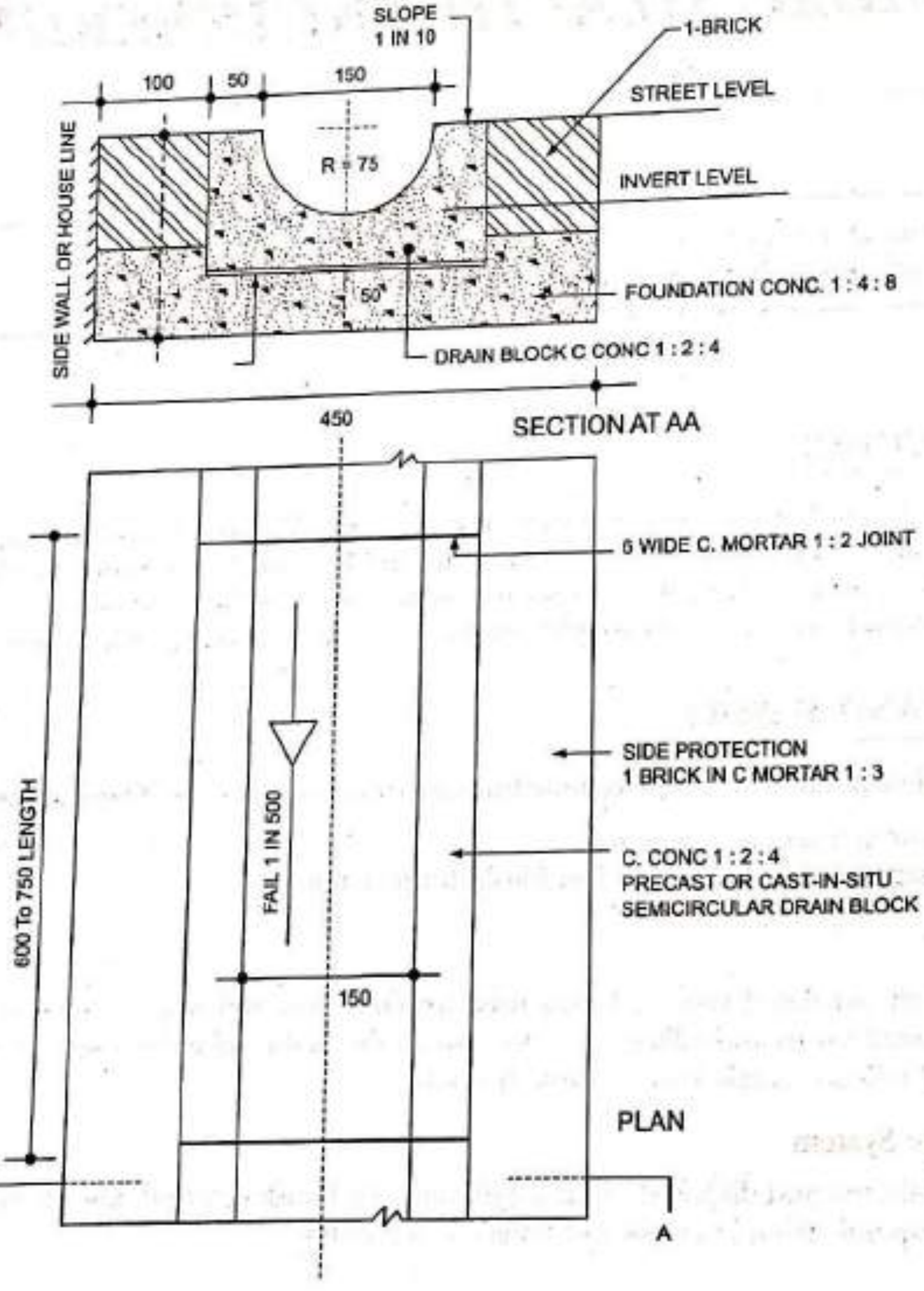


Fig. 17.1 SEMI CIRCULAR DRAIN

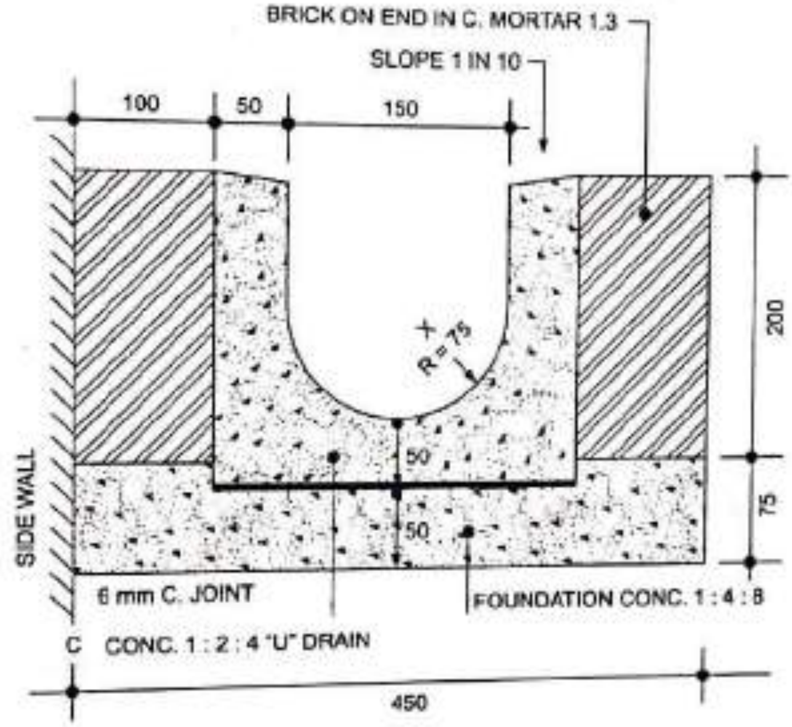
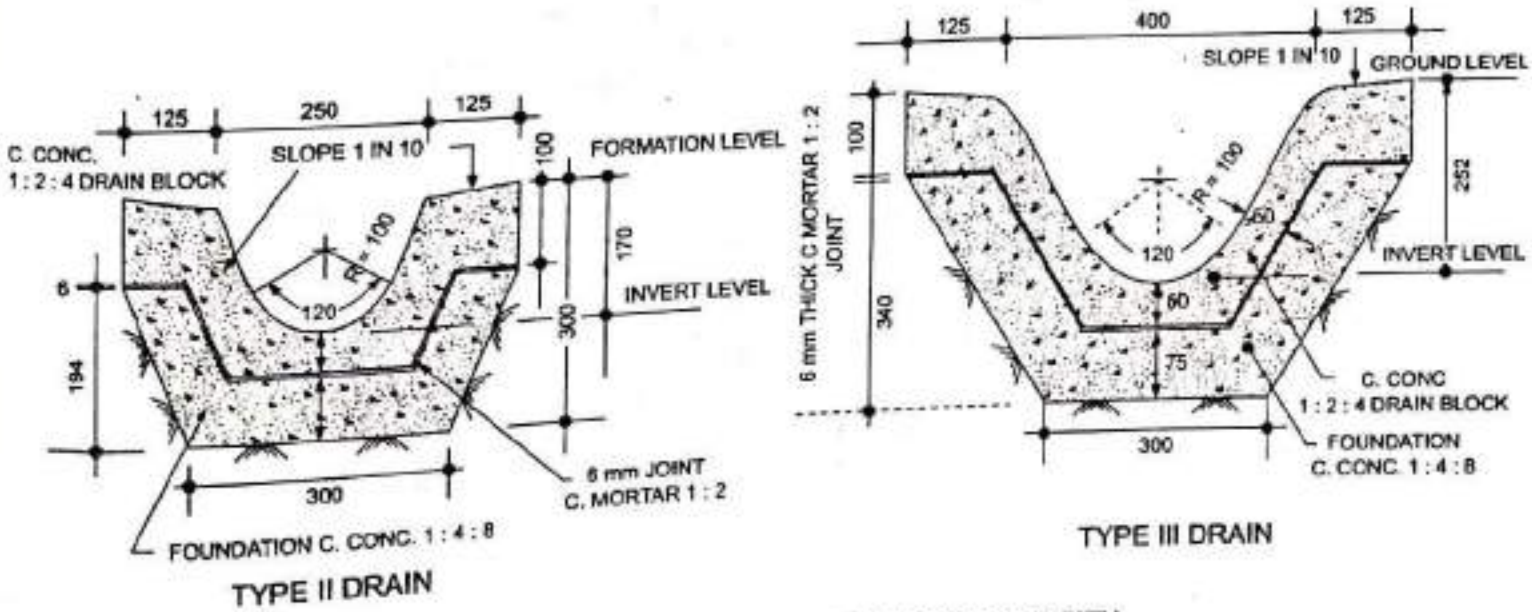
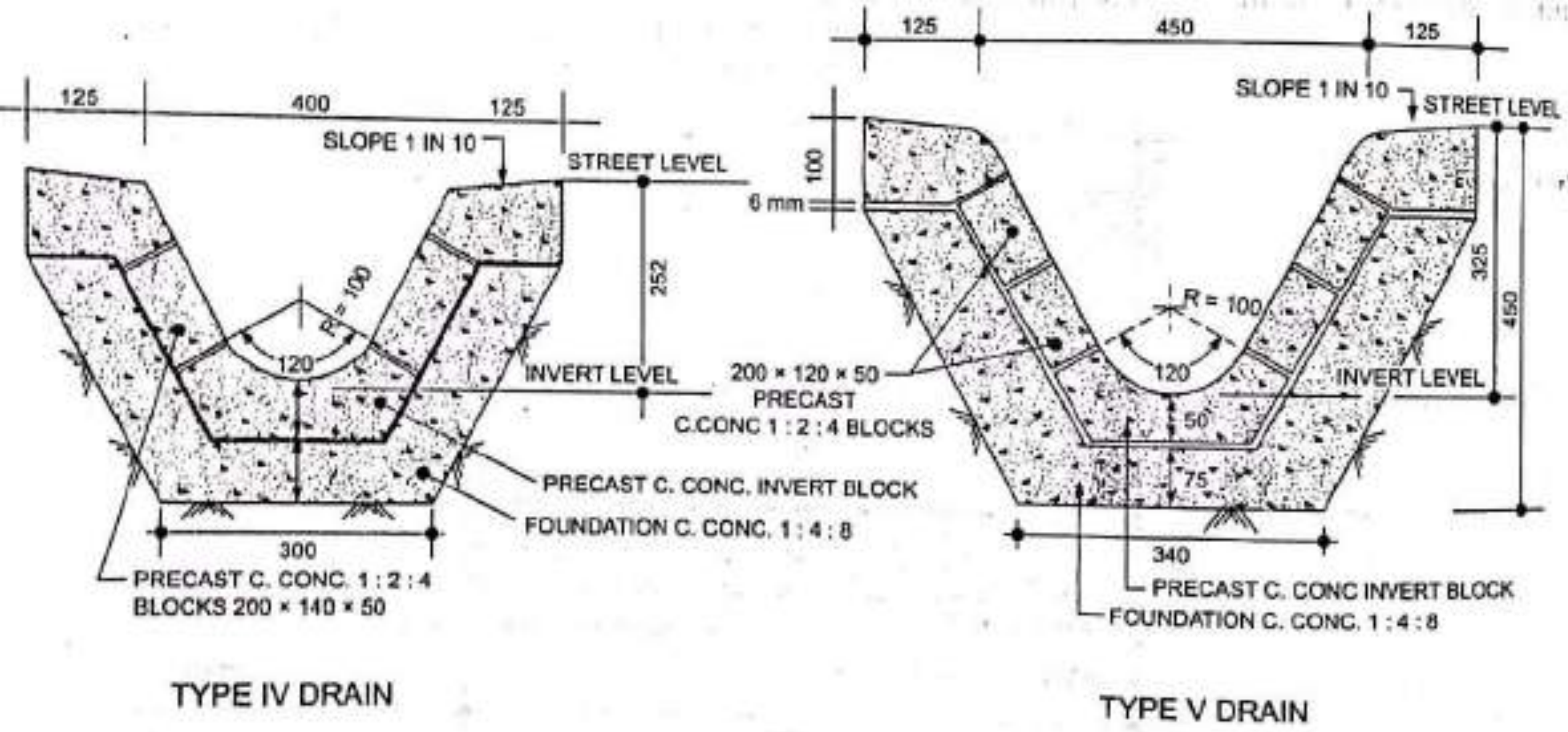


Fig. 17.2 'U' SHAPED DRAIN



Figs. 17.3 & 17.4 'V' SHAPED DRAINS CAST IN SITU



Figs. 17.5 & 17.6 'V' SHAPED DRAINS PRECASE

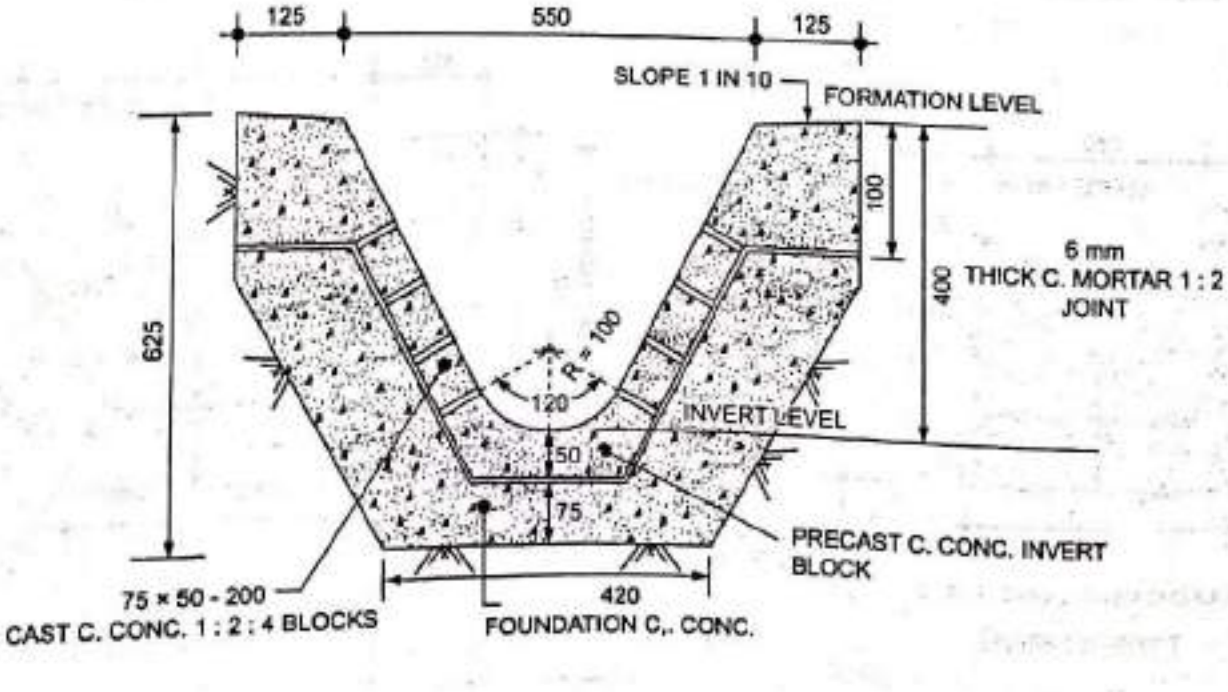


Fig. 17.7(a) TYPE VI DRAIN

20.38. REINFORCED CEMENT CONCRETE SEWER

R.C.C. pipe sewers are available from 150 mm diameter to 1500 mm diameter. These are very strong and durable pipes with precisely controlled quality. Now-a-days R.C.C. pipes are very extensively used.

Fig. 20-70 shows the cross-section of an R.C.C. pipe sewer.

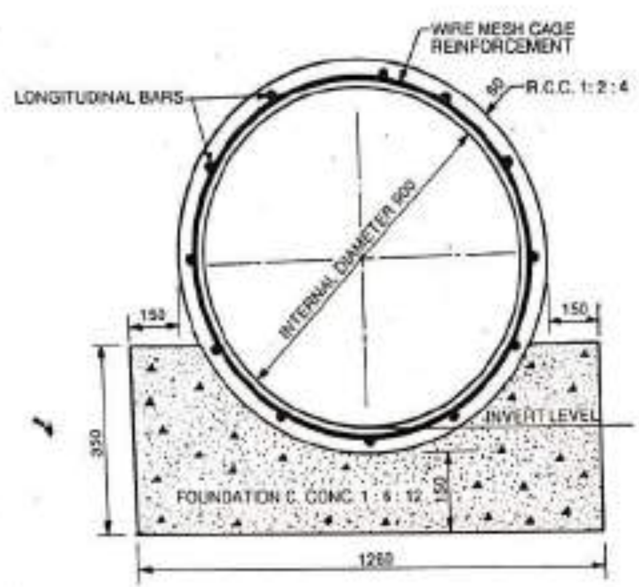


Fig. 20-70. R.C.C. Pipe Sewer.

Fig. 20-71 shows an R.C.C. pipe collar joint.

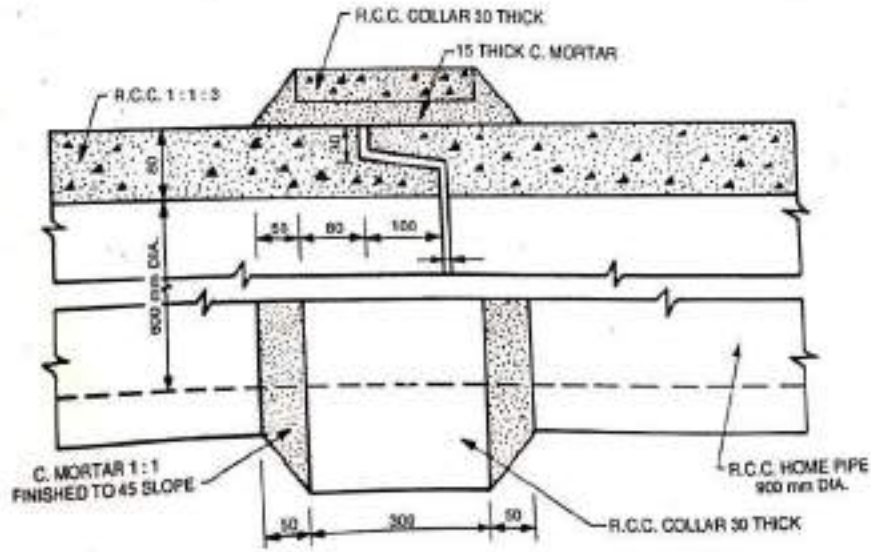


Fig. 20-71. R.C.C. Pipe Sewer Collar Joints.

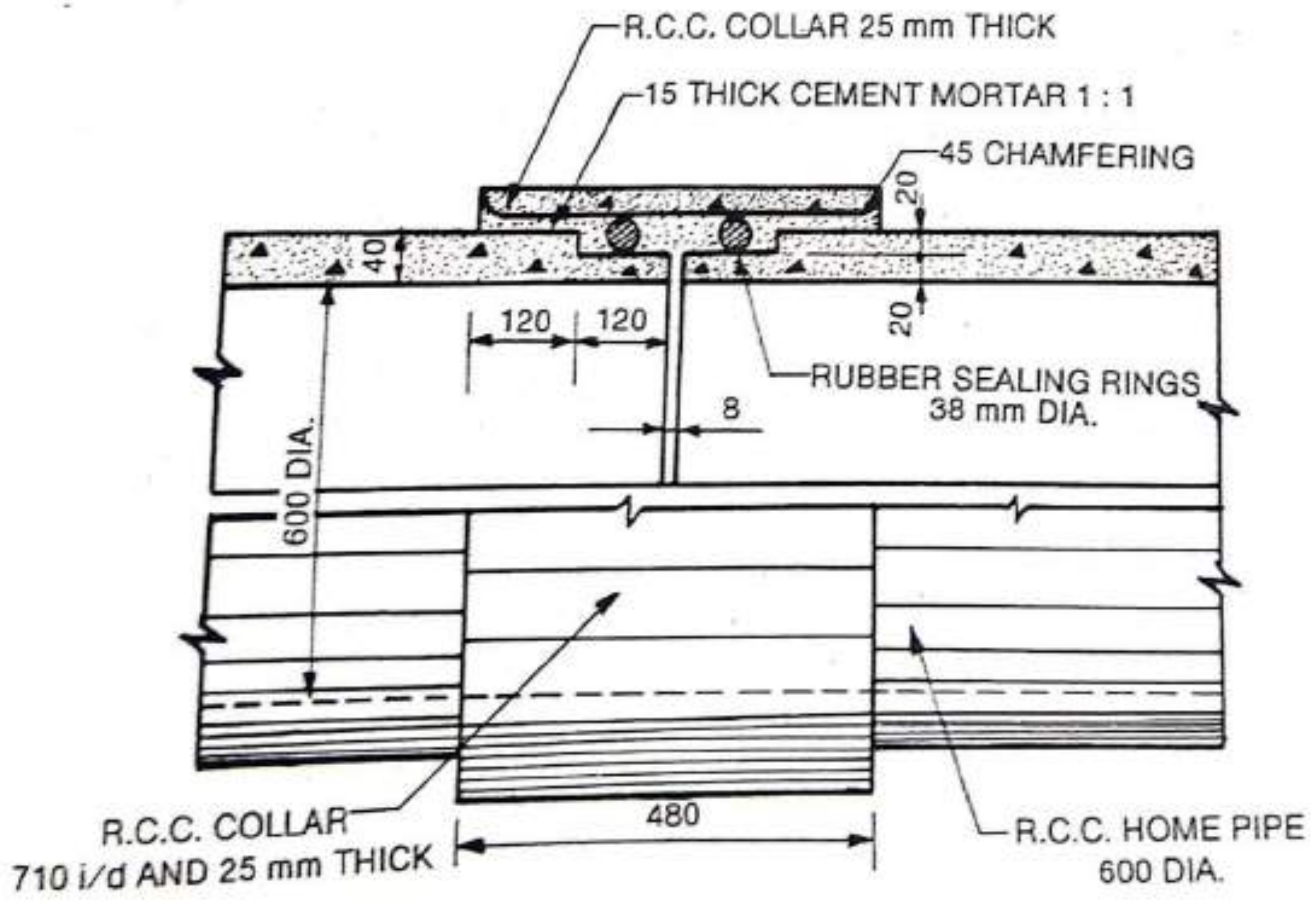


Fig. 20-72. Semi-Flexible Collar Joints R.C.C. Pipe Sewer.

20.16. FLOOR TRAPS

A trap provided to recieve waste water from floors, wash basins and sinks etc is called a *Floor Trap*. Fig. 20-17 shows a cast iron floor trap with sizes along with Table showing different sizes.

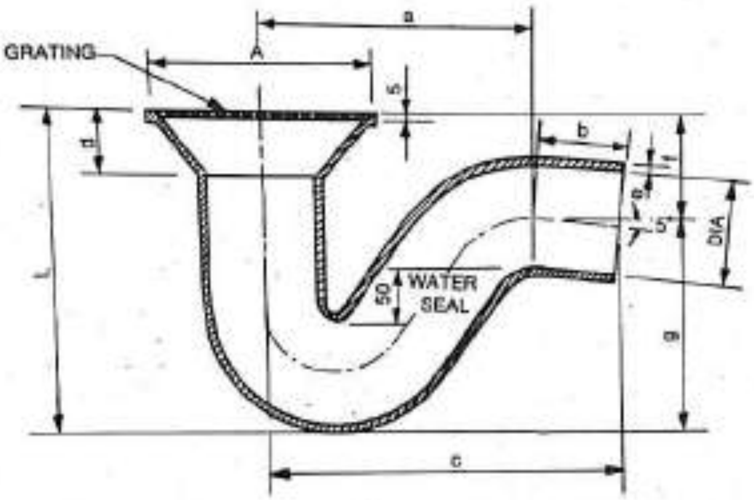


Fig. 20-17. Vitreous China Orissa Pattern Pan Trap.

Table 20.IV. Sizes Of Cast Iron Floor Trap

Nominal Diameter	*A*	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*L*
50	100	137	99	236	30	3.5	45	133	175
75	100	170	105	275	40	3.5	60	165	225
100	200	214	116	330	60	4.0	90	206	296

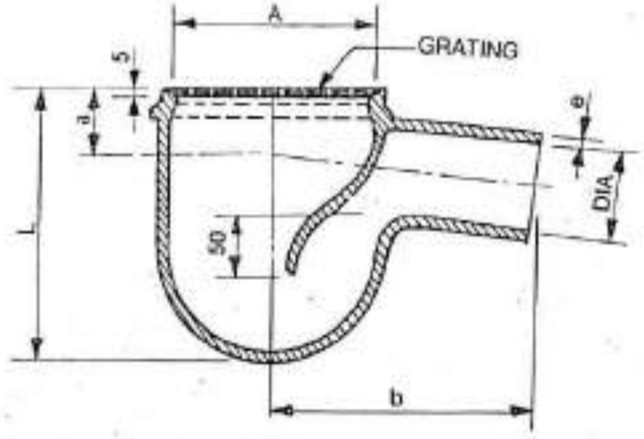


Fig. 20-18. Cast iron Nahani Floor.

Table 20.V. Size Nahani Floor Trap

Nominal Diameter	*L*	*A*	*a*	*b*	*c*
50	175	165	45	205	4.0
75	225	165	60	215	6.50

All sizes in mm.

Fig. 20-19 shows a vitreous floor trap.

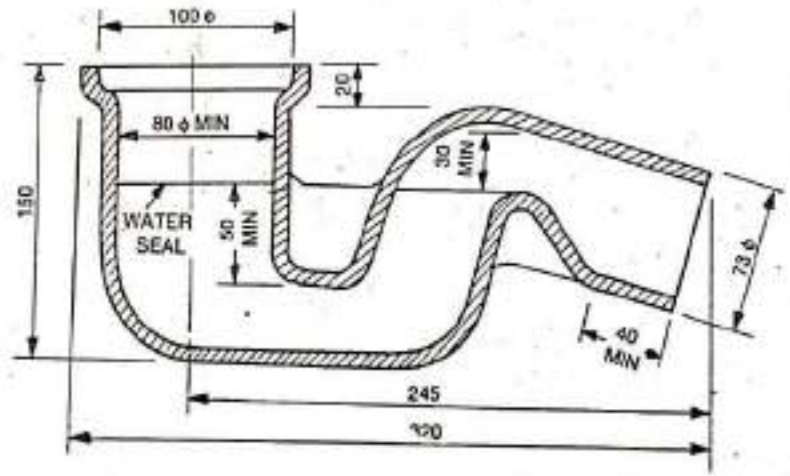


Fig. 20-19. Vitreous Floor Trap.

20.17. GULLY TRAP

A deep seal trap provided on the external face of wall for disconnecting the waste flowing from kitchen, bath, wash basin and floors, from the main drainage system is called a *Gully Trap*.

Gully trap prevents the passage of foul gases from house drain to inside of the building. It is made of cast iron or glazed stoneware.

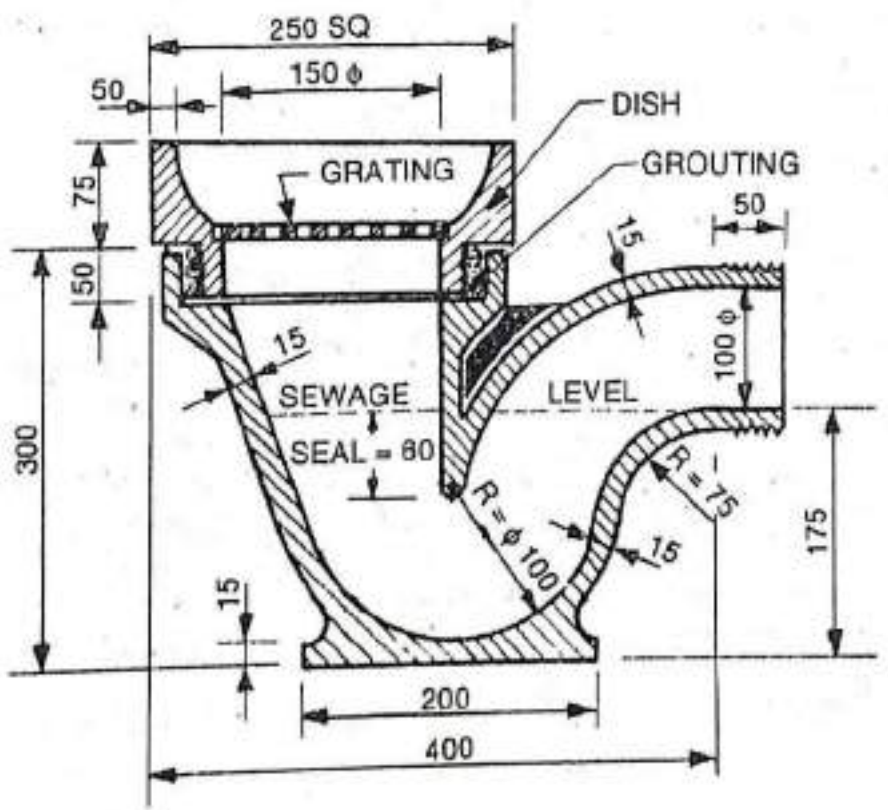


Fig. 20-20. Gully Trap.

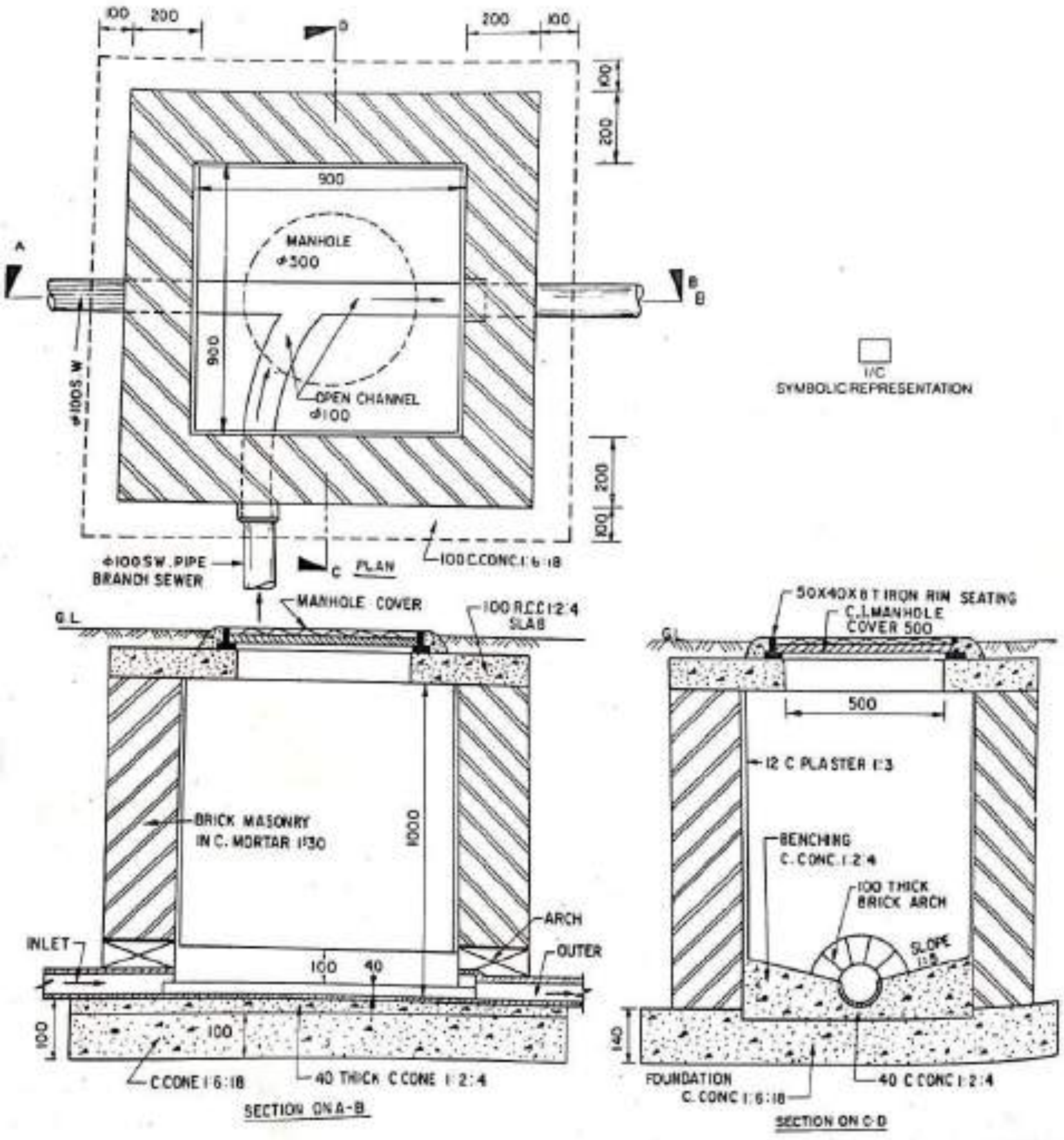
20.48. INSPECTION CHAMBER

A chamber of smaller size mainly provided in house drainage system, is called an *Inspection Chamber.*

Inspection chamber is like a manhole but without rungs. Inspection chamber takes waste water through Gully Traps and further disposes of to a manhole.

Example 24. *Draw the sectional plan, cross-sectional and sectional side elevation of an Inspection Chamber 900 mm × 900 mm. Inside depth is 1000 mm. A branch sewer pipe of 100 mm diameter is at right angles to them in sewer pipe. The data not given may be assumed.*

Solution. Fig. 20-85 shows the sectional plan, cross-section and sectional side elevation of the inspection chamber.



Example 25. *Draw the sectional plan, cross-section and sectional side elevation $1.0\ m \times 1.0\ m \times 1.0\ m$ inspection chamber with corbelling on all side. All other data may be assumed. Also show the position of another pipe at right angles.*

Solution. For solution see Fig. 20-86 which shows a Manhole Inpsection Chamber corbelling type in sectional plan, cross-section and sectional side elevation.

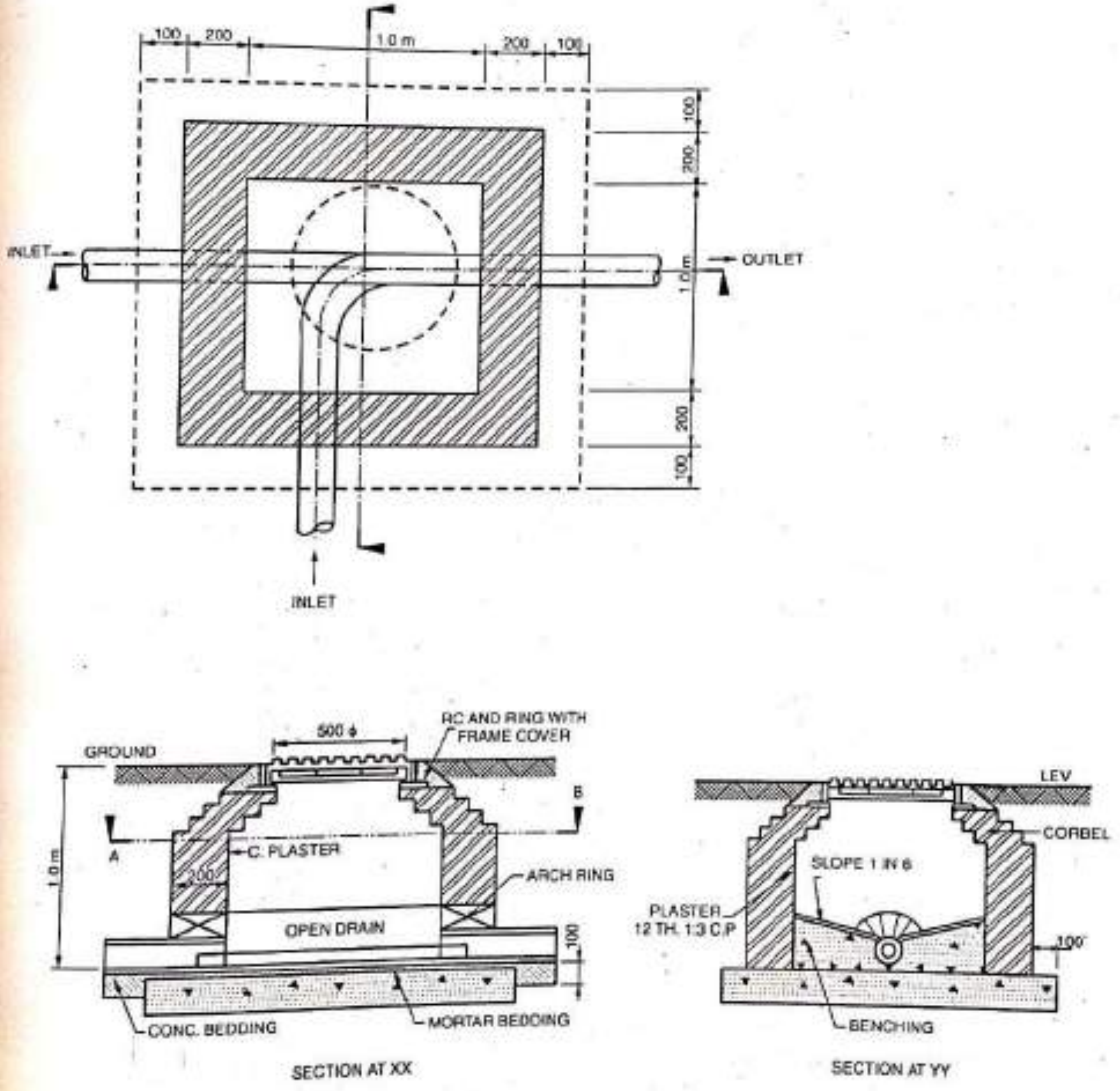


Fig. 20-86. Inspection Chamber.

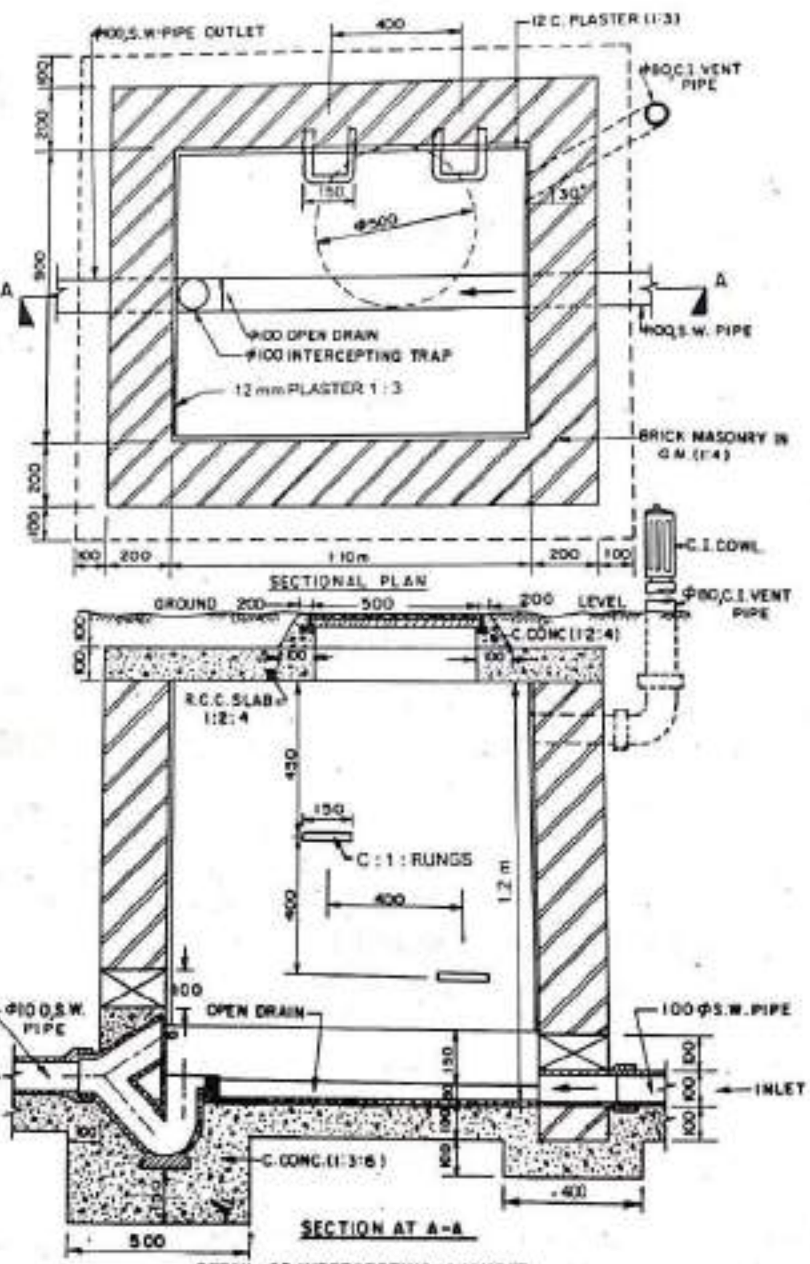
20.49. INTERCEPTING CHAMBER

The last manhole which connects the house drain to the public sewer is called an *Intercepting Chamber*.

It is also like a manhole. It is provided with a intercepting or a master trap along with a vent pipe.

Example 26. *Draw the sectional plan and cross-section of an Intercepting Chamber 1.10 m × 0.90 m. Inside depth upto invert is 1.20 m. Other suitable data may be assumed.*

Solution. For solution see Fig. 20-87.



DETAIL OF INTERCEPTING CHAMBER

20.42. MANHOLE

An opening by which a man may enter or leave a drain, a sewer or other closed structure for inspection, cleaning and other maintenance operations fitted with a suitable cover at top is called a *Man Hole.*

A manhole can be square, rectangular or circular in shape. Depth of a manhole goes on increasing according to the falling gradient of the sewer. A chamber without gully connections is also called a man hole.

Man holes are of two types :

(*i*) **Shallow Manhole.** A manhole having depth less than 2.0 m is called a *Shallow Manhole.*

(*ii*) **Deep Manhole.** A manhole having depth more than 2.0 m is called a *Deep Manhole.*

20.43. SPACING OF MANHOLES

Table 20.IVX shows the spacing of manhole on any sewer line or pipe line.

Table 20.IVX. Spacing of Manholes

Pipe Diameter mm	Spacing m
upto 300	45
301 to 500	75
501 to 900	90
Beyond 900	Any interval depending on local conditions and as approved by administrative authority.

Manhole should also be built in the following situations :

(*i*) Every change of alignment or gradient.
(*ii*) At the head of all sewers and branches.
(*iii*) At every junction of two or more sewers.
(*iv*) Every change of sizes of sewer.

In case of large sewers where a man can enter it is not essential to have at manhole a every change in alignment upto 30° curve. Manhole chambers can be omitted in very large sewers where a man can stand easily. In such cases sewer is connected by an *Access Shaft.*

20.44. SIZES OF MANHOLES

(*i*) **Shallow Manhole (Depth less than 2.0 m).**

Min. size of rectangular manhole = 1200 mm on sewer line × 750 across.

Min. size of circular manhole = 1200 mm diameter.

(*ii*) **Deep Manhole (Depth more than 2.0 m).**

Minimum opening should be 1.5 m diameter. It is not possible to lay down any standard dimensions as these will depend on the size and depth of sewer.

1. Sizes of Various Parts of Manhole.

Size of chamber for upto 1.0 m depth = 800 × 800 mm.
Size of chamber for 1.0 m to 1.5 m depth = 1200 × 1000 mm.
Size of chamber from 1.5 m and above depth = 1200 × 1200 mm.
Minimum size of circular chamber = 1200 mm diameter.

2. **Thickness of walls.** The thickness of walls will be 25 cm in cement mortar 1 : 3 constructed on cement concrete 1 : 2 :4 slab foundation. The foundation should be safe enough to carry weight of walls, cover, the wheel loads, impact of traffic and also water pressure if any. The thickness of walls shall not be less than 23 cm with 13 mm thick cement plaster 1 : 3 both inside and outside. Channel or drain at the bottom of chamber should be plastered with cement mortar 1 : 2.

Thickness of wall 20 cms min, for ordinary manholes upto 1.5 m depth and 30 cms for more than 1.5 m depth.

3. **Working chamber.** The lower most portion of a manhole is called a *Working Chamber.*

Minimum size of rectangular working chamber 1.35 m (length) × 1.00 m (breadth) × 1.75 m (height).

Size of circular working chamber = 1.20 m to 1.35 m diameter.

4. **Shaft.** The vertical passage to the manhole chamber from manhole cover is called a *Shaft.*

Minimum size of rectangular access shaft = 0.75 m × 0.60 m.

Diameter of circular access shaft = 0.65 m to 0.75 diameter.

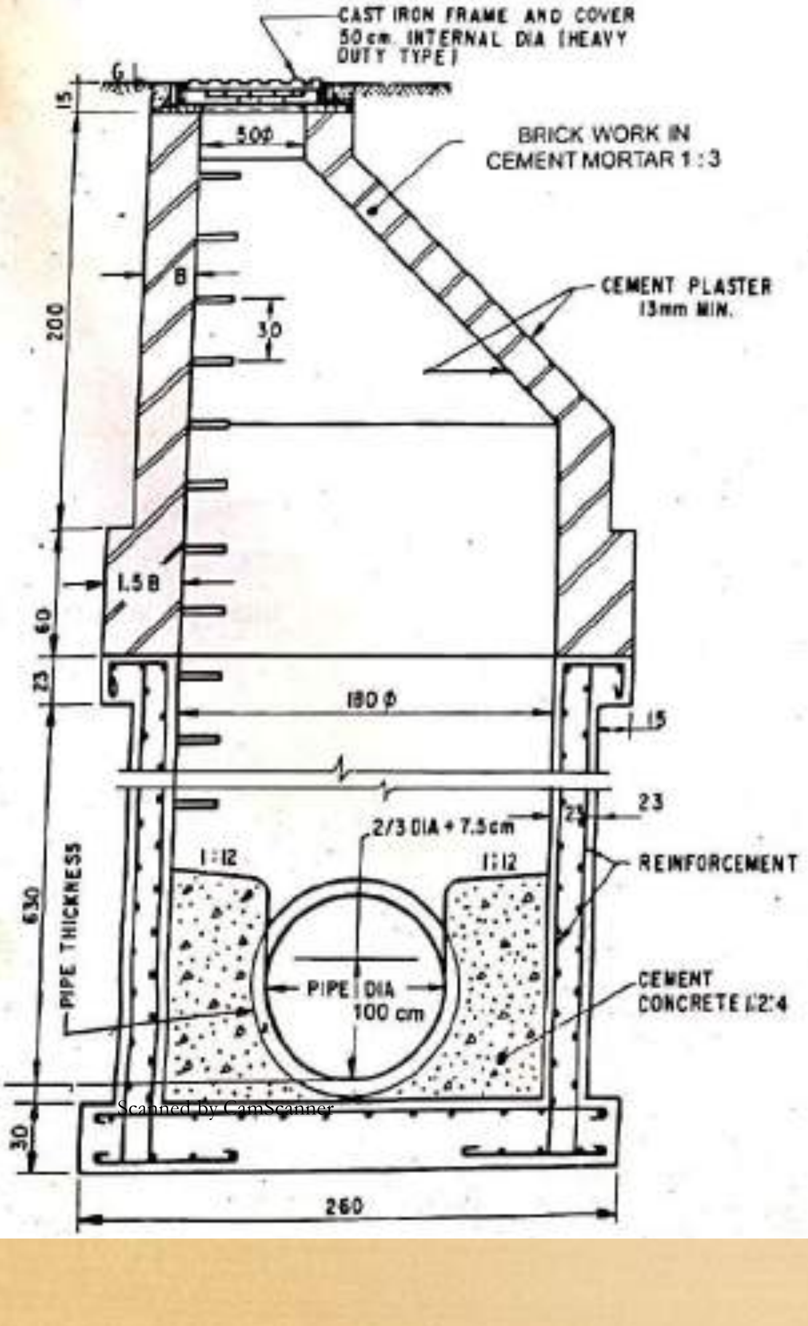
5. **Rungs.** Rungs shall be provided in all manholes over 0.8 m in depth. Rungs should be set staggard in two vertical runs which may be 38 cms apart horizontally. The first rung at the top should be fixed at a depth of 45 cms from the manhole cover and lowest not more than 30 cms above benching.

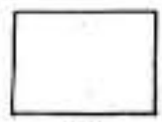
6. **Cover.** The cast iron cover should minimum 500 mm in diameter for manholes exceeding 0.9 m depth with a cast iron frame. The frame is fixed at the top in R.C.C. slab covering.

7. **Slab.** The slab should not be less than 150 mm thickness so as to carry all probable superimposed loads.

20.45. R.C.C. MANHOLE IN HIGH SUBSOIL WATER CONDITIONS

Fig. 20-79 shows an R.C.C. manhole constructed in high subsoil water conditions.





B = THICKNESS OF WALLS

Example 18. *Draw the cross-section of an R.C.C. manhole to be constructed in high subsoil water condition*

Solution. For solution change the size and see Fig. 20.79.

Example 19. *Draw the sectional plan and cross sections of a circular R.C.C. manhole in high subsoil water condition with following data :-*

Diameter of manhole at bottom	*= 1.40 m*
Diameter of top of neck	*= 500 mm*
Depth of neck	*= 900 mm*
Total depth of manhole excluding 150 mm thick R.C.C. base	*= 5.00 m*
Diameter of sewer pipe	*= 300 mm*

Other data may be suitably assumed.

Solution. For solution see Fig. 20-80.

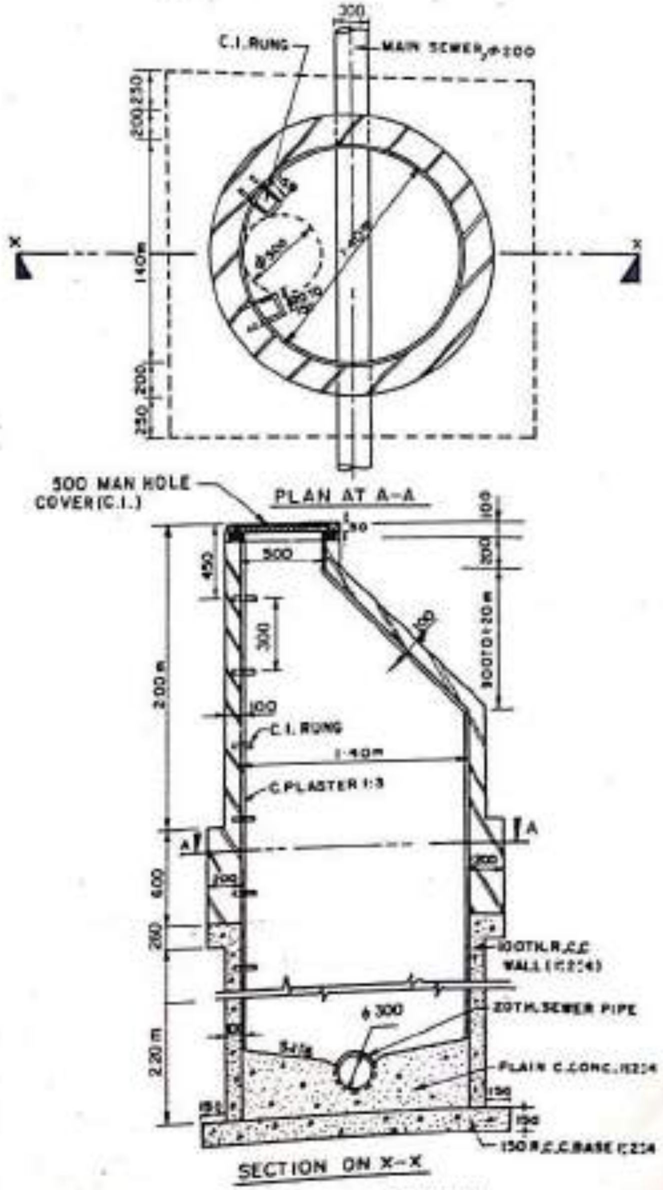


Fig. 20-80. R.C.C. Manhole

Example 20. *Draw the sectional plan and cross-section of a circular masonry sewer manhole with the following size :*

Depth of Manhole upto top of Sewer Pipe = 2.60 m

Inner Dia of Manhole = 1.40 m

R.C.C. Sewer Pipe = 200 mm ϕ

Branch Sewer Pipe = 100 ϕ at 45°

Other data may be assumed.

Solution. For solution see Fig. 20-81.

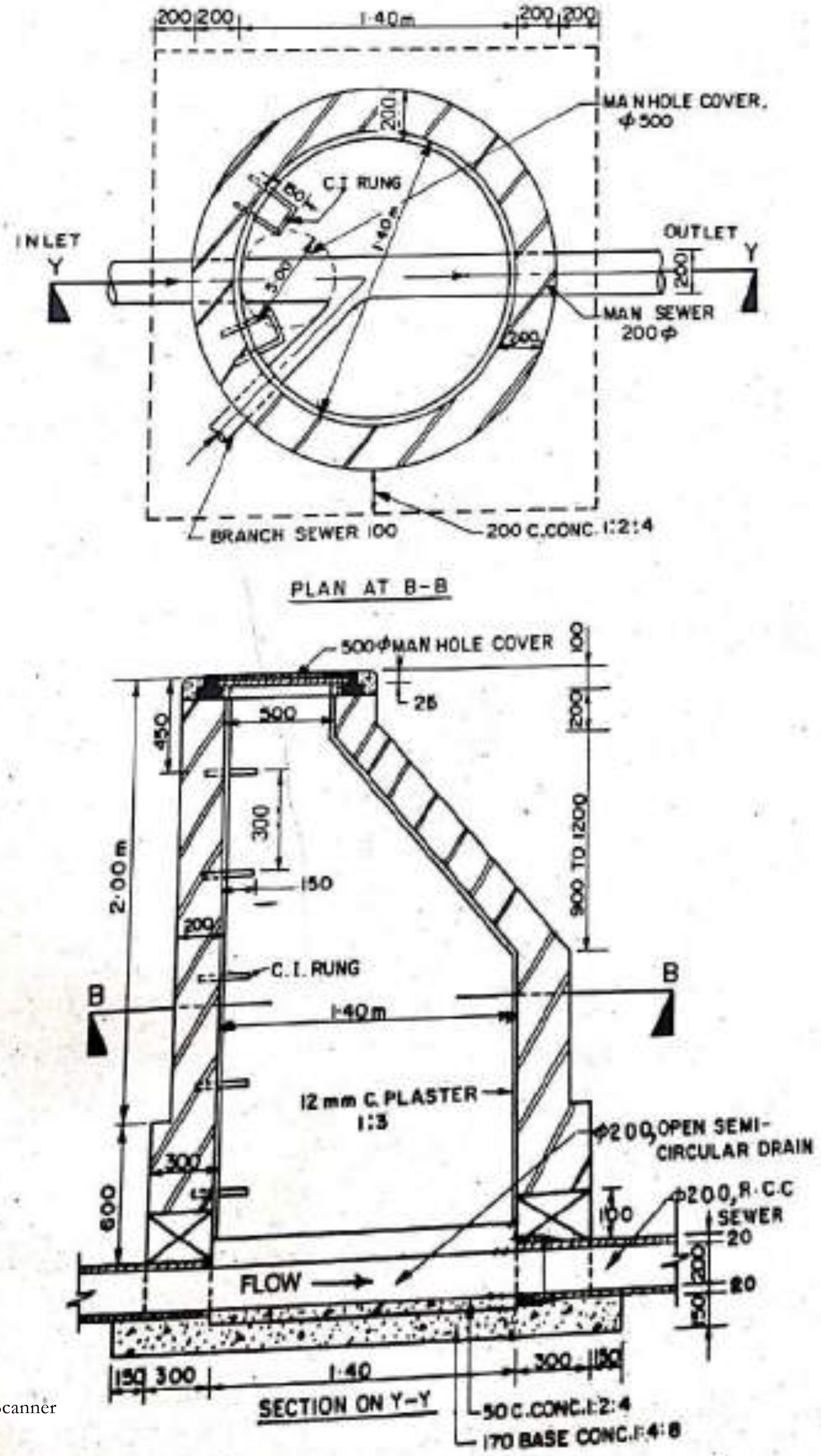


Fig. 20-81. Masonry Manhole.

Example 21. *Draw the sectional plan and cross-section of a manhole with three side corbelling type 900 × 700 mm. Depth upto invert is 1.20 mm. Diameter of pipe is 150 mm. Diameter of branch pipe at right angle to main pipe is 100 mm other data may the suitably assumed.*

Solution. For solution see Fig. 20-82.

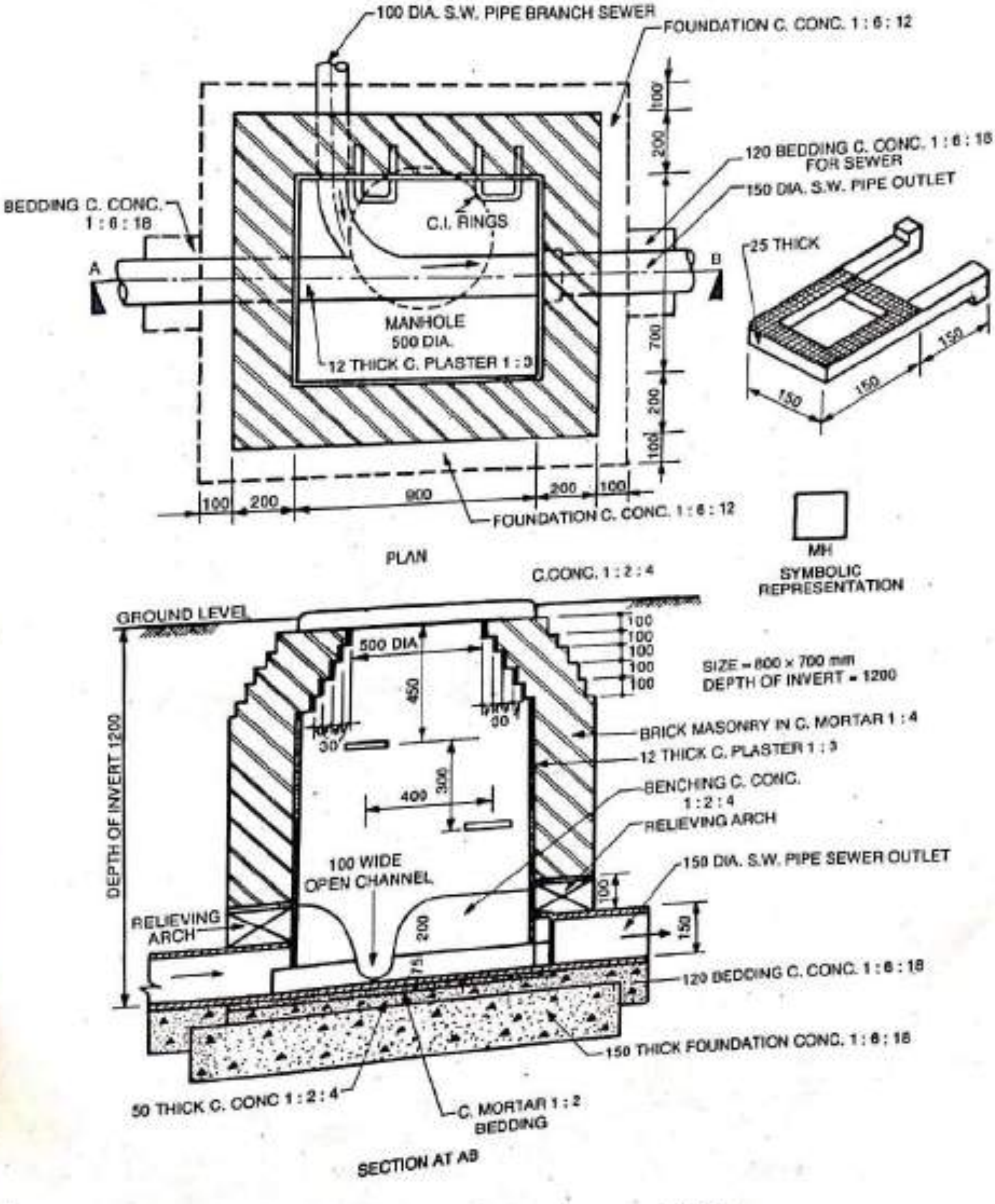


Fig. 20.82. Manhole with Three Sides Corbelling.

2.2 ITEMS OF WORK

1. **Earth work :** Earth work in excavation and in filling should be taken out separately under different types. Quantity of earth work is worked out in cubic contents.

i.e. length × breadth × Depth or height.

2. **Bed concrete in foundation :** It is calculated by taking length, breadth and thickness of concrete bed; and measured in cubic meter.

3. **Soling :** When the soil is soft, one layer of brick or stone is laid below the bed concrete. It is measured in square meter and expressed with specified thickness.

4. **D. P. C. (Damp Proof Course) :** It is a course provided at the plinth level under the wall for the full width of plinth wall. It is not provided at the sill of door and verandah openings for which deduction is made while calculating length of D.P.C. It is measured in square meter and expressed with specified thickness. In general 2.5 cm thick cement concrete $(1 : 1\frac{1}{2} : 3)$ with water proofing material is used as D.P.C.

5. **Masonry :** Masonry for foundation and plinth is taken under one item and masonry for super structure is taken under separate item. It is computed in cubic meter by taking length, breadth and height. In case of wall footing, masonry for steps is calculated separately and added together. In buildings having more than one floor, the masonry for superstructure for each floor is computed separately. Deductions for openings like doors, windows, cupboards, etc. is done.

Deduction for lintels for openings is also done by taking length, breadth and height. Different types of masonry are taken under separate items. Thin partition walls of thickness less than 10 cm, honeycomb brickwork is taken under separate item in square meter and no deduction for holes is done.

6. **Lintel :** Lintels are carted in R.C.C. and quantity is calculated in cubic meter. Length of lintel is taken equal to size of opening plus of 150 mm each on both sides.

7. **R.C.C. :** R.C.C. work is calculated for beams, lintels, columns, footing, slab etc. it is calculated in cubic meter, by taking length, breadth and thickness. No deduction for steel is done while calculating the quantity of concrete, which includes centering, shuttering and fixing of reinforcement in position. Reinforcement (quantity of steel) is taken under separate item, including bending and measured in kg, quintals, or in metric tonne. If detail drawings are not available 0.8 to 3% of concrete may be taken by volume as a quantity of steel which is further multiplied by density.

8. **Flooring :** For grounds floor, cement concrete and floor finishing of stone, marble or mosaic tiles are taken under one item and quantity is calculated in square meter. For upper floors, bed of R.C.C. is taken in cubic meter and floor finishing is taken separately in square meter.

9. **Roof :** In case of roof, flat roofs are calculated in cubic meter like slab and for pitched roof, quantity of trusses and other members is calculated in cubic meter.

In case of roofing material tiles, G.I. sheets or A.C. sheets are measured in square meter. Tiles on hip and valley are measured in running meter.

10. **Plastering and Pointing :** Plastering is calculated in square meter and expressed with specified thickness. For masonry the measurements are taken for whole face of wall for both sides as solid and deduction for openings are made.

External and internal plastering for building are taken out separately under different items.

Pointing of walls is calculated in square meter for whole surface and deductions are made similar to plastering.

5.2 The Units of Measurements and Payments for' Various Items of Works and Materials

Sl. No.	Particulars of Items	Units of measurement in MKS	Units of Payment in MKS	Units of payment in FPS
	Earthwork :			
1.	Earthwork in excavation in ordinary soil, earth-work in mixed soil with kankar, bajri, etc. earthwork in hard soil ...	cu m	per % cu m	% cu ft
2.	Rock excavation ...	cu m	per % cu m	% cu ft
3.	Earthfilling in excavation in foundation	cu m	per % cu m	% cu ft
4.	Earthfilling in foundation trenches *(Usually not measured and not paid separately)*	cu m	per % cu m	% cu ft
5.	Earthfilling in plinth ...	cu m	per % cu m	% cu ft
6.	Earthwork in banking, cutting, in road and irrigation channel ...	cu m	per % cu m	% cu ft
7.	Surface dressing and levelling, cleaning, etc.	sq m	per sq m	% sq ft
8.	Cutting of trees (Girth specified)	no.	per no.	per no
9.	Puddling, puddle clay core ...	cu m	per % cu m	% cu ft
10.	Sand filling ...	cu m	per cu m	% cu ft
11.	Quarrying of stone or boulder ...	cu m	per cu m	% cu ft
12.	Blasting of rock (Blasted stone stacked and then measured) ...	cu m	per cu m	% cu ft
Note : *(For earthwork, normal lead is 30 m and normal lift is 1.5 m).*				

Sr. No.	Particulars of Items	Units of measurement in MKS	Units of payment in MKS	Units of payment in FPS
	Concrete			
1.	Lime concrete in foundation ...	cu m	per cu m	% cu ft
2.	Lime concrete in roof terracing, thickness specified ...	sq m	per sq m	% sq ft
3.	Cement concrete (C.C.) ...	cu m	per cu m	per cu ft
4.	Reinforced cement concrete (R.C.C.) ...	cu m	per cu m	per cu ft
5.	C.C. or R.C.C. Chujja, sun shade ...	cu m	per cu m	per cu ft
6.	Precast C.C. or R.C.C. ...	cu m	per cu m	per cu ft
7.	Jali work or jaffri work or C.C. tracery panels (Thickness specified) ...	sq m	per sq m	per sq ft
8.	Cement concrete bed ...	cu m	per cu m	per cu ft
	D.P.C. :			
9.	Damp proof course – Cement concrete, Rich cement mortar, Asphalt, etc. (Thickness specified) ...	sq m	per sq m	% sq ft
	Brickwork :			
1.	Brickwork in foundation and plinth, in superstructure, in arches, etc., in cement, lime or mud mortar ...	cu m	per cu m	% cu ft
2.	Sun dried brickwork ...	cu m	per cu m	% cu ft
3.	Honey-comb brickwork, thickness specified ...	sq. m	per sq m	% sq ft
4.	Brickwork in jack arches, if measured separately ...	cu m	per cu m	*07t* cu ft
5.	Jack arch roofing including top finishing ..	sq m	per sq m	% sq ft
6.	Brickwork in well steining ...	cu m	per cu m	% cu ft
7.	Half-brickwork with or without reinforcement	sq m	per sq m	% sq ft
8.	Thin partition wall ...	sq m	per sq m	% sq ft
9.	Reinforced brickwork (R.B. work) ...	cu m	per cu m	% cu ft
10.	String course, drip course, weather course, coping etc. (Projection specified) ...	metre	per m	per r ft
11.	Cornice (Projection and type specified) ...	metre	per m	per r ft
12.	Brickwork in Fire place, Chulla, Chimney ...	cu m	per cu m	% cu ft
13.	Pargetting Chimney, fire place flue ...	metre	per m	per r ft
14.	Brick edging (by road side) ...	metre	per m	per r ft
	Stone work :			
1.	Stone masonry, Random Rubble masonry, Coursed Rubble masonry, Ashlar masonry in walls, in arches, etc. ...	cu m	per cu m	% cu ft
2.	Cut stone work in lintel, beam, etc. ...	cu m	per cu m	per cu ft
3.	Stone slab in roof, shelve, etc., stone chujjas, stone sun shed, etc. (Thickness specified) ...	sq m	per sq m	% sq ft
4.	Stone work in wall facing or lining (Thickness specified) ...	sq m	per sq m	per sq ft

Sr. No.	Particulars of Items	Units of measurement in MKS	Units of payment in MKS	Units of payment in FPS
	Wood work :			
1.	Wood work, door and window frame or chowkhat, rafters beams, roof trusses, etc. ...	cu m	per cu m	per cu ft
2.	Door and window shutters or leaves, panelled, battened, glazed, part panelled and part glazed, wire gauged, etc. (Thickness specified) ...	sq m	per sq m	per sq ft
3.	Door and window fittings as hinges tower bolts, sliding bolts, handles, etc. ...	no.	per no.	per no.
4.	Timbering, boarding (Thickness specified) ...	sq m	per sq m	per sq ft
5.	Timbering of trenches (Area of face sup-ported) ...	sq m	per sq m	per sq ft
6.	Sawing of timber ...	sq m	per sq m	per sq ft
7.	Woodwork in partition, Ply wood, etc. ...	sq m.	per sq m	per sq ft
8.	Baffles (Diameter specified) ...	metre	per m	per r ft
	Steel work :			
1.	Rolled Steel joists, Channels, Angles, T-irons, Flats, Squares, Rounds, etc. ...	quintal	per q	per cwt
2.	Steel reinforcement bars, etc., in R.C.C., R. B. work ...	quintal	per q	per cwt
3.	Bending, binding of steel reinforcement ...	quintal	per q	per cwt
4.	Fabrication and hoisting of steel work ...	quintal	per q	per cwt
5.	Fabric reinforcement, wire netting ...	sq m	per sq m	per sq ft
6.	Iron work in struss ...	quintal	per q	per cwt
7.	Gusset plate (Minimum rectangular size from which cut) ...	quintal	per q	per cwt
8.	Cutting of Iron Joists, channels ...	cm	per cm	per inch
9.	Cutting, Angles, Tees, Plate ...	sq cm	per sq cm	per sq inch
10.	Threading in iron ...	cm	per cm	per inch
11.	Welding, solder of sheets, plates ...	cm	per cm	per inch
12.	Boring holes in iron ...	no	per no.	per no.
13.	Cast Iron (C.I.) pipe, Dia. specified ...	metre	per m	per ft
14.	Rivets, Bolts and nuts, Anchor bolts. Lewis bolts, Holding down bolts, etc. ...	quintal	per q	per cwt
15.	Barbed wire fencing ...	metre	per m	% r ft
16.	Iron gate ... *(May also be by weight, quintal)*	sq m	per sq m	per sq ft
17.	Iron hold fast ... *(May also be by no.)*	quintal	per q	per cwt
18.	Iron railing (Height and types specified) ...	metre	per m	per r ft

Sr. No.	Particulars of Items	Units of measurement in MKS	Units of payment in MKS	Units of payment in FPS
7.	Distempering ...	sq m	per sq m	% sq ft
8.	Snow cement washing or finishing ...	sq m	per sq m	% sq ft
9.	Painting, Varnishing ...	sq m	per sq m	% sq ft
10.	Polishing of wood work	sq m	per sq m	% sq ft
11.	Painting letters and figures (Height specified) ...	no.	per no.	per no.
12.	Oiling and clearing of doors and windows ...	sq m	per sq m	% sq ft
13.	Coal tarring ...	sq m	per sq m	% sq ft
14.	Removing of paint or varnish ...	sq m	per sq m	% sq ft
15.	Gobri Lepping (cow dung wash) ...	sq m	per sq m	% sq ft
	Flooring :			
1.	C.C. over L.C. Floor (including L.C.) ...	sq m	per sq m	% sq ft
2.	Conglomerate floor ...	sq m	.per sq m	% sq ft
3.	Stone floor flag stone floor L.C. (including L.C.) ...	sq m	per sq m	% sq ft
4.	2.5 cm (1") marble flooring over L.C. (including L.C.) ...	sq m	per sq m	per sq ft
5.	Mosaic or terrazo or granolithic floor over L.C. (including L.C.) ...	sq m	per sq m	per sq ft
6.	Brick flat floor over L.C. (including L.C) ...	sq m	per sq m	% sq ft
7.	Brick on edge floor over L.C. ...	sq m	per sq m	% sq ft
8.	Mud flooring finished gobri lepping ...	sq m	per sq m	% sq ft
	Miscellaneous Items :			
1.	Ornamental cornice (Projection, type specified) ...	metre	per in	per r ft
2.	Moulding String course, Drip course, Beading, Throating, etc. ...	metre	per m	per r ft
3.	Ornamental Pillar caps, Pillar base, Flowers, Brackets, etc. ...	no.	per no.	per no.
4.	Railing (Height and type specified)	metre	per m	per r ft
5.	Surface drain small (size, material, etc. specified) ...	metre	per m	per r ft
6.	Surface drain large (item wise) --			
	(*i*) Masonry ...	cu m	per cu m per sq m	% cu ft
	(*ii*) Plastering ...	sq m		% sq ft
7.	Pipe – rainwater, sanitary, water pipe, etc. (Dia. specified) ...	metre	per m	per r ft
8.	Laying pipe line – sanitary, water pipe, etc. (Dia. depth, bedding etc. specified) ...	metre	per m	per r ft

Sr. No.	Particulars of Items	Units of measurement in MKS	Units of payment in MKS	Units of payment in FPS
9.	Jungle clearance ... *(May also be per km for road and irrigation channel)*	sq m or hectare	per sq m or per hectare	% sq ft or per acre
10.	Silt clearance in irrigation channels (Similar to earthwork) ... *(For thin layer upto 5 cm may be on area basis)*	cu m	per % cu m	% cu ft
11.	Easing doors and windows ...	no.	per no.	per no.
12.	Fixing doors and windows ...	no.	per no.	per no.
13.	Supply and - fixing of Hinges, Tower bolts, Hasp and staples, Handles, Hardwares, etc ...	no.	per no.	per no.
14.	Glazing ...	sq m	per sq m	per sq ft.
15.	Glass panes (supply) ...	sq m	per sq m	per sq ft.
16.	Fixing of glass panes or cleaning ...	no.	per no.	per no.
17.	Renewing of glass panes ...	no.	per no.	per no.
18.	Well sinking (Masonary or tube well) ...	metre	per m	per r ft.
19.	Pile driving or sinking ...	metre	per m	per r ft
20.	Furnitures – Chairs, tables, etc. (size shape specified) ...	no.	per no.	per no.
21.	Pitching of brick, stone, kankar, etc. ...	cu m	per cu m	% cu ft
22.	Lining of Irrigation Channel, Tunnel, etc.	sq m	per sq m	% sq ft
23.	Bituminous road surfacing ...	sq m	per sq m	% sq ft
23.	Dismantling of brick masonry ...	cu m	per cu m	% cu ft
23.	Grouting (Bituminous grouting of road metal, cement grouting of concrete) ...	sq m	per sq m	% sq ft
25.	Grouting of cracks, joints, etc. ...	metre	per m	per r ft
26.	Electric Wiring or Electrification Light, Fan, Plug points ...	point	per point	per point
27.	Waterclaset (W.C.), Wash hand basin, Manhole, etc. (size specified) ...	no	per no	per no
	Materials :			
1.	Supply of bricks ...	% nos.	per % nos.	% nos.
2.	Supply of Sand, Surkhi, Cinder, etc. ...	cu m	per cu m	% cu ft
3.	Supply of cement ...	bag of 50 kg	per bag or per quintal or per tonne	per cwt or per ton
4.	Supply of lime unslaked ...	quintal	per quintal	per maund
5.	Supply of lime slaked ... *(May also be in volume basis in cu m)*	quintal	per quintal	per maund
6.	Supply of Brick ballast, Stone ballast, Aggregate, etc. ...	cu m	per cu m	% cu ft

2.8 RULES FOR MEASUREMENTS

Based upon Indian standard (IS-1200), there are some rules which should be followed strictly at work place for easement of work.

General Rules :

1. All measurement shall be item wise and description of each item shall be made so that the works involved in item is self explanatory
2. While booking dimensions the order shall be in the sequence of lengths, breadth and height or depth.
3. Each work has tolerance :
   (*i*) Dimension shall be measured to the nearest 0.01 m

(*ii*) Area shall be measured to the nearest 0.01 m^2

(*iii*) Volume or cubic contents shall be measured nearest to 0.01 m^3.

4. Same work under different conditions and nature shall be measured separately.
5. There must be full description of materials, ratio or proportions, workmanship etc in the bill of quantities.

1. **Long wall and short wall method :** This is simple method, and there are less chances of mistakes. In this method long walls and short walls are worked out separately, in case of long wall external length of walls running in the longitudinal directional (*i.e.* long walls) out to out, and the internal lengths (*i.e.* short walls) running in transverse direction in-to-in are worked out. To calculate quantities multiply the length by breadth and height of wall.

For *long walls* add to the centre length one breadth of wall, which gives the length of the wall out-to-out, multiply this length by the breadth and the height and get the quantities. Thus for finding the quantities of earthwork in excavation, for length of the trench out-to-out add to the centre length one breadth of foundation. Adopt the same process for foundation concrete, and for each footing. It should be noted that each footing is to be taken separately and the breadth of the particular footing is to be added to the centre length.

(Long wall length out-to-out = centre to centre length + half breadth on one side + half breadth on the other side = centre to centre length + one breadth).

For *short or cross* walls subtract (instead of adding) from the centre length one breadth of wall, which gives the length in-to-in, and repeat the same process as for long walls. subtracting one breadth instead of adding.

(Short wall length in-to-in = centre to centre length — one breadth).

This method can also be worked out in a quicker way. For long walls find the length of the foundation trench of the long wall out-to-out in the same manner as explained above, the length of the foundation concrete is the same, for the length of the first footing or first step-of brick wall subtract two offsets in foundation concrete from the length of the trench or concrete, for the second footing subtract from the length of 1st footing two offsets in footingfor the third footing subtract from the length of the 2nd footing two offset in this way deal the long walls up to the superstructure.

For short wall follow the same method but instead of subtracting, add two offsets to get the corresponding length in-to-in.

It will be noticed that by taking dimensions in this way, the long walls are gradually decreasing in length from foundation to superstructure, while the short walls are increasing in length.

It may also be noted that the wall which is taken first is to be treated as long wall though its length may be lesser, and the other wall be treated as short wall.

2. **Centre line Method :** In this method sum-total length of centre lines of walls, (long and short) has to be worked out. After finding out the total length of centre lines of walls, of same types of formations and footings quantities one worked out by multiplying the total centre length by respective breadth and height or depth. This method is quick but require special attention at the junctions, meeting points of partition walls etc.

This method is very simple in case of rectangular circular polygonal *i.e.* hexagonal, octagonal etc. buildings having no cross or inter walls, but for buildings having cross or partition walls special consideration is to be given to find out dimensions. Buildings having different types of walls *i.e.* having different formations and footings must be taken separately. Following points should be taken separately. Following points should be kept in mind while work out dimensions :

1. In a building at corners where two walls are meeting no deduction or addition is made.
2. In case of number of footing the length of first footing is to be worked out by subtracting $\frac{1}{2}$ breadth of footing per junction from the total centre line length and them the length of the subsequent footing can be worked out by adding one offset of footing for every junction to the length of the previous footing.

Thumb rule for centre line method

Long wall = c/c	length of long wall = A
Short wall = c/c	length of short wall = B

Total centre line = A + B.

In a building having different walls, let building is composed of Two types of walls (1) outer walls (2) cross walls. Let outer walls be of type 'P' and cross walls of type 'Q'. First of all length of 'P' types of walls are worked out jointly, then length, of 'Q' types of walls are worked out separately. In this case no subtraction is made for 'P' type *i.e.* outer or main walls but $\frac{1}{2}$ breadth of type 'P' walls shall be deducted from total centre length of type 'Q' walls for each junction. Also in case of corner where two walls are meeting no addition or deduction is made.

20.50. SEPTIC TANK

A combined sedimentation cum digestion tank in which flow of sewage is slowed down so that solids in suspension settle down, along with conversion of sewage into gaseous and liquid form by anaearobic bacterial action is called a *Septic Tank.*

In simple words, septic tank is a sedimention cum digestion tank of sewage. After this action, effluent that flows out of tank contains considerable amount of dissolved and suspended organic solids and other harmful matter. So this effluent should be properly disposed off in either soak pit or dispersion trenches for absorption in the soil. A septic tank may be of brick masonry, stone masonry or concrete. Tank should be so designed that detention period of sewage should be 24 hrs to 48 hrs, based on an average daily flow of anitcipated flow.

20.51. SIZES OF SEPTIC TANK

The following are the sizes of the septic tank as well as the different parts of the septic tank, See Fig. 20.89

(*i*) Length of septic tank (L) = 2 to 4 times Breadth (B = 0.75 m min.)

Depth of septic tank = Water depth + Free board

= 1000 to 1800 mm + 300 to 450 mm.

= 1300 to 2250 mm

Depth = 1.3 m minimum and 2.25 m maximum

or Total Depth = $D + F$, where D = Depth below water surface and F = Free board (*ii*) Table 20.XV shows the sizes of septic tank according to number of users as per IS 2470.

Table 20.XV. Recommended Capacities and Sizes of Septic Tanks

No. of Users	Length L	Breadth B	Liquid Depth D (For cleaning Interval of)			Liquid Capacity (For cleaning Interval of)			Sludge to be removed (For cleaning Interval of)			Depth of Sludge to be Withdrawn In		
			6 months	1 years	2 years	6 months	1 years	2 years	6 months	1 years	2 years	6 months	1 years	2 years
	m	m	m	m	m	m^3	m^3	m^3	m^3	m^3	m^3	m	m	m
5	1.50	0.75	–	1.00	1.05	–	1.12	1.18	–	0.36	0.72	–	0.32	0.64
10	2.00	0.90	–	1.00	1.40	–	1.80	2.52	–	0.72	1.44	–	0.40	0.80
15	2.00	0.90	–	1.30	2.00	–	2.34	3.60	–	1.08	2.16	–	0.60	1.20
20	2.30	1.10	1.00	1.30	1.80	2.53	3.30	4.55	0.72	1.44	2.88	2.28	0.57	1.14
25	4.00	1.40	1.00	1.30	2.00	5.60	7.28	11.20	1.80	3.60	7.20	0.32	0.64	1.28

Note 1. The capacities recommended provide for waste water also.

Note 2. A provision of 30 cm should be made for free board.

2. Inlet Pipe. An elbow or *T*-pipe of 100 mm diameter and submerged to a depth of 250 mm to 600 mm below the liquid level may be provided. For large size tank more number of inlet pipe can be provided at a horizontal gap of 750 mm. Sometimes an elbow or *T*-pipe is not provided.

3. Outlet Pipe. An elbow or *T*-pipe of 100 mm diameter, submerged to a depth of 200 to 500 mm below the liquid depth should be provided. It should be 50 mm below the inlet pipe level.

4. Baffle-Walls. For smaller tanks, only hanging type of baffle walls are provided. The inlet end of baffle-wall should be placed at a distance of $\frac{1}{5}$ th length of the tank.

Baffle wall should be extended 150 mm above the scum level and 400 to 700 mm below it. The thickness of the wall may vary from 40 to 80 mm in medium size septic tank only one wall is constructed.

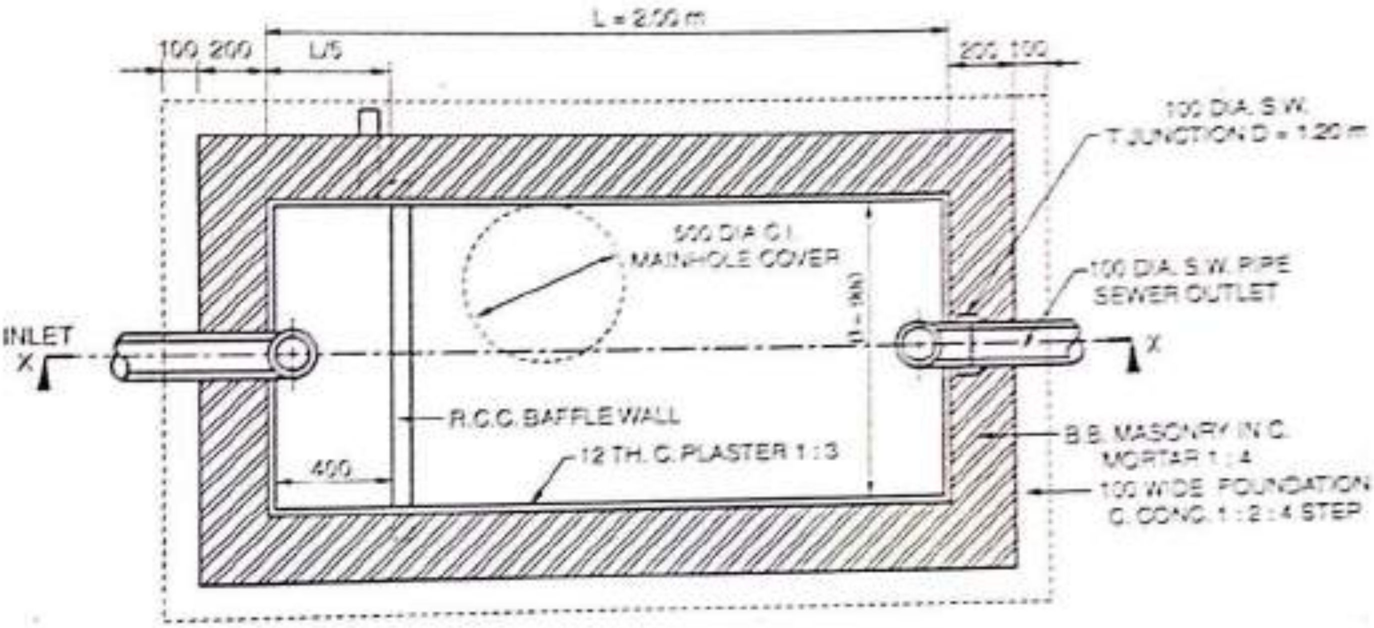
5. Roofing-Slab. The tank is covered with on R.C.C. slab 80 mm thick with an access for inspection and desludging.

Circular opening provided is 500 mm in diameter and rectangular opening 450 × 600 mm.

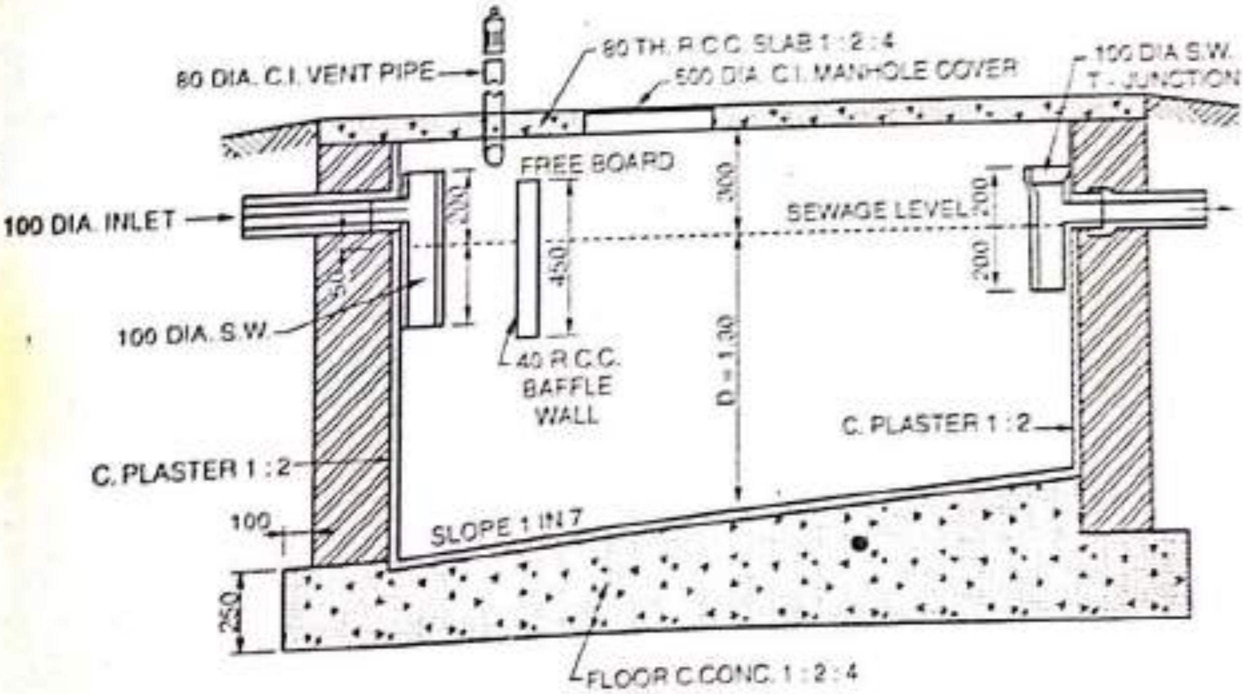
6. Flooring. The floor has all sides sloping (1 in 7 slope) towards one point to facilitate collection of sludge.

7. Desludging pipe. Sludge is taken out of septic tank by hydrostatic pressure Size of desludging pipe should be 100 to 150 mm. Desludging is controlled by sluice valve fixed on a pipe.

Fig. 20-89 shows a septic tank for 15 users as per IS 2470.



PLAN



SECTION AT XX

Fig 20-89 Septic Tank for 15 Users (1–Year Cleaning)

Example 28. *Draw the sectional plan and cross-section of a septic tank for 10 users with cleaning interval as 1 year as per IS 2470.*

Solution. For solution see Fig. 20·90.

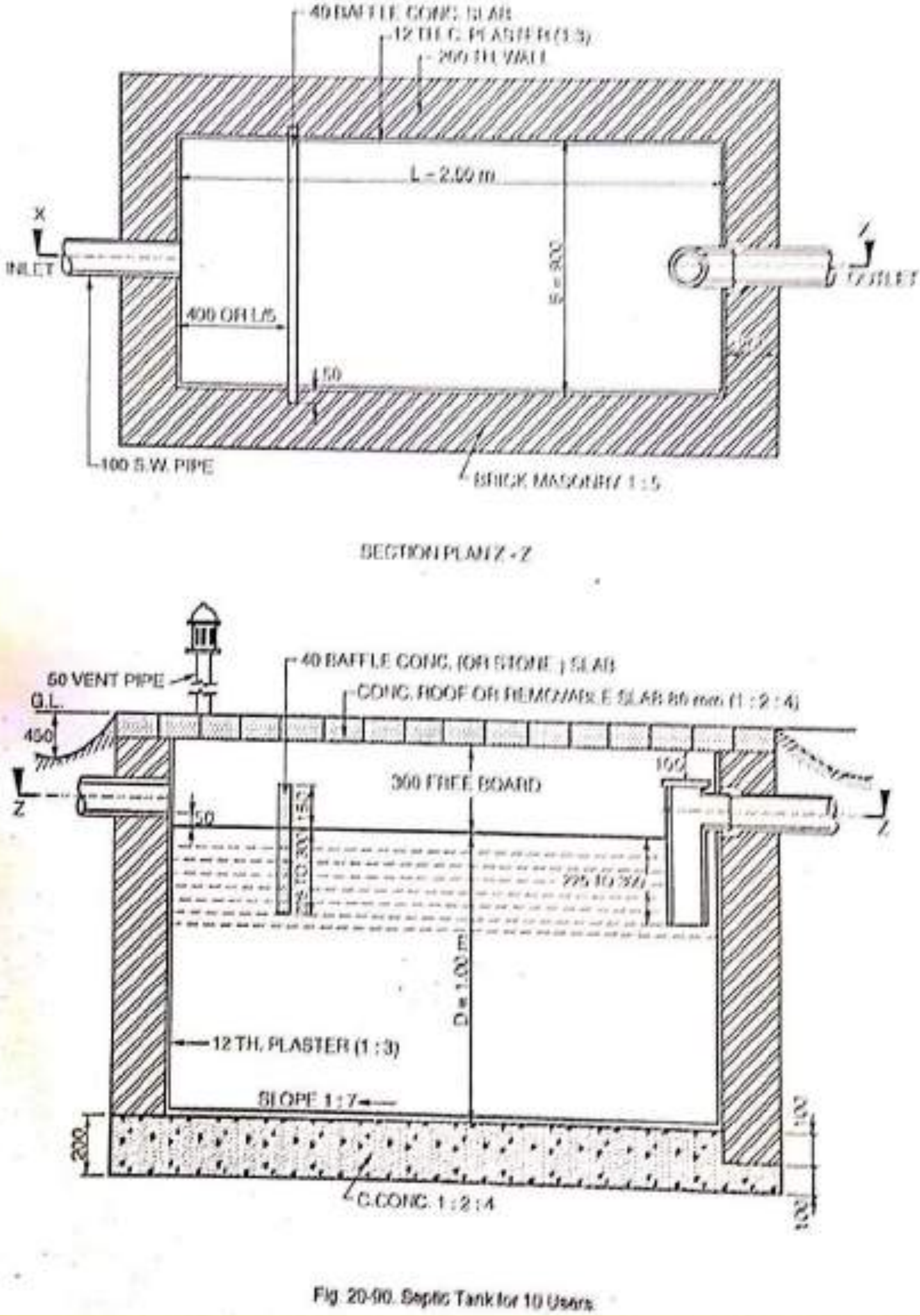


Fig. 20·90. Septic Tank for 10 Users

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Example 29. *Draw the sectional plan, cross-section and sectional side elevation of a septic tank for 15 users and one year cleaning provisions for desludging hydraulically should be made as per IS 2470.*

Solution. For solution see Fig. 20-91.

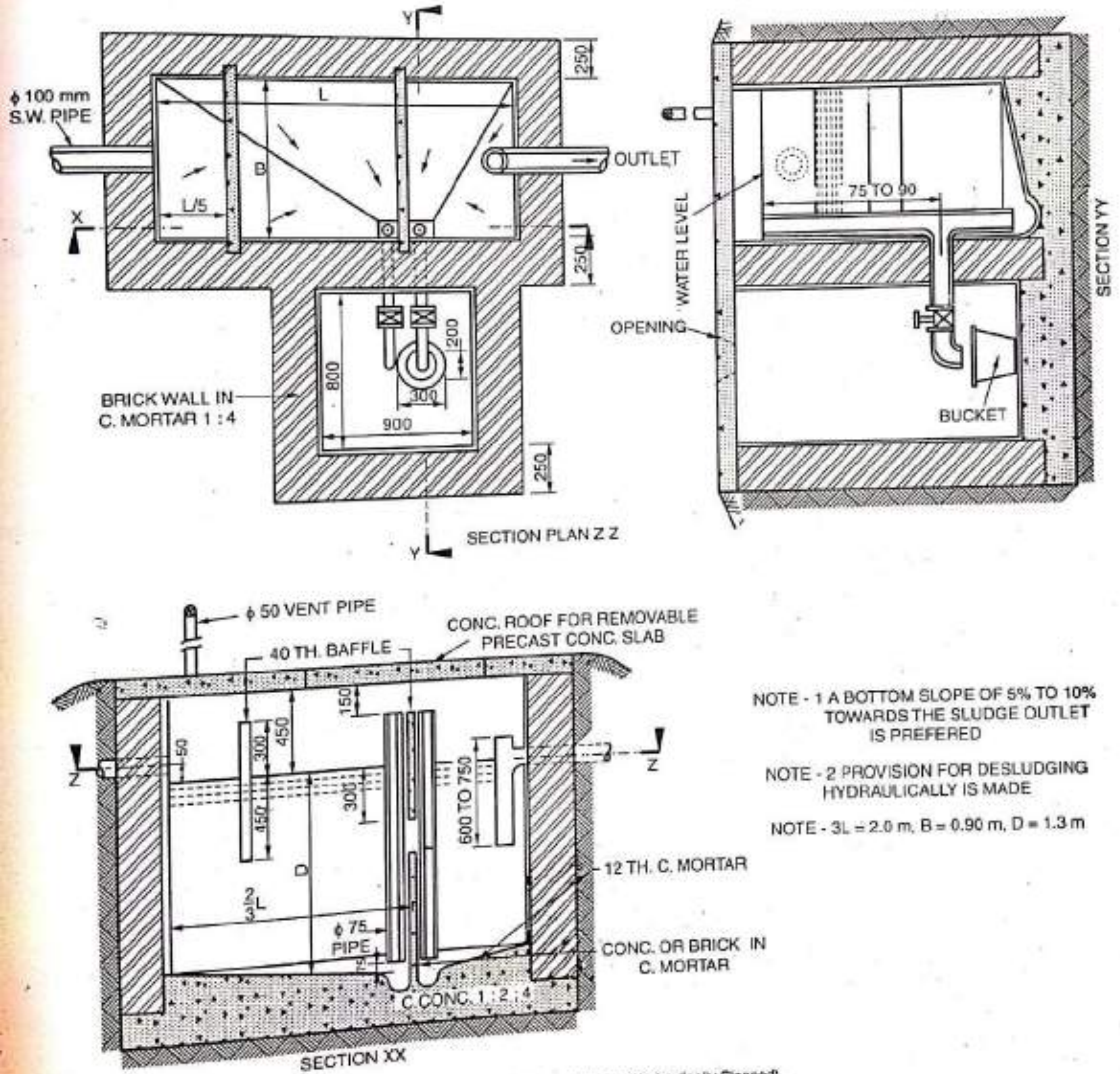


Fig. 20-91. Septic Tank for 15 Users (Hydraulically Cleaned).

Septic Tank Effluent Disposal. The effluent from septic tank is foul smelling and there is dissolved and suspended organic matter in it. Thus it requires to be properly treated and disposed off so as to have minimum risk of nuisance to the health of the users. Effluent from septic tank is disposed by secondary treatment.

The following are two method of diposing off the effluent from septic tank :

1. Discharge into soil absorption system such as soak pits or seepage pits.
2. Sub-surface irrigation using absorption field method.

20.52. SOAK PIT

A covered pit provided for the disposal of individual house drainage by seepage in surrounding soil is called a *Soak Pit.*

Seepage in soak-pit is a method of disposal of sewage from an individual house drain. The diameter of pit varies from 2 m to 3 m and depth from 3 m to 4 m or more upto depth where sandy layer starts. The walls of pit are lined with open jointed brick or stone masonry. The effluent from the septic tank of house drain gets absorbed in the soil by seepage.

An effluent from a septic tank should never be allowed to flow into any open drain.

Sizes of soak pit or seepage pit.

Minimum diameter = 900 mm.

Depth below invert of inlet pipe = 1000 mm.

The brick lining above inlet level is in cement mortar and below it is open jointed masonry.

Following are the different types of soak pits.

(i) **Empty Soak Pit or Seepage Pit.** Effluent from septic tank is put in empty soak and it is absorbed in the sub soil and through open joints of open jointed masonry.

Fig. 20-91 shows an empty soak or seepage pit.

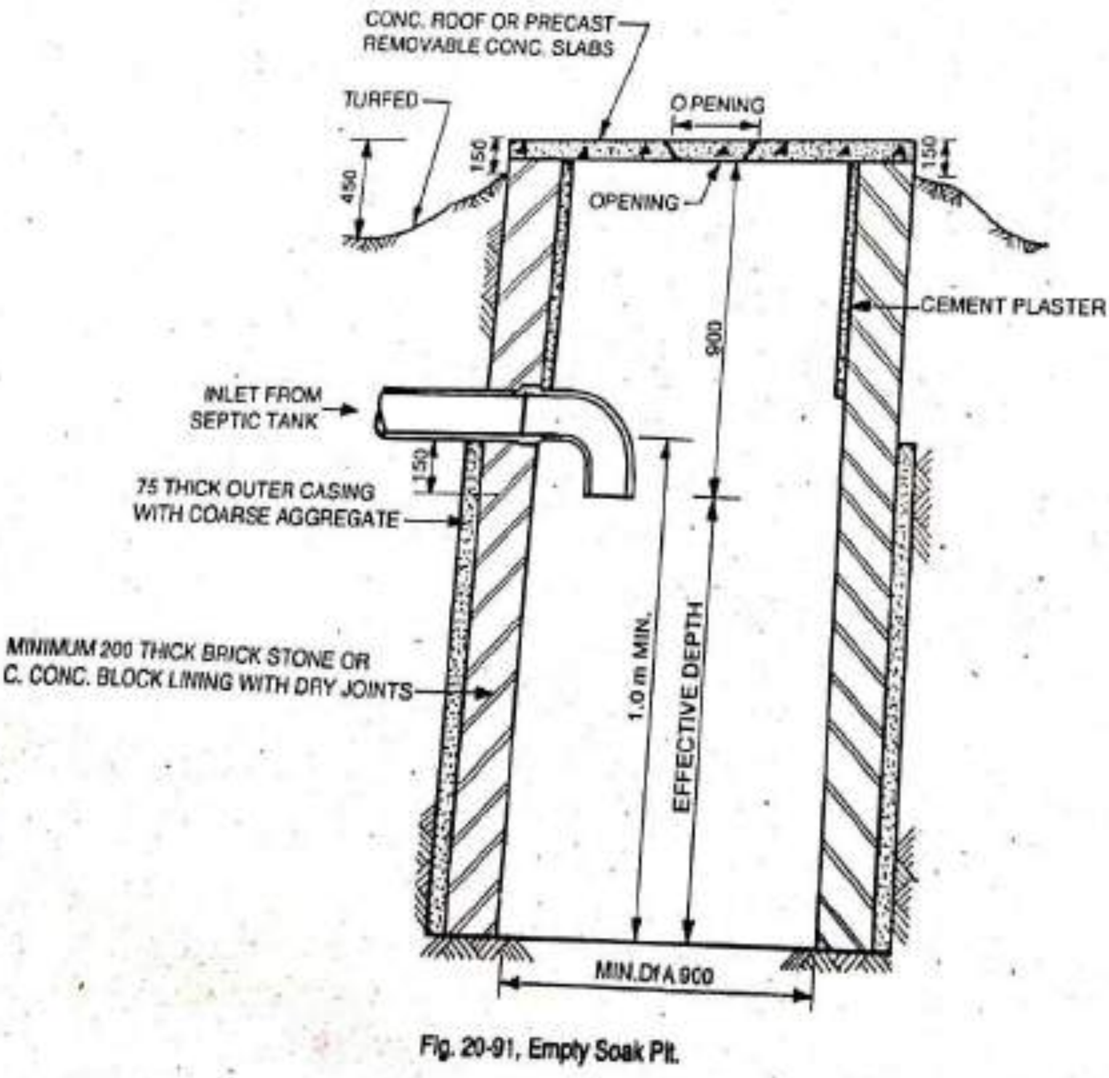


Fig. 20-91. Empty Soak Pit.

(ii) **Filled Soak Pit.** Filled soak pit is an unlined soak pit filled with rubble or brick bats. Fig. 20-92 shows a filled soak pit.

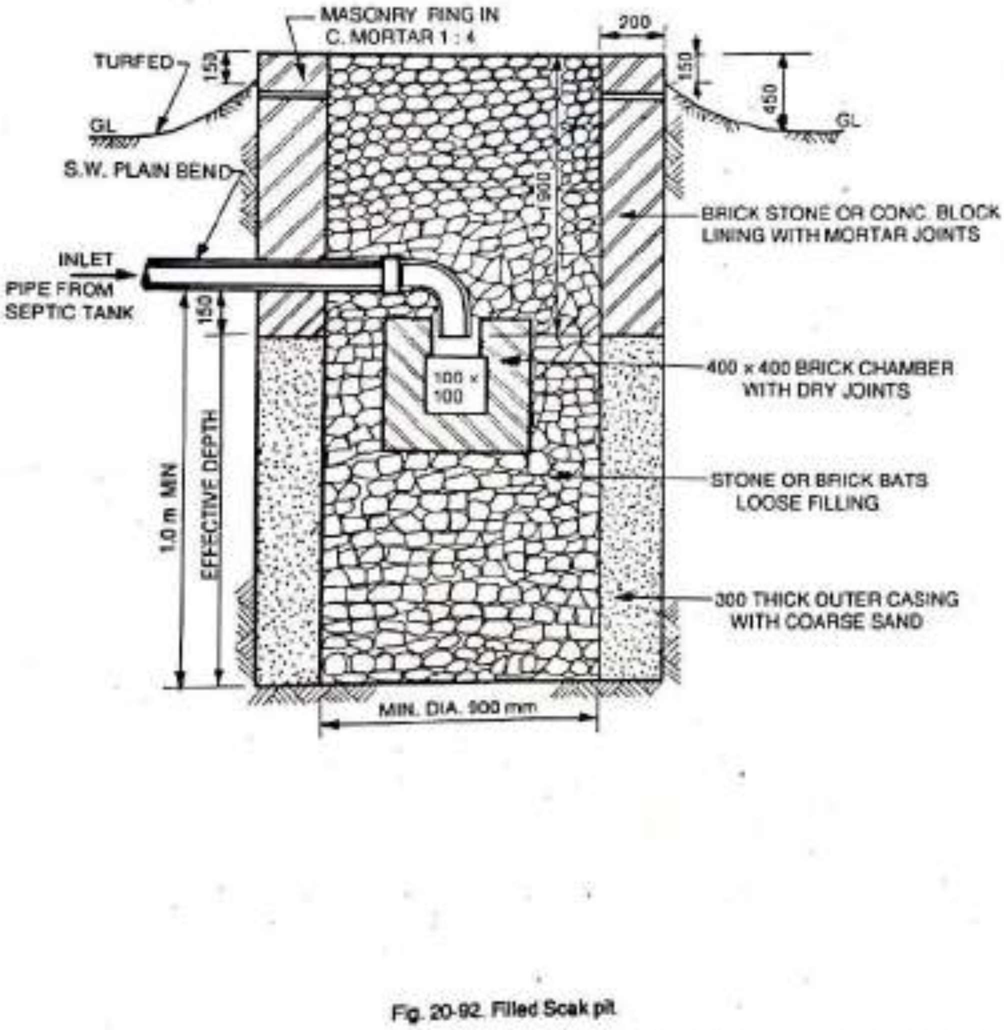


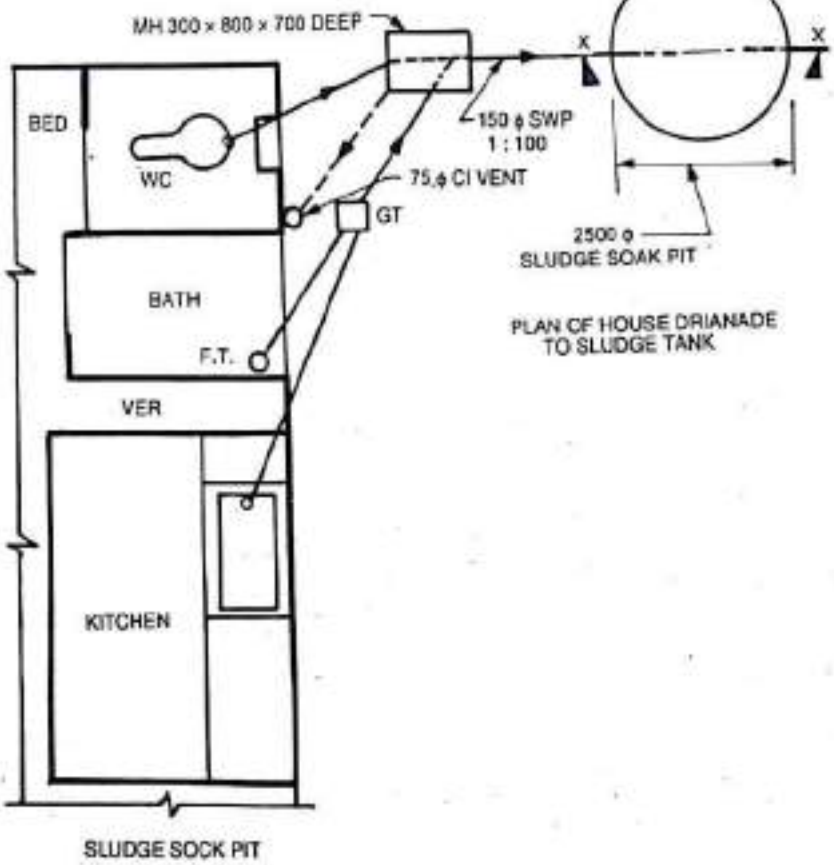
Fig. 20-92. Filled Soak pit

(iii) **Sludge Soak Pit.** Sludge soak pit is an alternative method of sewage disposal for an individual house. The diameter of pit varies from 2 m to 3 m and depth from 3 m to 4 m. The effluent from an individual house is directly discharged in the sludge soak pit. In this case, septic tank is not provided. The liquid part of the effluent gets absorbed in to the soil through open joints by seepage and sludge gets digested be anaerobic bacterias which settles down.

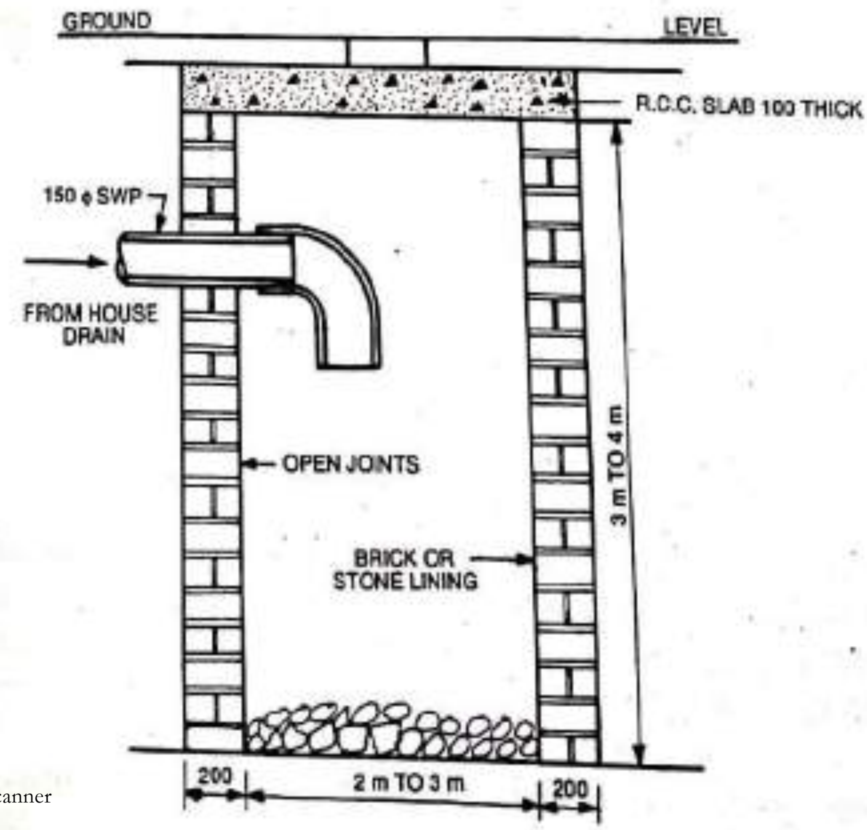
The walls of pit have open jointed brick or stone masonry. The pit is covered with slab at top.

One pit can serve for many years. When the pit gets filled it is emptied after removing covering slab. The contents of empty pit can be used as fertilizer. Put is again put to use.

Fig. 20-93 (*i*), (*ii*) shows a detail to house draingage to sludge soak pit.



(i)



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(ii)

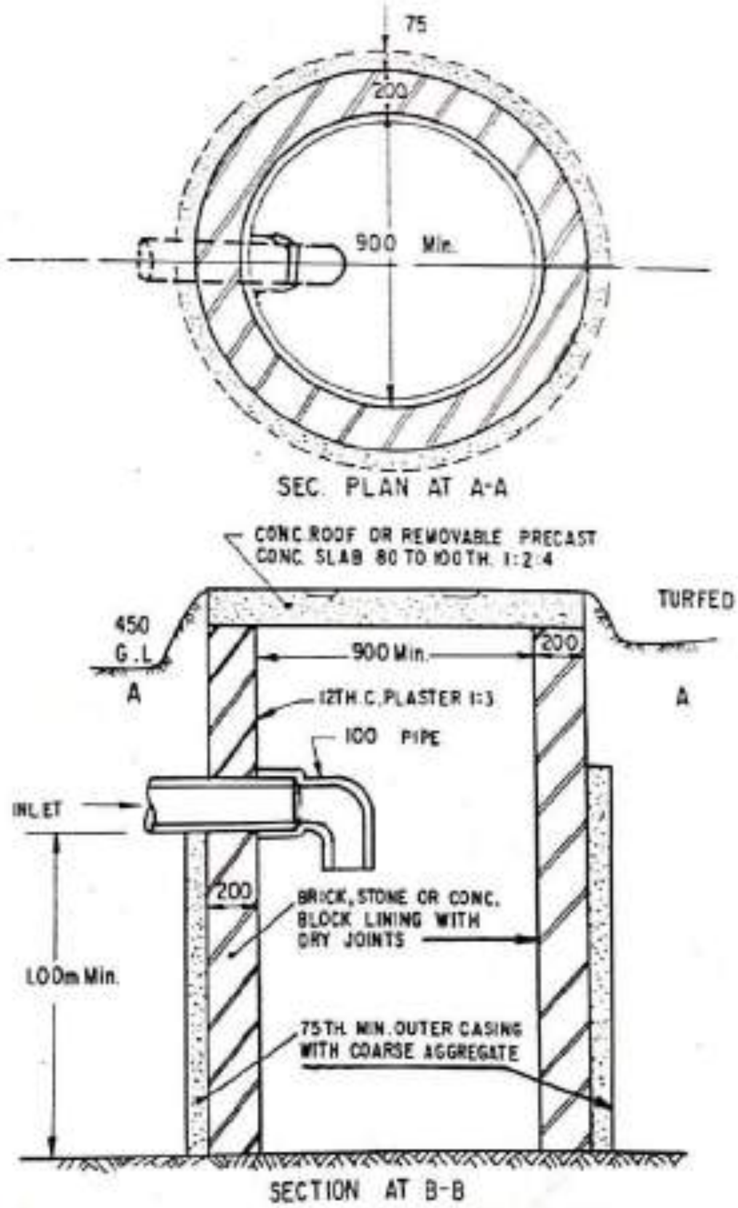
Fig. 20-93. Sludge Soak Pit.

Example 30. *Draw the sectional plan and sectional elevation of a Soak Pit with 900 mm diameter 3.00 mm effective depth.*

(*i*) *Empty Soak Pit.*

(*ii*) *Filled Soak Pit.*

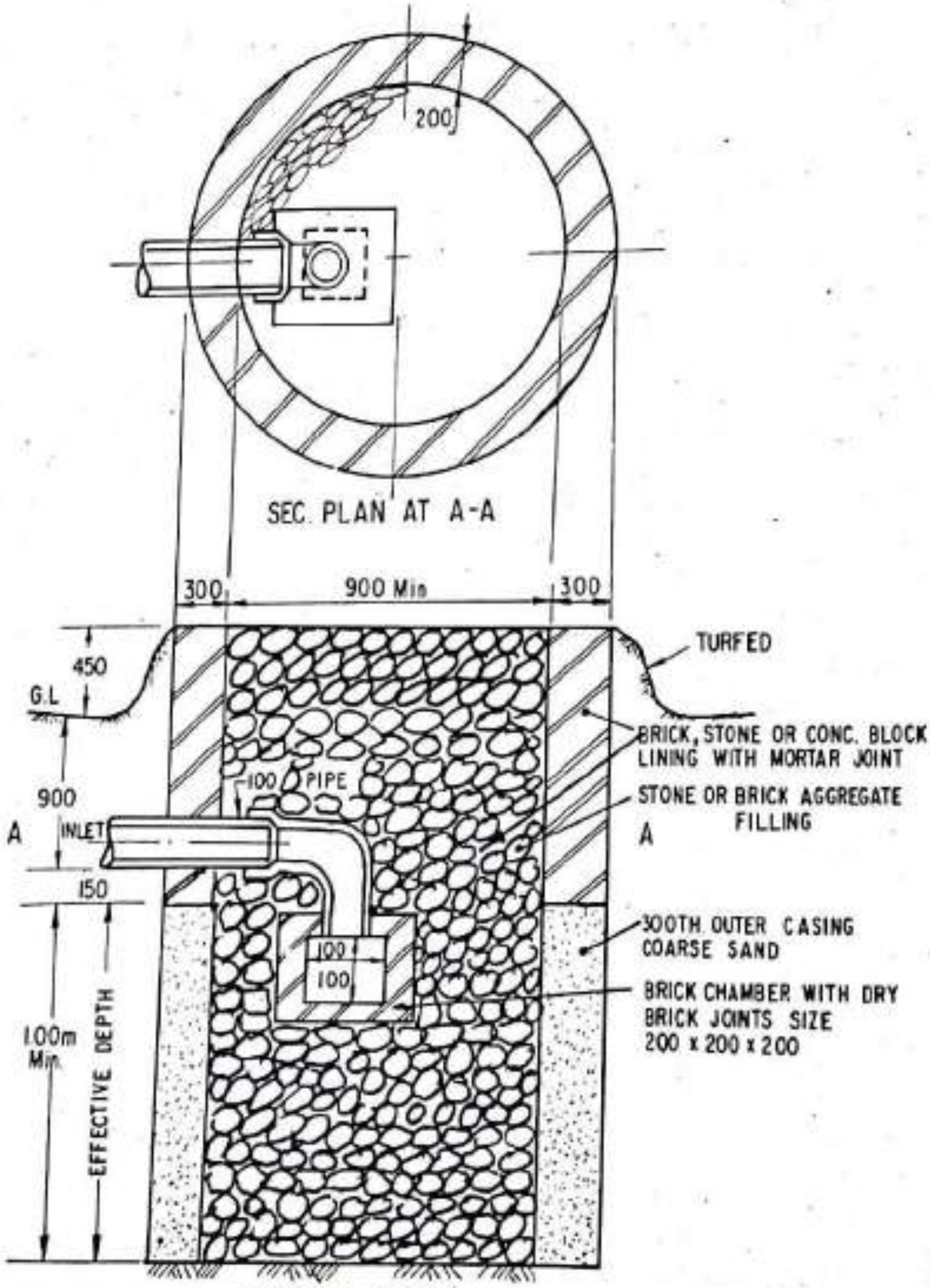
Solution. (*i*) For solution see Fig. 20-94.



SECTION AT B-B

EMPTY SOAK PIT (WITH LINING)

(ii) For solution see Fig. 20-95.



SECTION AT B-B

FILLED SOAK PIT (WITHOUT LINING)

14.10 WATER CLOSETS (W.C.)

Water closet *may be defined as a water flushed plumbing fitting designed to receive human excreta directly from the user.*

In other words, it is an appliance provided to receive human excreta directly.

In residential buildings they should be located keeping in view the ventilation, so as not to cause any nuisance.

They are made of either of Glazed Earth Ware or pottery or porcelain ware and are available in the market in different verities.

Requirements of Good Water Closet :

(*i*) It should be such that night soil do not stick to it so inner side is glazed.
(*ii*) It must provide easy flushing.
(*iii*) It must be suitable in use with less water.
(*iv*) When night soil falls into the trap, its water should not be splashed.

14.10.1 Types of Water Closets

Water closets are of following types :

1. Indian or squatting type or oriental type
2. European or Pedestal type or western type

1. *Indian or Squatting Type* : It is made of vitreous China clay having its inner portion glazed to make it easy in cleaning. The pan is 450 mm to 630 mm in overall length and 450 mm to 500 mm height. The pan is connected with flushing cistern. Footrests are constructed integratedly with pan or are separately fixed on the floor.

They are provided with a high level flushing cistern at a height of 2 m above the water closet. Fig. 14.7 shows the section through an Indian type water closet. This is manufactured in two parts — (*i*) squatting pan and (*ii*) trap. The pan is provided with an integral flushing cistern. Inside the pan suitable slope is provided towards the outlet for quick disposal of human excreta during flushing. The trap is connected with soil pipe. The pan is connected to the flushing cistern by means of flushing pipe. Fig. 14.8 shows the pictorial view of an Indian type W.C. The Indian style W.C. are Long pattern and Rural pattern.

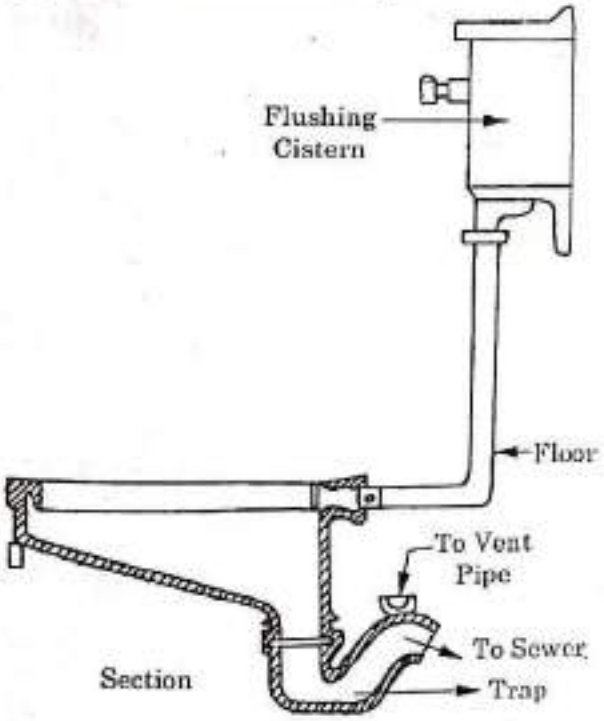


Fig. 14.7 : Section of Indian Type Water Closet

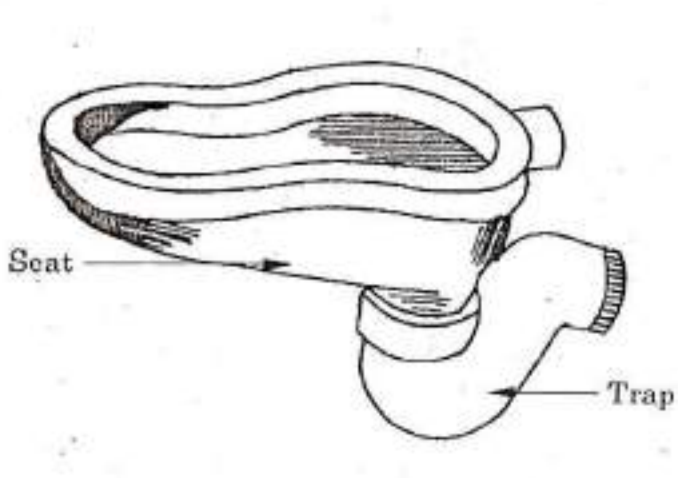


Fig. 14.8 : Pictorial View of Indian Type Water Closet

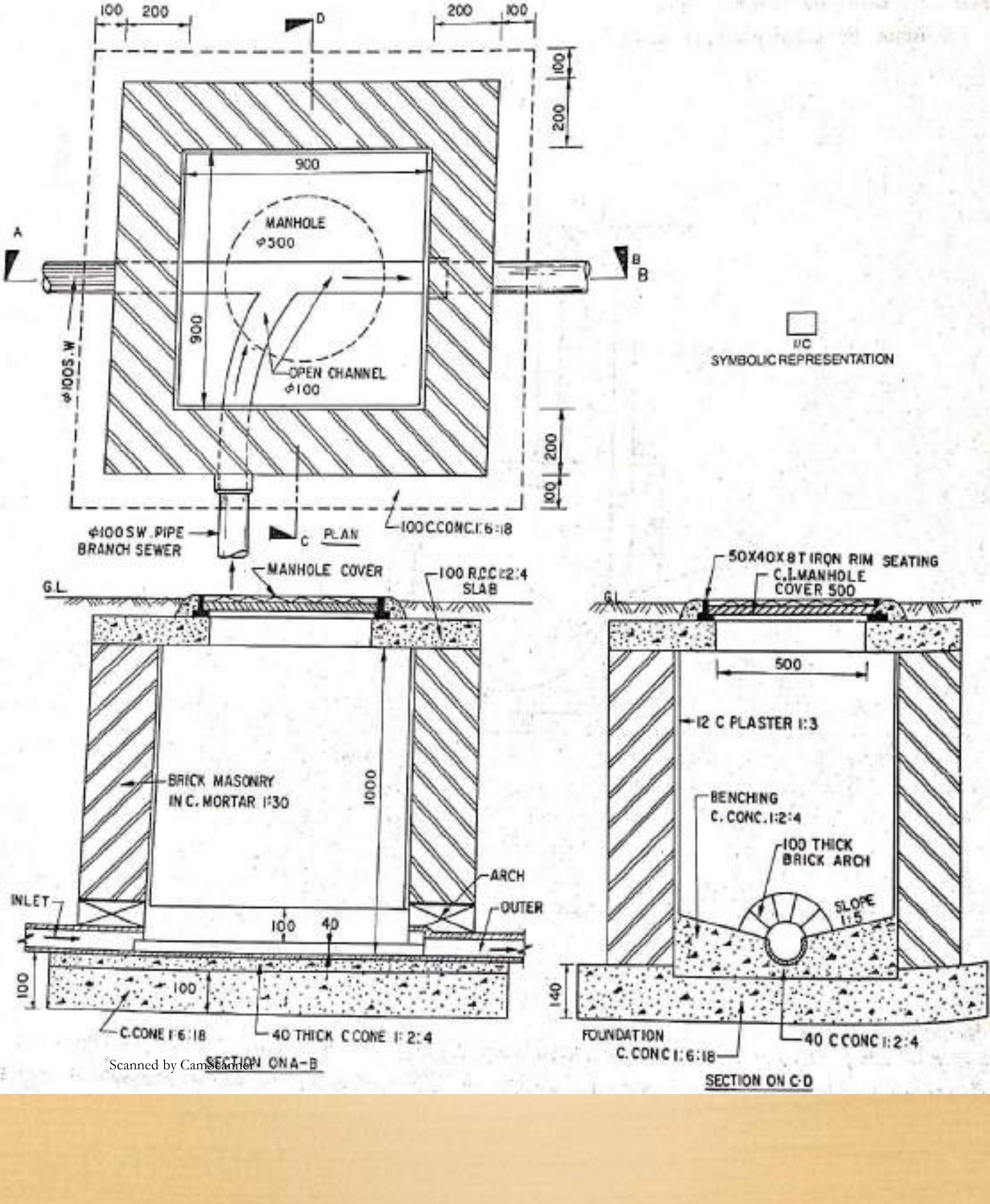
20.48. INSPECTION CHAMBER

A chamber of smaller size mainly provided in house drainage system, is called an *Inspection Chamber.*

Inspection chamber is like a manhole but without rungs. Inspection chamber takes waste water through Gully Traps and further disposes of to a manhole.

Example 24. *Draw the sectional plan, cross-sectional and sectional side elevation of an Inspection Chamber 900 mm × 900 mm. Inside depth is 1000 mm. A branch sewer pipe of 100 mm diameter is at right angles to them in sewer pipe. The data not given may be assumed.*

Solution. Fig. 20-85 shows the sectional plan, cross-section and sectional side elevation of the inspection chamber.



Example 25. *Draw the sectional plan, cross-section and sectional side elevation 1.0 m × 1.0 m inspection chamber with corbelling on all side. All other data may be assumed. Also show the position of another pipe at right angles.*

Solution. For solution see Fig. 20-86 which shows a Manhole Inpsection Chamber corbelling type in sectional plan, cross-section and sectional side elevation.

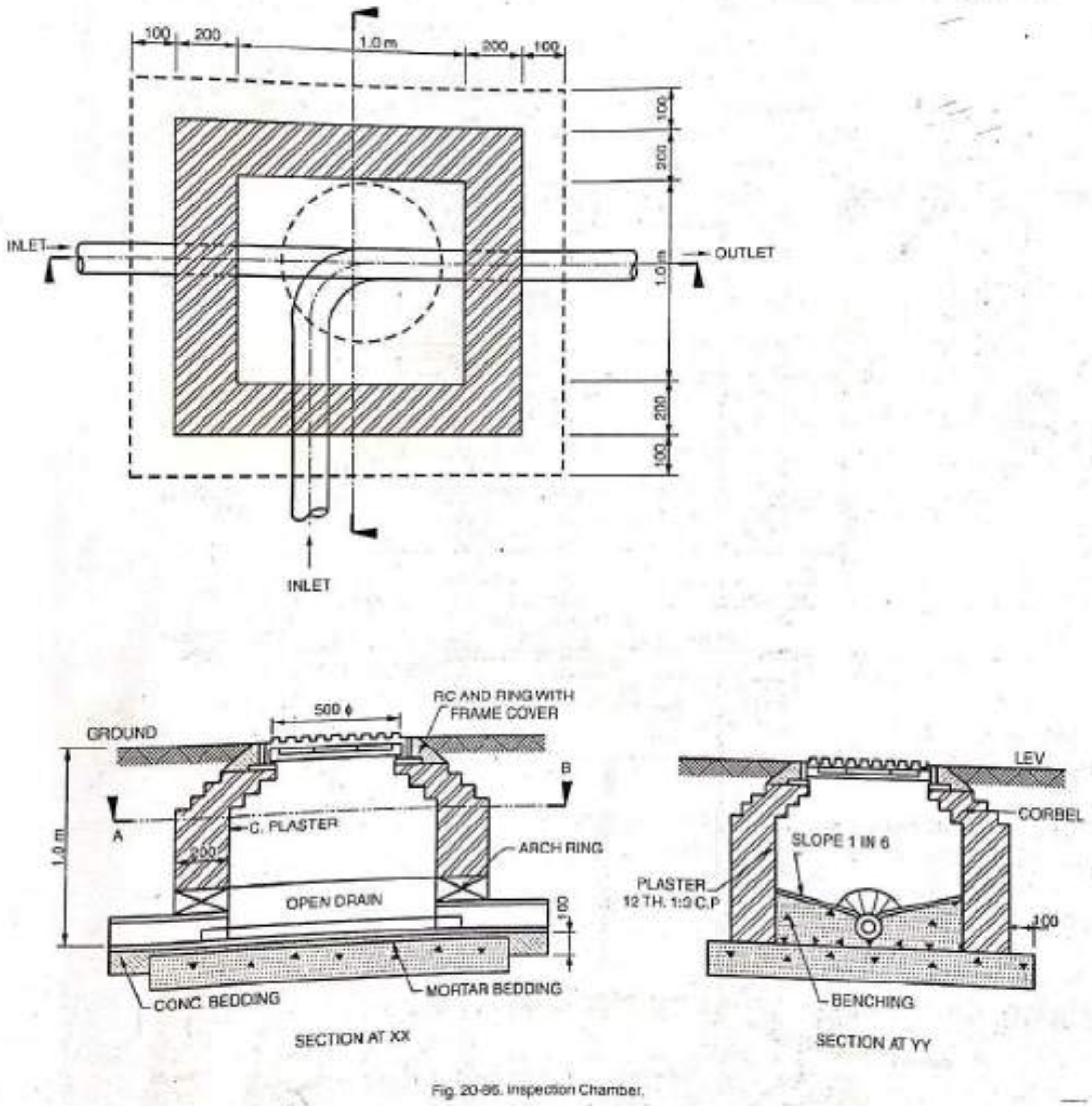


Fig. 20-86. Inspection Chamber.

20.24. BATH TUB

A tub used for taking bath is called a *Bath Tub*. Fig. 20-37 shows a Bath Tub

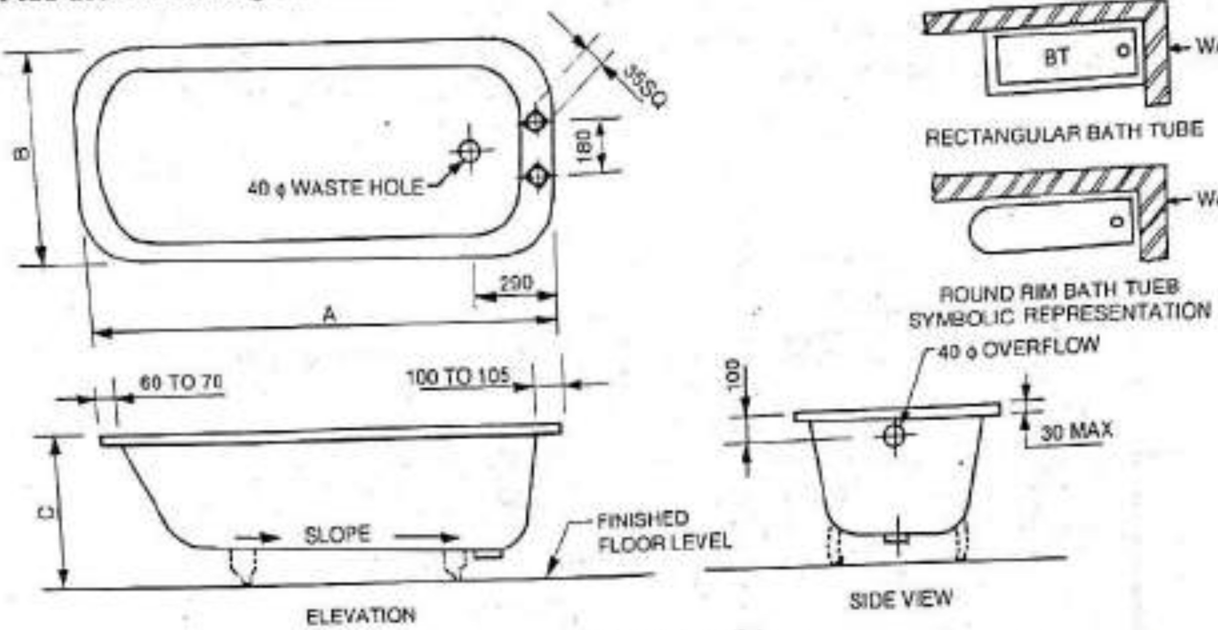


Fig. 20-37. Bath Tub.

Table 20.X. Size of Bath Tubs.

Overall Length at Top mm	Overall Width at Top mm	Height Above Floor mm
A	B	C
1650	730	500
to	to	to
1700	760	570

Fig. 20-38 shows a Bath Tub with fittings.

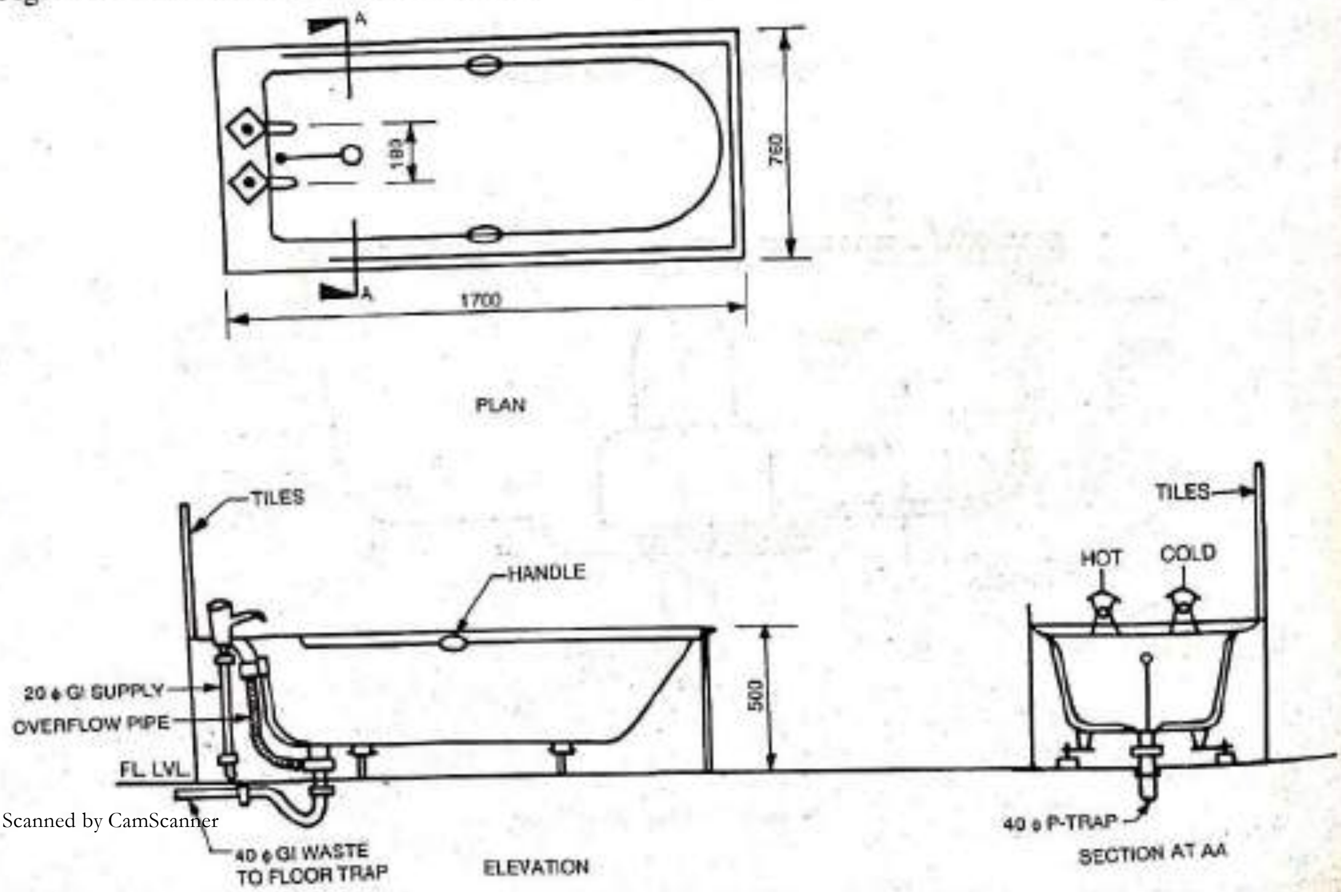


Fig. 20-38. Bath Tub with Fittings.

14.8 WASH BASIN

A basin provided for the purpose of washing hands, mouth etc. is known as *Wash basin* or *lavatory basin.*

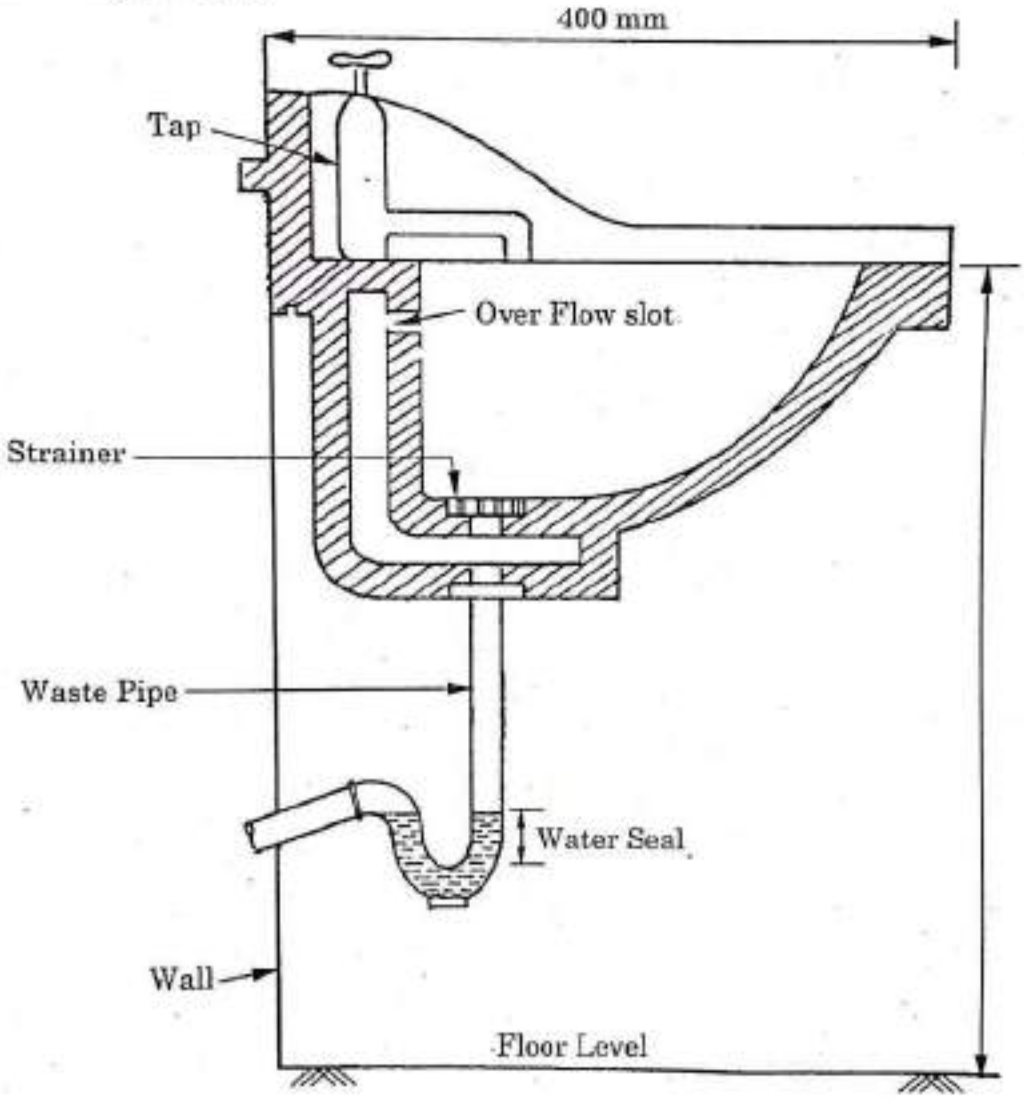


Fig. 14.3 : Pedestal Type Wash Basin

1. Tap. Tap is used at the end of a pipeline for draw off purposes. Tap is also called Bib cock or Bib Tap. See Fig. 20-1.

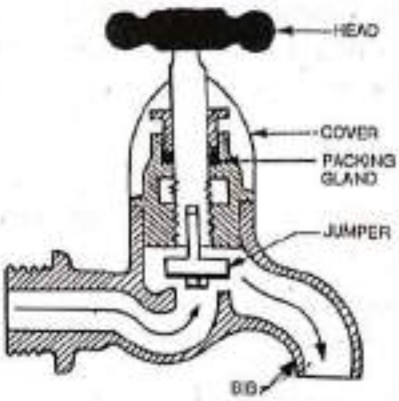


Fig. 20-1. Bib Tap

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20.28. ONE PIPE SYSTEM

In one pipe system, one pipe is provided for discharge from W.C., urinals, waste water from kitchen bath, wash basin and sink etc. Such pipe is called soil cum waste pipe. A separate ventilation pipe is provided to all floor traps. Gully trap is not provided in this system. Soil cum waste pipe is directly connected to main drainage system. Traps are essential in this system. Traps should be of deep water seal type, preferably 75 mm depth of seal, should be provided. Diameter of ventilating pipe should not be less than 50 mm.'

Fig. 20-47 shows a One Pipe System in a building.

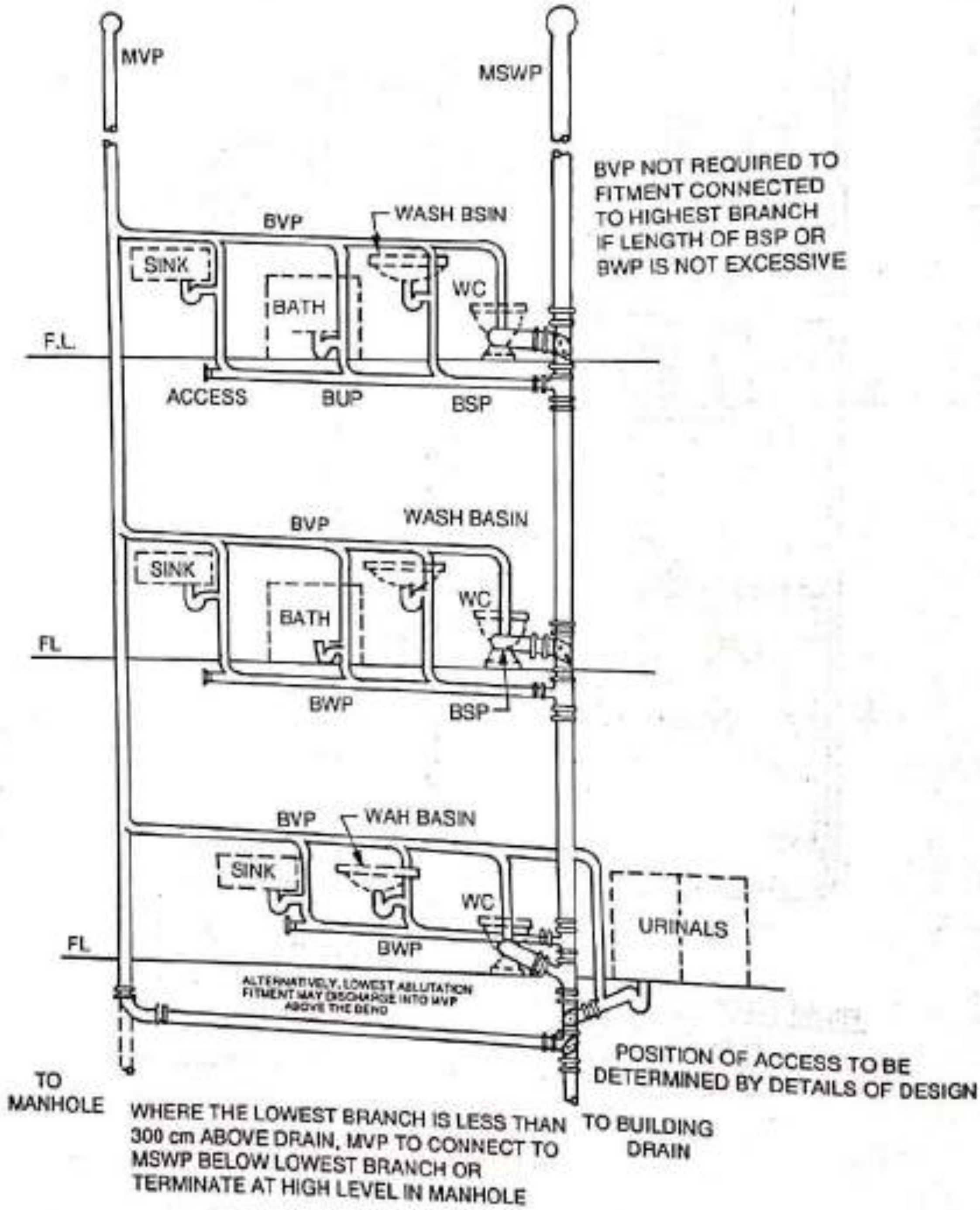

Fig. 20-47. One-Pipe System.

20.27. TWO PIPE SYSTEM

The foul matter from W.C. and urinals is discharged into one pipe *i.e.* Soil Pipe and waste water from kitchen, bath, wash basin, sink and floor traps (other than W.C. and urinals) is discharged into another pipe *i.e.*, Waste Pipe. The soil pipe is directly connected to drainage system. The waste pipe is connected to the drainage system through Gully trap. The Gully trap is provided at the foot of waste pipe. Ventilation pipes are connected to each stack. So in two pipes system four pipes are needed.

Fig. 20-46 shows the Two Pipe System in a building.

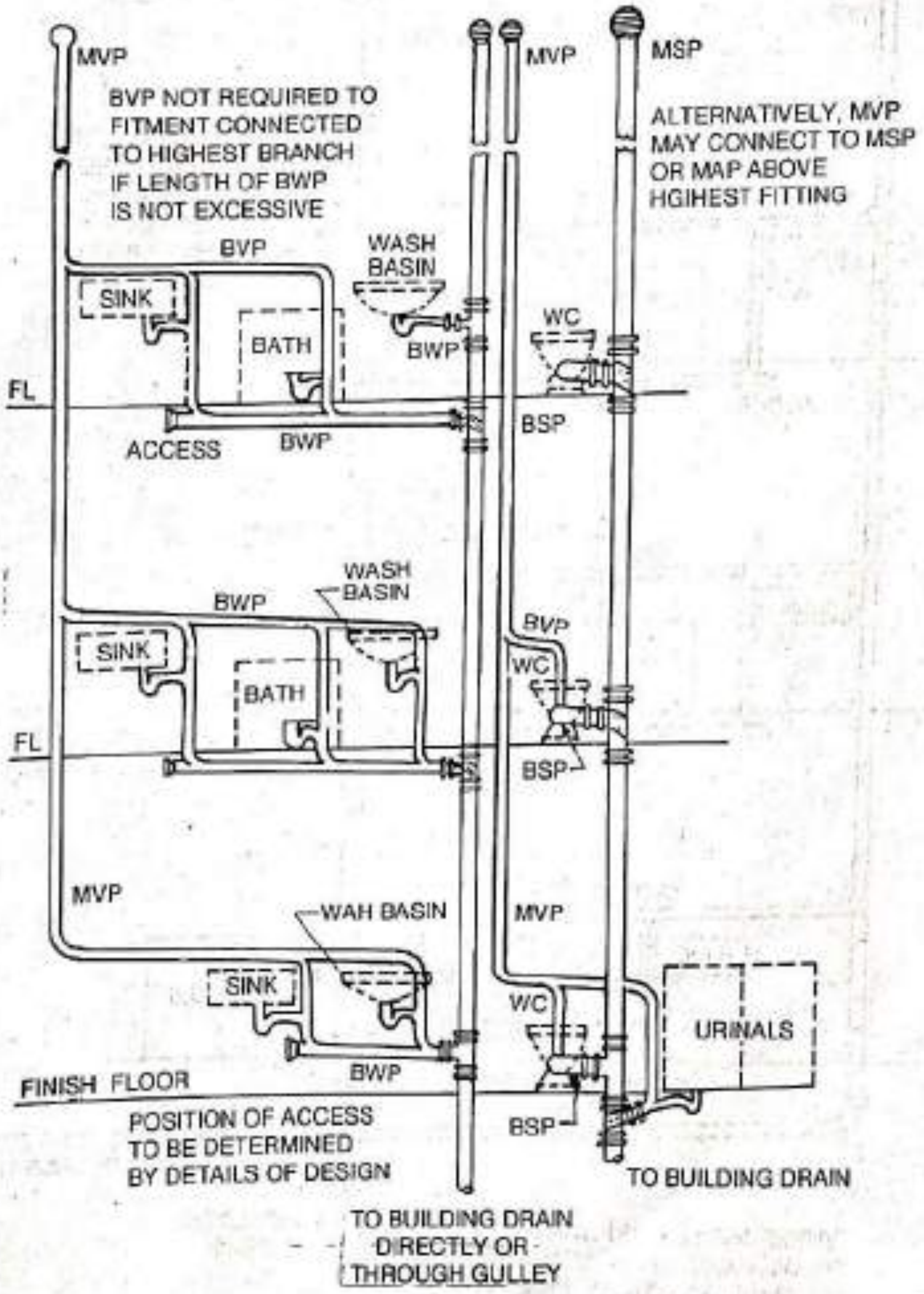

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Fig. 20-46. Two-Pipe System.

20.30. SINGLE STACK SYSTEM

Single stack system is a simplified form of one pipe system. There is no separate ventilation pipe. It is very economical system as there is a single stack for soil and waste fittings. Fig. 20-49 shows a single line diagram and Fig. 20-50 shows single stack system in a building.

References :	
WC	Water closet
S	Sink
WB	Wash Basin
FT	Floor Trap
FL	Floor Level

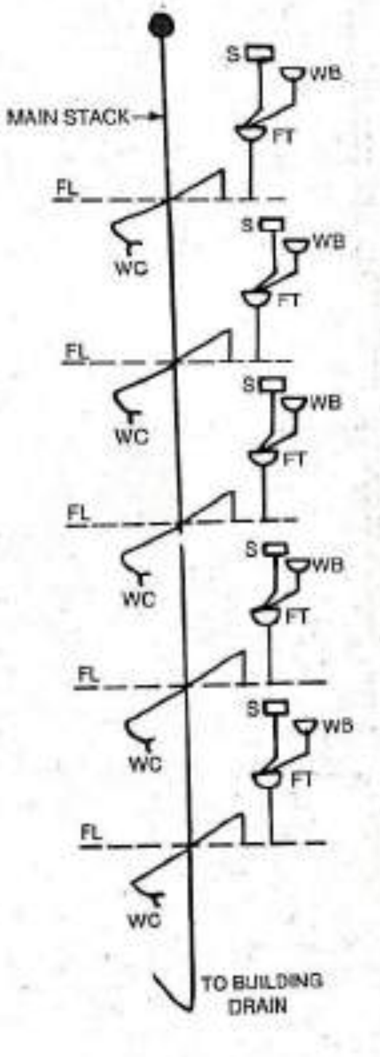

Fig. 20-49. Single Stack System (Indian Practice)

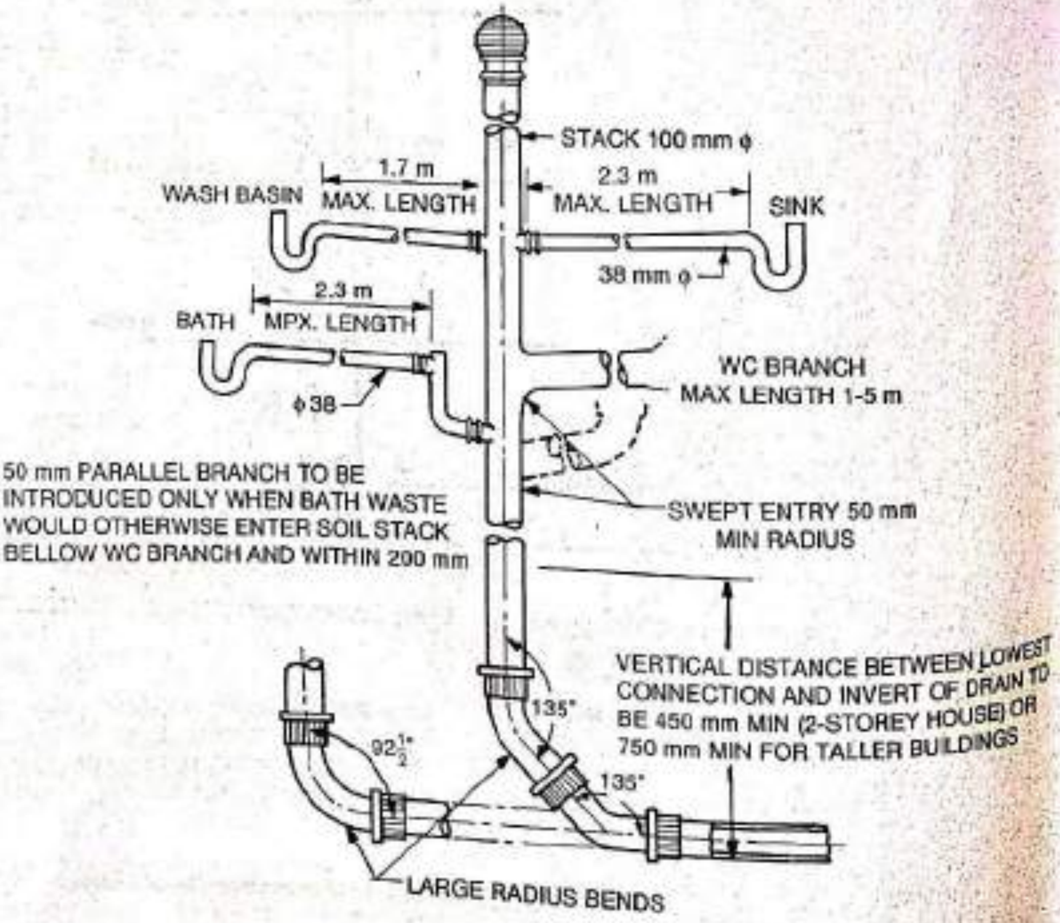

Fig. 20-50. Single Stack System (Western Style)

Fig. 20-51 shows end connection for ventilation.

References :	
MH	Man hole
MSP	Main Soil Pipe
MVP	Main Vent Pipe
BSP	Branch Soil Pipe
BWP	Branch Waste Pipe
MWP	Main Waste Pipe
GL	Ground Level
WC	Water Closet
FT	Floor Trap
WB	Wash Basin
S	Sink

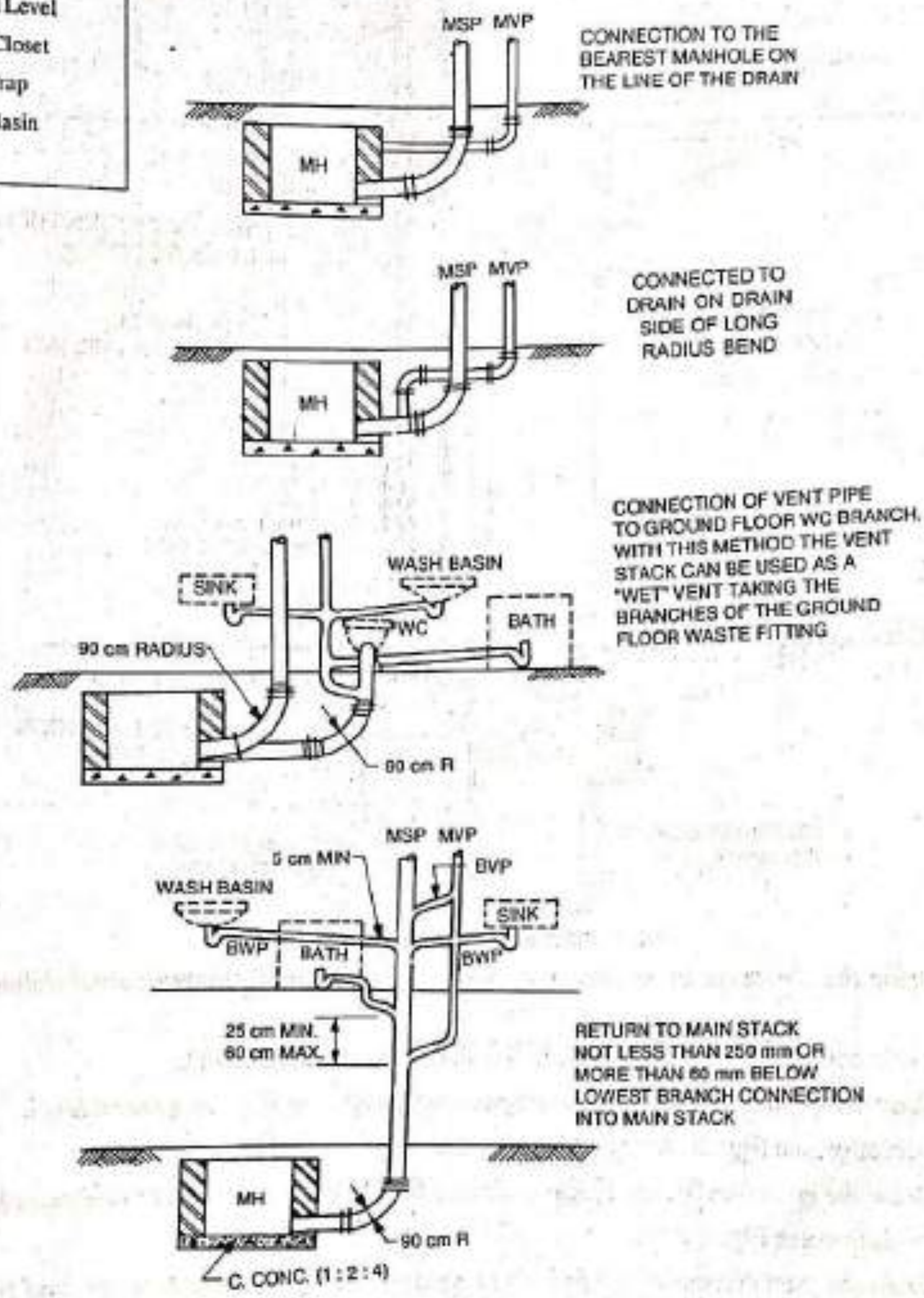

Fig. 20-51. Connections for Ventilation.

31. ANTI-SYPHONAGE PIPE

In multistoreyed buildings where W.C.'s of more than one floor are connected to same soil pipe, a sudden ...h of water from upper storey results in suction of water in branch pipe connecting the W.C. in lower floors. Partial ...uum is formed on the down stream side of trap of W.C. in lower floor, thereby causing break of water seal by this ...honic action. So this is prevented by connecting the crowns of W.C. traps on all floors to a common pipe opening ...op. Such pipe is called anti-syphonage pipe.

20.11. SANITARY ENGINEERING

A branch of public health engineering, which deals in disposal of waste water, sewage and other effluents is called *Sanitary Engineering*.

20.12. TECHNICAL TERMS

Some of the technical terms used in sanitary engineering are as follows :

1. **Garbage.** Dry refuse from houses, streets, markets and other such places in a town is called *Garbage*.

2. **Sullage.** A discharge from bathrooms, kitchens and washbasins etc is called *Sullage*.

It does not include discharge from hospitals, operation theaters and slaughter houses etc. Basically sullage is waste water of not very foul character. It can be disposed off in open drains. Its quantity for disposal purposes may be taken as 92 to 225 litres/capita.

3. **Sewage.** Rain water, solid and fluid waste from houses, factories, hospitals and industries is called *Sewage*. Sewage being highly putrifiable in nature should be disposed through covered drainage system.

4. **Storm Water.** The run-off water during and immediately after rain fall is called *Storm Water*.

5. **Sewer.** An under-ground conduit or pipe through which the sewage is conveyed for disposal is called *Sewer*.

6. **Drain.** A pipe or an open channel which carries the sewage to the sewer from a house or group of houses is called a *Drain*.

7. **Sewerage.** The complete process of collecting and carrying is called *Sewerage*.

8. **Soil Pipe.** A pipe carrying discharge from W.C. or urinal is called a *Soil Pipe*.

9. **Waste Pipe.** A pipe which carries discharge from kitchen, bath room, floor traps etc is called a *Waste Pipe*.

10. **Stack.** A vertical pipe line of a drainage system is called a *Stack*.

11. **Waste Appliances.** Wash basins sinks, bath tubs, drinking water fountains etc are *Waste Appliances*.

20.13. TRAPS

A fitting provided in a drainage system to prevent entry of foul air or gases from the sewer or drains in a building is called a *Trap.*

Water seal is a trap provided to act as a barrier to the entry of foul air and gases. Traps are of different shapes and they are generally named, after the shape of the alphabet, they resemble. Commonly used traps are of the shape of letters *P*, *Q* and *S*. They are named as *P*-trap, *Q*-trap and *S*-trap. Traps are normally made of cast iron glazed stoneware, polythelene etc. Fig. 20-12 shows sketches of *P*, *Q* and *S*-traps in basic form.

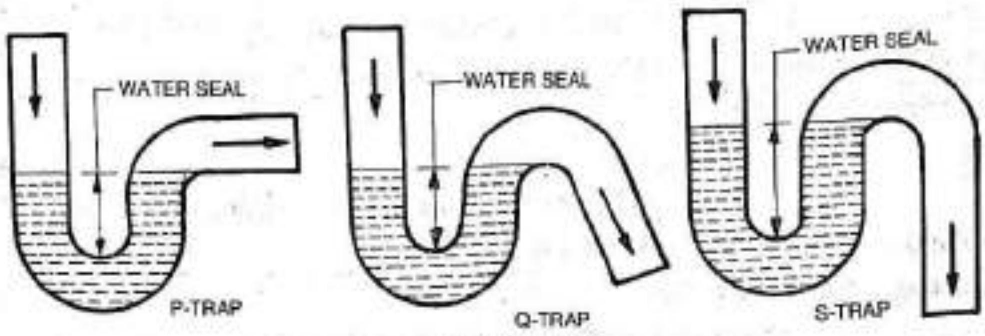

Fig. 20-12. Traps.

20.14. TYPES OF TRAPS

Different types of traps used in sanitary fittings are shown as under.

1. *P*, *Q* or *S*-trap (cast iron). Sectional forms of cast iron *P*, *Q* and *S*-traps. (spigot and socket type) arrangement are in section alongwith table giving sizes are shown in Table 20.III.

Table 20.III. Sizes of P, Q or S-traps

Pipe Diameter	vent	*a*	*b*	*c*	*d*	*e*	*L*	*f*	*g*	*h*	*J*
100	50	214	116	330	—	4.0	135	71	80	165	206
100	50	214	175	338	32	4.0	135	71	80	165	206
100	50	214	184	291	—	4.0	135	71	80	165	206

Angle of *P*-trap = 95°

Angle of *Q*-trap = 135°

Angle of *S*-trap = 180°.

All sizes in mm.

Fig. 20-13 shows a *P*, *Q* and *S*-traps without vent hole.

Fig. 20-14 shows a *P*, *Q* and *S*-trap with vent hole.

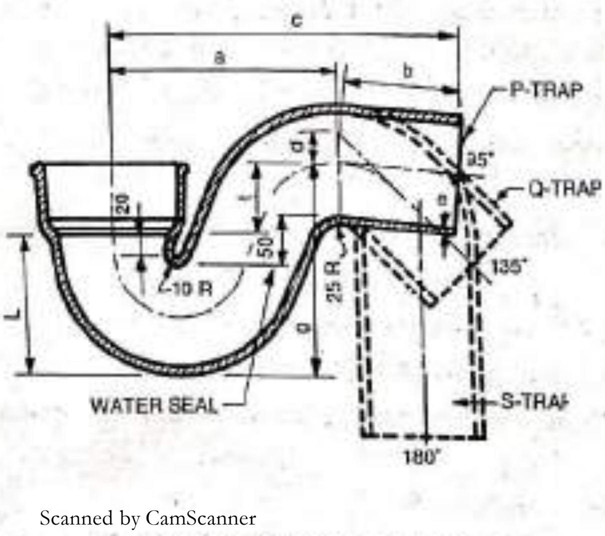

Fig. 20-13. P, Q or S–Trap without Vent Pipe.

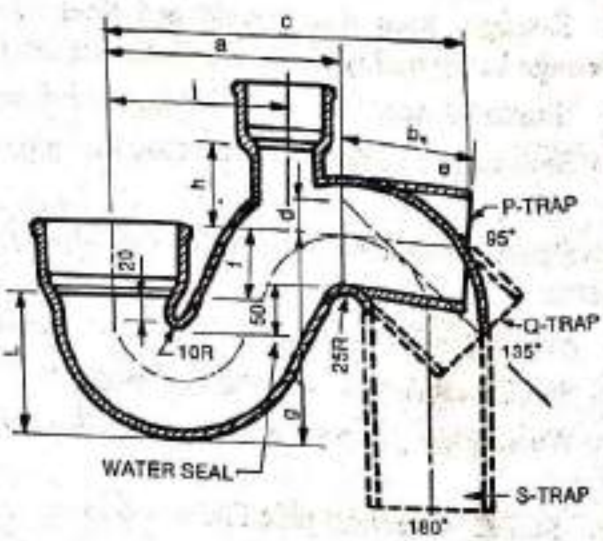

Fig. 20-14. P, Q or S-Trap with Vent Pipe.

20.15. ORISSA PATTERN PAN TRAP

(*i*) Fig. 20-15 shows an Orissa pattern pan trap *P* or *S* shaped. Thus is made of vitreous China.

(*ii*) Fig. 20-16 show a long Orissa pattern trap *P* or *S* shaped. This made of earthenware.

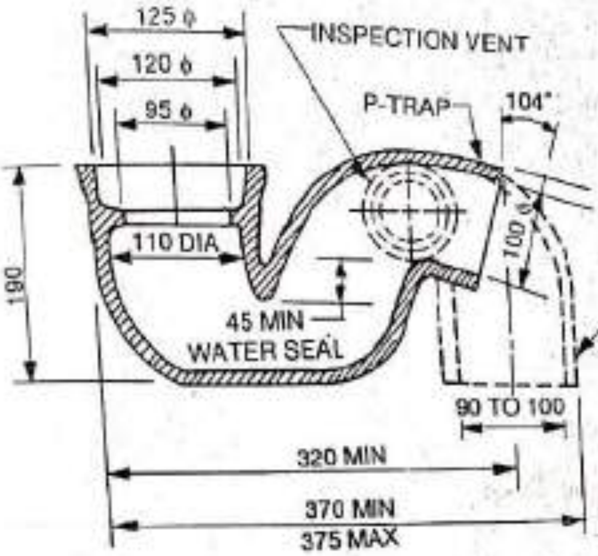

Fig. 20-15. *P* or *S* Trap without Vent Pipe.

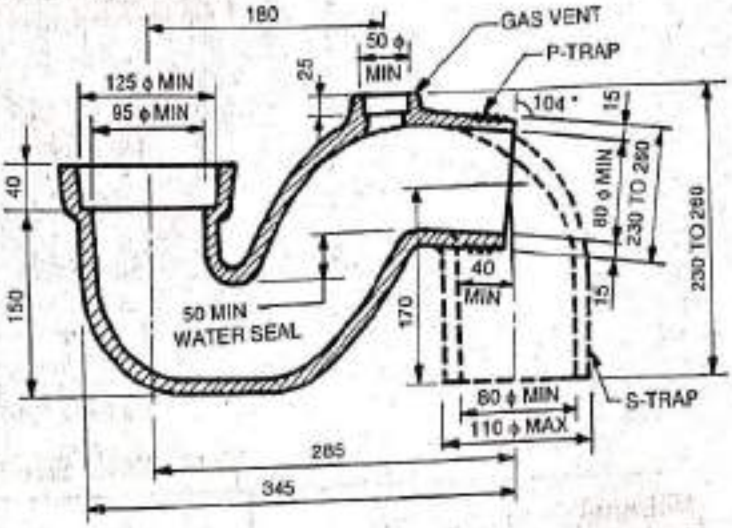

Fig. 20-16. *P* or *S* Trap with Vent Pipe.

20.16. FLOOR TRAPS

A trap provided to recieve waste water from floors, wash basins and sinks etc is called a *Floor Trap*.

Fig. 20-17 shows a cast iron floor trap with sizes along with Table showing different sizes.

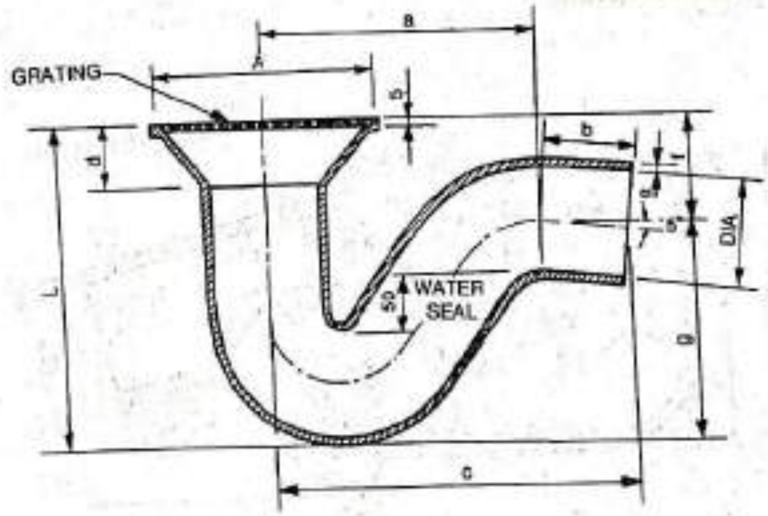

Fig. 20-17. Vitreous China Orissa Pattern Pan Trap.

Table 20.IV. Sizes Of Cast Iron Floor Trap

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20.22. SANITARY FITTINGS

Various fittings such as wash basins, kitchen sinks, water closets and urinals etc are essential features of building.

The following are the general sanitary fittings of a building :

1. Wash Basin. The wash basins are of two types

(*i*) **Flat Back Wash Basin.** Fig. 20-26 shows a Flat back Wash Basin with single tap.

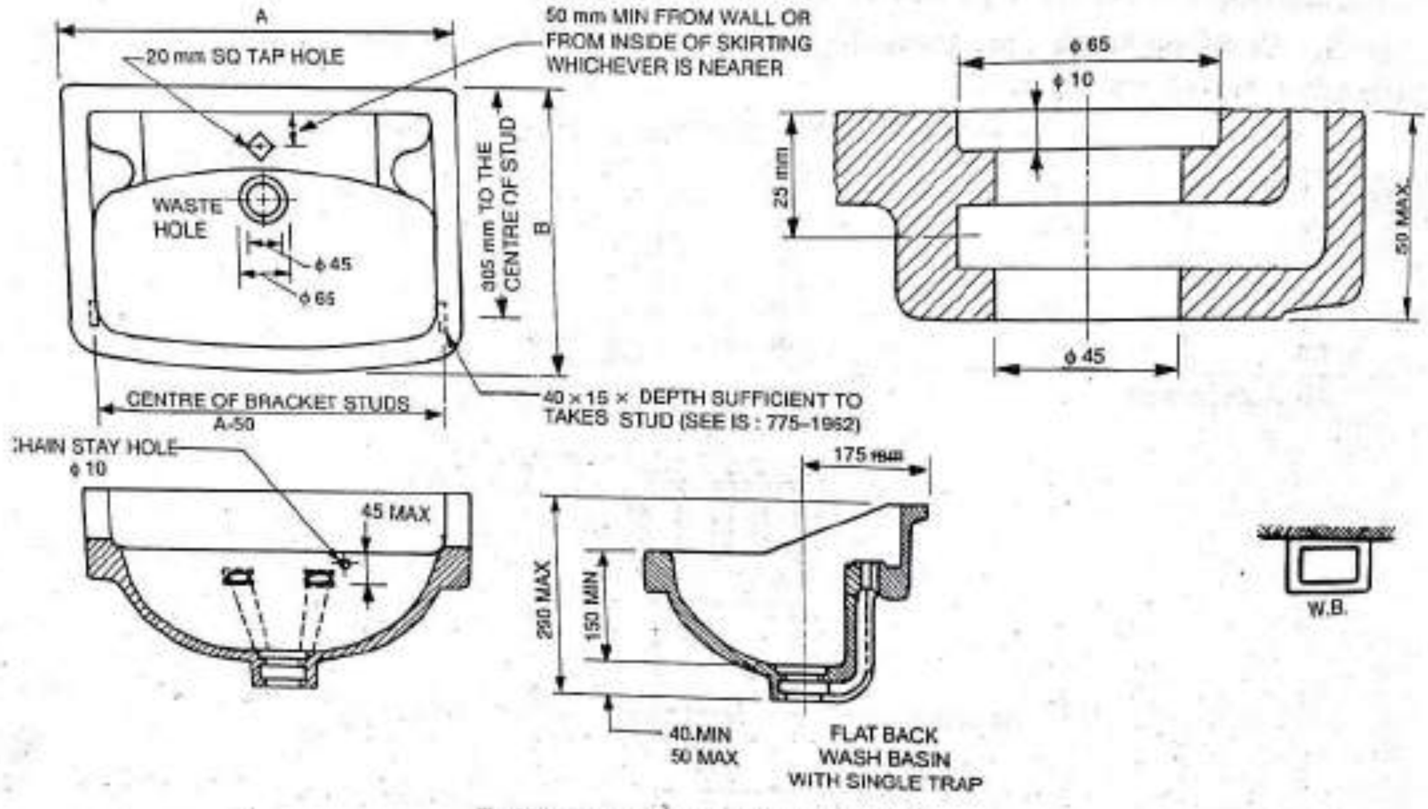

Fig. 20.26. Flat Back Wash Basin with Single Trap.

20.23. FLUSHING CISTERN

A storage system provided for discharge of water for flushing of contents from a water closet or urinal is called a *Flushing Cistern*. Fig. 20-35 shows, a rapidly filled in water closet cistern and Fig. 20-36 shows an automatic urinal cistern. High level cistern to Indian W.C. is provided at a height of 1.8 m to 2 m from floor level. English type WC is provided with low level cistern at a height of 300 mm above top of pan and under side of cistern.

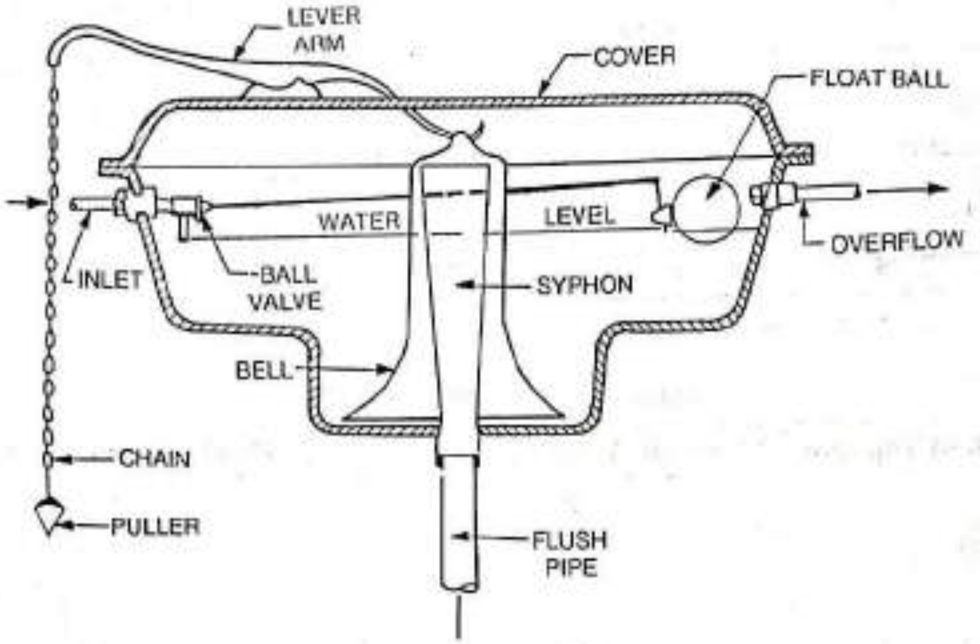

Fig. 20-35. Rapidly Filled-in WC Cistern.

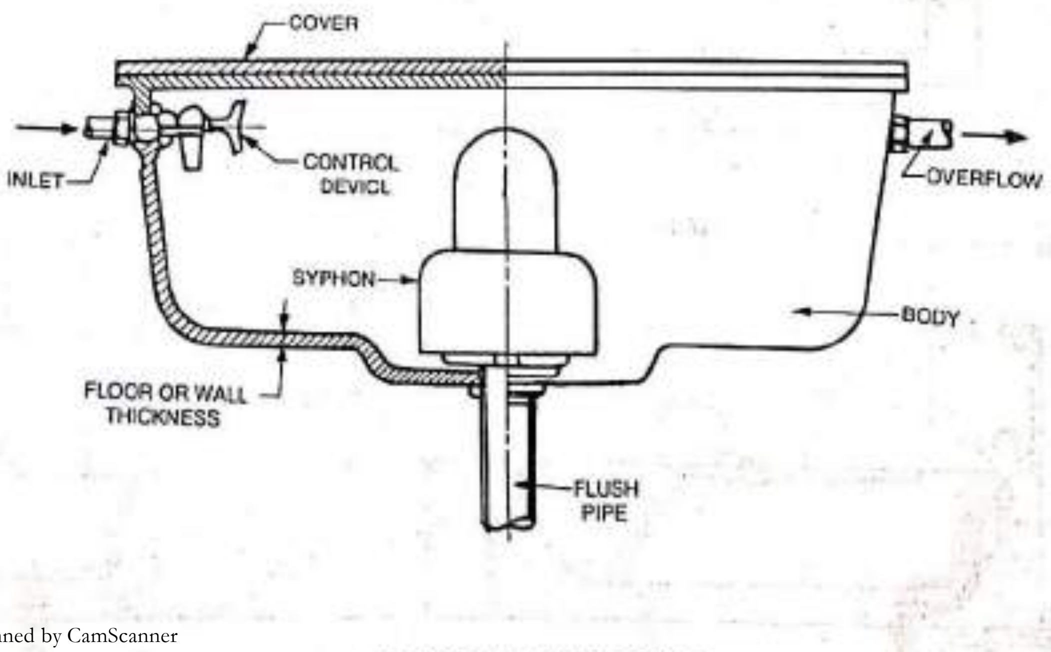

Fig. 20-36. Automatic Urinal Cistern.

THANKS

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Government Polytechnic Nanakpur

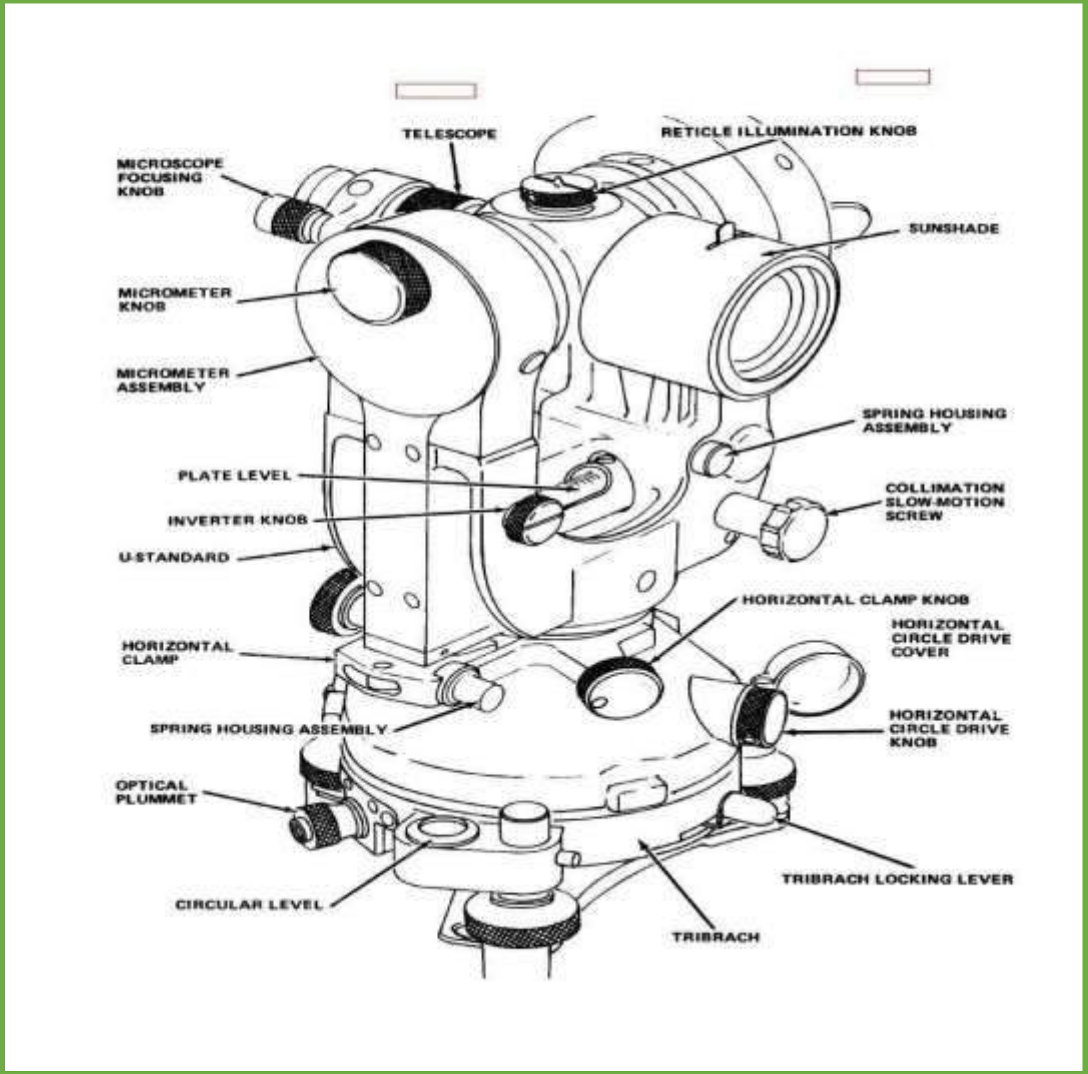
E- Content

By-Er Sachin

DEPARTMENT OF CIVIL ENGINEERING

PRESENTATION ON CONTOUR

1. contouring

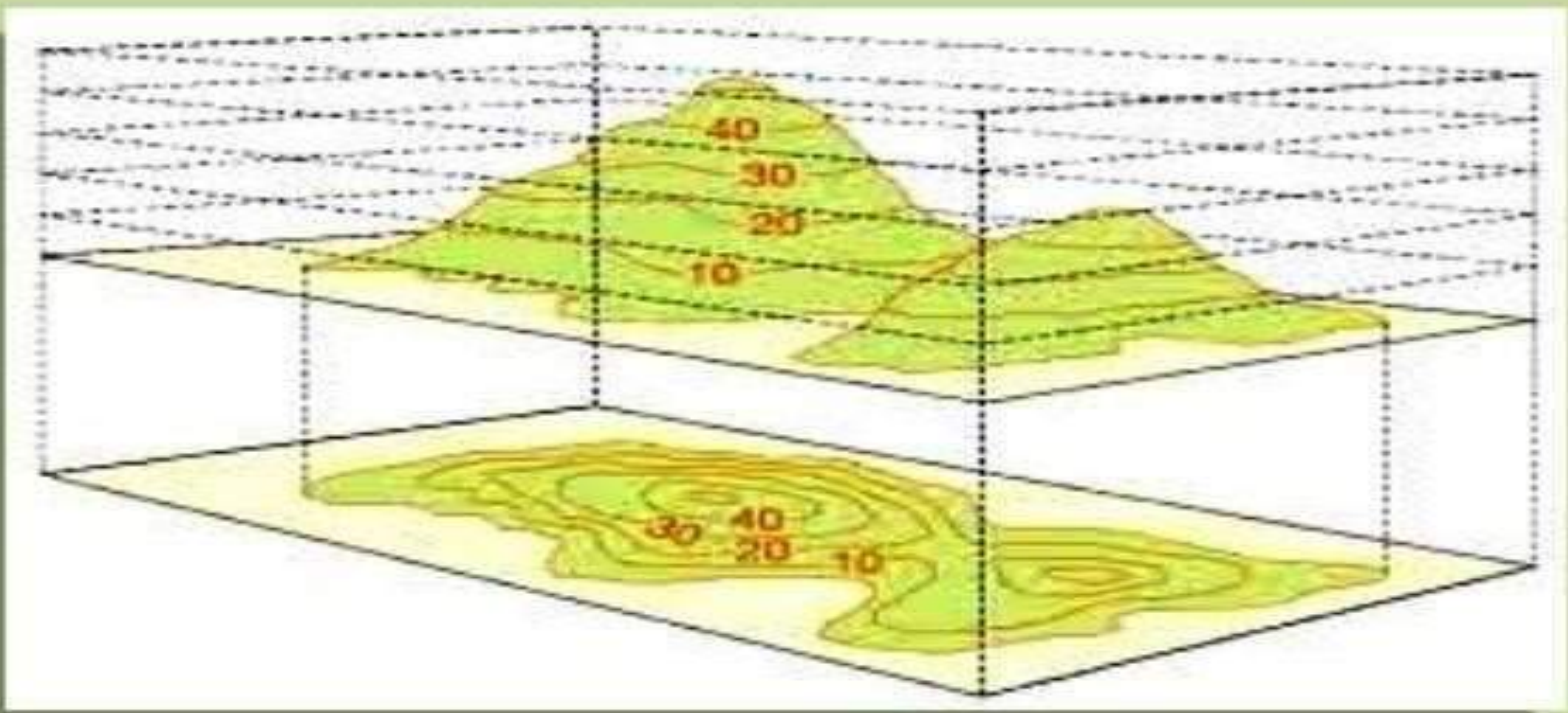


Contouring

Contouring

- Contour – définitions, objectives, contour interval, horizontal equivalent, uses and characteristics of contour lines, methods of plotting contours, direct and indirect methods of contouring, Contour gradient.

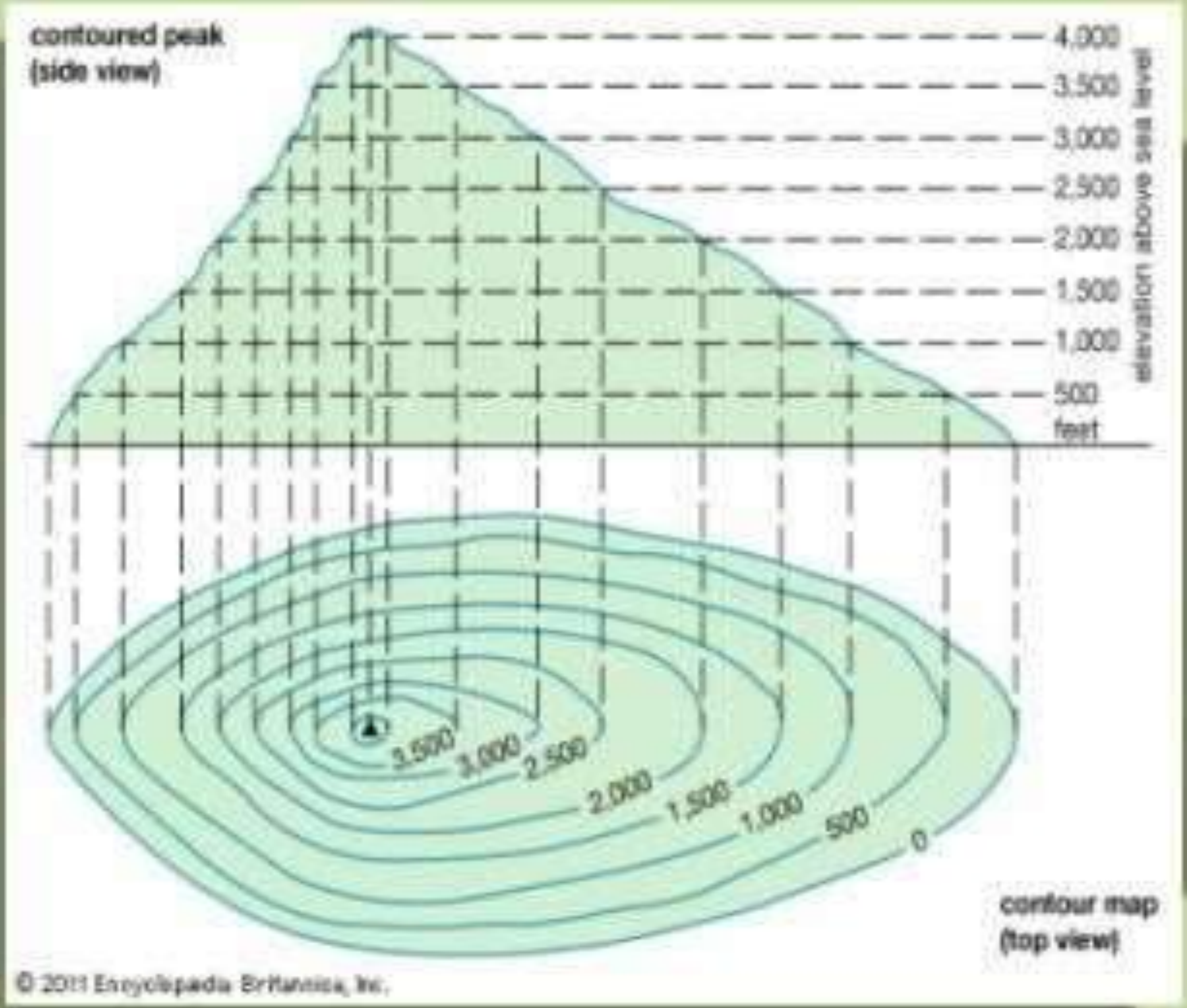
Levelling and Contouring

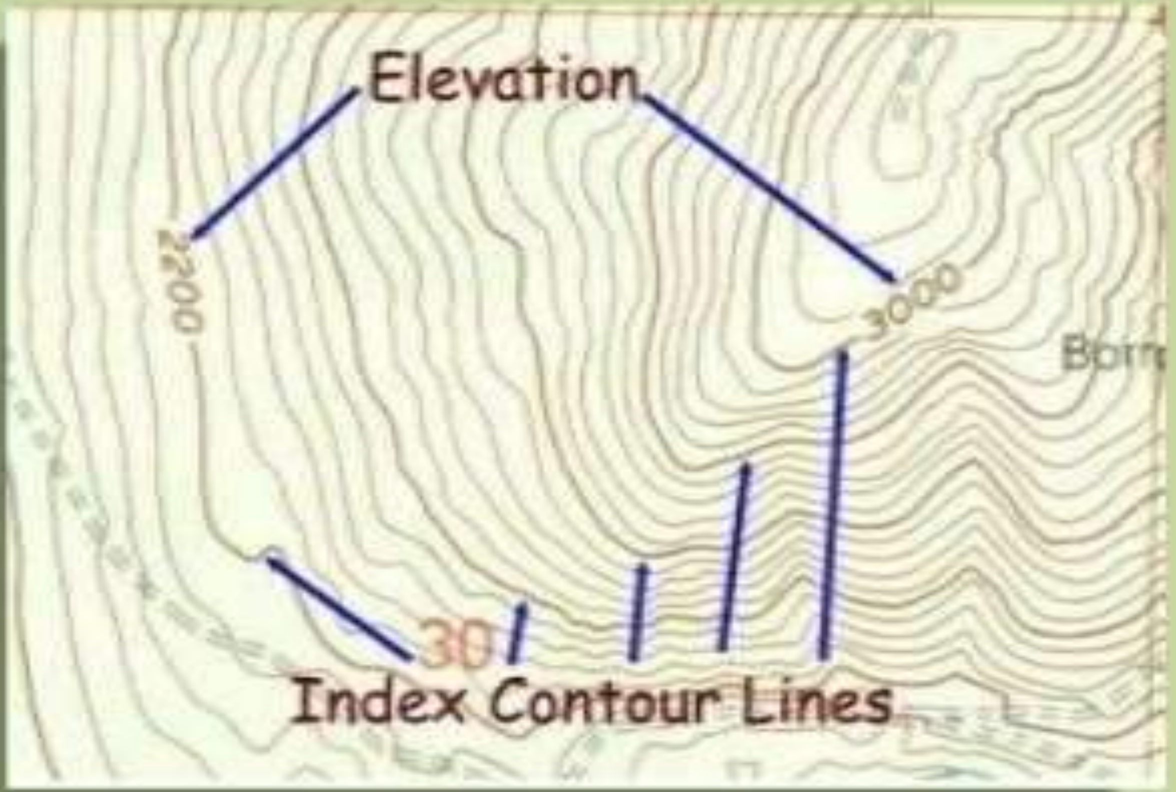


Contour Line

- A contour line may be defined as "***An imaginary line passing through points of equal reduced levels***". A contour line may also be defined "***as the intersection of a level surface with the surface of the earth***". Thus, contour lines on a plan illustrates the topography of the area.
- For ex a contour of 90 m indicates that all the points on this line have RL of 90 m. Similarly, in a contour of 89 m all the points have RL of 89 m and so on.

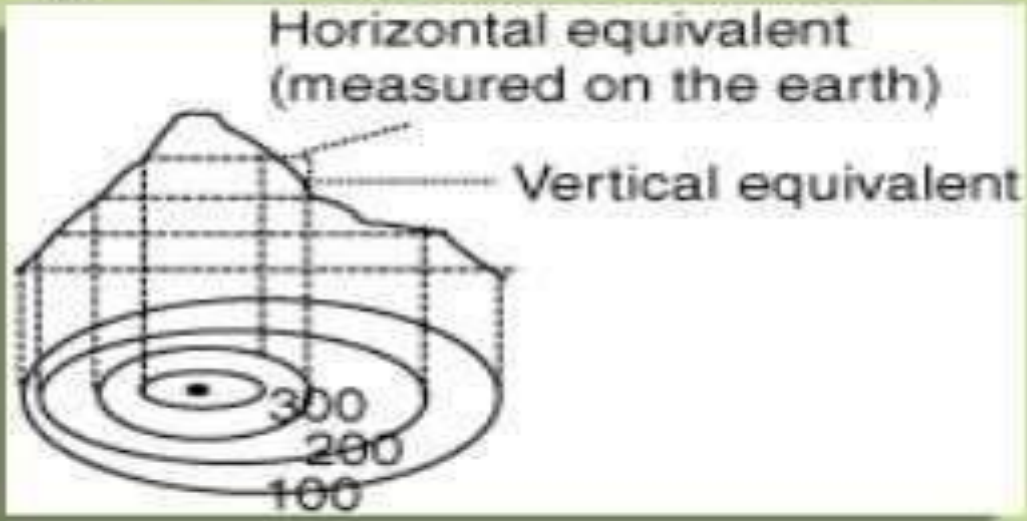
Contour Line





Horizontal Equivalent

- The horizontal distance between any two consecutive contours is known as **horizontal equivalent**. It is not constant. It varies from point to point depending upon the steepness of the ground. Steeper the ground, lesser is the horizontal equivalent.



Use of Contour Map

- Contour maps provide valuable information about the topography of the area, whether it is flat, undulating or mountainoueous. The nature of the ground surface of an area can be understood by studying a contour map.

The following are the specific uses of the contour map.

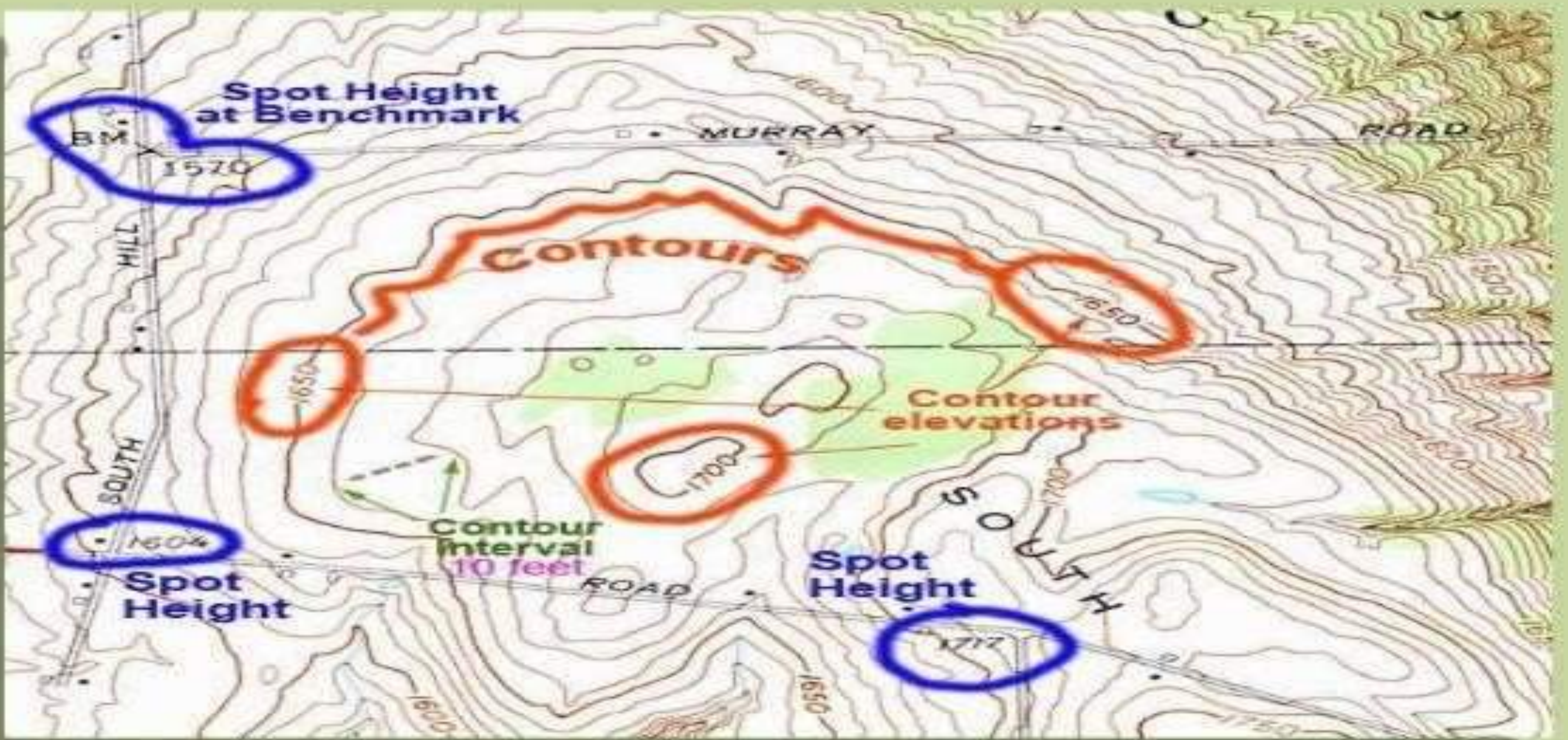
- To select sites for engineering projects such **as roads, canals, railways.**
- To find the **possible route of communication between different places.**
- The **capacity of a reservoir** and the **area of submergence** can be computed
- To ascertain the **indivisibility of stations**.
- To ascertain the profile of the ground surface along any direction.
- A suitable route for given gradient can be marked on the map.

Use of Contour Map

Characteristics of Contours

- Since every point on **a contour line has the same elevation**, a contour map with a constant interval portrays the conformation of the ground in a **characteristics manner**. The knowledge of **contour characteristics** helps in identifying the **natural features of the area** from the given map and in avoiding mistakes in plotting the contours correctly.

Characteristics of Contours



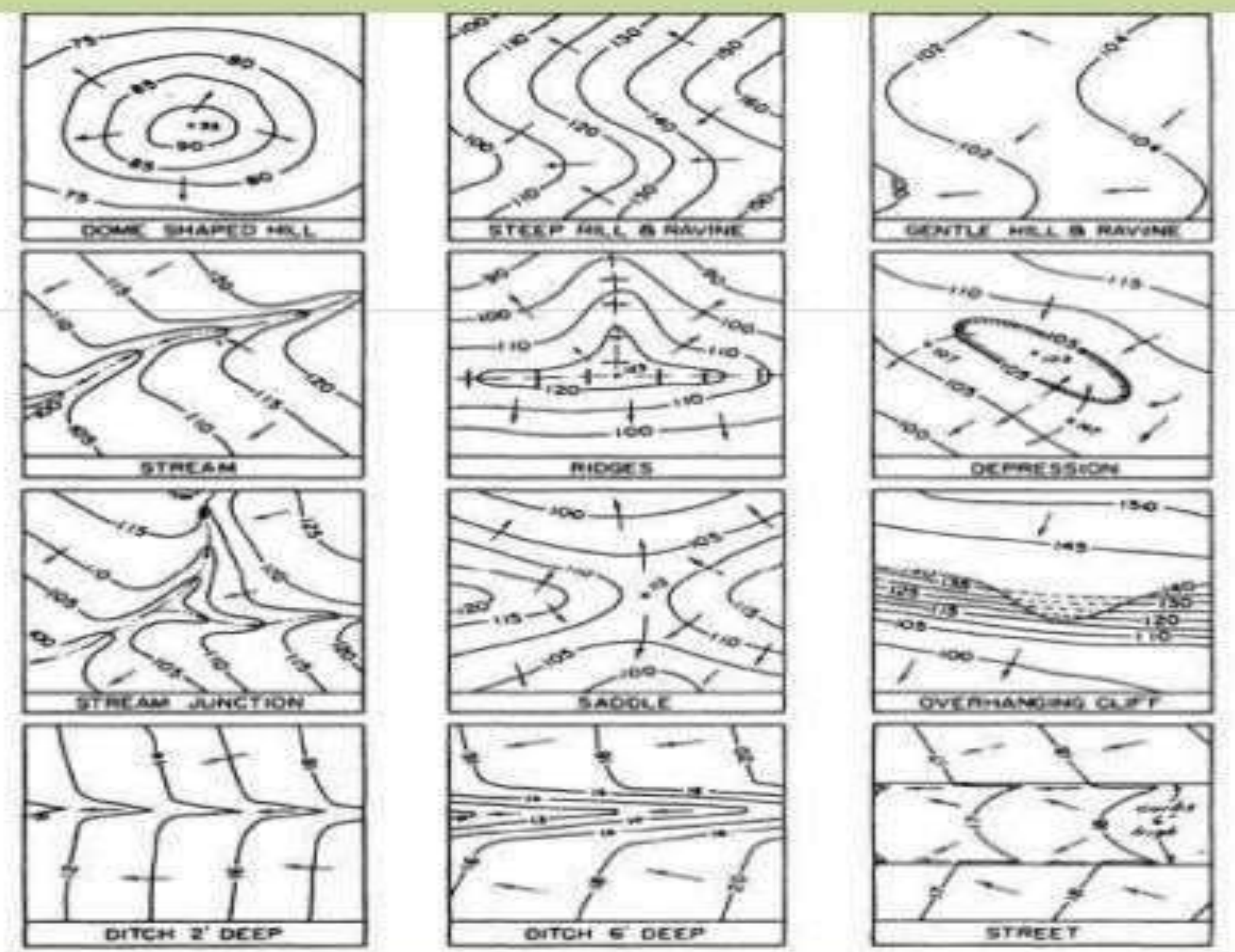
Characteristics of Contours

- ***The following characteristics help in plotting or reading a constant map.***
- All the **points on a contour line have the same elevation**. The elevations of the contour are indicated either by inserting the figure in a break in respective contour or printed close to the contour.
- **Two contour lines do not intersect** with each other.
- **Contour lines always from a closed circuit**. But these lines may be within or outside the limit of the map.
- **Contour do not have sharp turning.**

Characteristics of Contours

- The **contour lines are closer near the top of a hill** or high ground and wide apart near the foot. This **indicates a very steep slope towards** the peak and a flatter slope towards the foot.
- The **contour lines are closer near the bank** of a **pond or depression and wide towards the centre**. This indicates a **steep slope near the bank and a flatter slope at the centre**.
- **Uniformly spaced contour** lines indicate a **uniform slope.**

Characteristics of Contours



Characteristics of Contours

RULES FOR CONTOUR LINES

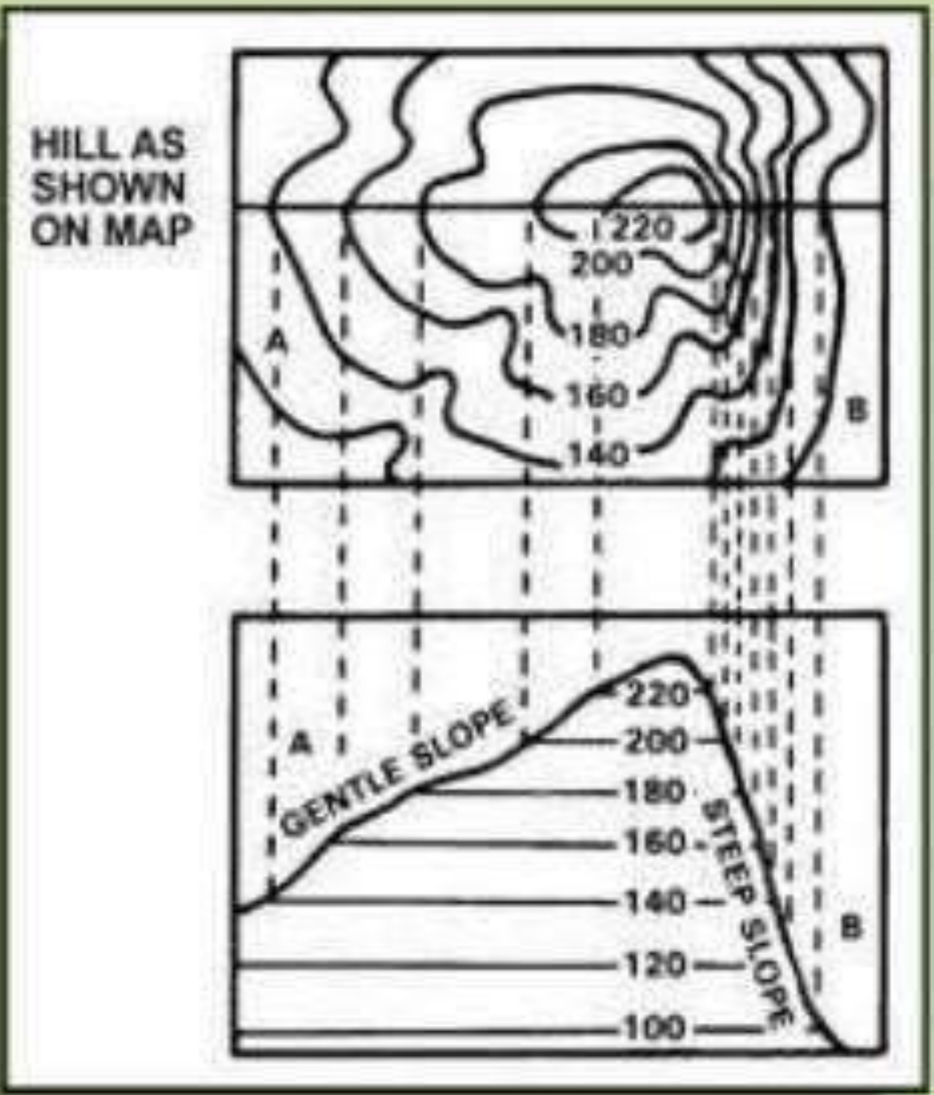
1. Every point on a contour line is of the exact same elevation; that is, contour lines connect points of equal elevation.
2. Contour lines always separate points of higher elevation (uphill) from points of lower elevation (downhill). You must determine which direction on the map is higher and which is lower, relative to the contour line in question, by checking adjacent elevations.
3. Contour lines always close to form an irregular circle. But sometimes part of a contour line extends beyond the mapped area so that you cannot see the entire circle formed.
4. The elevation between any two adjacent contour lines of different elevation on a topographic map is the *contour interval*. Often every fifth contour line is heavier so that you can count by five times the contour interval. These heavier contour lines are known as *index contours*, because they generally have elevations printed on them.
5. Contour lines never cross one another except for one rare case: where an overhanging cliff is present. In such a case, the hidden contours are dashed.
6. Contour lines can merge to form a single contour line only where there is a vertical cliff.
7. Evenly spaced contour lines of different elevation represent a uniform slope.
8. The closer the contour lines are to one another the steeper the slope. In other words, the steeper the slope the closer the contour lines.
9. A concentric series of closed contours represents a hill:

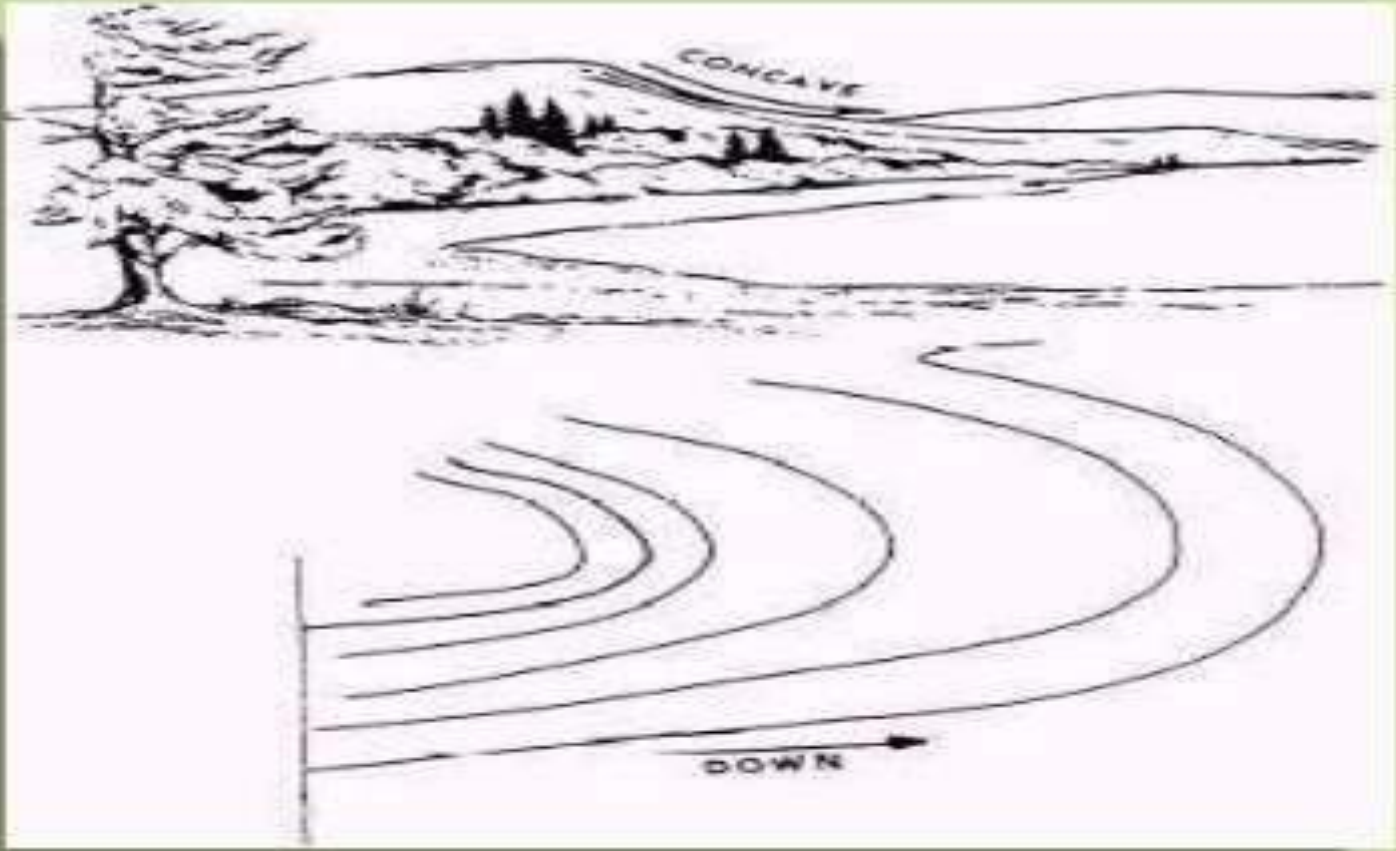
10. *Depression contours* have hachure marks on the downhill side and represent a closed depression:

11. Contour lines form a V pattern when crossing streams. The apex of the V always points upstream (uphill):

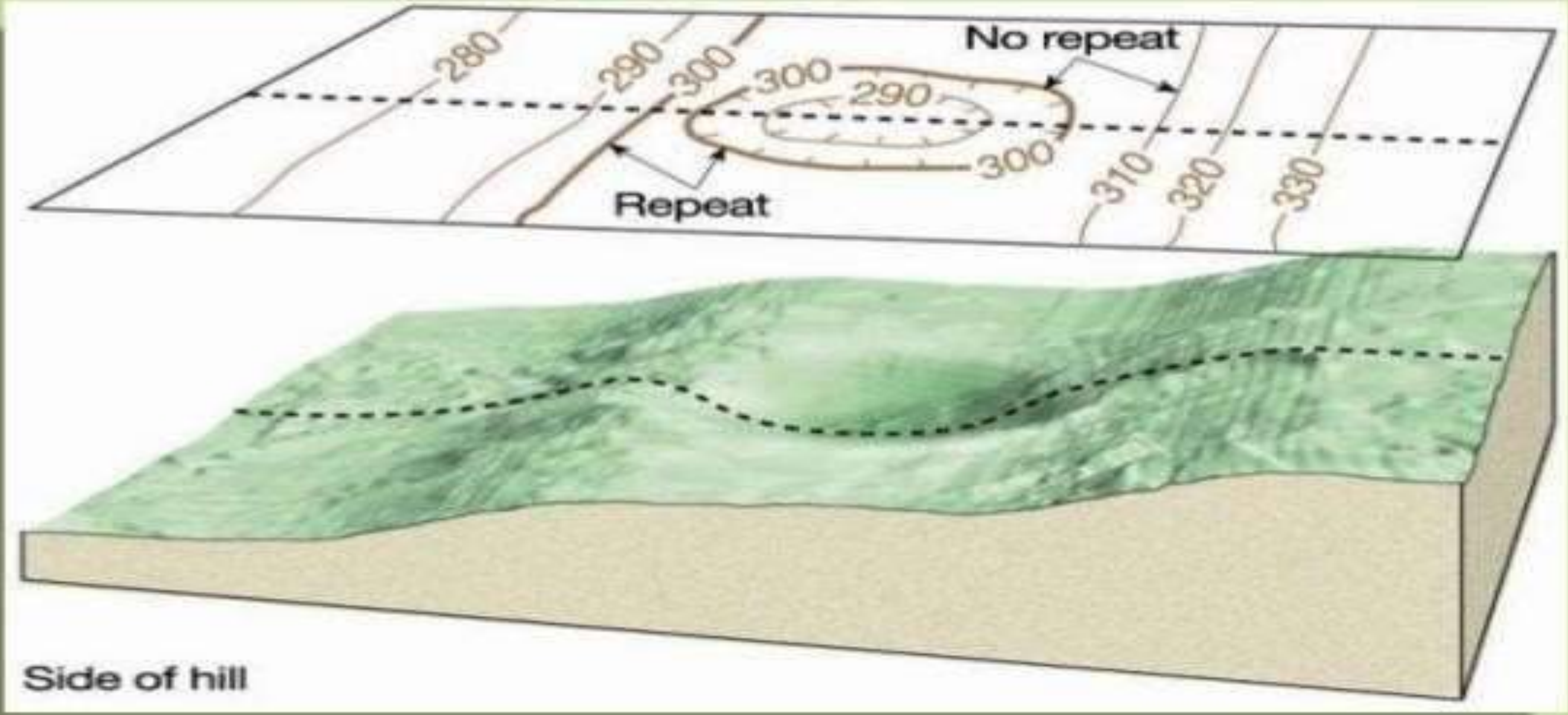
12. Contour lines that occur on opposite sides of a valley always occur in pairs.
13. Topographic maps published by the U.S. Geological Survey are contoured in feet or meters referenced to sea level.

Characteristics of Contours

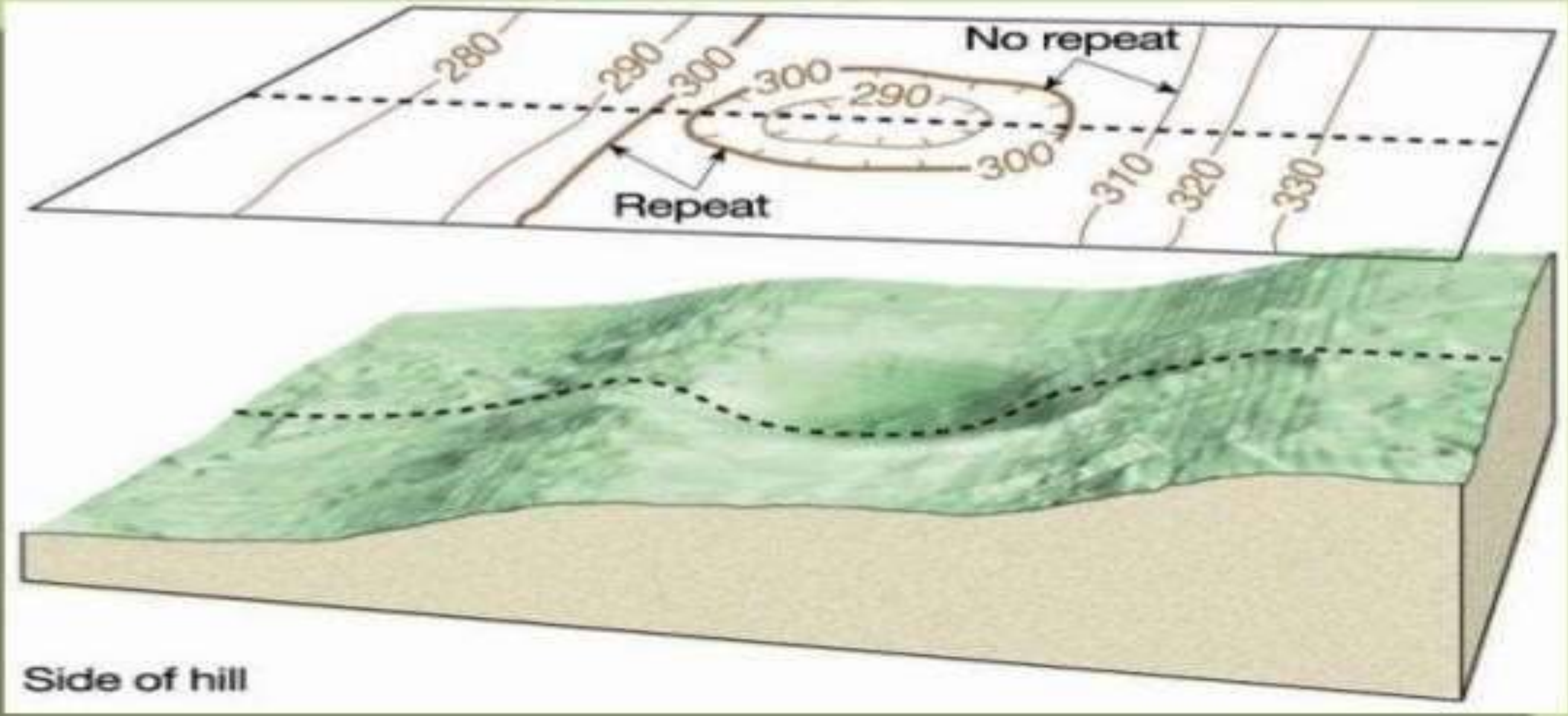




Characteristics of Contours



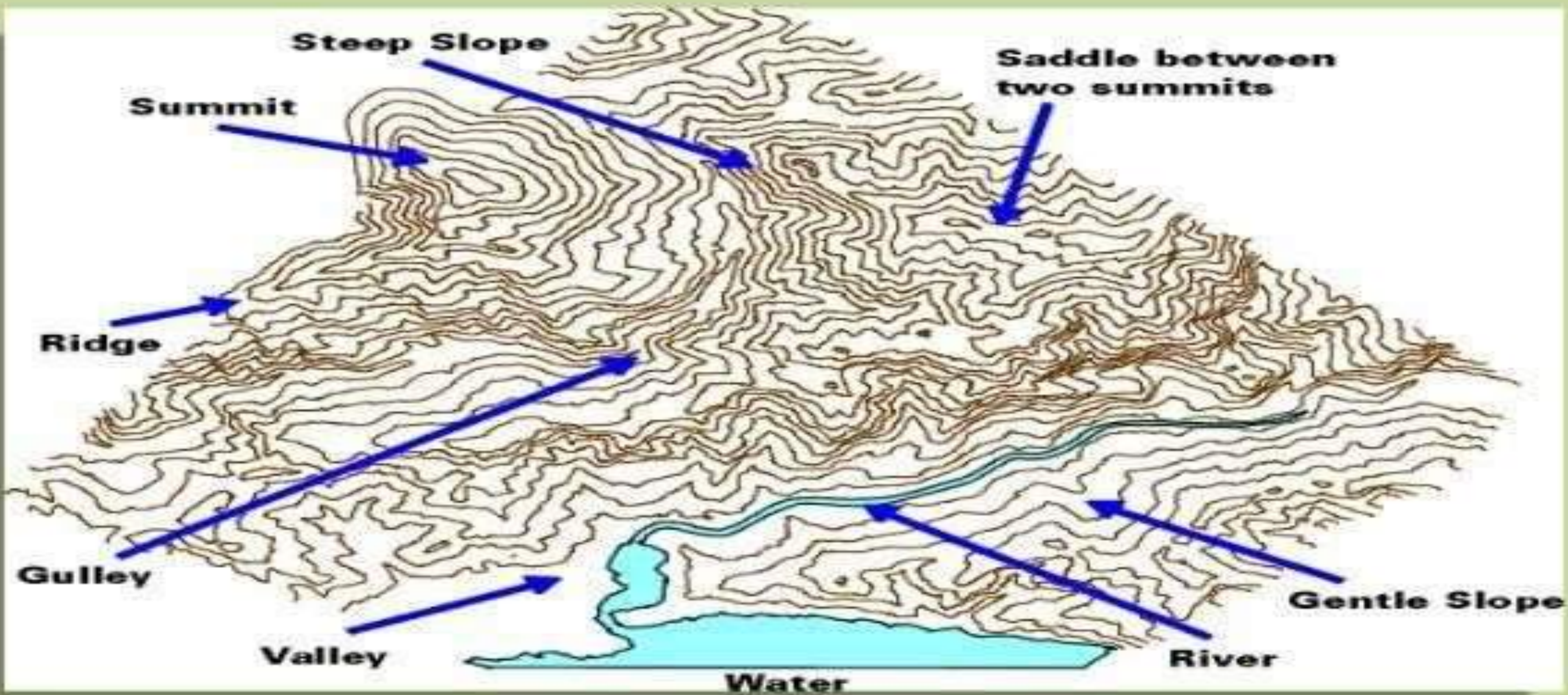
Characteristics of Contours



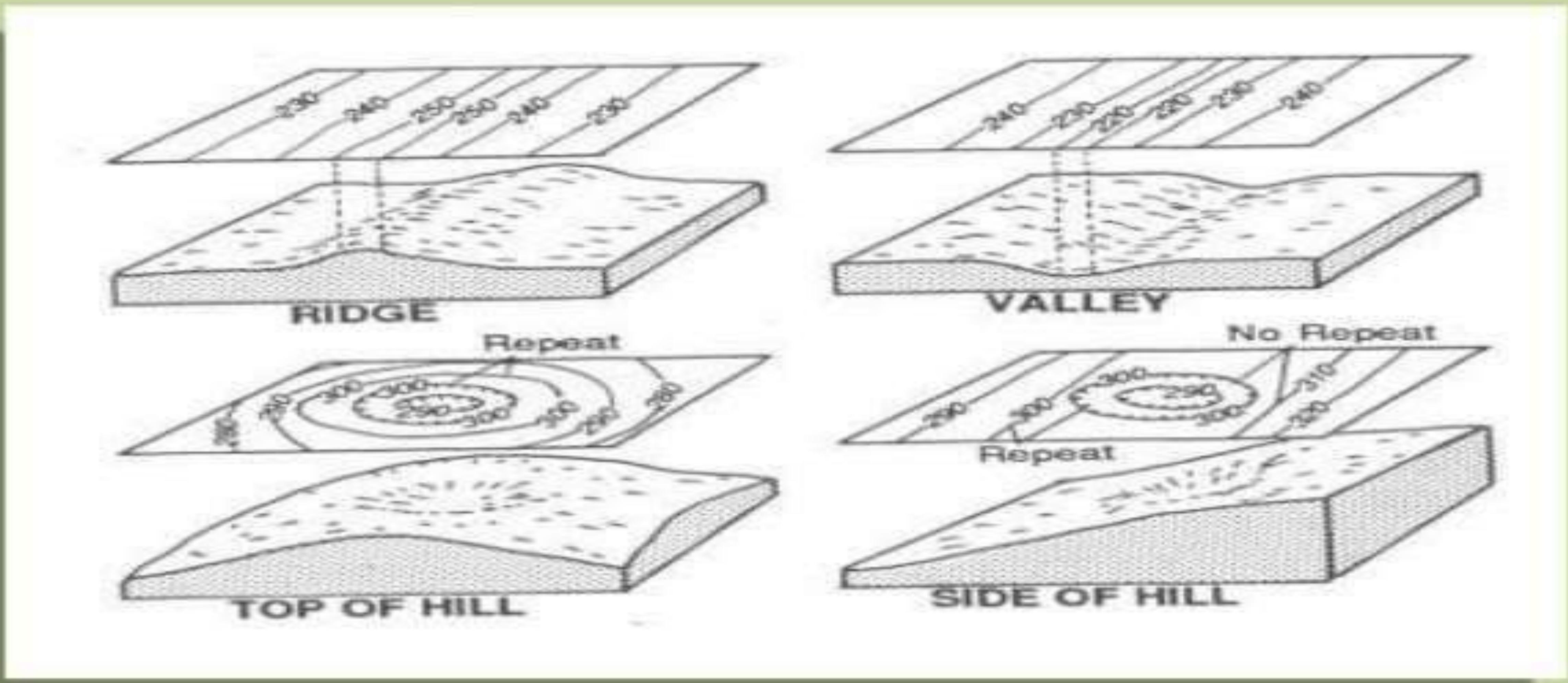
Characteristics of Contours

- **A series of closed contour always indicates a depression or summit**. The **lower values being inside the loop indicates a depression** and **the higher values being inside the loop indicates a summit**. (Hillock)
- Contour deflect uphill at valley lines and downhill at the ridge lines. Contour lines in U-shape cross a ridge and V-shape cross a valley at ridge angles. The concavity in contour lines is towards higher ground in the case of ridge and towards lower ground in the case of valley.
- **Contour lines meeting at a point** indicate a **vertical cliff**.
- **Contour lines cannot cross one another, except in the case of an overhanging cliff**. But the overhanging portion must be shown by a dotted line.

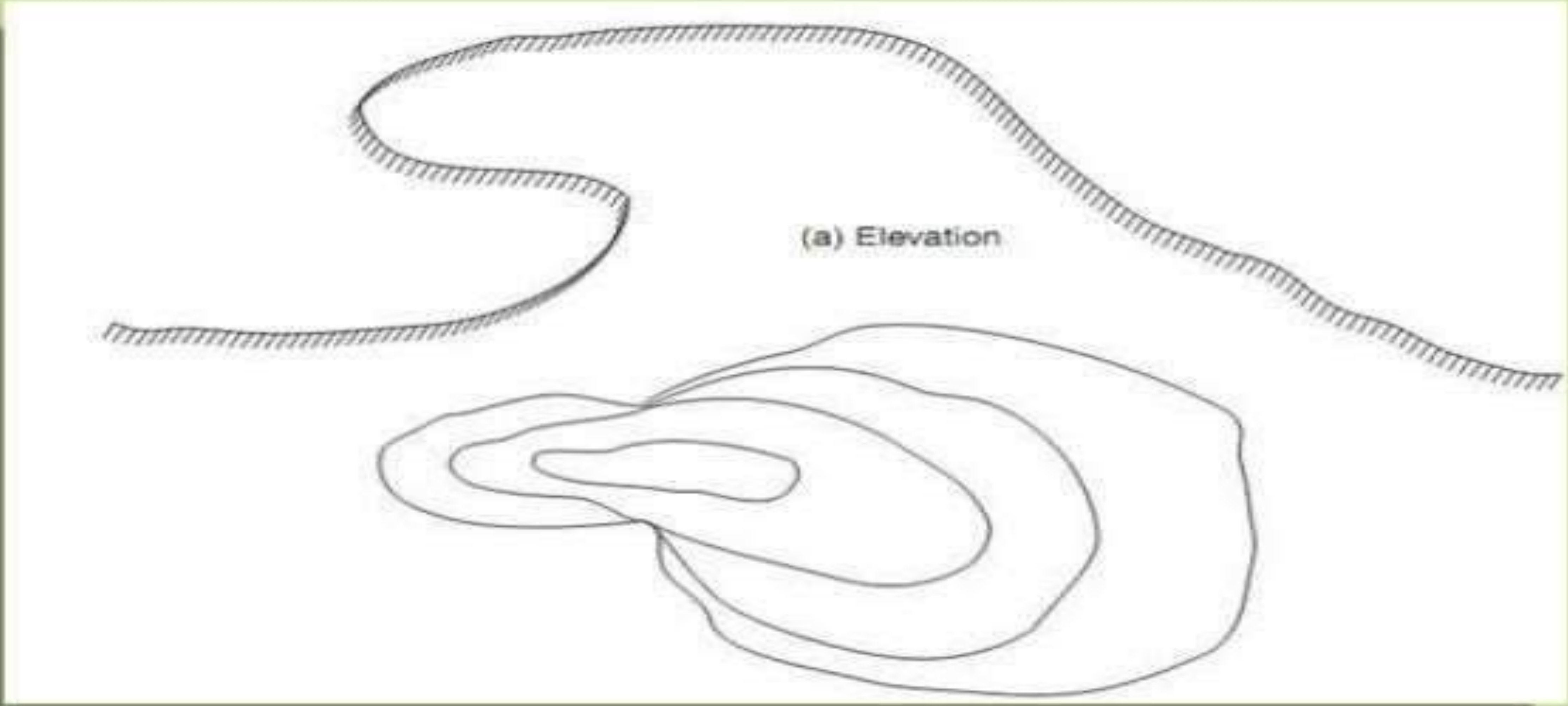
Typical Land features and their contour forms



Typical Land features and their contour forms



Typical Land features and their contour forms



Methods of Contouring

- Contouring requires the planimetric position of the points whose elevation have been determined by leveling. The methods of locating contours, therefore depending upon the instruments used to determine the horizontal as well as vertical position of several points in the area.

Methods of Contouring

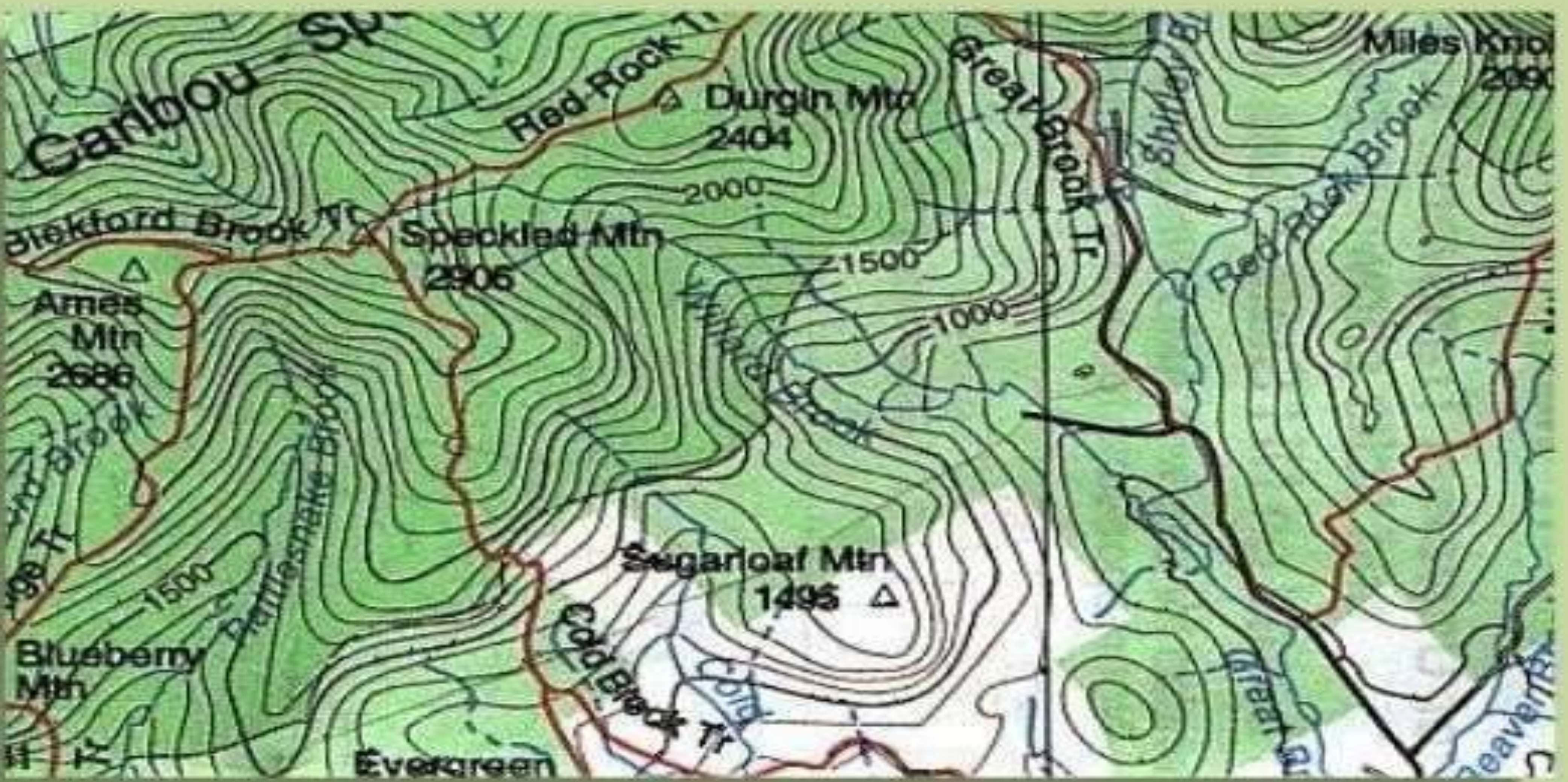
- Broadly, the method can be divided into the following two classes.
- Direct methods
- Indirect methods

Methods of Contouring

Direct Method

- In the direct method of contouring, the reduced level of various selected points on a contour line are obtained and their positions are located. The contours are then drawn by joining these points. It is a very accurate method but it is slow and tedious.
- This method is employed only for small area where superior accuracy is demanded. The method of locating contours directly consists of horizontal and vertical control. The horizontal control for a small area can be exercised by a chain or tape and a large area by compass, theodolite or plane table. For vertical control either a level and staff or a hand level may be used.

Methods of Contouring

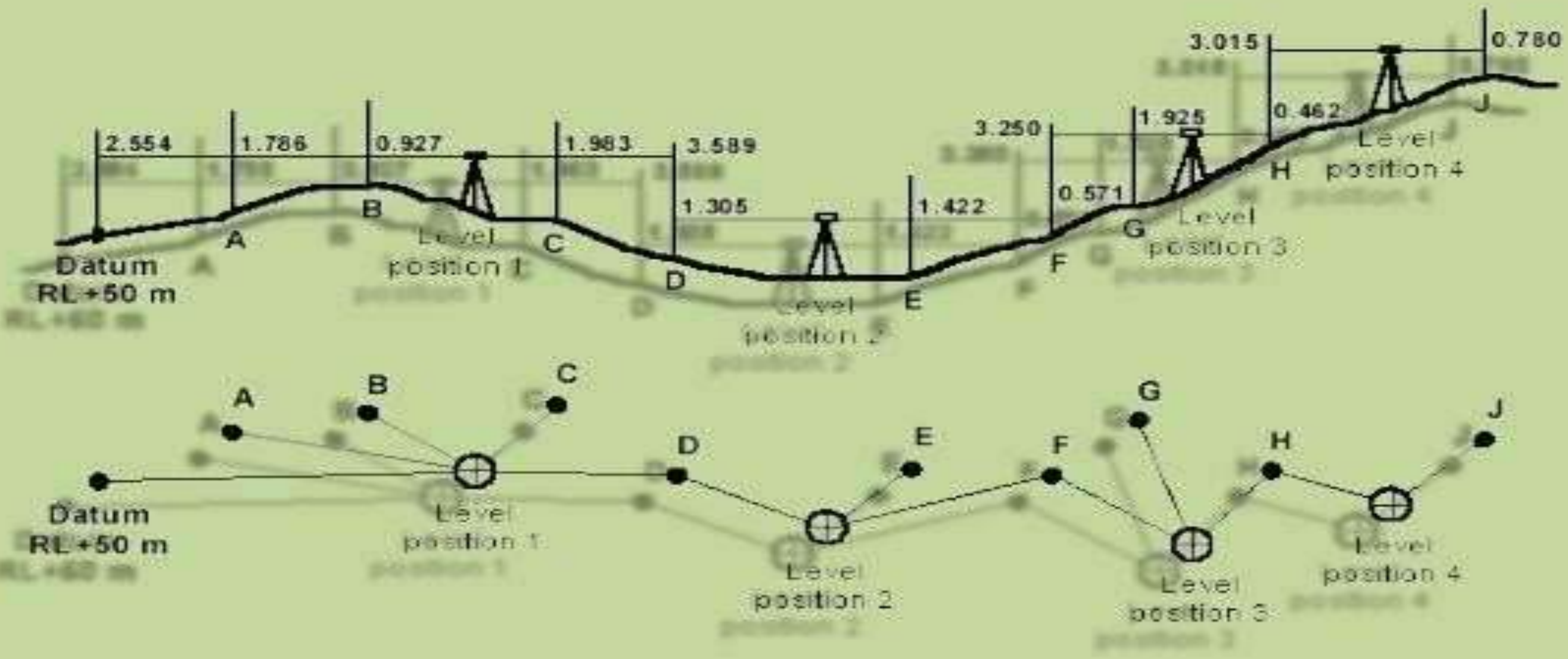


Methods of Contouring

By Level and Staff

- The method consists of locating a series of points on the ground having the same elevation by using a level and leveling staff. Instrument is setup in such a way that number of readings can be taken from the area to be surveyed. The instrument is set up and RL of HI is determined from the nearest benchmark. For a particular contour value, the staff reading is worked out. A series of points having the same staff reading is worked out, and thus the same elevations are plotted and joined by a smooth curve.

Methods of Contouring

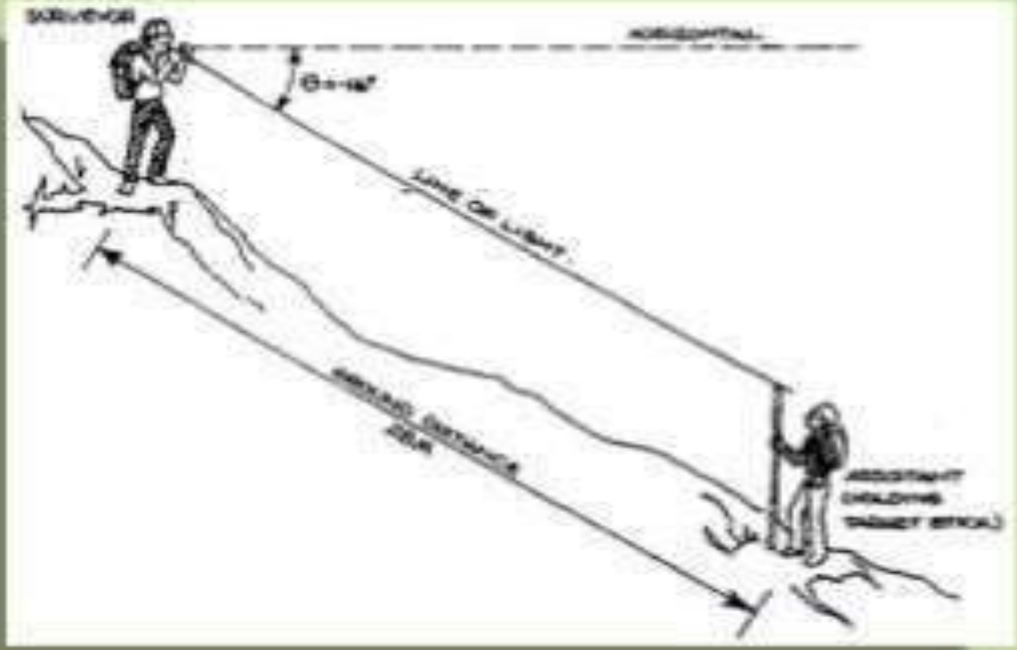


Methods of Contouring

By Hand Level

- The principle used is the same as that used in the method using a level and staff. Instead of the hand level, an abbey level may also be used. However this method is very rapid and is preferred for certain works.

Methods of Contouring



Methods of Contouring

Indirect Methods

- Indirect methods are less expensive, less time consuming and less tedious as compared with the direct methods. These methods are commonly employed in small scale survey of large areas.

Methods of Contouring

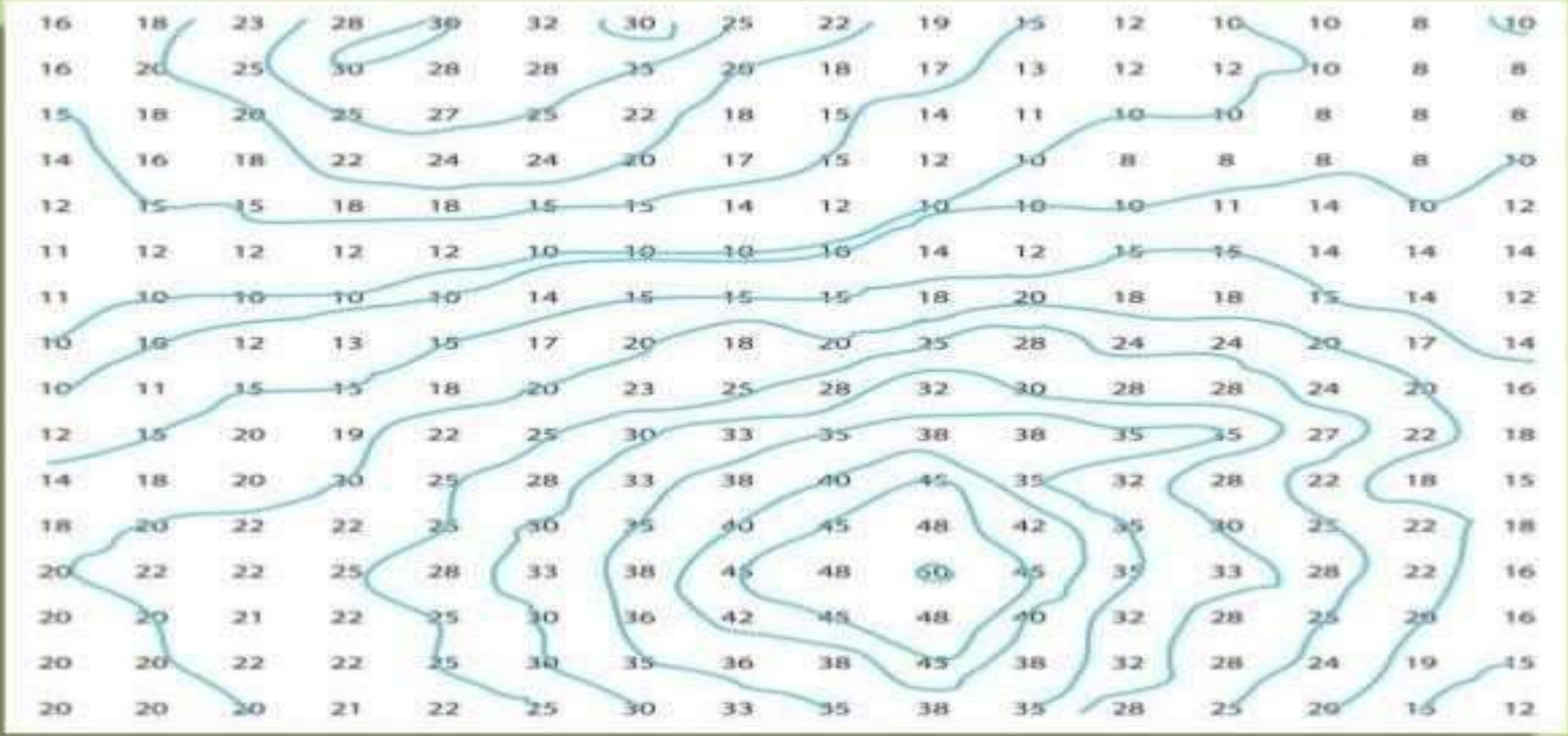
- There are three different ways of employing the indirect methods of contouring
- (i) Grid Method
- (ii) Cross-Sectional Method
- (iii) Radial line method or
  Tachometric method

Methods of Contouring

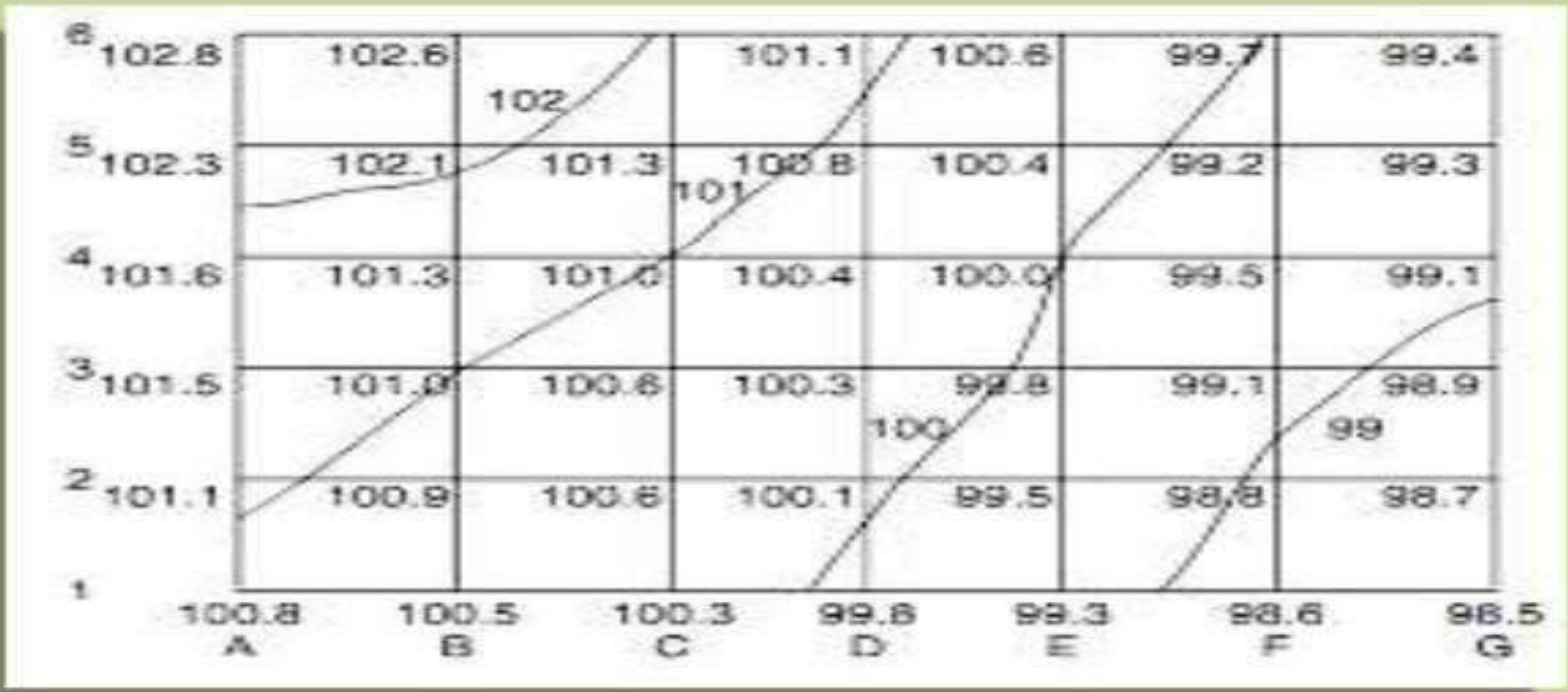
Grid Method

- If the area is not large, it is divided into a grid or series of squares. **The grid size may vary from 5m x 5 m to 25 m x 25 m** depending upon the nature of the ground, the contour interval and the scale of the map. The grid corner are marked on the ground and spot levels of these corners are then determined by normal method of leveling using a level.
- The grid is plotted to the scale of the map and the spot levels of the grid corners are entered, the contours of desired values are then locked by interpolation. This method is very suitable for a small open area where contour are required at a closed vertical interval

Methods of Contouring



Methods of Contouring



Methods of Contouring

Cross-Sectioning Method

- In this method, suitable spaced cross –sections are projected on either side of the centre line of the area. Several points are chosen at reasonable distances on either sides. The observations are made in the usual manner with a level. The cross-section lines are plotted to the scale, the points on these lines are marked and reduced levels are entered. The contours of desired values are then located by interpolation. This method is suitable for road, railway and canal survey.

Methods of Contouring

Radial Line Method or Tachometric Method

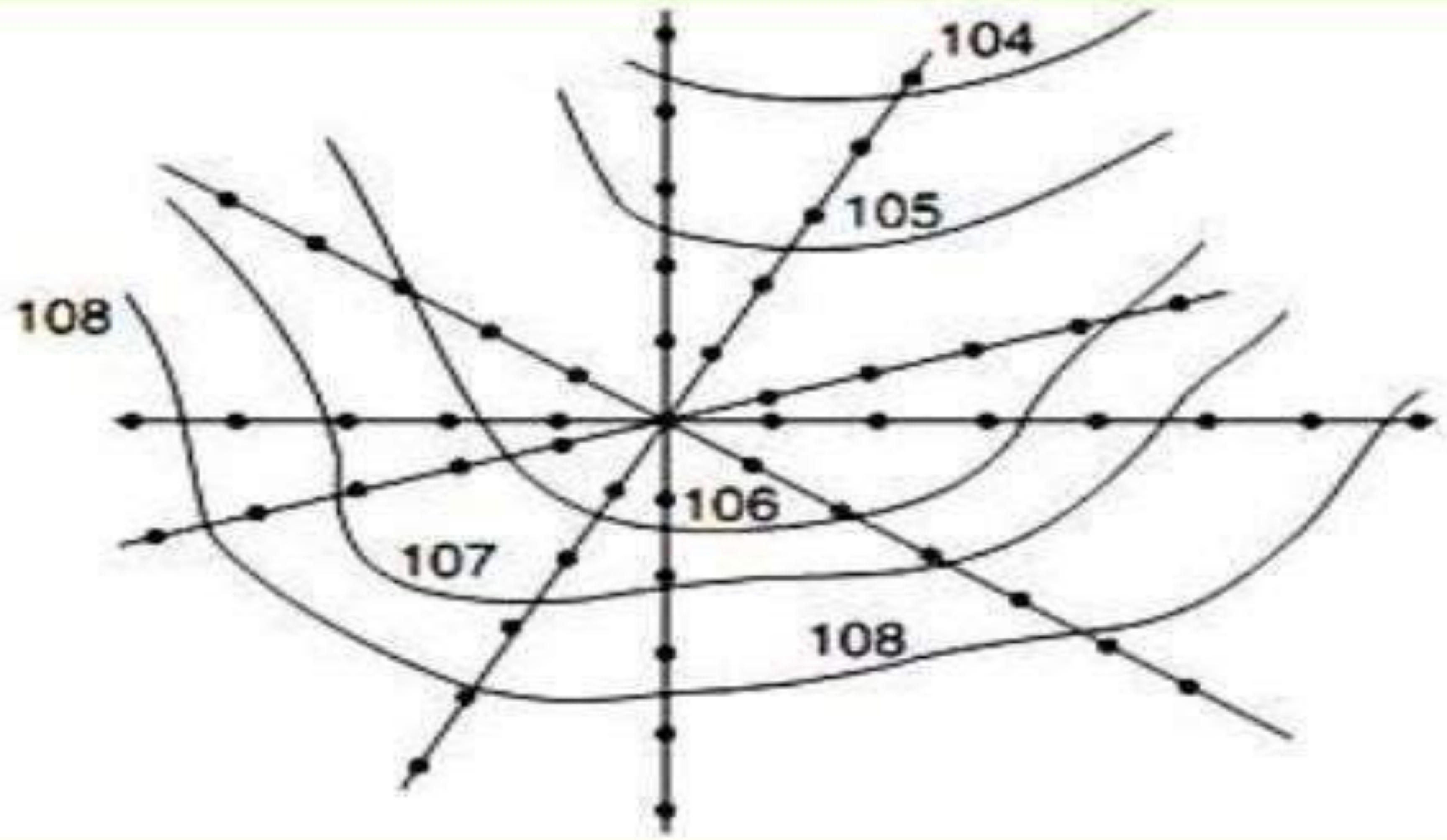
- In this method, a number of radial lines are set out at known angular interval (i.e. 15^{0} or 30^{0}) at each station. The point are selected on a line depend on the nature of the ground surface. Instead of the level, a tachometer may be used. The observations are taken on the staff stations and elevations and distances are then calculated. A traverse and radial lines are plotted to the scale RLs of the point entered. The contour of desired values are then located by interpolation . This method is convenient in hilly area.

Methods of Contouring

- Comparison of direct and Indirect methods of contouring

Direct Method	Indirect Method
Most accurate but slow and tedious	Not so accurate but rapid and less tedious
Expensive	Cheaper
Not suitable for hilly area	Suitable for hilly area
During the work calculations can be done	Calculations are not required in the field
Calculation can not be checked after contouring	Calculation can be checked as and when required

Radial Line Method



Interpolation of Contours

- The process of locating the contours proportionately between the plotted point is termed interpolation may be done by:
- Estimation
- Arithmetical Calculation
- Graphical Method

Interpolation of Contours

Estimation

- The points on the required contour are located by eye judgment or estimation between points whose elevations are already known. This method is good for small scale maps. It is assumed that slope between the ground points is uniform.

Interpolation of Contours

Arithmetic Calculations

- This methods is used when high accuracy is required and scale of the map is of intermediate or large. In this method the distances between two points of known elevation are accurately measured. Then with the help of arithmetic calculations, the positions of the required elevation points are computed.

Interpolation of Contours

Graphical Method

- When high accuracy is required and many interpolation are to be made, this method of plotting contours proves to be most rapid and convenient. For this purpose tracing paper is used.

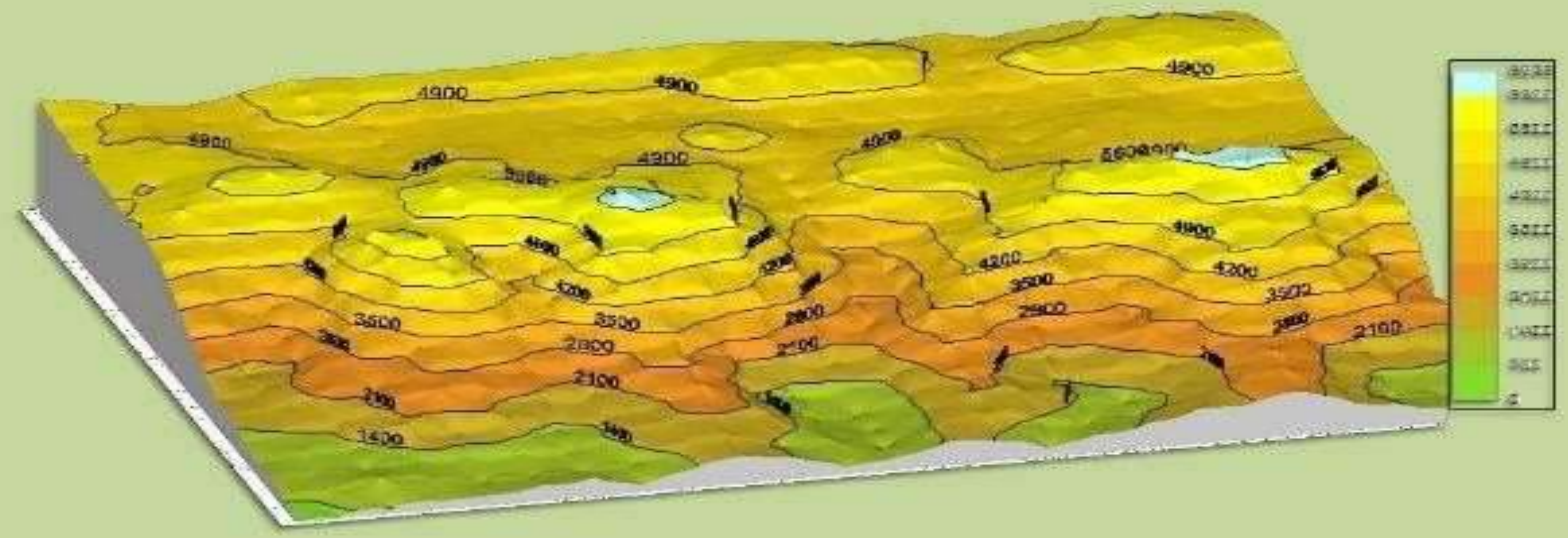
Plotting of a Contour Map

- Before plotting the contour map, suitable scale is selected.
- e.g. 1 cm = 1 m, 1 cm = 2 m, 1 cm = 2.5 m, 1 cm = 4 m or 1 cm = 5 m etc. Here 1 cm = 2m is selected.
- A horizontal line is drawn as the centre line
- The chainages are marked along the horizontal line according to the scale.
- Ground levels are written from the level book according to the chainage.

Plotting of a Contour Map

- The cross-section (L/s and R/S) are also plotted (perpendicular lines) at each of the chainage.
- By interpolation contours are joined by smooth curves keeping in mind the characteristics of contour.
- First find out maximum and minimum RL values and then first plot full values contour lines i.e.. 47 , 48, 49 etc. Contour interval is 1 m. After plotting these contour lines reduces contour interval and it is taken 0.5 m and contour lines i.e. 47.5, 48.5, 49.5 etc are plotted.
- Contour lines are then inked.

Plotting of a Contour Map



Chapter -2

THEODOLITE SURVEYING

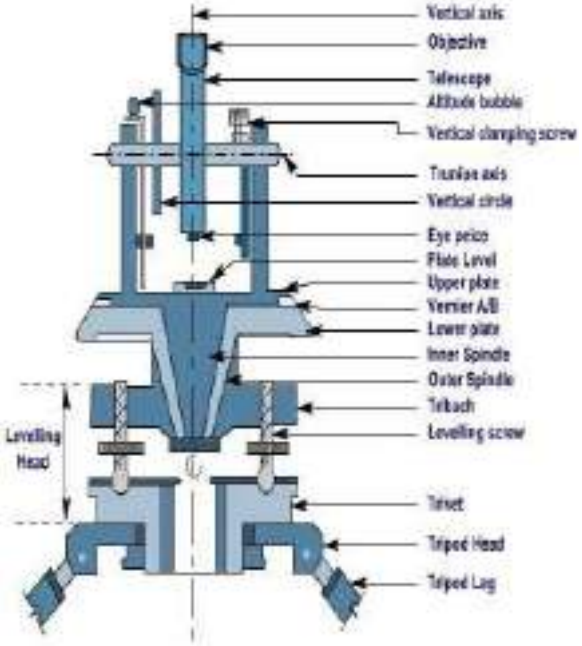


Figure 20.4 Sectional view of a Theodolite

So far we have been measuring horizontal angles by using a *Compass* with respect to *meridian*, which is *less accurate* and also it is not possible to measure vertical angles with a Compass.

So when the objects are at a considerable distance or situated at a considerable elevation or depression ,it becomes necessary to measure horizontal and vertical angles more precisely. So these measurements are taken by an instrument known as a *theodolite*.

THEODOLITE SURVEYING

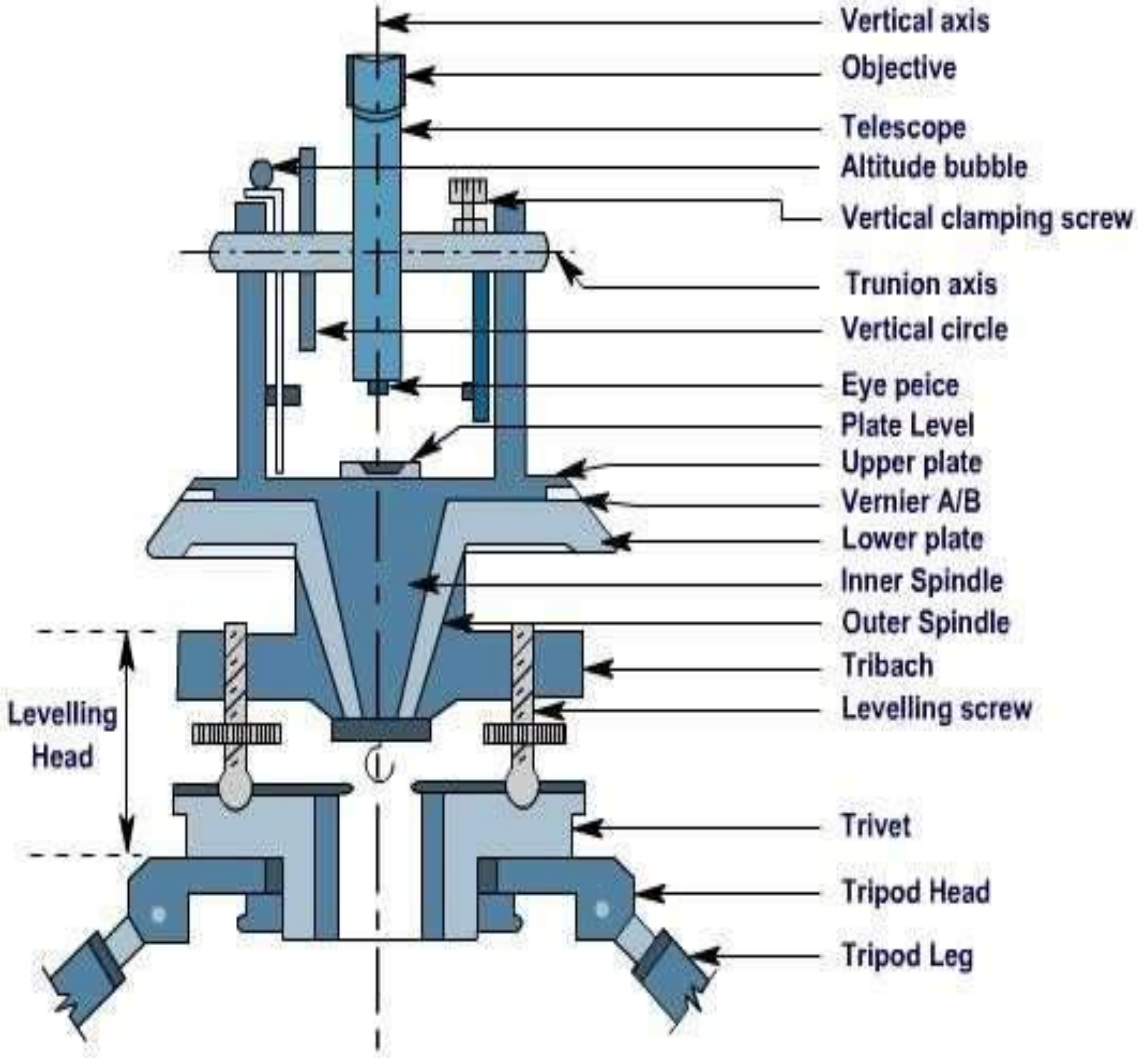
The system of surveying in which the angles are measured with the help of a theodolite, is called Theodolite surveying.

THEODOLITE

The Theodolite is a most accurate surveying instrument mainly used for :

- **Measuring horizontal and vertical angles.**
- **Locating points on a line.**
- **Prolonging survey lines.**
- **Finding difference of level.**
- **Setting out grades**
- **Ranging curves**
- **Tacheometric Survey**

TRANSIT VERNIER THEODOLITE



TRANSIT VERNIER THEODOLITE

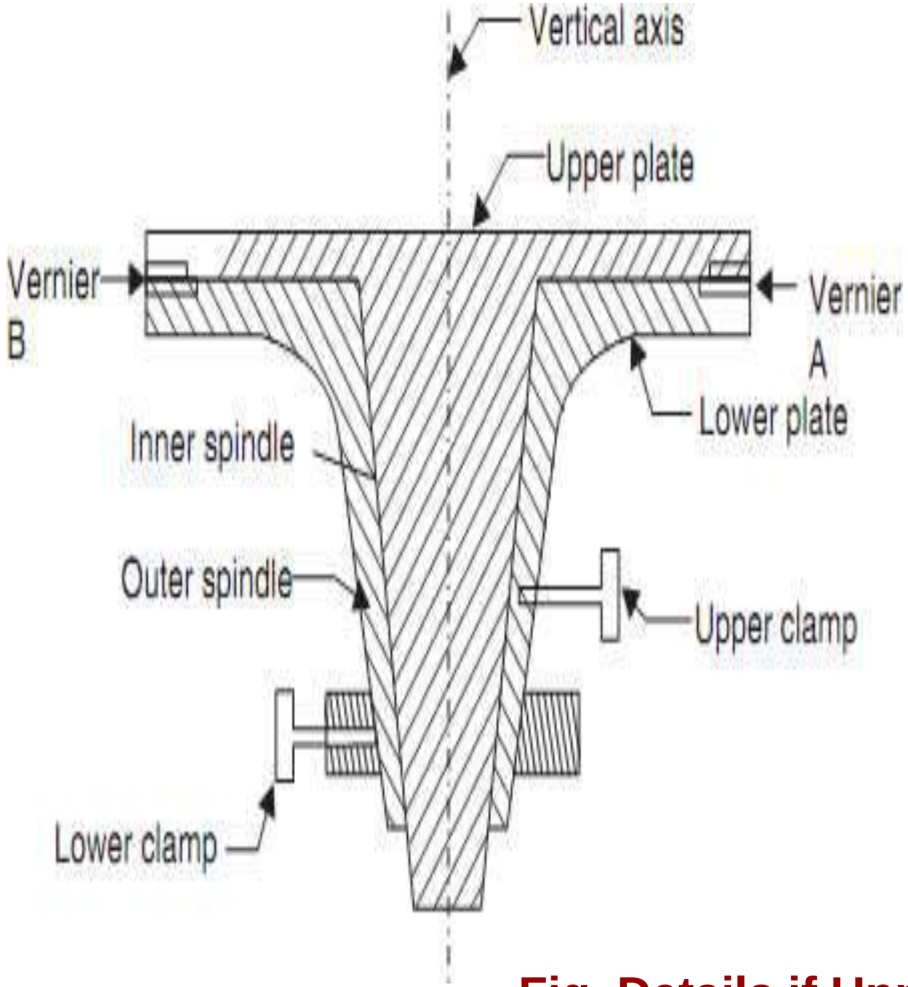
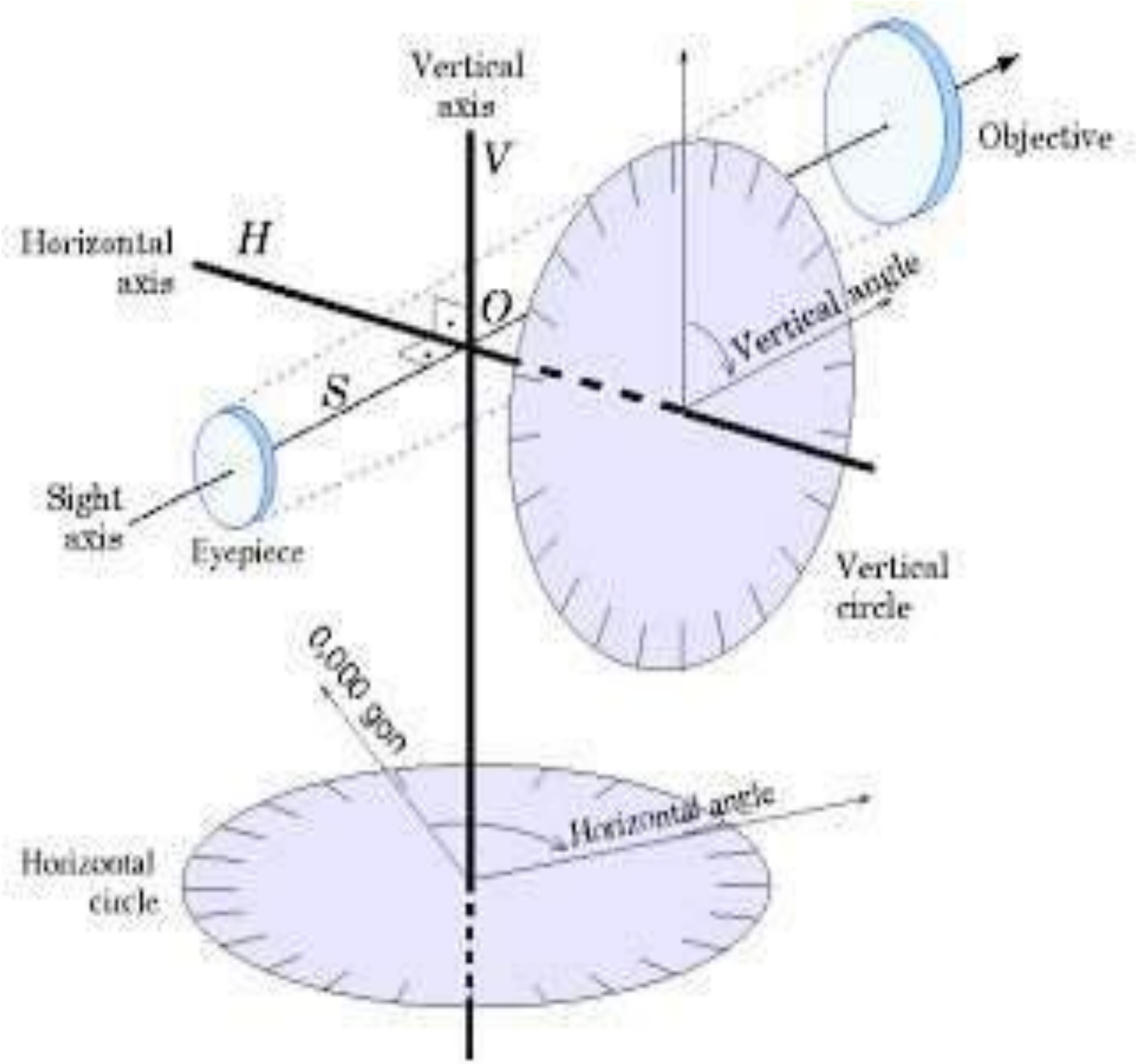
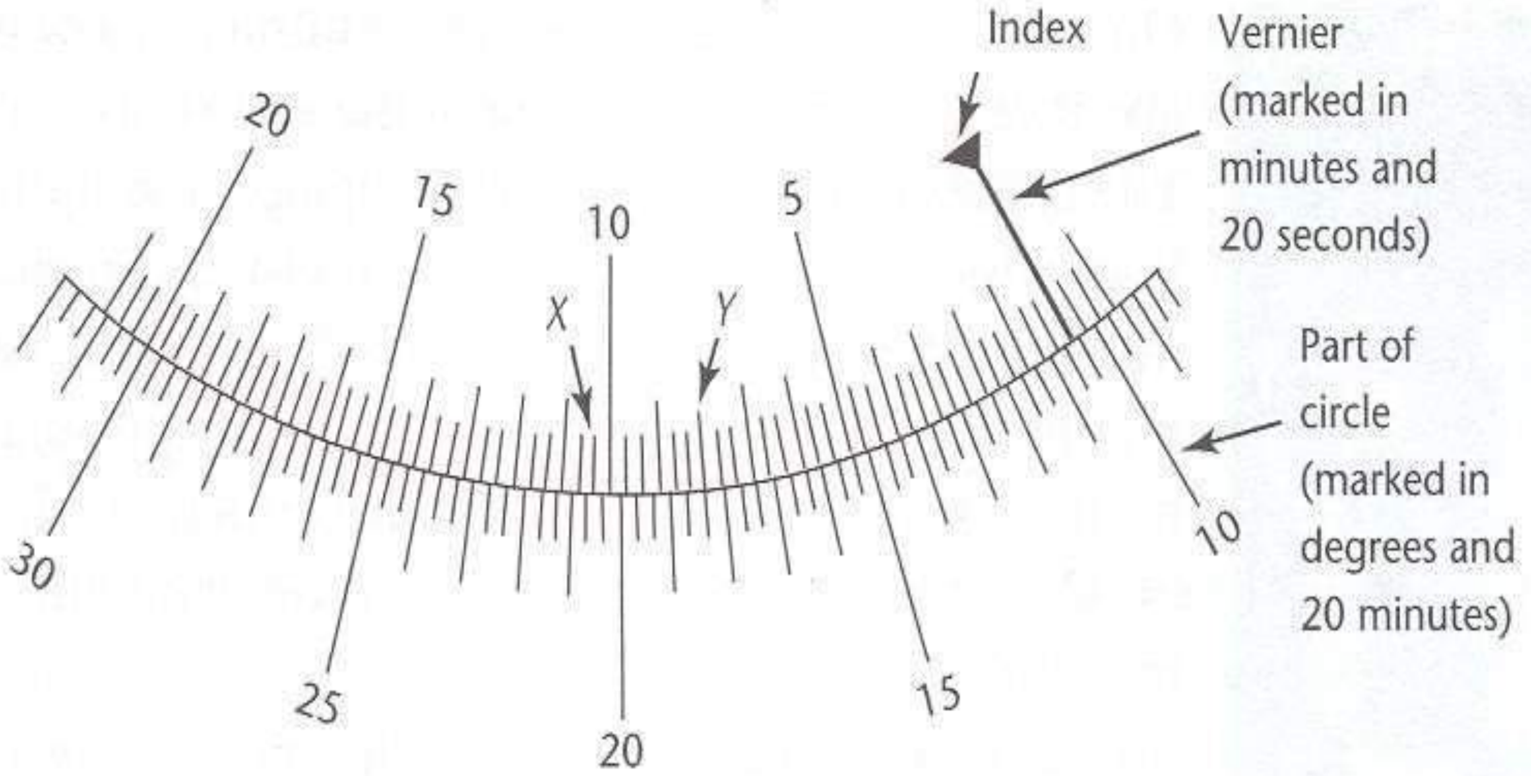


Fig. Details if Upper & Lower Plates.

TRANSIT VERNIER THEODOLITE





Index
Vernier
(marked in
minutes and
20 seconds)
Part of
circle
(marked in
degrees and
20 minutes)
20
15
10
5
X
Y
30
25
20
15
10

CLASSIFICATION OF THEODOLITES

Theodolites may be classified as ;

A.

i) Transit Theodolite.

ii)Non Transit Theodolite.

B.

iii)Vernier Theodolites.

iv)Micrometer Theodolites.

CLASSIFICATION OF THEODOLITES

A. **Transit Theodolite:** A theodolite is called a transit theodolite when its telescope can be transited i.e revolved through a complete revolution about its horizontal axis in the vertical plane, whereas in a-

Non-Transit type, the telescope cannot be transited. They are inferior in utility and have now become *obsolete.*

CLASSIFICATION OF THEODOLITES

B. Vernier Theodolite: For reading the graduated circle if verniers are used ,the theodolite is called as a Vernier Theodolite.

Whereas, if a *micrometer* is provided to read the graduated circle the same is called as a Micrometer Theodolite.

Vernier type theodolites are commonly used .

SIZE OF THEODOLITE

A theodolite is designated by diameter of the graduated circle on the lower plate.

The common sizes are *8cm to 12 cm* while *14 cm to 25 cm* instrument are used for *triangulation work*.

Greater accuracy is achieved with larger theodolites as they have bigger graduated circle with larger divisions hence used where the survey works require high degree of accuracy.

DESCRIPTION OF A

TRANSIT VERNIER THEODOLITE

A Transit vernier theodolite essentially consist of the following :

1. Levelling Head.
2. Lower Circular Plate.
3. Upper Plate.
4. Telescope.
5. Vernier Scale.
6. T- Frame.
7. Plumb –bob.
8. Tripod Stand.

1. **Centering** : Centering means setting the theodolite exactly over an instrument- station so that its vertical axis lies immediately above the station- mark. It can be done by means of plumb bob suspended from a small hook attached to the vertical axis of the theodolite.

The centre shifting arrangement if provided with the instrument helps in easy and rapid performance of the centring.

TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

2. Transiting :

Transiting is also known as *plunging* or *reversing*. It is the process of turning the telescope about its horizontal axis through 180^0 in the vertical plane thus bringing it upside down and making it point , exactly in opposite direction.

TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

3. Swinging the telescope

It means turning the telescope about its vertical axis in the horizontal plane.

A swing is called *right* or *left* according as the telescope is rotated clockwise or counter clockwise.

TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

4. Face Left

If the vertical circle of the instrument is on the left side of the observer while taking a reading ,the position is called the *face left* and

the observation taken on the horizontal or vertical circle in this position, is known as the *face left observation*

TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

5. Face Right

If the vertical circle of the instrument is on the right side of the observer while taking a reading ,the position is called the *face right* and

the observation taken on the horizontal or vertical circle in this position, is known as the *face right observation.*

TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

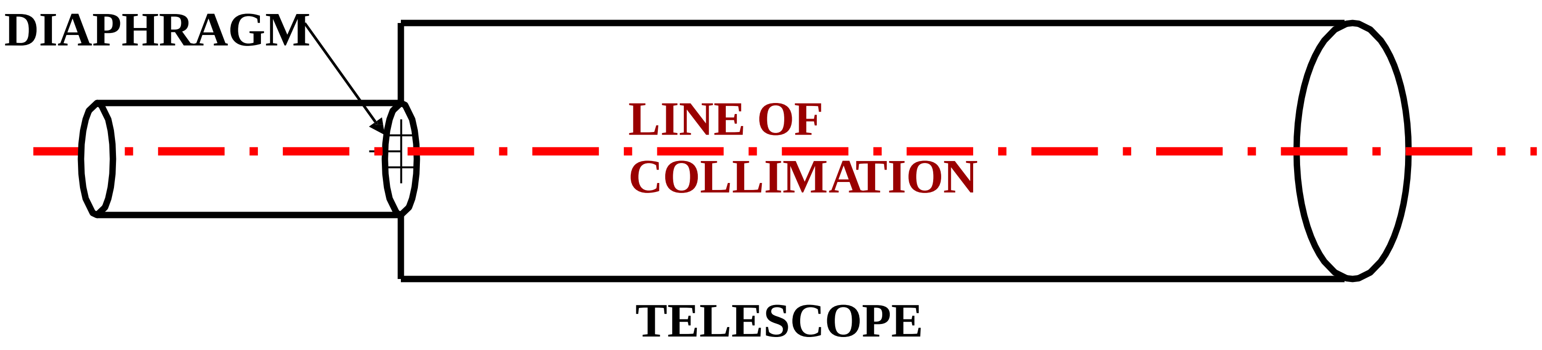
6. Changing Face

It is the operation of bringing the vertical circle to the right of the observer ,if originally it is to the left , and vice – versa.

It is done in two steps; Firstly revolve the telescope through 180^0 in a vertical plane and then rotate it through 180^0 in the horizontal plane i.e first transit the telescope and then swing it through 180^0.

TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

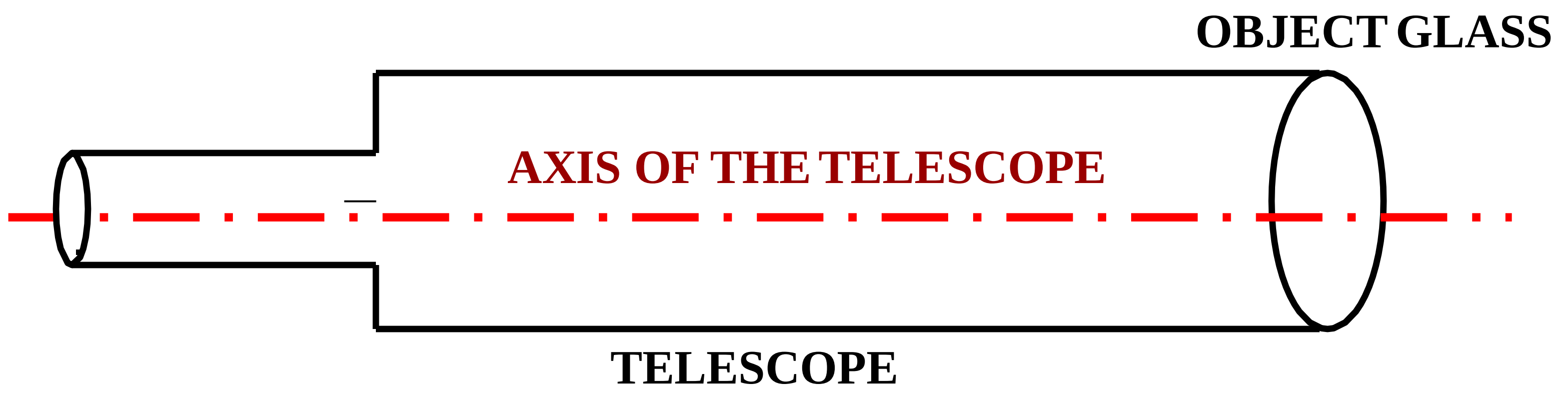
7. Line of Collimation



It is also known as the line of sight .It is an imaginary line joining the intersection of the cross- hairs of the diaphragm to the optical centre of the object- glass and its continuation.

TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

8. Axis of the telescope



It is also known an imaginary line joining the optical centre of the object- glass to the centre of eye piece.

TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

9. Axis of the Level Tube

It is also called the bubble line.

It is a *straight* line *tangential* to the *longitudinal curve* of the level tube at the centre of the tube. It is horizontal when the bubble is in the centre.

TERMS USED IN MANIPULATING A TRANSIT VERNIER THEODOLITE.

10. Vertical Axis

It is the axis about which the telescope can be rotated in the horizontal plane.

11. Horizontal Axis

It is the axis about which the telescope can be rotated in the vertical plane.

It is also called the *trunion axis.*

ADJUSTMENT OF A THEODOLITE

The adjustments of a theodolite are of two kinds :-

1. **Permanent Adjustments.**
2. **Temporary Adjustments.**

1) Permanent adjustments: The permanent adjustments are made to establish the relationship between the *fundamental lines* of the theodolite and , once made , they last for a long time. They are essential for the accuracy of observations.

ADJUSTMENT OF A THEODOLITE

1. **Permanent adjustments:** The permanent adjustments in case of a transit theodolites are :-

i) **Adjustment of Horizontal Plate Levels.** The axis of the plate levels must be perpendicular to the vertical axis.

ii) **Collimation Adjustment.** The line of collimation should coincide with the axis of the telescope and the axis of the objective slide and should be at right angles to the horizontal axis.

iii) **Horizontal axis adjustment.** The horizontal axis must be perpendicular to the vertical axis.

ADJUSTMENT OF ATHEODOLITE

1. **Permanent adjustments (contd.):**

iv)**Adjustment of Telescope Level or the Altitude Level Plate Levels.** The axis of the telescope levels or the altitude level must be parallel to the line of collimation.

v)**Vertical Circle Index Adjustment.** The vertical circle vernier must read zero when the line of collimation is horizontal.

ADJUSTMENT OF A THEODOLITE

2. Temporary Adjustment

The temporary adjustments are made at each set up of the instrument before we start taking observations with the instrument. There are three temporary adjustments of a theodolite:-

i) Centering.

ii) Levelling.

iii) Focussing.

MEASUREMENT OF HORIZONTAL ANGLES:

There are three methods of measuring horizontal angles:-

- i) **Ordinary Method.**
- ii) **Repetition Method.**
- iii) **Reiteration Method.**

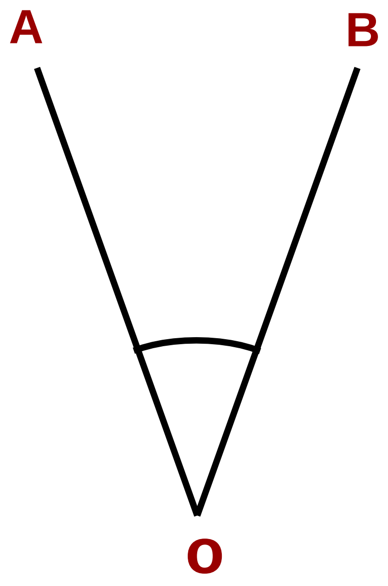
MEASUREMENT OF HORIZONTAL ANGLES:

i) Ordinary Method. To measure horizontal angle AOB:-

i) Set up the theodolite at station point O and level it accurately.

ii) Set the vernier A to the zero or 360^0 of the horizontal circle. Tighten the upper clamp.

iii) Loosen the lower clamp. Turn the instrument and direct the telescope towards A to bisect it accurately with the use of tangent screw. After bisecting accurately check the reading which must still read zero. Read the vernier B and record both the readings.



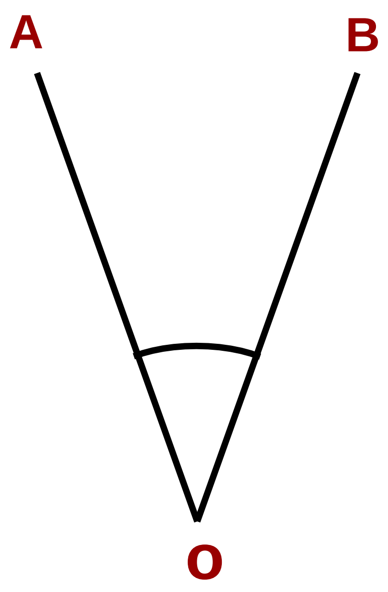
HORIZONTAL ANGLE AOB

MEASUREMENT OF HORIZONTAL ANGLES:

i) Ordinary Method. To measure horizontal angle AOB:-

iv) **Loosen the upper clamp and turn the telescope clockwise until line of sight bisects point B on the right hand side. Then tighten the upper clamp and bisect it accurately by turning its tangent screw.**

v) **Read both verniers. The reading of the vernier a which was initially set at zero gives the value of the angle AOB directly and that of the other vernier B by deducting 180^0 .The mean of the two vernier readings gives the value of the required angle AOB.**



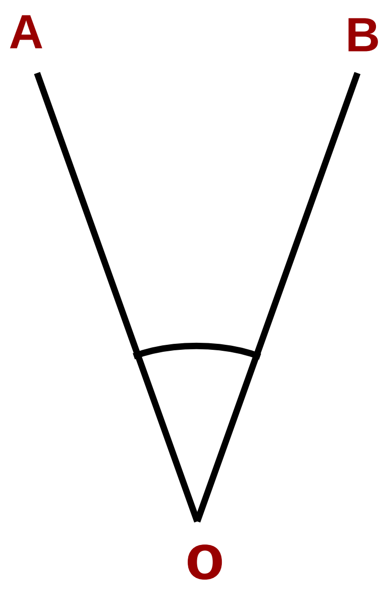
HORIZONTAL ANGLE AOB

MEASUREMENT OF HORIZONTAL ANGLES:

i) Ordinary Method. To measure horizontal angle AOB:-

vi) Change the face of the instrument and repeat the whole process. The mean of the two vernier readings gives the second value of the angle AOB which should be approximately or exactly equal to the previous value.

vii) The mean of the two values of the angle AOB ,one with face left and the other with face right ,gives the required angle free from all instrumental errors.



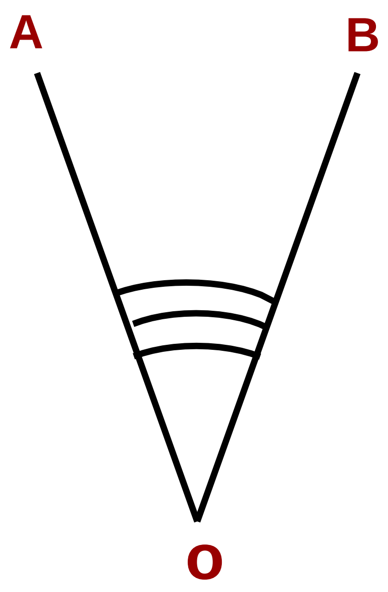
HORIZONTAL ANGLE AOB

MEASUREMENT OF HORIZONTAL ANGLES:

ii) Repetition Method.

This method is used for very accurate work. In this method ,the same angle is added several times mechanically and the correct value of the angle is obtained by dividing the accumulated reading by the no. of repetitions.

The No. of repetitions made usually in this method is six, three with the face left and three with the face right .In this way ,angles can be measured to a finer degree of accuracy than that obtainable with the least count of the vernier.



HORIZONTAL ANGLE AOB

MEASUREMENT OF HORIZONTAL ANGLES:

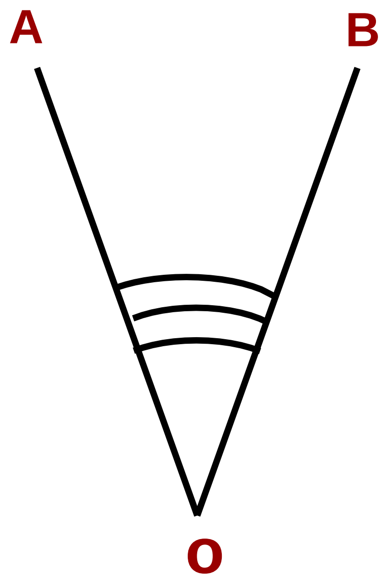
ii) Repetition Method.

To measure horizontal angle by repetitions:-

i) Set up the theodolite at starting point O and level it accurately.

ii) Measure The horizontal angle AOB.

iii) Loosen the lower clamp and turn the telescope clock – wise until the object (A) is sighted again. Bisect B accurately by using the upper tangent screw. The verniers will now read the *twice* the value of the angle now.

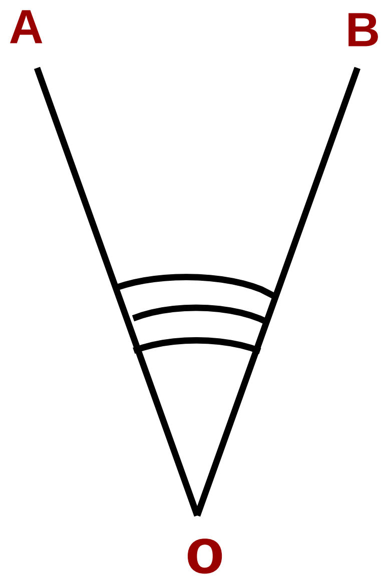


HORIZONTAL ANGLE AOB

MEASUREMENT OF HORIZONTAL ANGLES:

ii) Repetition Method contd...

iv) Repeat the process until the angle is repeated the required number of times (usually 3). Read again both verniers . The final reading after *n repetitions* should be approximately n X (angle). *Divide* the *sum* by the *number of repetitions* and the result thus obtained gives the *correct value of the angle* AOB.



HORIZONTAL ANGLE AOB

v) Change the face of the instrument. Repeat exactly in the same manner and find another value of the angle AOB. The *average* of two readings gives the required precise value of the angle AOB.

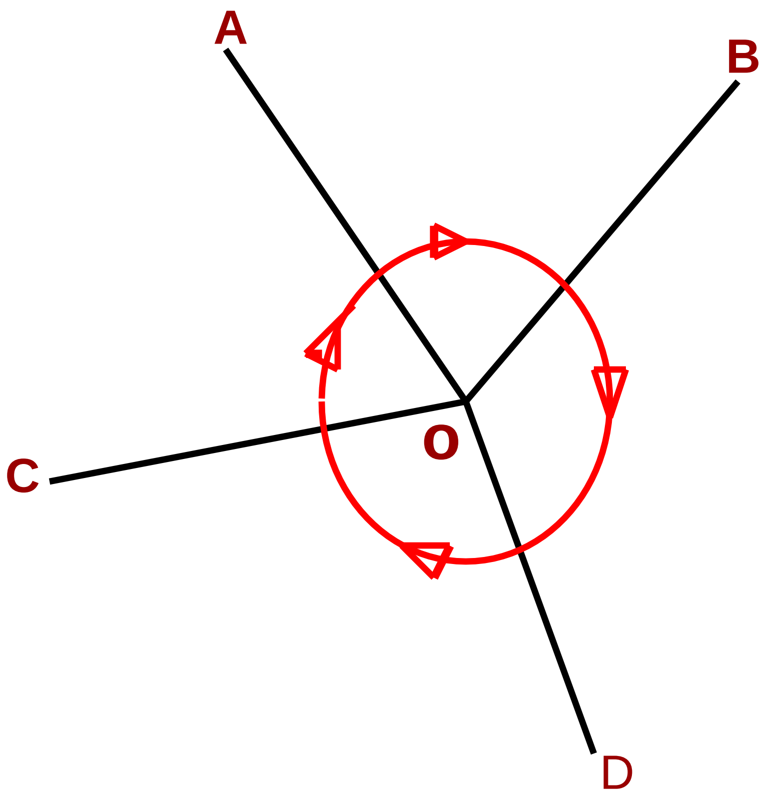
MEASUREMENT OF HORIZONTAL ANGLES:

iii) Reiteration Method.

This method is another *precise* and comparatively *less tedious* method of measuring the horizontal angles.

It is generally preferred when *several angles* are to be measured at a particular station.

This method consists in measuring several angles successively and finally closing the horizon at the starting point. The *final reading* of the vernier A should be *same* as its *initial reading*.



Reiteration Method

MEASUREMENT OF HORIZONTAL ANGLES:

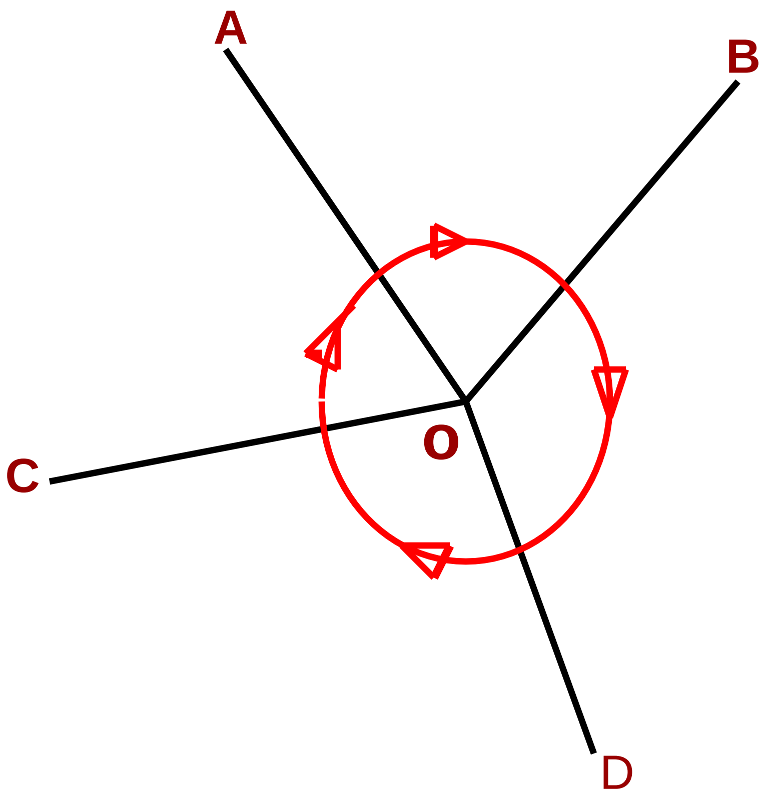
iii) Reiteration Method.

…If not ,the discrepancy is equally distributed among all the measured angles.

Procedure

Suppose it is required to measure the angles AOB,BOC and COD. Then to measure these angles by repetition method :

i) Set up the instrument over station point O and level it accurately.



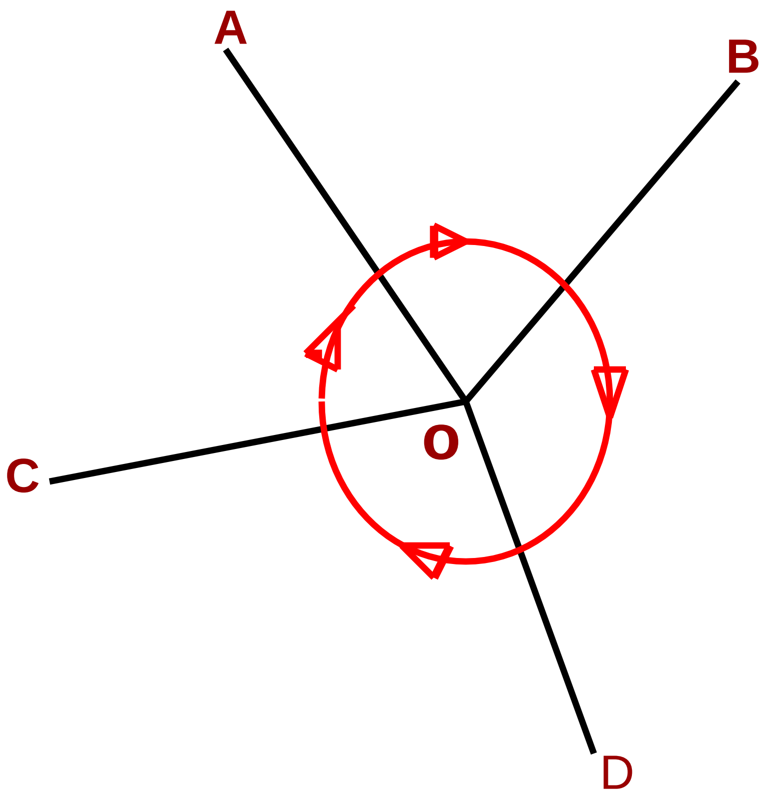
Reiteration Method

iii) Reiteration Method.

Procedure

ii) Direct the telescope towards point A which is known as referring object. Bisect it accurately and check the reading of vernier as 0 or 360^0 . Loosen the lower clamp and turn the telescope clockwise to sight point B exactly. Read the verniers again and The mean reading will give the value of angle AOB.

iii) Similarly bisect C & D successively, read both verniers at-



Reiteration Method

MEASUREMENT OF HORIZONTAL ANGLES:

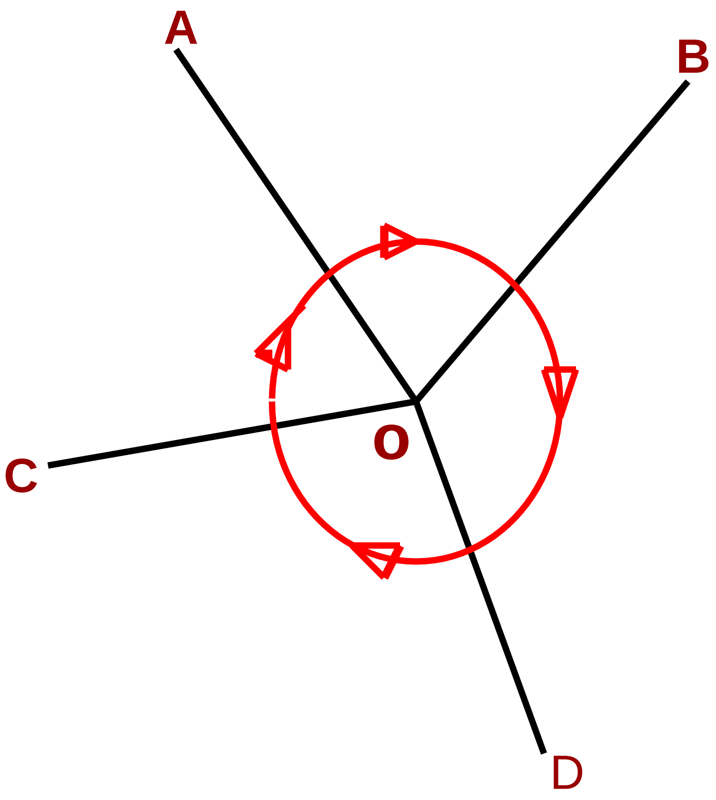
iii) Reiteration Method (contd.).

Procedure. each bisection, find the value of the angle BOC and COD.

iv) Finally close the horizon by sighting towards the referring object (point A).

v) The vernier A should now read 360^0. If not note down the error .This error occurs due to *slip* etc.

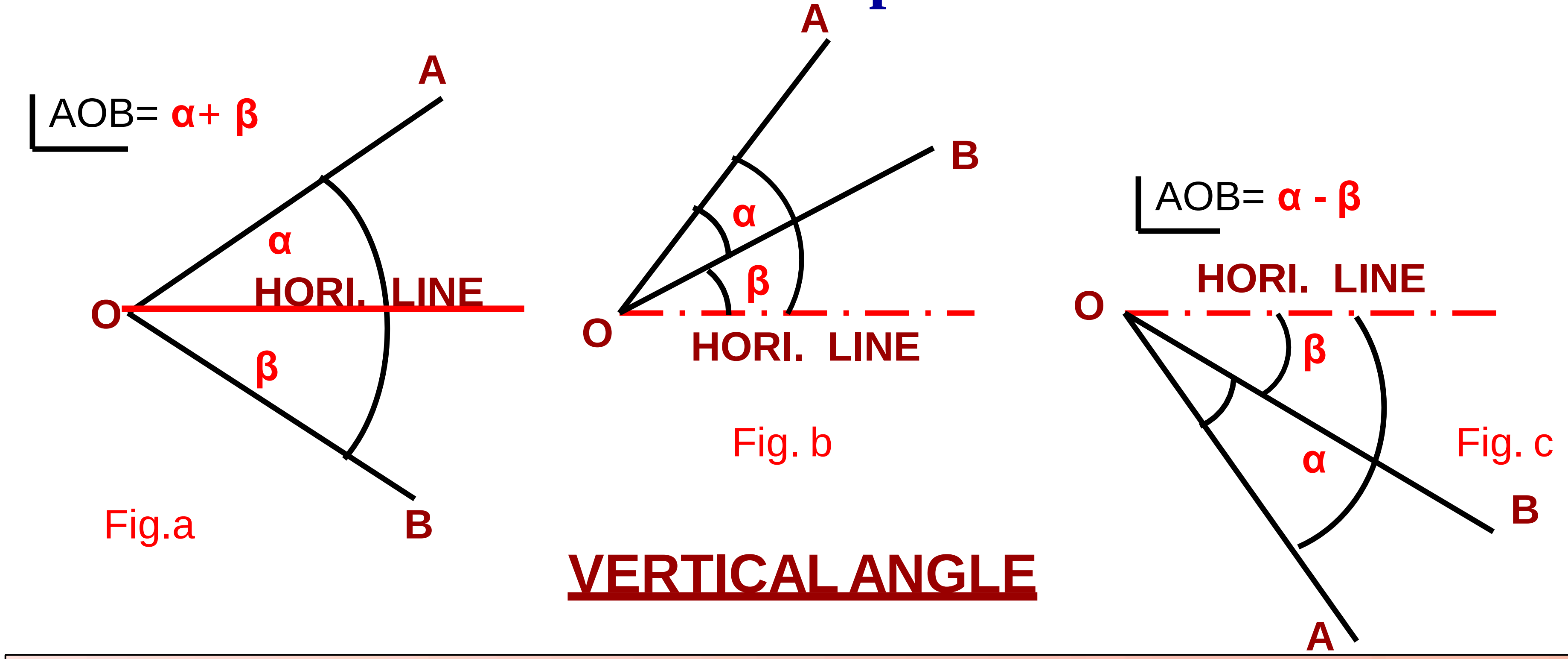
vi) If the error is small, it is *equally distributed* among the several angles .If *large* the readings should be *discarded* and a new set of readings be taken.



Reiteration Method

MEASUREMENT OF VERTICAL ANGLES:

Vertical Angle : A vertical angle is an angle between the *inclined line of sight* and the *horizontal*. It may be an angle of *elevation* or *depression* according as the object is above or below the horizontal plane.



VERTICAL ANGLE

MEASUREMENT OF VERTICAL ANGLES:

To Measure the Vertical Angle of an object A at a station O:

(i) Set up the theodolite at station point O and level it accurately with reference to the altitude bubble.

(ii) Set the zero of vertical vernier exactly to the zero of the vertical circle clamp and tangent screw.

(iii) Bring the bubble of the altitude level in the central position by using clip screw. The line of sight is thus made horizontal and vernier still reads zero.

(iv) Loosen the vertical circle clamp screw and direct the telescope towards the object A and sight it exactly by using the vertical circle tangent screw.

MEASUREMENT OF VERTICAL ANGLES:

(v)Read both verniers on the vertical circle, The mean of the two vernier readings gives the value of the required angle.

(vi)Change the face of the instrument and repeat the process. The mean of of the two vernier readings gives the second value of the required angle.

(vii)The average of the two values of the angles thus obtained, is the required value of the angle free from instrumental errors.

MEASUREMENT OF VERTICAL ANGLES:

For measuring Vertical Angle between two points A &B

i)Sight A as before , and take the mean of the two vernier readings at the vertical circle. Let it be α

ii)Similarly, sight B and take the mean of the two vernier readings at the vertical circle. Let it be β

iii)The sum or difference of these dings will give the value of the vertical angle between A and B according as one of the points is above and the other below the horizontal plane. or both points are on the same side of the horizontal plane Fig b & c

READING MAGNETIC BEARING OF A LINE

To find the bearing of a line AB as shown in fig .below

i) Set up the instrument over A and level it accurately

ii) Set the vernier to the zero of the horizontal circle.

iii) Release the magnetic needle and loosen the lower clamp.

iv) Rotate the instrument till magnetic needle points to North. Now clamp the lower clamp with the help of lower tangent screw .Bring the needle exactly against the mark in order to bring it in magnetic meridian. At this stage the line of sight will also be in magnetic meridian.

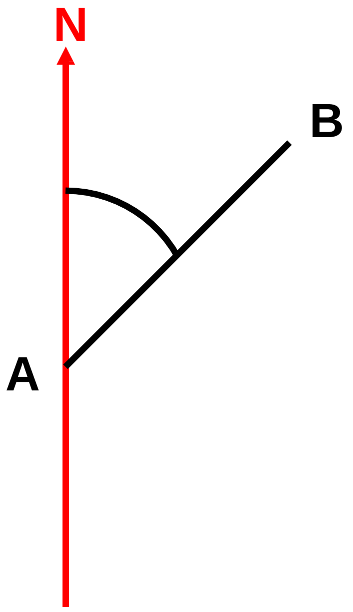


Fig.

Magnetic Bearing of a Line

READING MAGNETIC BEARING OF A LINE

iv) Now loose the upper clamp and point the telescope towards B .With the help of upper tangent screw ,bisect B accurately and read both the verniers .The mean of the two readings will be recorded as magnetic bearing of line.

v) Change the face of the instrument for accurate magnetic bearing of the line and repeat .the mean of the two values will give the correct bearing of the line AB.

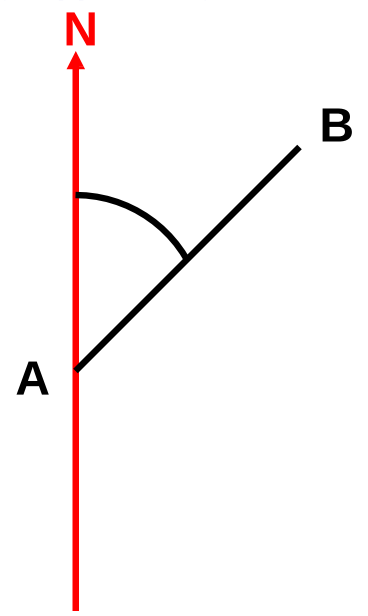


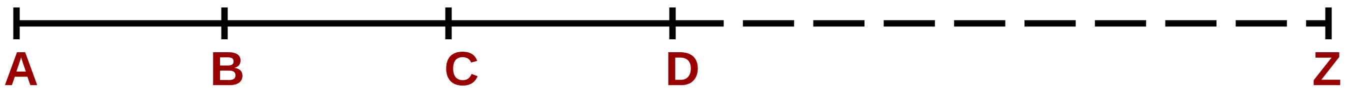
Fig.
Magnetic Bearing of a Line

PROLONGING A STRAIGHT A LINE

There are two methods of prolonging a given line such as AB

(1)Fore sight method ,and (2) Back Sight Method

(1)Fore Sight Method. As shown in the fig. below



i) **Set up the theodolite at A and level it accurately .Bisect the point b correctly. Establish a point C in the line beyond B approximately by looking over the top of the telescope and accurately by sighting through the telescope.**

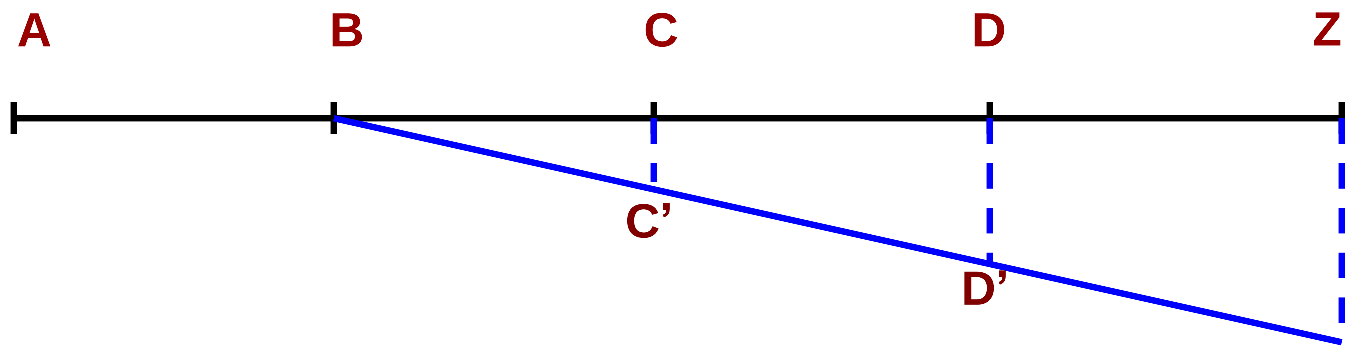
ii) Shift the instrument to B ,take a fore sight on C and establish a point D in line beyond C.

Fig.

iii) Repeat the process until the last point Z is reached.

PROLONGING A STRAIGHT A LINE

(2) Back Sight Method. As shown in the fig. below



i) Set up the instrument at B and level it accurately .

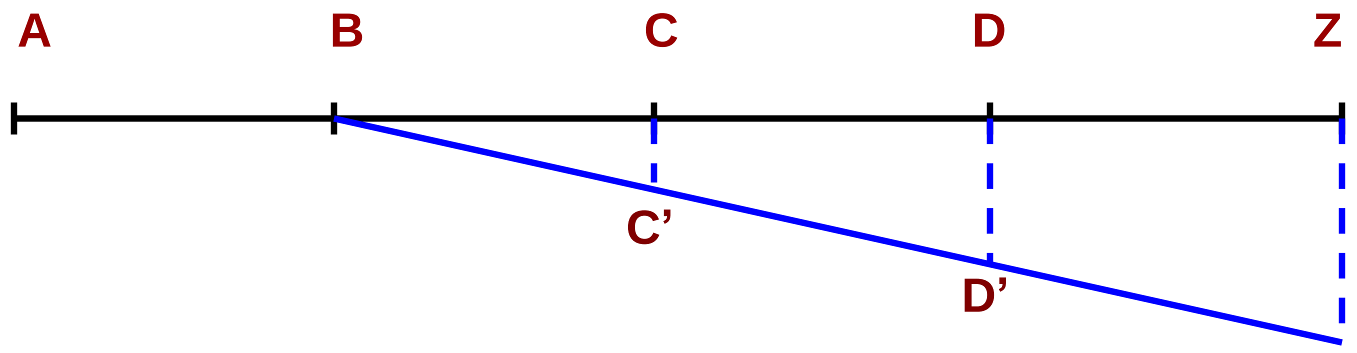
ii) Take a back sight on A.

iii) Tighten the upper and lower clamps, transit the telescope and establish a point C in the line beyond B.

iv) Shift the theodolite to C ,back sight on B transit the telescope and establish a point D in line beyond C. Repeat the process until the last point (Z) is established.

PROLONGING A STRAIGHT A LINE

(2) Back Sight Method.(contd.) As shown in the fig. below



Now if the instrument is in adjustment, the points A,B,C,D and Z will be in one line, which is straight but if it is not in adjustment i.e. line of collimation is not perpendicular to the horizontal axis ,then C’, D’ and Z’ will not be in a straight line.

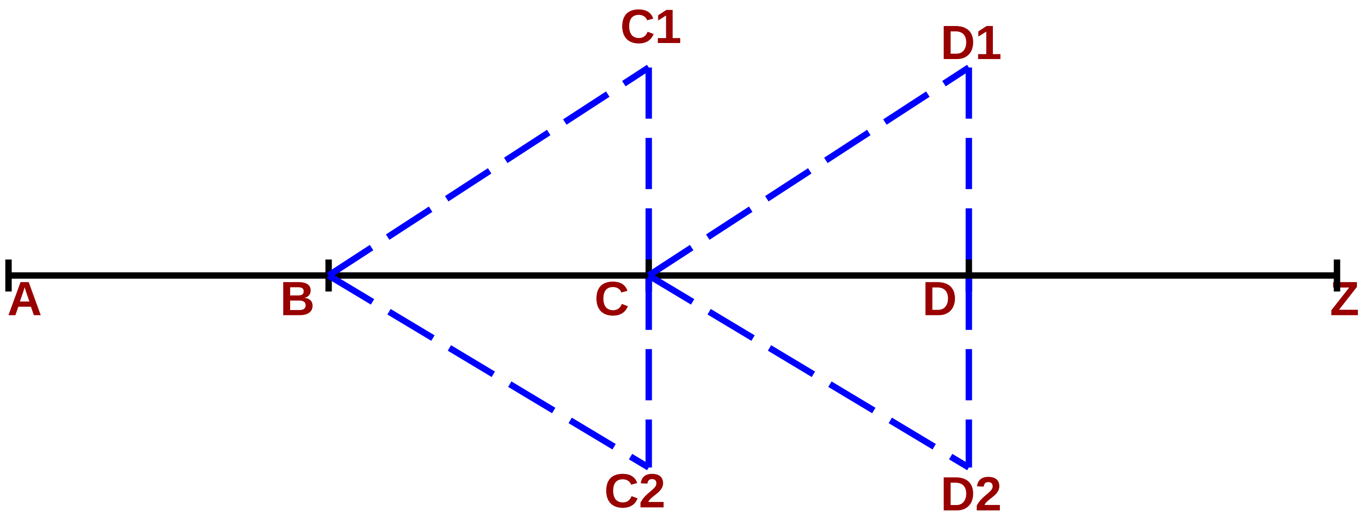
PROLONGING A STRAIGHT A LINE

Double reversing Method

When the line is to be prolonged with *high precision* or when the *instrument* is in *imperfect adjustment*, the process of *double sighting* or *double reversing*, is used.

Suppose the line AB is to be prolonged to a point Z.

Procedure: **As shown below:**



Double Sighting / Reversing Method

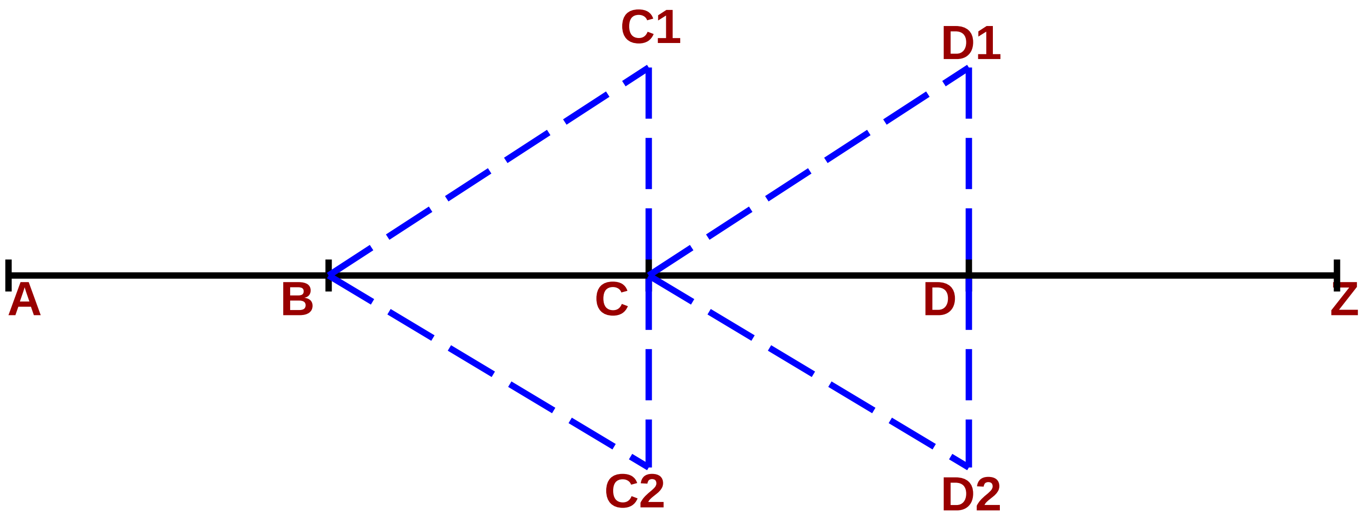
PROLONGING A STRAIGHT A LINE

Double reversing Method

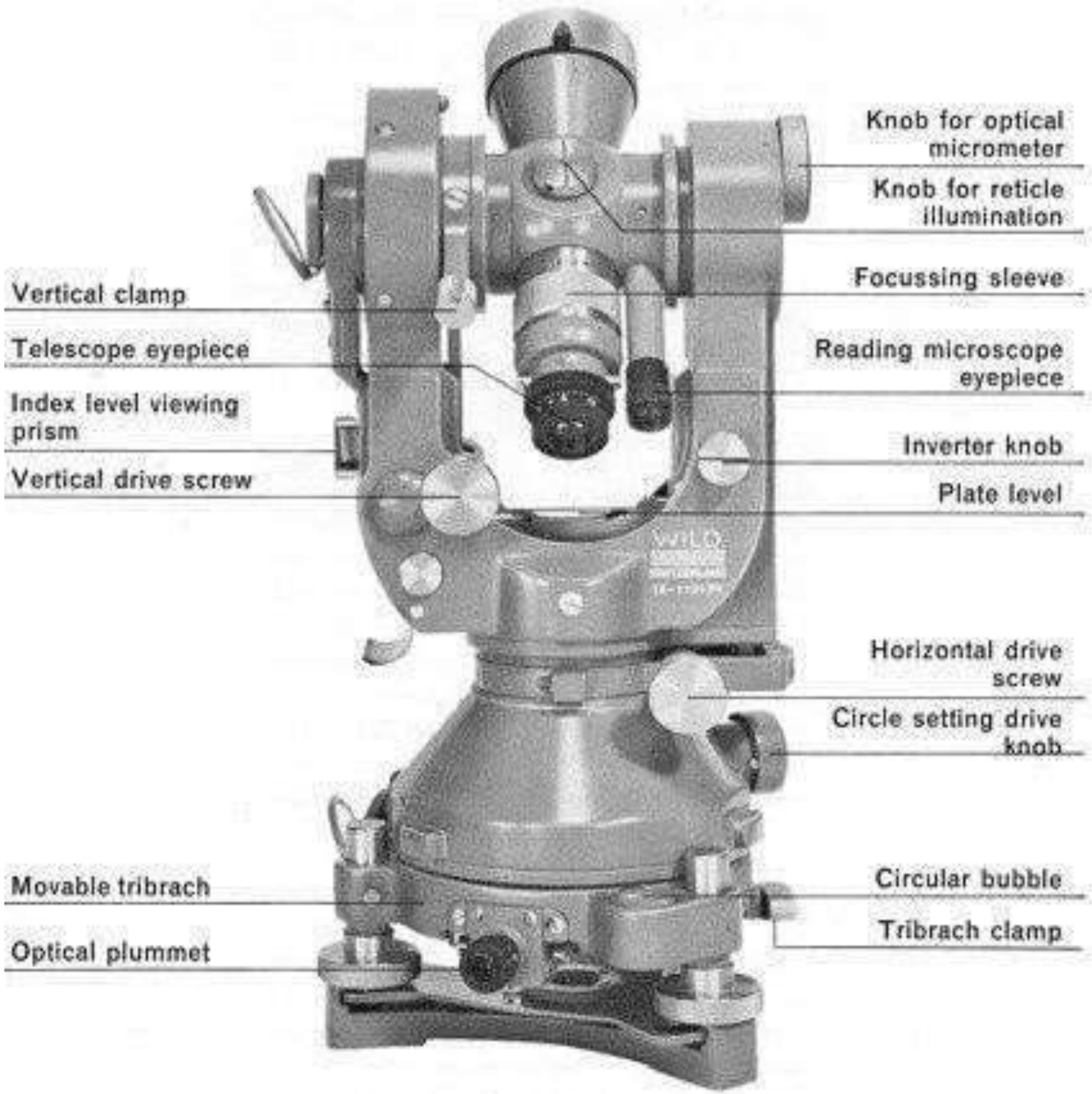
i) Set up the theodolite at B and level it accurately.

ii) With the face of instrument left, back sight on A and clamp both the upper and lower motions.

iii) Transit the telescope and set a point C_1 ahead in line.



Double Sighting / Reversing Method



Thank you

By:- Er Sachin

Government Polytechnic Nanakpur

DEPARTMENT OF CIVIL ENGINEERING

E - NOTES

SOFT SKILLS – II

BY:- Er. Manoj/Er. Sachin

LEARNING OUTCOMES

After undergoing this course, the students will be able to:

- Develop Communication Skills
- Work in a team
- Learn to resolve conflict by appropriate method
- Identify leadership traits and learn self motivation
- Follow ethics

Concept of Team Building

What is Teamwork & Team Building

Teamwork

- Concept of people working together as a team

Team player

- A team player is someone who is able to get along with their colleagues and work together in a cohesive group

Team Building

- Process of establishing and developing a greater sense of collaboration and trust between members

Teamwork

"Create A Story"












Why Should We Be a Team?

- When staff use their skills and knowledge together, the result is a stronger agency that can fulfill its mission

"To provide accurate information that would assist individuals in achieving a better quality of life."

- People working together can sustain the enthusiasm and lend support needed to complete the work of each program.

How does a Team Work Best?

A Teams succeeds when its members have:

- **a commitment to common objectives**
- **defined roles and responsibilities**
- **effective decision systems, communication and work procedures**
- **good personal relationships**

Developing Interpersonal Relationship

Empathy

- Being empathetic (also called “empathic”) means seeing things through someone else’s eyes or putting yourself in another person’s shoes and identifying with what the person is feeling (based on their statements, tone of voice, facial expression, body language, etc.).

Sympathy

- Sympathy, on the other hand, implies supportive feelings and offerings: we offer assistance and love, for example, by telling another person how sorry we feel for them.

Understanding Empathy and Sympathy

	Empathy	**Sympathy**
Brief Definition	Empathy is about *feelings*: we co-experience the emotions of a person with whom we connect.	Sympathy is about *support/care*: we feel sorry or feel pity for someone.
Example	"*I can imagine you must be feeling so many things – sadness, frustration, anger – since you lost your mother.*"	*"I'm so sorry to hear about the loss of your mother. My thoughts are with you."*

Communication Skills

Improving Non
Verbal Communication

7 Steps To Improving Non-Verbal Communication

- **Step 1: Watch yourself . . . and others**
- **Step 2: Maintain eye contact**
- **Step 3: Work on your posture**
- **Step 4: Straighten your desk**
- **Step 5: Read your audience**
- **Step 6: Listen to your voice**
- **Step 7: Question yourself**

Conflict management

Conflict management is the process of limiting the negative aspects of conflict while increasing the positive aspects of conflict. The aim of conflict management is to enhance learning and group outcomes, including effectiveness or performance in an organizational setting.

The Five Steps to Conflict Resolution

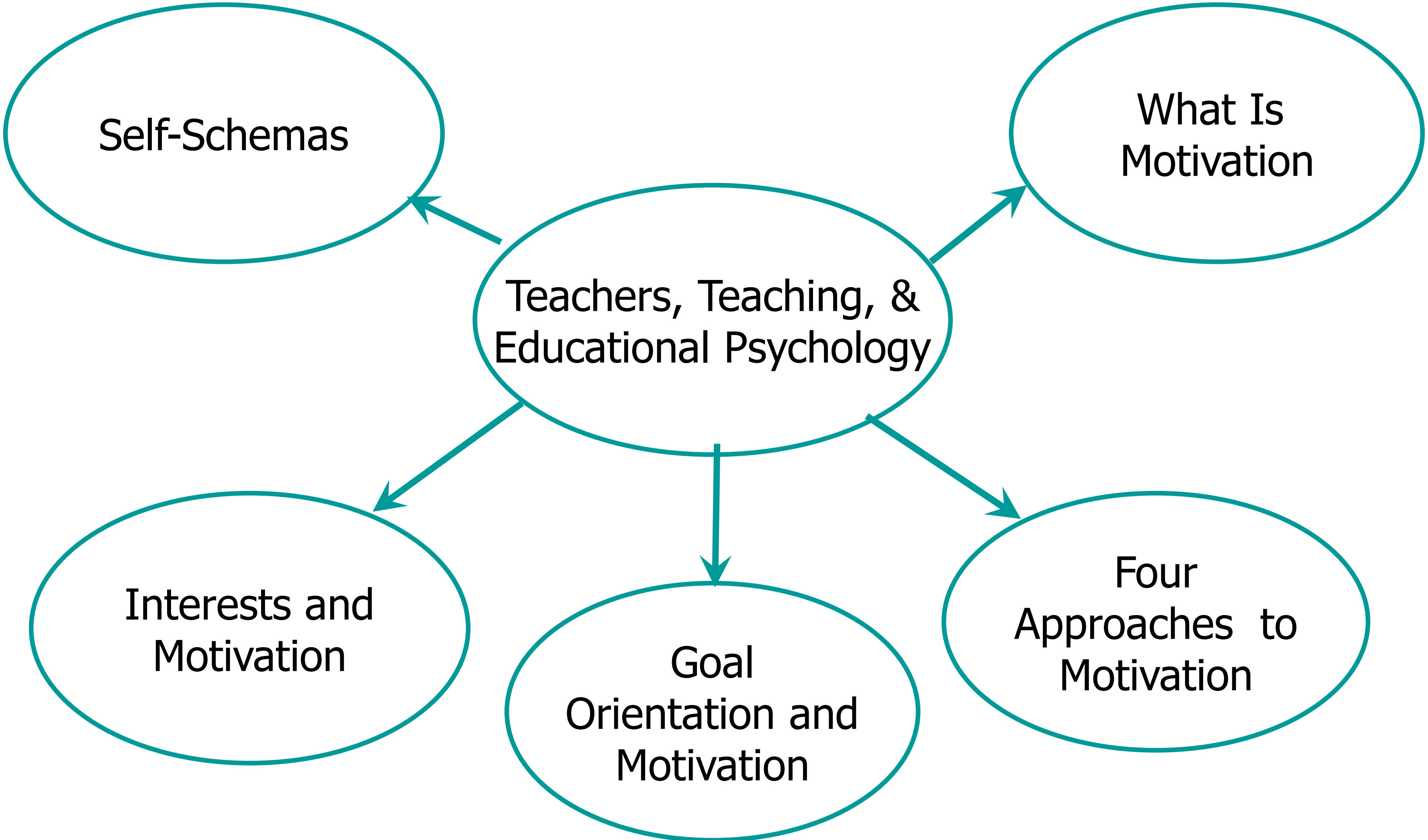
- **Step 1: Identify the source of the conflict**
- **Step 2: Look beyond the incident**
- **Step 3: Request solutions**
- **Step 4: Identify solutions both disputants can support**
- **Step 5: Agreement**

Motivation

- What Is Motivation?
- General Approaches to Motivation
- Goal Orientation and Motivation
- Interests and Motivation
- Self-Schemas

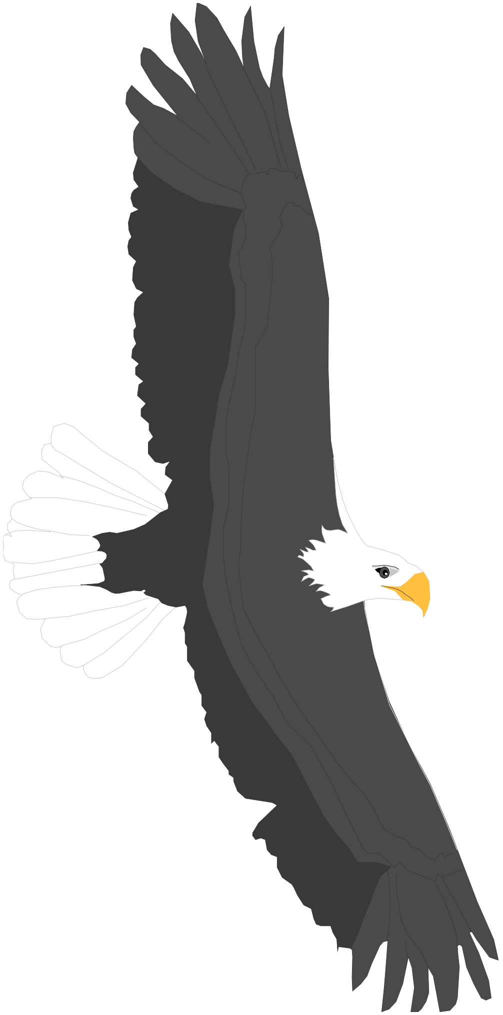
- Motivation defined:
  - Internal state
  - Arouses, directs, maintains behavior
- Intrinsic / Extrinsic
- Locus of causality

Concept Map


Self-Schemas
What Is Motivation
Teachers, Teaching, & Educational Psychology
Interests and Motivation
Goal Orientation and Motivation
Four Approaches to Motivation

Beliefs about Ability

- Entity view
- Incremental view
- Developmental differences
- Effects on types of goals



Beliefs about Self-Efficacy

- Self-efficacy, self-concept, & self-esteem
- Sources of self-efficacy
  - Mastery experiences
  - Vicarious experiences
  - Social persuasion
- Efficacy and motivation
- Teacher efficacy

Beliefs about Self

- Self-determination or other-determination
- Classroom environment & self-determination
- Cognitive evaluation theory
- Learned helplessness
- Self-worth
  - Mastery-oriented
  - Failure-avoiding
  - Failure-accepting

Leadership

Who is a leader?

What quality a leader should have?

Whom to call a leader?

Everybody seems to have a say when it comes to Leadership!!

Historical figures (Alexander, Napolean, Hitler??)

From business world (JRD Tata, Dhirubhai Ambani, Bill Gates etc..)

Leadership and the nature of an extraordinary life

1. *Be committed to a never-ending search for truth.*
2. *Take personal responsibility for the problems in your life.*
3. *Be committed to delaying gratification.*
4. *Be a person of honesty and integrity.*
5. *Be someone who is enrollable in life.*
6. *Be committed to living a life in which you do not make others wrong, you do not invalidate others, and you do not dominate others.*
7. *Be committed to courage.*
8. *Be a person who produces results in the world with absolutely no force.*
9. *Be a person who is peaceful in the chaos of life.*
10. *Be committed to the proposition that "Happiness is not the absence of problems, and it is not the accumulation of wealth or prestige".*
11. *Be committed to managing success, while being aware of its dangers.*

Thank You

BY:-Er. Manoj/Sachin

e-CONTENTS

on

IRRIGATION ENGINEERING

By:- Er. Sachin

1.1DEFINITION

The hub of a center-pivot irrigation system
Irrigation is the application of controlled amounts of water to plants at needed intervals. Irrigation helps to grow agricultural crops, maintain landscapes, and revegetate disturbed soils in dry areas and during periods of less than average rainfall.

1.2METHOD OF IRIGATION

There are three method of IRRIGATION

1.Surface Irrigation

2. Sub-Surface Irrigation

3. Sprinkler Irrigation

SUFACE IRRIGATION

Surface irrigation is the oldest form of irrigation and has been in use for thousands of years. In *surface* (*flood*, or *level basin*) irrigation systems, water moves across the surface of an agricultural lands, in order to wet it and infiltrate into the soil. Surface irrigation can be subdivided into furrow, *border strip or basin irrigation*. It is often called *flood .irrigation* when the irrigation results in flooding or near flooding of the cultivated land. Historically, this has been the most common method of irrigating agricultural land and is still used in most parts of the world.

SUB-SURFACE IRRIGATION

Drip (or micro) irrigation, also known as trickle irrigation, functions as its name suggests. In this system water falls drop by drop just at the position of roots. Water is delivered at or near the rootzone of plants, drop by drop. This method can be the most water-efficient method of irrigation,[32] if managed properly, evaporation and runoff are minimized.

SPRINKLER IRRIGATION

In *sprinkler* or overhead irrigation, water is piped to one or more central locations within the field and distributed by overhead high-pressure sprinklers or guns. A system using sprinklers, sprays, or guns mounted overhead on permanently installed risers is often referred to as a *solid-set* irrigation system.

1,3 ADVANTAGES OF IRRIGATION

1. For proper nourishment of crops certain amount of water is required. If rainfall is insufficient there will be deficiency in fulfillment of water requirement. Irrigation tries to remove this deficiency caused due to inadequate rainfall. Thus, irrigation comes to rescue in dry years.

2. Irrigation improves the yield of crops and makes people prosperous. The living standards of the people is thereby improved.

3. Irrigation also adds to the wealth of the country in two ways. Firstly as bumper crops are produced due to irrigation it makes country self-sufficient in food requirements. Secondly as the irrigation water is taxed when it is supplied to the cultivators, it adds to the revenue.

4. Irrigation makes it possible to grow cash crops which give good returns to the cultivators than the ordinary crops they might have grown in absence of irrigation. Fruit gardens, sugarcane, potato, tobacco etc., are the cash crops.

5. Sometimes large irrigation channels can be used as a means of communication.

1.4 DISADVANTAGES OF IRRIGATION

1. Excessive seepage and leakage of water forms marshes and ponds all along the channels. The marshes and the ponds in course of time become the colonies of the mosquito, which gives rise to a disease like malaria.

2. Excessive seepage into the ground raises the water-table and this in turn completely saturates the crop root-zone. It causes waterlogging of that area.

3. It lowers the temperature and makes the locality damp due to the presence of irrigation water.

4. Under irrigation canal system valuable residential and industrial land is lost.

5. Initial cost of irrigation project is very high and thereby the cultivators have to pay more taxes in the form of levy.

1.5 SINGLE AND MULTIPLE PROJECTS

Single purpose project are those where there is a single objective in minor projects the area irrigated is less than 2000 hectares and single purpose in nature

Multiple purpose projects are those where more than one objetivs is fullfille in medium projects are irrigated is between 2000 and 10000 hectares

1.6 QUALITY OF IRRIGATION WATER

The following are quality of irrigation water

SALTS ;Les than 700 ppm

BORON CONECTRATION ; Below 0.5 ppm

SODIUM CONECTRATION ; Less than 60% of total salts

1.7 TECHNICAL TERMS

- Hydroscopic Water: That water is adsorbed from an atmosphere of water vapour because of attractive forces in the surface of particles.
- Hysteresis: It is the log of in one of the two associated process or phenomena during reversion.
- Indicator Plant: It is the plant, which reflects specific growing condition by its presence or character of growth.
- Infiltration Rate: It is the maximum rate at which a soil under given condition and at given time can absorb water when there is no divergent flow at borders

- Intake Rate or Infiltration Velocity: It is the rate of water entry into the soil expressed as a depth of water per unit area applicable or divergence of flow in the soil.
- Irrigation Requirement: It refers to the quantity of water, exclusive of precipitation, required for crop production. This amounts to net irrigation requirement plus other economically avoidable losses. It is usually expressed in depth for given time.
- Leaching: It is removal of soluble material by the passage of water through the soil.
- Leaching Requirement: It is the fraction of water entering the soil that must pass through the root zone in order to prevent soil salinity from exceeding a specific value.
- Oasis effect: It is the exchange of heat whereby air over crop is cooled to supply heat for evaporation.
- Percolation: It is the down word movement of water through the soil.
- Permanent Wilting Point (PWP): Permanent wilting point is the moisture content in percentage of soil at which nearly all plants wilt and do not recover in a humid dark chamber unless water is added from an outside source. This is lower limit of available moisture range for plant growth ceases completely. The force with which moisture is held by dry soil this point corresponds to 15 atmospheres.
- Permeability: Permeability is the property of a porous medium to transmit fluids It is a broad term and can be further specified as hydraulic conductivity and intrinsic permeability.
- PF: It is the logarithm of height in cm of column of water which represents the total stress with which water is held by soil.
- PH: It is the negative logarithm of hydrogen ion concentration.
- Potential Evaporation: It represents evaporation from a large body of free water surface. It is assumed that, there is no effect of addictive energy .It is primarily a function of evaporative demand of climate.
- Potential Evapo-transpiration: It is the amount of water evaporated in a unit time from short uniform green crop growing actively and covering an extended surface and never short of water. Penman prefers the term potential transpiration.
- Seepage: It is the water escaped through the soil under gravitational forces.
- Agricultural Drainage: It is removal of excess water known as free or gravitational water from the surface or below the surface of farm land to create favorable condition for proper growth and development of the plot.

- Surface Drainage: when the excess water saturates the pores spaces removal of water of water by downward flow through the soil is called subsurface drainage.

WATER REQUIREMENT OF CROPS

2.1 GENERAL

The water requirement of crops is growth of crops as soil fertility is must be .

The water requirements of crops means the total quantity of crops

2.2 Common Indian Soil

- Clayey Soil
- Sandy Soil
- Black Cotton Soil
- Laterite Soil
- Alluvial Soil
- Residual Soil

2.3 BASE PERIOD

The time between the first watering the crop during sowing it last watering before harvesting

2.4 DELTA

Every crops require certain amount water after fixed interval of time during of growth

The depth of water required each time various from 5 to 10 cm .it is denoted by DELA

2.5 DUTY

Duty of water is the lesion between the volume of water field area of the crops it mature .it is denoted by D

2.6 FACTOR AFFCTING THE DUTY OF CANAL SYSTEM

1.Method and system of irrigation
(i) Furrow method ⇢ High duty
(ii) flood irrigation ⇢less duty than furrow system
(iii) Perennial system ⇢ high duty
(iv) Inundation system ⇢ low duty than the perennial system
(v) basin irrigation ⇢ low duty

2.Types of Crops
Different crops needs completely different quantities of water. So, duty of water varies from crop to crop. The crops that need large volume of water have lower duty of water than for the crops which needs less amount of water.

3. Quality of irrigation water
(i) Harmful salt and alkali content leads to a lower duty of water due to the wastage of considerable amount of water.
(ii) Fertilizing matter in water increase duty

4.Method of Cultivation:
If the land is correctly plowed up to the specified depth and created quite loose before irrigating, the soil can have high water holding capability within the root zone of the plants. this may cut back the quantity of watering and hence result in a higher duty of water.
5.Time of irrigation
(i) within the initial stages, the land to be cultivated might, not be properly leveled arid hence more than the required amount of water may be applied, which leads to a lower duty of water.
5.Time of irrigation
(i) within the initial stages, the land to be cultivated might, not be properly leveled arid hence more than the required amount of water may be applied, which leads to a lower duty of water.

(ii) Gradual rise of water table with time because of continuous irrigation. will make water accessible in the root zone of the plants, therefore comparatively less amount of water are going to be needed to be applied ,which will result in a higher duty of water.
6. Canal Condition
(i) Earthen canal⇢ percolation loss is high ⇢which leads a lower duty of water.

(ii) Lined canal⇢ percolation loss will be less⇢ hence ,the duty of water will be high.
7. Climatic condition of the area
The climatic condition which affect the duty of water is
(i) Temperature ⇢ high temperature ⇢loss of water will be more due to Evapotranspiration ⇢so, low duty

(ii) wind-higher wind velocity-loss of water will be more due to evaporation -low duty.

(iii) Humidity⇢ high humidity⇢ loss of water will be less due to Evapotranspiration's, high duty.

(iv) Rainfall l⇢ increase duty
8. Base periods of crops
When base period of a crop is long, more water may be required so leading to a lower duty of water.

9. Character of soil and sub soil of the canal
(i) Coarse grained soil⇢ seepage and percolation losses are high⇢so less duty.

(ii) Fined grained soil⇢ Percolation losses are less ⇢so, high duty.
10. Method of assessment
(i) Volumetric method⇢moreduty(economical use of water)
(ii)crop rate or area basis⇢less duty(more water to be used)

2.7 INDIAN CROPES AND THERE CLASSIFICATION

A crop is a plant that is cultivated or grown on a large scale. Crops are generally grown so they can be commercially traded. i.e any plant that is grown and harvested extensively for profit purposes. There are two major types of crops that are grown in India. Let us take a look at these.

Kharif Crops

The word "Kharif" is Arabic for autumn since the season coincides with the beginning of autumn or winter. Kharif crops also are known as *monsoon crops*. These are the crops that are cultivated in the monsoon season. The Kharif season differs in every state of the country but is generally from June to September. These crops are usually sown at the beginning of the monsoon season around June and harvested by September or October. Rice, maize, bajra, ragi, soybean, groundnut, cotton are all Kharif types crops. Let us take a detailed look at few of these,

Rabi Crops

The Arabic translation of the word “Rabi” is spring. These crops’ harvesting happens in the springtime hence the name. The Rabi season usually starts in November and lasts up to March or April. Rabi crops are mainly cultivated using irrigation since monsoons are already over by November. In fact, unseasonal showers in November or December can ruin the crops. The seeds are sown at the beginning of autumn, which results in a spring harvest. Wheat, barley, mustard and green peas are some of the major rabi types of crops that grow in India.

2.8 CROP ROTATION

Crop rotation is the practice of growing a series of dissimilar or different types of crops in the same area in sequenced seasons. It is done so that the soil of farms is not used for only one set of nutrients. It helps in reducing soil erosion and increases soil fertility and crop yield.

2.9 CROSS COMMANDED AREA (G.C.A)

These terms are mainly used in canal irrigation engineering. When a new canal is constructed, the engineers create its design maps etc.

Gross Command Area=Cultivable Command Area + Uncultivable Area

2.10 CULTURABLE COMMANDED AREA (C.C.A)

Cultivable Command Area is that part of Gross Command Area, which is fit for cultivating crops. So, cultivable area excludes forest and barren land fr

2.11 INTENSITY F IRRIGATION

Once the amount of water to be taken as seasonally available for design purposes is determined, the key question is then the area to be supplied. This involves consideration of cropping pattern, water requirements of individual crops, land availability, and the socioeconomic question of intensity of irrigation.

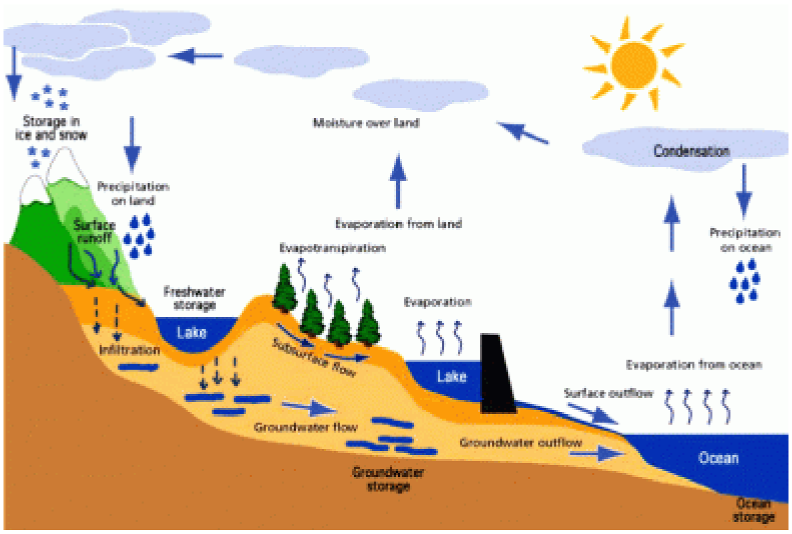
RAINFALL AND RUN-OFF

3.1 HYDROLOGY

“The study of water in all its forms (rain, snow and water on the earth’s surface), and from its origins to all its destinations on the earth is called hydrology.”

3.2 HYDROLOGY CYCLE

The hydrologic cycle describes the continuous re–circulating transport of the waters of the earth, linking atmosphere, land and oceans.



3.3 RUNOFF AND SURFACE RUNOFF

Surface runoff (also known as overland flow) is the flow of water that occurs when excess stormwater, meltwater, or other sources flows over the Earth's surface. This might occur because soil is saturated to full capacity, because rain arrives more quickly than soil can absorb it, or because impervious areas (roofs and pavement) send their runoff to surrounding soil that cannot absorb all of it. Surface runoff is a major component of the water cycle.

3.4 HYDROGRAPH

A hydrograph is a graph showing the rate of flow (discharge) versus time past a specific point in a river, channel, or conduit carrying flow. The rate of flow is typically expressed in cubic meters or cubic feet per second (cms or cfs). It can also refer to a graph showing the volume of water reaching a particular outfall, or location in a sewerage network. Graphs are commonly used in the design of sewerage, more specifically, the design of surface water sewerage systems and combined sewers.

3.5 MEASURMENT OF RAINFALL

There are four types of measurement of rainfall

1 . STANDRAD RAIN GAUGE

2. SYMONS RAIN GAUGE

3. AUTOMATICE RECORDING RAIN GAUGE

4. FLOAT TYPE AUTOMATIC RAIN GAUGE

3.6 FACTOR AFFECTNG RUNOFF

Amount of rainfall is affected by many factors. Main factor is atmospheric temperature. Pressure is also a factor. Wind speed and direction are the two other important factors that determines the type, occurrence and amount of precipitation. Also the characteristics of particular land influence the rainfall.Mountains,plateaus,forests all of these have influence in rainfall.

3.7 UNIT HYDROGRAPH

It can be defined as the direct runoff hydrograph (DRH) resulting from one unit (e.g., one cm or one inch) of effective rainfall occurring uniformly over that watershed at a uniform rate over a unit period of time.

3.8 ASSUMPTION OF UNIT HYDROGRAPH

- This model is based on the pure translation method, which assumes that all flow at any particular location flows with the same speed. The model does not take into account storage effects of the watershed.
- The unit hydrograph is a linear response function of the watershed. It assumes that the time base of the hydrograph remains constant regardless of the amount of
  resulting from different storms with the same duration.

METHOD OF IRRIGATION

4.1 METHOD OF IRRIGATION

1. Surface Irrigation:

In this method water flows and spreads over the surface of the land. Varied quantities of water are allowed on the fields at different times. Hence, flow of water under surface irrigation comes under unsteady flow. As a result it is very difficult to understand the hydraulics of surface irrigation. However, suitable and efficient surface irrigation method can be adopted after taking into consideration various factors which are involved in the hydraulics of surface irrigation.

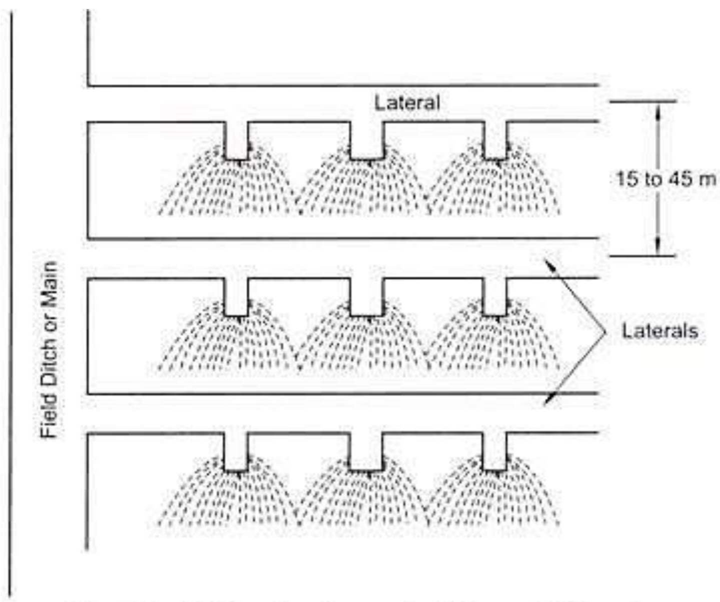


Fig. 6.1. (a) Free-flooding method for erodable soils

2. Overhead or Sprinkler Irrigation:

In this method an attempt is made to simulate natural rainfall. Irrigation water is applied to the land in the form of a spray. This method is also known as sprinkler irrigation,

Fig. 6.6.

Sprinkler Irrigation

3. Drip or Trickle Irrigation:

It is a latest advancement over other methods. The name of the method itself implies water saving. In this method irrigation water is conveyed on the surface in 12 to 16 mm diameter tubing’s fed from large feeder pipes. The water is allowed to drip or trickle slowly through the nozzle or orifices at practically zero pressure. In this way the soil in the root-zone of crops is constantly kept wet.

4.2 ADVANTAGES AND DISADVANTAGES

The advantages and disadvantages of subsurface drip irrigation (SDI) as compared to alternative

irrigation systems are conceptually discussed. Each category (advantages and disadvantages) is

subdivided into three groups: 1) Water and soil issues; 2) Cropping and cultural practices, and 3)

System infrastructure issues. The adaptation and adoption of SDI systems into diverse cropping

systems, geographical regions, soils and climate depends, to a large extent, on how potential

advantages are balanced against potential disadvantages. In some cases, just a few advantages are expressed for a given cropping system, but are expressed so strongly that they provide a good

counterbalance to the potential disadvantages.

DESIGN OF IRRIGATION CANAL

5.1 GENERAL

The entire water conveyance system for irrigation, comprising of the main canal, branch canals, major and minor distributaries, field channels and water courses have to be properly designed.

5.2 CROPING PATTERN

Cropping pattern means the preparation of area under the different crops (the rotation of crops and the area under double cropping in the country). According *to P.V John* "The term cropping pattern indicates the product mix or crop mix, which the cultivator gets from his land". The analysis of this kind is necessary an identification of the major crops that are grown in the district or state. The farmers generally produce two types of crops, food crops and non-food crops or commercial crops. Mere commercial crops like cotton, sugarcane, coffee, tea depending on irrigation. The study of these two crops would reveal the stages of the agricultural development and the nature of the economy. It is generally observed that larger the area under non-food crops greater will be the development. Balanced cropping means to grow both food and commercial crops in sufficient required proportions

5.3 CLASSIFICATION OF CANAL

Irrigation canal.

Navigation canal.

Power canal.

Carrier canal.

Link canal.

Feeder canal.

5.4 ALIGNMENT OF CANAL

Irrigation canals can be aligned in any of the three ways:

1. As watershed canal

2. As contour canal; and

3. As side �'slope canal

Watershed Canal. The dividing line between the catchment area of two drains (streams) is called the watershed. Thus, between two major stream, there is the main watershed which divides the drainage areas of the two. Similarly, between any tributary and the main stream, and also between any two tributaries there, are subsidiary watersheds, dividing the drainage between the two streams on either side.

For canal system in plain areas, it is often necessary as well as advantageous to align all channels on the watersheds of the areas, they are designed to irrigate. The canal, which is aligned along any natural watershed, is called a watershed canal. From such a canal irrigation, water is taken out by gravity on either side of the canal, directly or through small irrigation channels.

Moreover, cross �'drainage works are avoided, as the natural drainage will never cross a watershed, because all the drainage flows away from the watershed. Sometimes, watershed may have to be abandoned in order to bypass localities settled on the watershed.

(ii) Contour Canal: The above arrangement of providing the canals along the watershed is not possible in hill areas. In the hills, the river flows in the valley, while the watershed or the ridge line may be hundred of metres above it. It becomes uneconomical to take the canal on top of such a ridge. The channel, in such cases, is generate sufficient flow velocities, are given to it.

The maximum designed slope that can be provided in the canal without generating excessive velocities, is generally less than the available country slope. The difference is accommodated by providing canal falls at suitable places. A contour channel irrigates only on one side, because the areas on the other side are higher.

As the drainage flow is always at right angles to the ground contours, such a channel would definitely have to cross drainage lines. Suitable cross drainage works are then provided.

(iii) Side Slope Canal: A side slope channel is that which is aligned at right angles to the contours, i.e. along the side slopes, as shown in figure.

Such a channel is parallel to the natural drainage flow and hence, does not intercept cross drainage, and hence no cross drainage works are required.

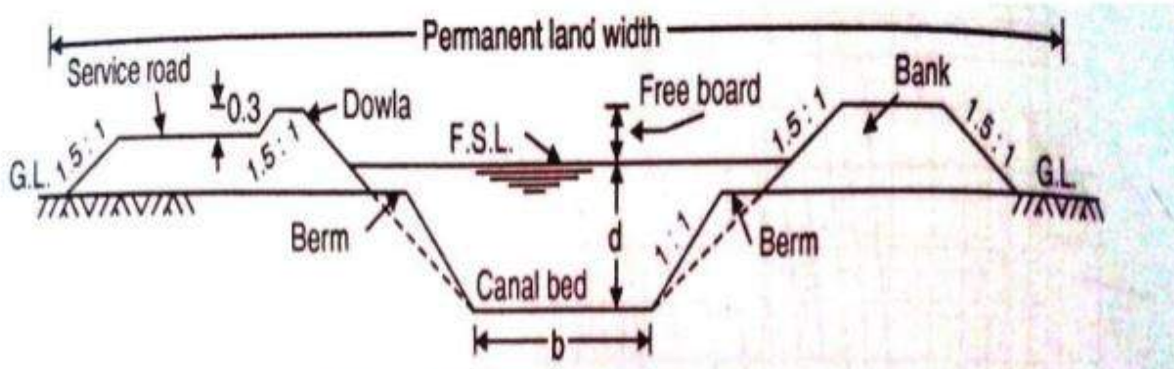
5.4 SILT THEORIES

There are two theorys

1. Kennedy'stheory
2. Lacey's theory

5.5 CANAL SECTION

Cross-section of canal:-



(a) Canal section in part cutting and filling

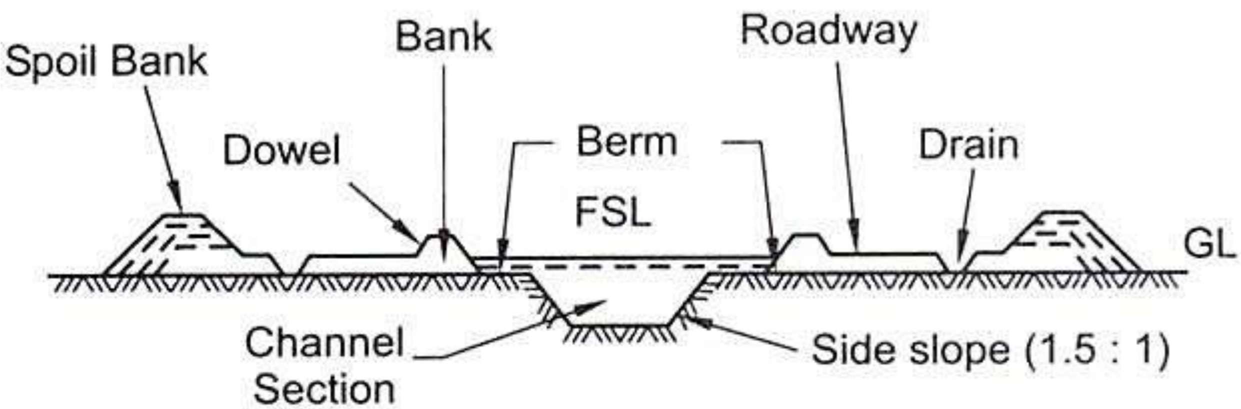
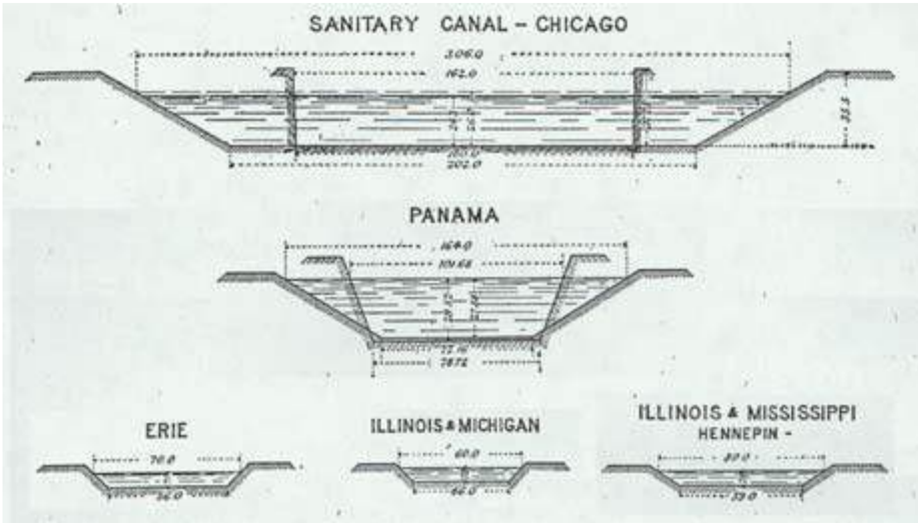


Fig. 9.9. Typical cross-section of canal showing component parts



5.5 ELEMENTS OF CANAL SECTION

1. BERMS
2. SIDE SLOPES
3. BANKS
4. SPOILS BANKS
5. FREE BOARD
6. SERVICE ROAD
7. DOWLA
8. BORROW PITS

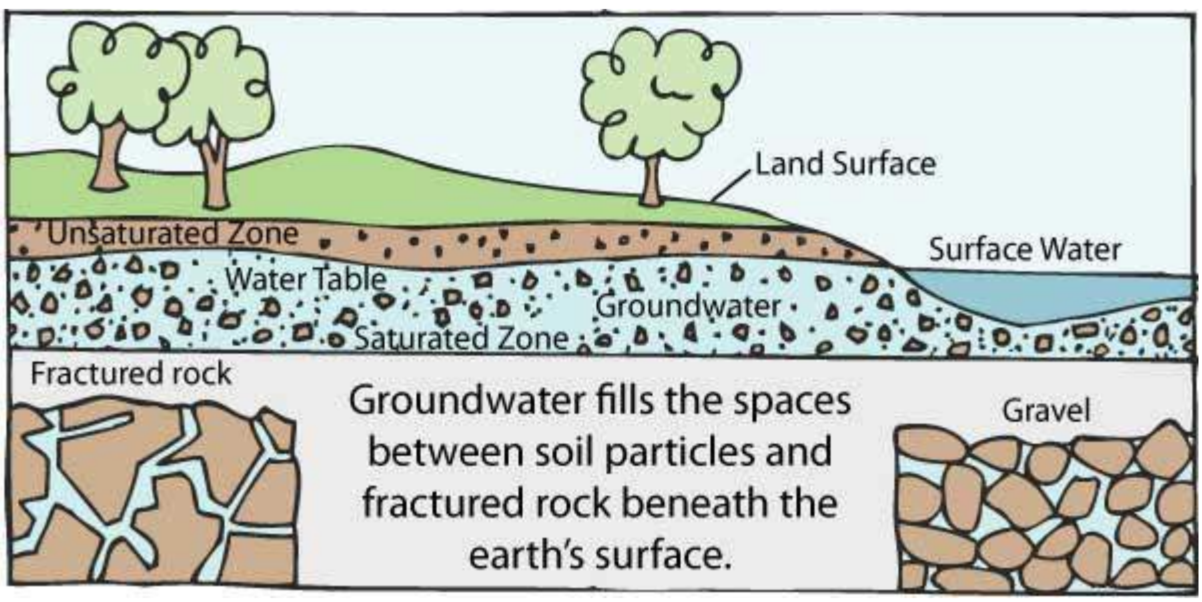
5.6 MAINTENANCE OF CANAL IRRIGATION

Improvements, such as the lining of a canal section, may be postponed until the end of an irrigation season, when canals are dry and farmers have more time available. ... Maintenance of an irrigation canal system is usually carried out in between two irrigation seasons, or at times of low water demand.

TUBE WELL IRRIGATION

6.1 GROUND WATER

Groundwater is the water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rocks called aquifers.



6.2 DIFFERENT FORMS OF GROUND WATER

Groundwater Occurrence and Types of Ground Water

Rivers.

Lakes.

Natural springs.

Rain.

Snow.

Glaciers.

Aquifers etc.

6.3 ACQUIFERS

An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt). Groundwater can be extracted using a water well. The study of water flow in aquifers and the characterization of aquifers is called hydrogeology.

There are two types of Aquifers

1. UNCONFINED aquifers
2. CONFINED aquifers

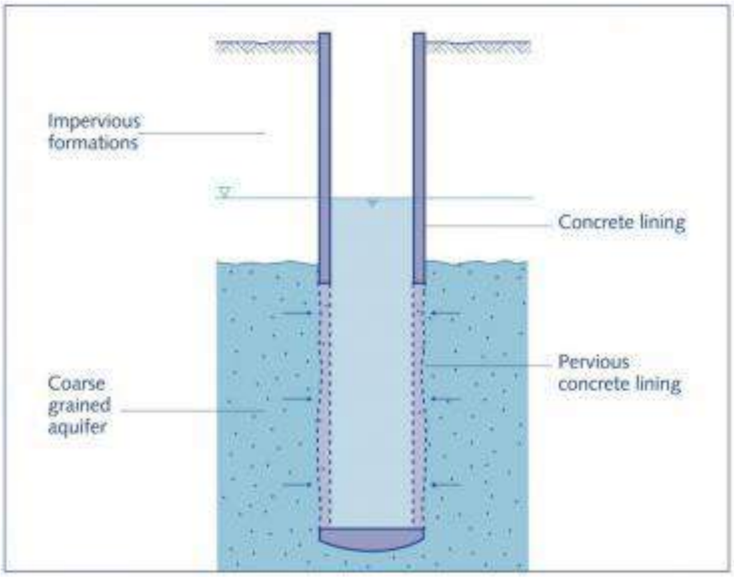
6.4 CLASSIFICATION OF WELL

There are three classification of well

1. DUG WELL
2. DRIVEN WEL
3. TUBE WELL

DUG WELL

Dug wells are holes in the ground dug by shovel or backhoe. Historically, a dug well was excavated below the groundwater table until incoming water exceeded the digger's bailing rate. The well was then lined (cased) with stones, brick, tile, or other material to prevent collapse.



6.5 TYPES OF TUBE WELL

1. Strainer Type Tube Wells:

In tube wells the metal pipe driven in ground is perforated to allow only clear water to enter the hole. It is obvious that if no other means is adopted the perforations in the metal tube will have to be made very fine. It is very costly process.

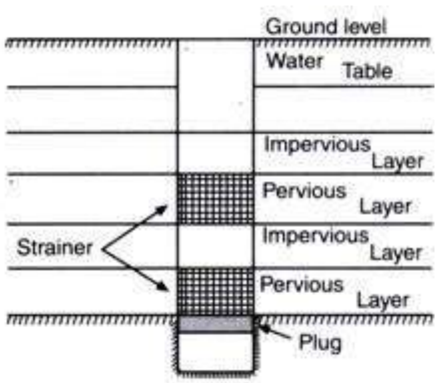


Fig. 18.1. Strainer type tubewell

2. Cavity Type Tube Well:

In this type water contribution to bore hole takes place through the bottom layer only. From Fig. 18.2, it is clear that in principle it is similar to the category of the deep wells under open wells.

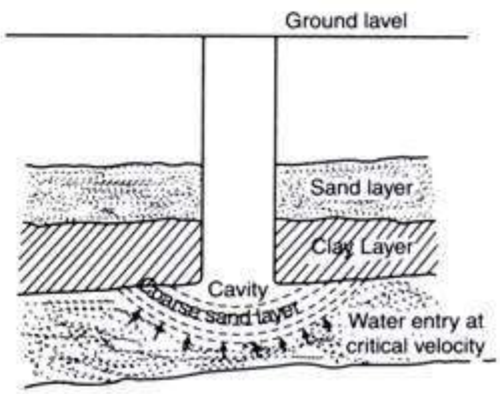


Fig. 18.2. Cavity type tubewell

3. Slotted Type Tube well:

Sometimes the nature of subsoil formation is not anticipated correctly. Obviously bore hole driven for constructing strainer well will be a failure. If a mota formation is present cavity well may be resorted to. But if neither of the conditions are existing the slotted tube well can be rightly constructed. There should be of course an aquifer present at the bottom.

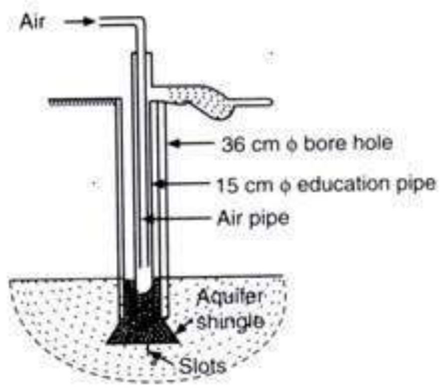
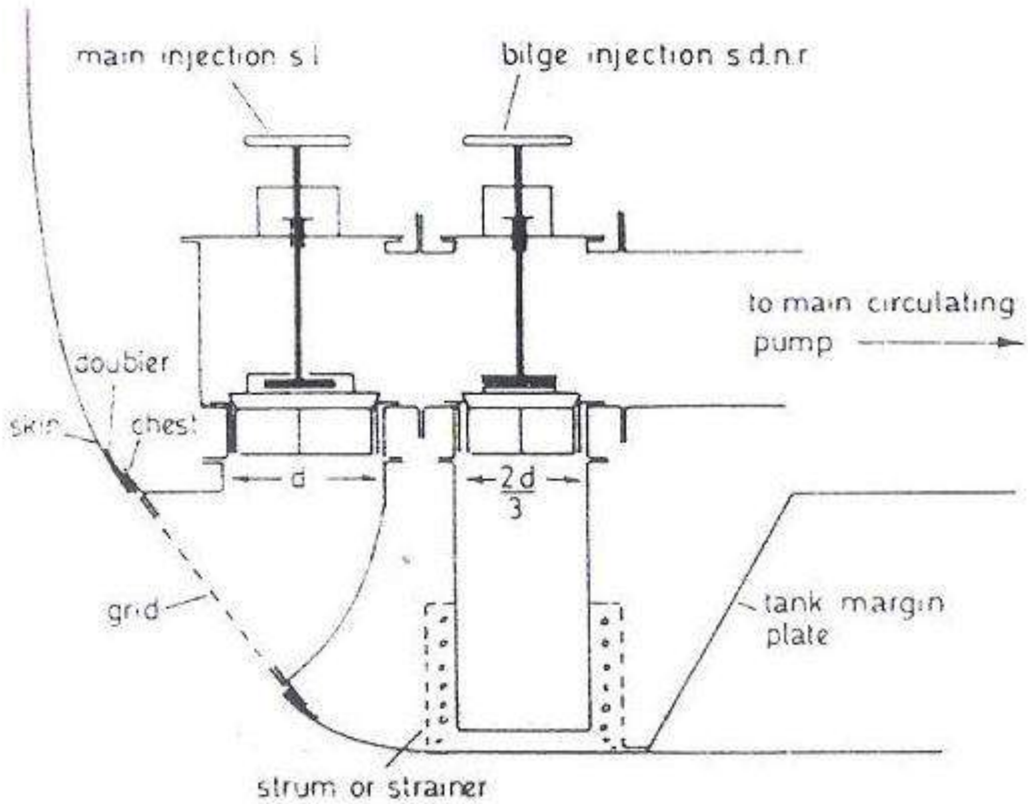


Fig. 18.3. Slotted type tubewell

6.5 PUMPING ARRENGMENT



There are two typrs of pumping arrengment

1. BORE HOLES
2. CENTRIFUGAL

DAMS AND RESERVOIRS

7.1 GENERAL

A reservoir usually means an enlarged natural or artificial lake, storage pond or impoundment created using a dam or lock to store water. Reservoirs can be created by controlling a stream that drains an existing body of water. They can also be constructed in river valleys using a dam.

7.2 TYPES OF DAMS

1. ARCHED DAM
2. BUTTERESS DAM
3. COFFER DAM
4. DIVERSION DAM
5. EARTH DAM
6. GRAVITY DAM
7. MESONARY DAM
8. ROCK FILL DAM
9. STEL DAM
10. TIMBER DAM

7.3 CLASSIFICATION OF DAM

1. Storage of water for water supply scheme
2. Storage of water for flood control
3. Storage and control of water for increasing water dept for nagivation
4. Storage for hydroelectric projects
5. Storage and control of water for irrigation
6. Storage for reclamation of low lying lands
7. Storage for recreation purpose such as boating

THANKS

By:- Er. Sachin

e-CONTENTS

ON

CONCRETE TECHNOLOGY

4th semester

Er. Manoj Kumar
Lecturer

CIVIL ENGINEERING

Govt. Polytechnic, Nanakpur

UNIT- 1

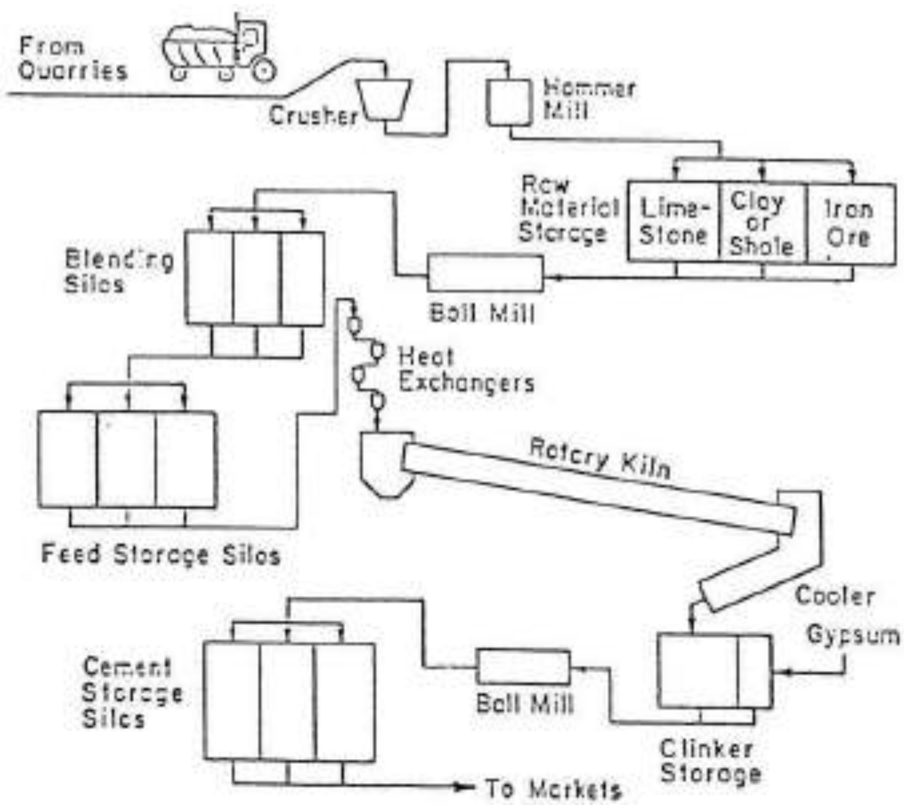
Cement, Aggregates and Admixtures

1.1 Portland Cement

Concrete is made by portland cement, water and aggregates. Portland cement is a hydraulic cement that hardens in water to form a water-resistant compound. The hydration products act as binder to hold the aggregates together to form concrete. The name portland cement comes from the fact that the colour and quality of the resulting concrete are similar to Portland stone, a kind of limestone found in England.

1.1.1 Manufacture of Portland cement

Portland cement is made by blending the appropriate mixture of limestone and clay or shale together and by heating them at 1450^{O}C in a rotary kiln. The sequence of operations is shown in following figure. The preliminary steps are a variety of blending and crushing operations. The raw feed must have a uniform composition and be a size fine enough so that reactions among the components can complete in the kiln. Subsequently, the burned clinker is ground with gypsum to form the familiar grey powder known as Portland cement.



The raw materials used for manufacturing Portland cement are limestone, clay and Iron ore. a) Limestone ($CaCO_3$) is mainly providing calcium in the form of calcium oxide (CaO)

$$CaCO_3\ (1000^oC) \rightarrow CaO + CO_2$$

b) Clay is mainly providing silicates (SiO_2) together with small amounts of $Al_2O_3 + Fe_2O_3$

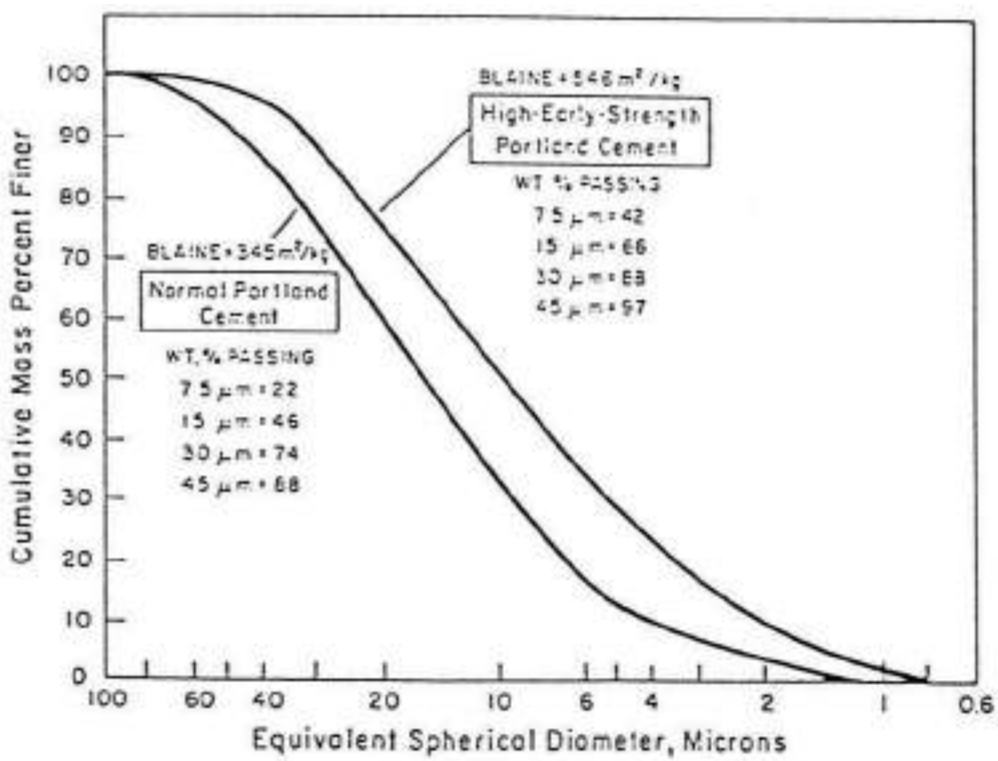
$$Clay\ (1450^oC) \rightarrow SiO_2 + Al_2O_3 + Fe_2O_3 + H_2O$$

c) Iron ore and Bauxite are providing additional aluminium and iron oxide (Fe_2O_3) which help the formation of calcium silicates at low temperature. They are incorporated into the raw mix.

Limestone		$3\ CaO^oSiO_2$
	High temperature	$2\ CaO^oSiO_2$
Clay	$\longrightarrow$	
	($1{,}450\ ^oC$)	$3\ CaO^oAl_2O_3$
Iron Ore, Bauxite		$4\ CaO^oAl_2O_3{}^oFe_2O_3$

d) The clinker is pulverized to small sizes (< 75 µm). 3-5% of gypsum (calcium sulphate) is added to control setting and hardening.

The majority particle size of cement is from 2 to 50 µm. A plot of typical particle size distribution is given below. (Note: "Blaine" refers to a test to measure particle size in terms of surface area/mass)



1.1.2 Chemical composition

a) Abbreviation:

CaO = C, SiO_2 = S, Al_2O_3 = A; Fe_2O_3 =F, $Ca(OH)_2$ = CH,

H_2O = H, $SO_3 = \bar{S}$ (sulphur trioxide)

Thus we can write 3 CaO = C_3 and 2 $CaO^{o}SiO_2$ = C_2S.

b) Major compounds:

Compound	Oxide composition	colour	Common name	Weight percentage
Tricalcium Silicate	C_3S	white	Alite	50%
Dicalcium Silicate	C_2S	white	Belite	25%
Tricalcium Aluminate	C_3A	white/grey	---	12%
Tetracalcium Aluminoferrite	C_4AF	black	Ferrite	8%

Since the primary constituents of Portland cement are calcium silicate, we can define Portland cement as a material which combine CaO SiO_2 in such a proportion that the resulting calcium silicate will react with water at room temperature and under normal pressure.

c) Minor components of Portland cement

The most important minor components are gypsum, MgO, and alkali sulphates.

Gypsum ($2CaSO_4{}^{o}2H_2O$) is an important component added to avoid flash set.

Alkalies (MgO, Na_2O, K_2O) can increase pH value up to 13.5 which is good for reinforcing steel protection. However, for some aggregates, such a high alkaline environment can cause alkali aggregate reaction problem.

1.1.3 Hydration

The setting and hardening of concrete are the result of chemical and physical processes that take place between Portland cement and water, i.e. hydration. To understand the properties and behaviour of cement and concrete some knowledge of the chemistry of hydration is necessary.

A) Hydration reactions of pure cement compounds

The chemical reactions describing the hydration of the cement are complex. One approach is to study the hydration of the individual compounds separately. This assumes that the hydration of each compound takes place independently of the others.

I. Calcium silicates

Hydration of the two calcium silicates gives similar chemical products, differing only in the amount of calcium hydroxide formed, the heat released, and reaction rate.

$2\ C_3S + 7\ H \rightarrow C_3S_2H_4 + 3\ CH$ $2\ C_2S + 5\ H \rightarrow C_3S_2H_4 + CH$

The principal hydration product is $C_3S_2H_4$, calcium silicate hydrate, or C -S-H (non-stoichiometric). This product is not a well-defined compound. The formula $C_3S_2H_4$ is only an approximate description. It has amorphous structure making up of poorly organized layers and is called glue gel binder. C-S-H is believed to be the material governing concrete strength. Another product is CH - $Ca(OH)_2$, calcium hydroxide. This product is a hexagonal crystal often forming stacks of plates. CH can bring the pH value to over 12 and it is good for corrosion protection of steel.

II. Tricalcium aluminate

Without gypsum, C_3A reacts very rapidly with water:

$C_3A + 6\ H \rightarrow C_3AH_6$

The reaction is so fast that it results in flash set, which is the immediate stiffening after mixing, making proper placing, compacting and finishing impossible.

With gypsum, the primary initial reaction of C_3A with water is :

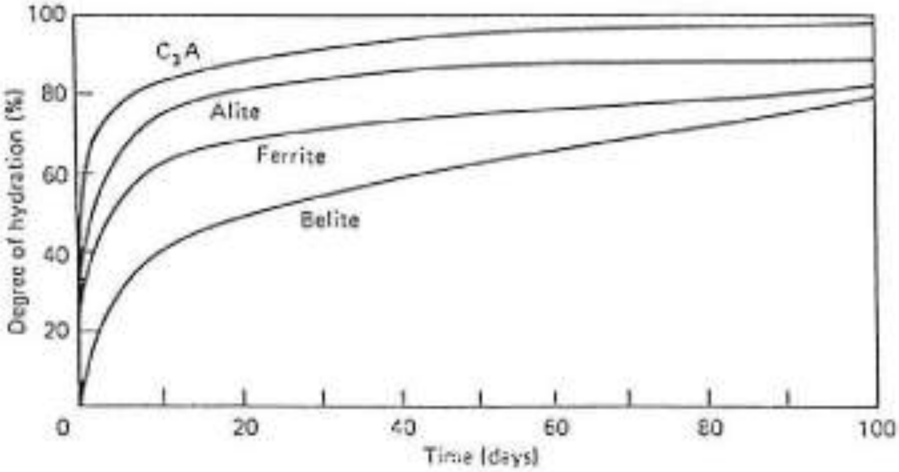
$C_3A + 3\ (C\bar{S}H_2) + 26\ H \rightarrow C_6A\bar{S}_3H_{32}$

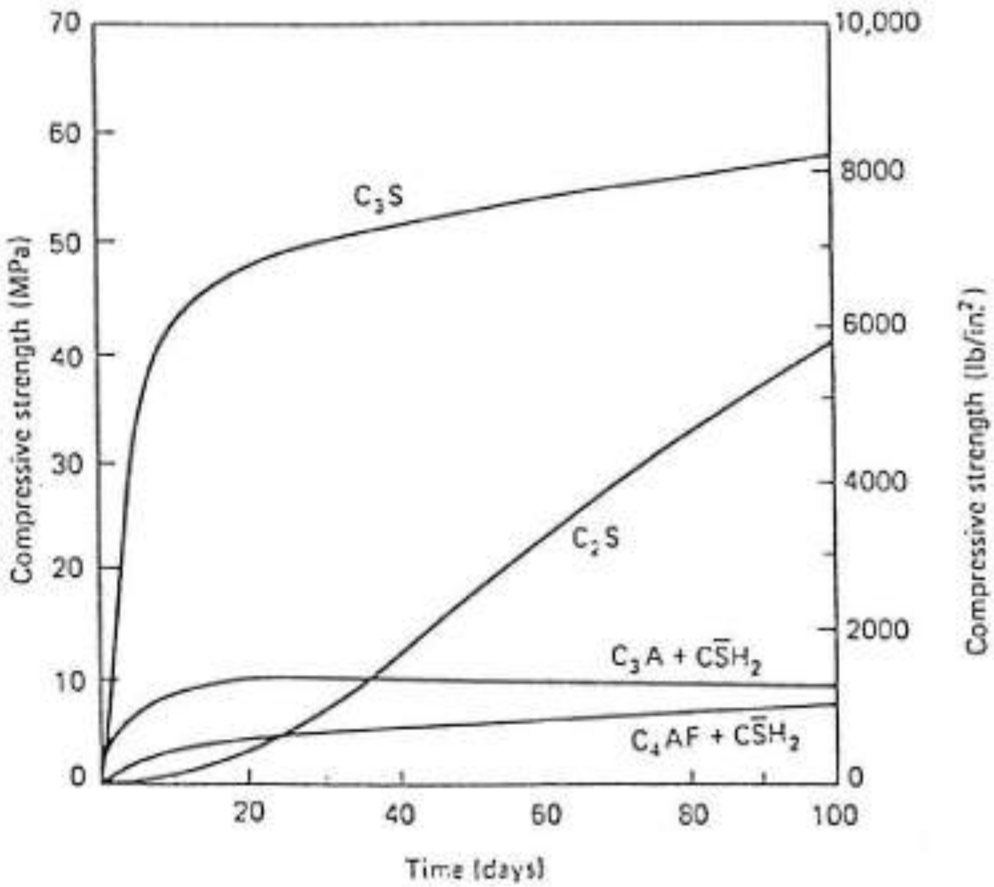
The 6 -calcium aluminate trisulfate-32-hydrate is usually called ettringite. The formation of ettringite slows down the hydration of C_3A by creating a diffusion barrier around C_3A. Flash set is thus avoided. Even with gypsum, the formation of ettringite occurs faster than the hydration of the calcium silicates. It therefore contributes to the initial stiffening, setting and early strength development. In normal cement mixes, the ettringite is not stable and will further react to form monosulphate ($C_4A\bar{S}H_{18}$).

B) Kinetics and Reactivities

The rate of hydration during the first few days is in the order of $C_3A > C_3S > C_4AF > C_2S$.

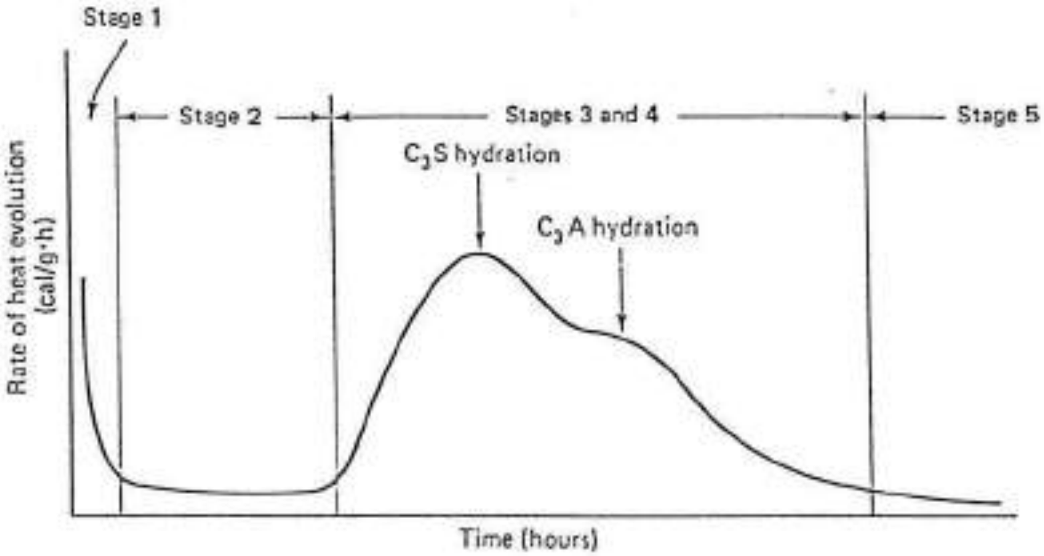
Their reactivities can be observed in the following figures.





C) Calorimetric curve of Portland cement

A typical calorimetric curve of Portland cement is shown in the following figure. The second heat peaks of both C_3S and C_3A can generally be distinguished, although their order of occurrence can be reversed.



From the figure, five stages can be easily identified. Since C_3S is a dominating component in cement, the five stages above can be explained using the reaction process of C_3S by the following table.

Reaction Stage	Kinetics of Reaction	Chemical Processes	Relevance to Concrete
1. Initial hydrolysis	Chemical control; rapid	Initial hydrolysis; dissolution of ions	-
2. Induction period	Nucleation control; slow	Continued dissolution of ions	Determines initial set
3. Acceleration	Chemical control: rapid	Initial formation of hydration products	Determines final set and rate of initial hardening
4. Deceleration	Chemical and diffusion control; slow	Continued formation of hydration products	Determines rate of early strength gain
5. Steady State	Diffusion control; slow	Slow formation of hydration products	Determines rate of later strength gain

On first contact with water, calcium ions and hydroxide ions are rapidly released from the surface of each C_3S grain; the pH values rises to over 12 within a few minutes. This hydrolysis slows down quickly but continues throughout the induction period. The induction (dormant) period is caused by the need to achieve a certain concentration of ions in solution before crystal nuclei are formed for the hydration products to grow from. At the end of dormant period, CH starts to crystallize from solution with the concomitant formation of C-S-H and the reaction of C_3 S again proceeds rapidly (the third stage begin). CH crystallizes from solution, while C-S-H develops from the surface of C_3 S and forms a coating covering the grain. As hydration continues, the thickness of the hydrate layer increases and forms a barrier through which water must flow to reach the unhydrated C_3S and through which ions must diffuse to reach the growing crystals. Eventually, movement through the C-S-H layer determines the rate of reaction. The process becomes diffusion controlled.

D) Setting and Hydration

Initial set of cement corresponds closely to the end of the induction period, 2-4 hours after mixing. Initial set indicates the beginning of forming of gel or beginning of solidification. It represents approximately the time at which fresh concrete can no longer be properly mixed, placed or compacted. The final set occurs 5-10 hours after mixing, within the acceleration period. It represents approximately the time after which strength develops at a significant rate.

In practice, initial and final set are determined in a rather arbitrary manner with the penetration test. While the determination of initial and the final set has engineering significance, there is no fundamental change in hydration process for these two different set conditions.

1.1.4 Types of Portland cements

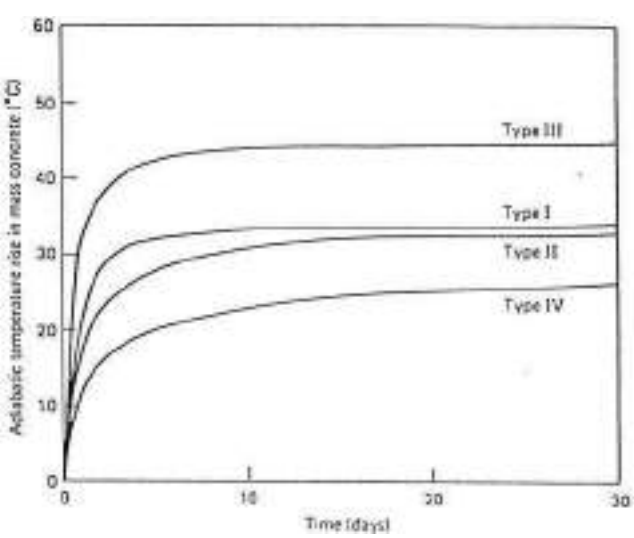
According to ASTM standard, there are five basic types of Portland cement.

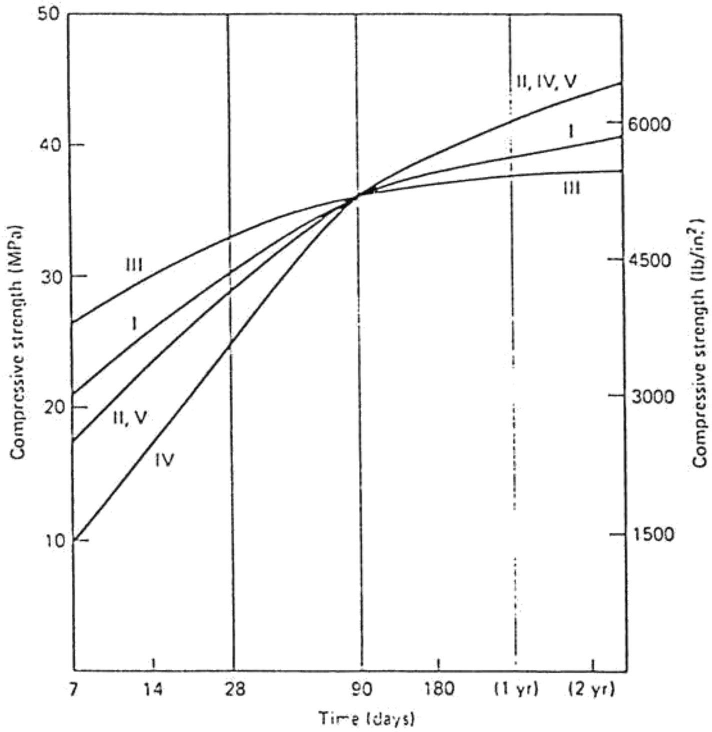
Type I Regular cement, general use, called OPC
Type II Moderate sulphate resistance, moderate heat of hydration, $C_3A < 7\%$
Type III With increased amount of C_3S, High early strength
Type IV Low heat
Type V High sulphate resistance –
(Note: sulphates can react with $C_4A\ S\ H_{18}$ to from an expansive product. By reducing the C_3A content, there will be less $C_4A\ S\ H_{18}$ formed in the hardened paste)

Their typical chemical composition is given in the following table:

	I	II	III	IV	V
C_3S	50	45	60	25	40
C_2S	25	30	15	50	40
C_3A	12	7	10	5	4
C_4AF	8	12	8	12	10
$C\bar{S}H_2$	5	5	5	4	4
Fineness (Blaine, m^2/kg)	350	350	450	300	350
Compressive strength at 1 day, MPa (psi)	7 (1,000)	6 (900)	14 (2,000)	3 (450)	6 (900)
Heat of hydration (7 days, J/g)	330	250	500	210	250

From the above table, we can evaluate the behaviour of each type of cement and provide the standard in selecting different cement types. The following figures show the strength and temperature rise for the different types of cement.





These graphs provide the basic justification in selecting the cement for engineering application. For instance, for massive concrete structure, hydration heat is an important consideration because excessive temperature increase (to above 50-60^{o}C) will cause expansion and cracking. Hence, type IV cement should be the first candidate and Type III should not be used. For a foundation exposed to groundwater with high concentration of sulphates, high sulphate resistance is needed. Thus, type V should be selected. If high early strength is needed, type III will be the best choice. But, generally, type I is the most popular cement used for civil engineering.

1.1.5 Porosity of hardened cement paste and the role of water

Knowledge of porosity is very useful since porosity has a strong influence on strength and durability. In hardened cement paste, there are several types of porosity, trapped or entrained air (0.1 to several mm in size), capillary pores (0.01 to a few microns) existing in the space between hydration products, and gel pores (several nanometres or below) within the layered structure of the C-S-H. The capillary pores have a large effect on the strength and permeability of the hardened paste itself. Of course, the presence of air bubbles can also affect strength.

From experiments, the porosity within the gel for all normally hydrated cements is the same, with a value of 0.26. The total volume of hydration products (cement gel) is given by

$$V_g = 0.68\alpha \text{ cm}^3/\text{g of original cement}$$

Where, α represents the degree of hydration.

The capillary porosity can be calculated by

$$P_c = (w/c) - 0.36\alpha \quad \text{cm}^3\text{/g of original cement}$$

Where, *w* is the original weight of water and *c* is the weight of cement and w/c is the water-cement ratio. It can be seen that with increase of w/c, the capillary pores increase.

The gel / space ratio (X) is defined as

$$X = \frac{\text{volume of gel (including gel pores)}}{\text{volume of gel + volume of capillary pores}} = \frac{0.68\alpha}{0.32\alpha + w/c}$$

The minimum w/c ratio for complete hydration is usually assumed to be 0.36 to 0.42. It should be indicated that complete hydration is not essential to attain a high ultimate strength. For pastes of low w/c ratio, residual unhydrated cement will remain.

To satisfy workability requirements, the water added in the mix is usually more than that needed for the chemical reaction. Part of the water is used up in the chemical reaction. The remaining is either held by the C -S-H gel or stored in the capillary pore. Most capillary water is free water (far away from the pore surface). On drying, they will be removed, but the loss of free water has little effect on concrete. Loss of adsorbed water on surfaces and those in the gel will, however, lead to shrinkage. Movement of adsorbed and gel water under load is a cause of creeping in concrete

1.1.6 Basic tests of Portland cement

a) Fineness (= surface area / weight): This test determines the average size of cement grains. The typical value of fineness is 350 m^2 / kg. Fineness controls the rate and completeness of hydration. The finer a cement, the more rapidly it reacts, the higher the rate of heat evolution and the higher the early strength.

	I	III	V
Fineness (m^2 / kg)	350	450	350
f'_c 1-day (MPa)	6.9	13.8	6.2

b) Normal consistency test: This test is to determine the water required to achieve a desired plasticity state (called normal consistency) of cement paste. It is obtained with the Vicat apparatus by measuring the penetration of a loaded needle.

c) Time of setting: This test is to determine the time required for cement paste to harden. Initial set cannot be too early due to the requirement of mixing, conveying, placing and casting. Final set cannot be too late owing to the requirement of strength development. Time of setting is measured by Vicat apparatus. Initial setting time is defined as the time at which the needle penetrates 25 mm into cement paste. Final setting time is the time at which the needle does not sink visibly into the cement paste.

d) Soundness: Unsoundness in cement paste refers to excessive volume change after setting. Unsoundness in cement is caused by the slow hydration of MgO or free lime. Their reactions are $MgO + H_2O = Mg(OH)_2$ and $CaO + H_2O = Ca(OH)_2$. Another factor that can cause unsoundness is the delayed formation of ettringite after cement and concrete have hardened. The pressure from crystal growth will lead to cracking and damage. The soundness of the cement must be tested by accelerated methods. An example is the Le Chatelier test (BS 4550) . This test is to measure the potential for volumetric change of cement paste. Another method is called Autoclave Expansion test (ASTM C151) which use an autoclave to increase the temperature to accelerate the process.

e) Strength: The strength of cement is measured on mortar specimens made of cement and standard sand (silica). Compression test is carried out on a 2" cube with S/C ratio of 2.75:1 and w/c ratio of 0.485 for Portland cements. The specimens are tested wet, using a loading rate at which the specimen will fail in 20 to 80 s. The direct tensile test is carried out on a specimen shaped like a dumbbell. The load is applied through specifically designed grips. Flexural strength is measured on a 40 x 40 x 160 mm prism beam test under a centre-point bending.

f) Heat of hydration test. (BS 4550: Part 3: Section 3.8 and ASTM C186). Cement hydration is a heat releasing process. The heat of hydration is usually defined as the amount of heat evolved during the setting and hardening at a given temperature measured in J/g. The experiment is called heat of solution method. Basically, the heat of solution of dry cement is compared to the heats of solution of separate portion of the cement that have been partially hydrated for 7 and 28 days. The heat of hydration is then the difference between the heats of solution of dry and partially hydrated cements for the appropriate hydration period. This test is usually done on Type II and IV cements only, because they are used when heat of hydration is an important concern.
Excessive heating may lead to cracking in massive concrete construction.

g) Other experiments. Including sulphate expansion and air content of mortar.

h) Cement S. G and U. W.: The S.G. for most types of cements is 3.15, and UW is 1000-1600 kg/m^3.

1.2 Aggregates

Aggregates are defined as inert, granular, and inorganic materials that normally consist of stone or stone-like solids. Aggregates can be used alone (in road bases and various types of fill) or can be used with cementing materials (such as Portland cement or asphalt cement) to form composite materials or concrete. The most popular use of aggregates is to form Portland cement concrete. Approximately three-fourths of the volume of Portland cement concrete is occupied by aggregate. It is inevitable that a constituent occupying such a large percentage of the mass should have an important effect on the properties of both the fresh and hardened products. As another important application, aggregates are used in asphalt cement concrete in which they occupy 90% or more of the total volume. Once again, aggregates can largely influence the composite properties due to its large volume fraction.

1.2.1 Classification of Aggregate

Aggregates can be divided into several categories according to different criteria.

a) **In accordance with size:**

Coarse aggregate: Aggregates predominately retained on the No. 4 (4.75 mm) sieve. For mass concrete, the maximum size can be as large as 150 mm.

Fine aggregate (sand): Aggregates passing No.4 (4.75 mm) sieve and predominately retained on the No. 200 (75 µm) sieve.

b) **In accordance with sources:**

Natural aggregates: This kind of aggregate is taken from natural deposits without changing their nature during the process of production such as crushing and grinding. Some examples in this category are sand, crushed limestone, and gravel.

Manufactured (synthetic) aggregates: This is a kind of man-made materials produced as a main product or an industrial by-product. Some examples are blast furnace slag, lightweight aggregate (e.g. expanded perlite), and heavy weight aggregates (e.g. iron ore or crushed steel).

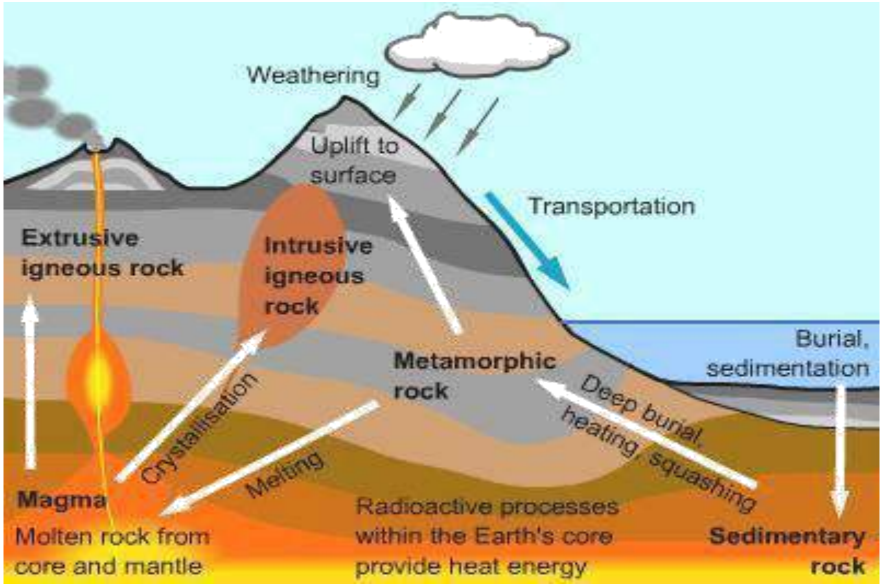
c) In accordance with unit weight:

Light weight aggregate: The unit weight of aggregate is less than 1120kg/m^3. The corresponding concrete has a bulk density less than 1800kg/m^3. (cinder, blast-furnace slag, volcanic pumice).

Normal weight aggregate: The aggregate has unit weight of 1520-1680kg/m^3. The concrete made with this type of aggregate has a bulk density of 2300-2400 kg/m^3.

Heavy weight aggregate: The unit weight is greater than 2100 kg/m^3. The bulk density of the corresponding concrete is greater than 3200 kg/m^3. A typical example is magnesite limonite, a heavy iron ore. Heavy weight concrete is used in special structures such as radiation shields.

d) In accordance with origin:



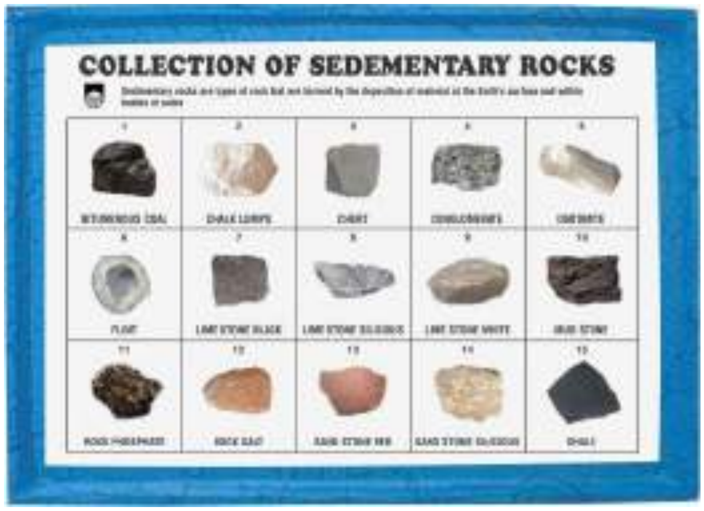
Igneous rock Aggregate:

- Hard, tough and dense.
- Massive structures: crystalline, glassy or both depending on the rate at which they are cooled during formation.
- Acidic or basic: percentage of silica content.
- Light or dark coloured.
- Chemically active: react with alkalis.

Sedimentary rock Aggregates:

- Igneous or metamorphic rocks subjected to weathering agencies.

- Decompose, fragmentise, transport and deposit deep beneath ocean bed are cemented together.
- Can be flaky.
- Range from soft-hard, porous-dense, light-heavy.
- Suitability decided by: degree of consolidation, type of cementation, thickness of layer and contamination.



Metamorphic rock Aggregate:

- Rocks subjected to high temperature and pressure.
- Economic factor into consideration.
- Least overall expense.

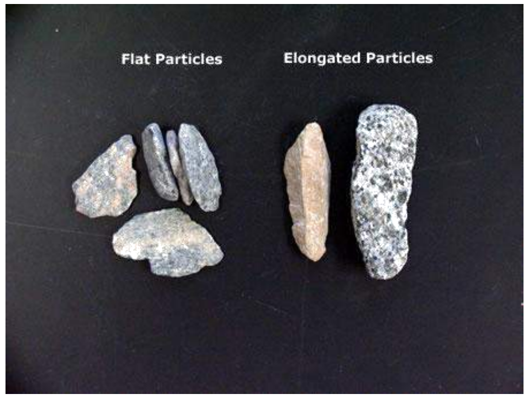
e)Particle shape:

- **Rounded Aggregate:** Good workability, low water demand, poor bond

- **Angular Aggregate:** Increased water demand, good bond

- **Flaky Aggregate:** Aggregate stacks give workability problems

- **Elongated Aggregate:** May lack cohesion and require increased fines



- **Irregular Aggregate:** Fair workability, low water demand. Irregular shape with rounded edges.

- **Angularity number (IS:2386-Part 1-1963):**
  - The concept of angularity number was suggested by Shergold.
  - It gives a qualitative representation of shape of aggregate.
  - In angularity number test, a quantity of single sized aggregate is filled into metal cylinder of 3 litres capacity. Then the aggregate is compacted in a standard manner and the percentage of void found out.
  - If the void content of the aggregate is 33% the angularity of such aggregate is considered 0.
  - If the void is 44%, the angularity number of such aggregate is considered 11.
- **Importance of Angularity Number:**

- The normal aggregate which are suitable for making concrete may have angularity number anything from 0 to 11.
- Angularity number 0 represents the most practicable rounded aggregate
- Angularity number 11 indicates the most angular aggregate that could be used for making concrete.

- **Angularity Index:**

  - Suggested by Murdock for expressing shape of aggregate.
  - Angularity index = fA = $\frac{3\,fH}{20}$ + 1.0
    Where, fH is the angularity number.

f) Texture:

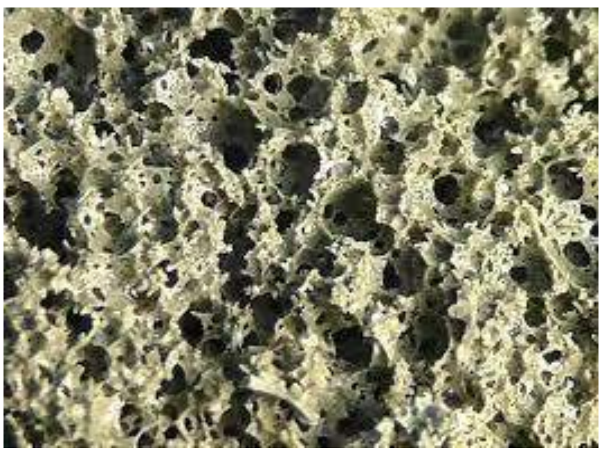
- It depends on hardness, grain size, pore structure, structure of the rock and degree to which forces acting on the particle surface have smoothened or roughened it.
- As surface smoothness increases, contact area decreases, hence a highly polished particle will have less bonding area with the matrix than a rough particle of the same volume.

Glassy textured aggregate

Smooth textured aggregate

Granular textured aggregate

Crystalline textured aggregate



Porous textured aggregate

1.2.2 Strength of Aggregates

- When the cement paste is of good quality & its bond with the aggregate is satisfactory, then the mechanical properties of rock or aggregate will influence the strength of concrete.
- The test for strength of aggregate is required to be made in the following situations:
  1. For production of high strength & ultra -high strength concrete.
  2. When contemplating to use aggregates manufacture from weathered rocks.
  3. Aggregates manufactured by industrial process.

1.3 Admixtures

Admixtures are those ingredients in concrete other than portland cement, water, and aggregates that are added to the mixture immediately before or during mixing.

1.3.1 Admixtures can be classified by function as follows:

1. Air-entraining admixtures
2. Water-reducing admixtures
3. Plasticizers
4. Accelerating admixtures
5. Retarding admixtures
6. Hydration-control admixtures
7. Corrosion inhibitors
8. Shrinkage reducers
9. Alkali-silica reactivity inhibitors
10. Colouring admixtures
11. Miscellaneous admixtures such as workability, bonding, dampproofing, permeability reducing, grouting, gas forming, anti-washout, foaming, and pumping admixtures.

Concrete should be workable, finishable, strong, durable, watertight, and wear resistant. These qualities can often be obtained easily and economically by the selection of suitable materials rather than by resorting to admixtures (except air-entraining admixtures when needed).

1.3.2 The major reasons for using admixtures

1. To reduce the cost of concrete construction
2. To achieve certain properties in concrete more effectively than by other means
3. To maintain the quality of concrete during the stages of mixing, transporting, placing, and curing in adverse weather conditions
4. To overcome certain emergencies during concreting operations

1.3.4 Classification of admixtures

Type of admixture	Desired effect	Material
Accelerators (ASTM C 494 and AASHTO M 194, Type C)	Accelerate setting and early-strength development	Calcium chloride (ASTM D 98 and AASHTO M 144) Triethanolamine, sodium thiocyanate, calcium formate, calcium nitrite, calcium nitrate
Air detrainers	Decrease air content	Tributyl phosphate, dibutyl phthalate, octyl alcohol, water-insoluble esters of carbonic and boric acid, silicones
Air-entraining admixtures (ASTM C 260 and AASHTO M 154)	Improve durability in freeze-thaw, deicer, sulfate, and alkali-reactive environments Improve workability	Salts of wood resins (Vinsol resin), some synthetic detergents, salts of sulfonated lignin, salts of petroleum acids, salts of proteinaceous material, fatty and resinous acids and their salts, alkylbenzene sulfonates, salts of sulfonated hydrocarbons
Alkali-aggregate reactivity inhibitors	Reduce alkali-aggregate reactivity expansion	Barium salts, lithium nitrate, lithium carbonate, lithium hydroxide
Antiwashout admixtures	Cohesive concrete for underwater placements	Cellulose, acrylic polymer
Bonding admixtures	Increase bond strength	Polyvinyl chloride, polyvinyl acetate, acrylics, butadiene-styrene copolymers
Coloring admixtures (ASTM C 979)	Colored concrete	Modified carbon black, iron oxide, phthalocyanine, umber, chromium oxide, titanium oxide, cobalt blue
Corrosion inhibitors	Reduce steel corrosion activity in a chloride-laden environment	Calcium nitrite, sodium nitrite, sodium benzoate, certain phosphates or fluosilicates, fluoaluminates, ester amines
Dampproofing admixtures	Retard moisture penetration into dry concrete	Soaps of calcium or ammonium stearate or oleate Butyl stearate Petroleum products
Foaming agents	Produce lightweight, foamed concrete with low density	Cationic and anionic surfactants Hydrolized protein
Fungicides, germicides, and insecticides	Inhibit or control bacterial and fungal growth	Polyhalogenated phenols Dieldrin emulsions Copper compounds
Gas formers	Cause expansion before setting	Aluminum powder
Grouting admixtures	Adjust grout properties for specific applications	See Air-entraining admixtures, Accelerators, Retarders, and Water reducers
Hydration control admixtures	Suspend and reactivate cement hydration with stabilizer and activator	Carboxylic acids Phosphorus-containing organic acid salts
Permeability reducers	Decrease permeability	Latex Calcium stearate
Pumping aids	Improve pumpability	Organic and synthetic polymers Organic flocculents Organic emulsions of paraffin, coal tar, asphalt, acrylics Bentonite and pyrogenic silicas Hydrated lime (ASTM C 141)
Retarders (ASTM C 494 and AASHTO M 194, Type B)	Retard setting time	Lignin Borax Sugars Tartaric acid and salts
Shrinkage reducers	Reduce drying shrinkage	Polyoxyalkylene alkyl ether Propylene glycol
Superplasticizers* (ASTM C 1017, Type 1)	Increase flowability of concrete Reduce water-cement ratio	Sulfonated melamine formaldehyde condensates Sulfonated naphthalene formaldehyde condensates Lignosulfonates Polycarboxylates

Type of admixture	Desired effect	Material
Superplasticizer* and retarder (ASTM C 1017, Type 2)	Increase flowability with retarded set Reduce water–cement ratio	See superplasticizers and also water reducers
Water reducer (ASTM C 494 and AASHTO M 194, Type A)	Reduce water content at least 5%	Lignosulfonates Hydroxylated carboxylic acids Carbohydrates (Also tend to retard set so accelerator is often added)
Water reducer and accelerator (ASTM C 494 and AASHTO M 194, Type E)	Reduce water content (minimum 5%) and accelerate set	See water reducer, Type A (accelerator is added)
Water reducer and retarder (ASTM C 494 and AASHTO M 194, Type D)	Reduce water content (minimum 5%) and retard set	See water reducer, Type A (retarder is added)
Water reducer—high range (ASTM C 494 and AASHTO M 194, Type F)	Reduce water content (minimum 12%)	See superplasticizers
Water reducer—high range—and retarder (ASTM C 494 and AASHTO M 194, Type G)	Reduce water content (minimum 12%) and retard set	See superplasticizers and also water reducers
Water reducer—mid range	Reduce water content (between 6 and 12%) without retarding	Lignosulfonates Polycarboxylates

* Superplasticizers are also referred to as high-range water reducers or plasticizers. These admixtures often meet both ASTM C 494 (AASHTO M 194) and ASTM C 1017 specifications.

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$

UNIT- 2

Fresh Concrete

2.1 There are two sets of criteria that we must consider when making concrete;

1) Long-term requirements of hardened concrete, such as, strength, durability, and volume stability,

2) Short-term requirements, like workability. However, these two requirements are not necessarily complementary.

2.2 For fresh concrete to be acceptable, it should:

1. Be easily mixed and transported.
2. Be uniform throughout a given batch and between batches.
3. Be of a consistency so that it can fill completely the forms for which it was designed.
4. Have the ability to be compacted without excessive loss of energy.
5. Not segregate during placing and consolidation.
6. Have good finishing characteristics.

2.3 Workability

All the characteristics above describe many different aspects of concrete behavior. The term workability is used to represent all the qualities mentioned. Workability is often defined in terms of the amount of mechanical energy, or work, required to fully compact concrete without segregation. This is important since the final strength is a function of compaction.

The concept of viscosity is a measure of how a material behaves under stress. For a Newtonian fluid, the relationship may be written as:

$$\tau = \eta D$$

Where ***t*** is the shear stress, ***n*** is the viscosity, and ***D*** is the rate of shear or velocity gradient.

For a very dilute suspension of solids in liquids, this relationship holds true. However, for large volumes of suspended solids, like concrete, the Newtonian model does not work. Concrete has an initial shear strength that must be exceeded before it will flow. This type of behaviour is described by the Bingham model:

$$\tau - \tau_0 = \eta D$$

Where t_0 is the yield shear stress, ***n*** is the plastic viscosity.

A third type of viscous behaviour is called thixotropic, where the apparent viscosity decreases with shear stress. Concrete will exhibit thixotropic characteristics.

2.4 Factors Affecting Workability

- **Water Content of the Mix** -- This is the single most important fact or governing workability of concrete. A group of particles requires a certain amount of water. Water is absorbed on the particle surface, in the volumes between particles, and provides "lubrication" to help the particles move past one another more easily. Therefore, finer particles, necessary for plastic behaviour, require more water. Some side-effects of increased water are loss of strength and possible segregation.

- **Influence of Aggregate Mix Proportions** -- Increasing the proportion of aggregates relative to the cement will decrease the workability of the concrete. Also, any additional fines will require more cement in the mix. An "over sanded" mix will be permeable and less economical. A concrete deficient of fines will be difficult to finish and prone to segregation.

- **Aggregate Properties** -- The ratio of coarse/fine aggregate is not the only factor affecting workability. The gradation and particle size of sands are important. Shape and texture of aggregate will also affect workability. Spherical shaped particles will not have the interaction problems associated with more angular particles. Also, spherical shapes have a low surface/volume ratio, therefore, less cement will be required to coat each particle and more will be available to contribute to the workability of the concrete. Aggregate which is porous will absorb more water leaving less to provide workability. It is important to distinguish between total water content, which includes absorbed water, and free water which is available for improving workability.

- **Time and Temperature** -- In general, increasing temperature will cause an increase in the rate of hydration and evaporation. Both of these effects lead to a loss of workability.

- **Loss of Workability** -- Workability will decrease with time due to several factors; continued slow hydration of C3S and C3A during dormant period, loss of water through evaporation and absorption, increased particle interaction due to the formation of hydration products on the particle surface. Loss of workability is measured as "slump loss" with time.

- **Cement Characteristics** -- Cement characteristics are less important than aggregate properties in determining workability. However, the increased fineness of rapid-hardening cements will result in rapid hydration and increased water requirements, both of which reduce workability.

- **Admixtures** -- In general, air-entraining, water-reducing, and set-retarding admixtures will all improve workability. However, some chemical admixtures will react differently with cements and aggregates and may result in reduced workability.

2.5 Segregation and Bleeding

2.5.1 Segregation refers to a separation of the components of fresh concrete, resulting in a non-uniform mix. This can be seen as a separation of coarse aggregate from the mortar, caused from either the settling of heavy aggregate to the bottom or the separation of the aggregate from the mix due to improper placement.

Some factors that increase segregation are:

1. Larger maximum particle size (25mm) and proportion of the larger particles.

2. High specific gravity of coarse aggregate.
3. Decrease in the amount of fine particles.
4. Particle shape and texture.
5. Water/cement ratio.

Good handling and placement techniques are most important in prevention of segregation.

2.5.2 Bleeding is defined as the appearance of water on the surface of concrete after it has consolidated but before it is set. Since mixing water is the lightest component of the concrete, this is a special form of segregation. Bleeding is generally the result of aggregates settling into the mix and releasing their mixing water. Some bleeding is normal for good concrete.

However, if bleeding becomes too localized, channels will form resulting in "craters". The upper layers will become too rich in cement with a high w/c ratio causing a weak, porous structure. Salt may crystalize on the surface which will affect bonding with additional lifts of concrete. This formation should always be removed by brushing and washing the surface. Also, water pockets may form under large aggregates and reinforcing bars reducing the bond.

Bleeding may be reduced by:

1. Increasing cement fineness.
2. Increasing the rate of hydration.
3. Using air-entraining admixtures.
4. Reducing the water content.

2.6 Measurement of Workability

Workability, a term applied to many concrete properties, can be adequately measured by three characteristics:

1. Compatibility, the ease with which the concrete can be compacted and air void removed.
2. Mobility, ease with which concrete can flow into forms and around reinforcement.
3. Stability, ability for concrete to remain stable and homogeneous during handling and vibration without excessive segregation.

Different empirical measurements of workability have been developed over the years. None of these tests measure workability in terms of the fundamental properties of concrete. However, the following tests have been developed:

- **Subjective Assessment** -- The oldest way of measuring workability based on the judgement and experience of the engineer. Unfortunately, different people see things, in this case concrete, differently.

- **Slump Test** -- The oldest, most widely used test for determining workability. The device is a hollow cone-shaped mould. The mould is filled in three layers of each volume. Each layer is rodded with a 16mm steel rod 25 times. The mould is then lifted away and the change in the height of the concrete is measured against the mould. The slump test is a measure of the resistance of concrete to flow under its own weight.

  There are three classifications of slump; "true" slump, shear slump, and collapse slump. True slump is a general reduction in height of the mass without any breaking up. Shear slump indicates a lack of cohesion, tends to occur in harsh mixes. This type of result implies the concrete is not suitable for placement. Collapse slump generally indicates a very wet mix. With different aggregates or mix properties, the same slump can be measured for very different concretes.

- **Compaction Test** -- Concrete strength is proportional to its relative density. A test to determine the compaction factor was developed in 1947. It involves dropping a volume of concrete from one hopper to another and measuring the volume of concrete in the final hopper to that of a fully compacted volume. This test is difficult to run in the field and is not practical for large aggregates (over 1 in.).

- **Flow Test** -- Measures a concretes ability to flow under vibration and provides information on its tendency to segregate. There are a number of tests available but none are recognized by ASTM. However, the flow table test described for mortar flows is occasionally used.

- **Remoulding Test** -- Developed to measure the work required to cause concrete not only to flow but also to conform to a new shape.
  - **Vebe Test** - A standard slump cone is cast, the mould removed, and a transparent disk placed on top of the cone. The sample is then vibrated till the disk is completely covered with mortar. The time required for this is called the Vebe time.
  - **Thaulow Drop Table** - Similar to the Vebe test except a cylinder of concrete is remoulded on a drop table. The number of drops to achieve this remoulding is counted.
  - **Penetration Test** -- A measure of the penetration of some indenter into concrete. Only the Kelly ball penetration test is included in the ASTM Standards. The Kelly ball penetration test measures the penetration of a 30 lb. hemisphere into fresh concrete. This test can be performed on concrete in a buggy, open truck, or in form if they are not too narrow. It can be compared to the slump test for a measure of concrete consistency.

2.7 Setting of Concrete

Setting is defined as the onset of rigidity in fresh concrete. Hardening is the development of useable and measurable strength; setting precedes hardening. Both are gradual changes controlled by hydration. Fresh concrete will lose measurable slump before initial set and measurable strength will be achieved after final set.

Setting is controlled by the hydration of C_3S. The period of good workability is during the dormant period, (stage 2). Initial set corresponds to the beginning of stage 3, a period of rapid hydration. Final set is the midpoint of this acceleration phase. A rapid increase in temperature is associated with stage 3 hydration, with a maximum rate at final set.

If large amounts of ettringite rapidly form from C_3A hydration, the setting times will be reduced. Cements with high percentages of C_3A, such as expansive or set-regulated cements, are entirely controlled by ettringite formation.

2.8 Abnormal Setting Behavior

- **False Set** -- Early stiffening of concrete, fluidity may be restored by remixing. Basically, it is a result of hydration of dehydrated gypsum, which forms rigid crystals. Because there are few of these crystals and they are weak, the matrix can be destroyed by remixing. Accelerated hydration of C3A will cause rapid development of ettringite and false set.

- **Flash Set** -- Stiffening of concrete due to the rapid development of large quantities of C3A hydration products which cannot be returned to a fluid state with mixing. This is generally no longer a problem since the introduction of gypsum to control C3A hydration. However, some admixtures will increase C3A hydration and flash set may be a problem.

2. 9 Tests of Fresh Concrete

1. They permit some estimation of the subsequent behaviour of the hardened concrete.
2. Changes in the properties of fresh concrete imply that the concrete mix is changing, so that some action can be taken if necessary.

Concrete is a composite material made from cement, aggregate, water, and admixtures. The variation of these components both in quality and quantity directly affects the resulting mix. When sampling fresh concrete for testing, it is important to take samples from various locations or several points during the discharge of the concrete. Samples should not have contacted forms or subgrade, and collection should be done in such a way that no segregation occurs.

- **Time of Setting** -- A penetration test, used to help regulate the times of mixing and transit, gauges the effectiveness of various set-controlling admixtures, and help plan finishing operations. The test is performed on the mortar faction, the amount of concrete passing a No. 4 sieve, of the concrete rodded into a container.

- **Air Content** -- These tests measure the total air content, entrained air plus entrapped air expressed in terms of the volume of concrete.

  - **Gravimetric Method** -- Compares the weight of a concrete containing air to that of a computed air-free concrete.
  - **Volumetric Method** -- Compares the volume of fresh concrete containing air with a volume of the same concrete after the air has be expelled by agitating the concrete under water. Difficult to measure in the field and required a large amount of physical effort.
  - **Pressure Method** -- The most common field measurement for air content. Compares the change in volume of a concrete under a given pressure. This change in volume is caused entirely by the compression of air in the concrete, both in the cement and the aggregate.

*** All these tests give no information about the spacing of the voids. They only measure the total air content of the concrete.

2.10 Unit Weight and Yield

The unit weight of fresh concrete can be determined by weighing a known volume. This is usually performed just before air content is determined since there is known volume concrete. The volume of a batch of concrete can be determined from the following relationship:

$$V = \frac{w}{Unit\ weight}(ft^3)$$

Where, **w** is the weight of the concrete components, including water.

The yield of a concrete mix can be determined from:

$$Y = \frac{V}{w_{cement}}\left(\frac{ft^3}{lb}\right)$$

Where, $\mathbf{w_{cement}}$ is the weight of the cement for a given mix.

2.11 Rapid Analysis of Fresh Concrete

There are a number of tests which separate the components of fresh concrete and test for a variety of mix properties; however, none are as yet accepted by ASTM. There are some tests that do not require separation of the components of the concrete:

- **Thermal Conductivity** -- Increase in water slows temperature rise.
- **Capacitance Test** -- Higher water content, increases dielectric constant.
- **Electrical Resistance** -- Electrical resistance of fresh concrete is inversely proportional to the water content.
- **Nuclear Methods** -- X-rays, gamma-rays, and neutron activation analysis can be used to measure the cement and water contents.

UNIT 3

Hardened Concrete

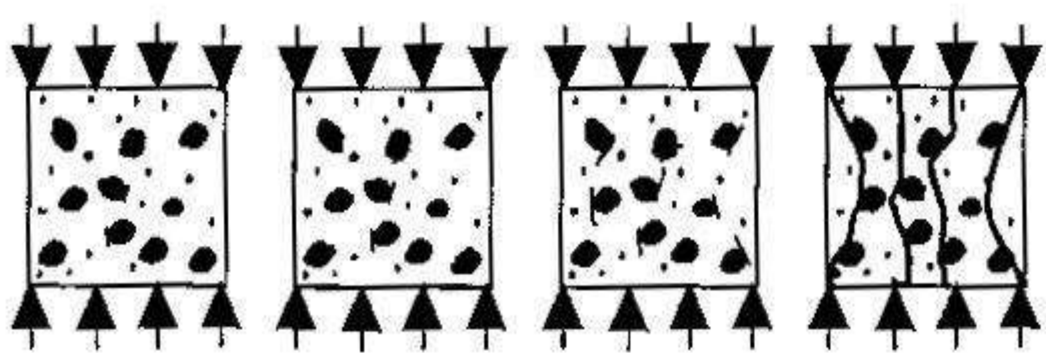
3.1 Strength of hardened concrete

Strength is defined as the ability of a material to resist stress without failure. The failure of concrete is due to cracking. Under direct tension, concrete failure is due to the propagation of a single major crack. In compression, failure involves the propagation of a large number of cracks, leading to a mode of disintegration commonly referred to as 'crushing'.
The strength is the property generally specified in construction design and quality control, for the following reasons:
(1) It is relatively easy to measure, and
(2) Other properties are related to the strength and can be deduced from strength data.

The 28-day compressive strength of concrete determined by a standard uniaxial compression test is accepted universally as a general index of concrete strength.

3.2 Compressive strength and corresponding tests

(a) Failure mechanism

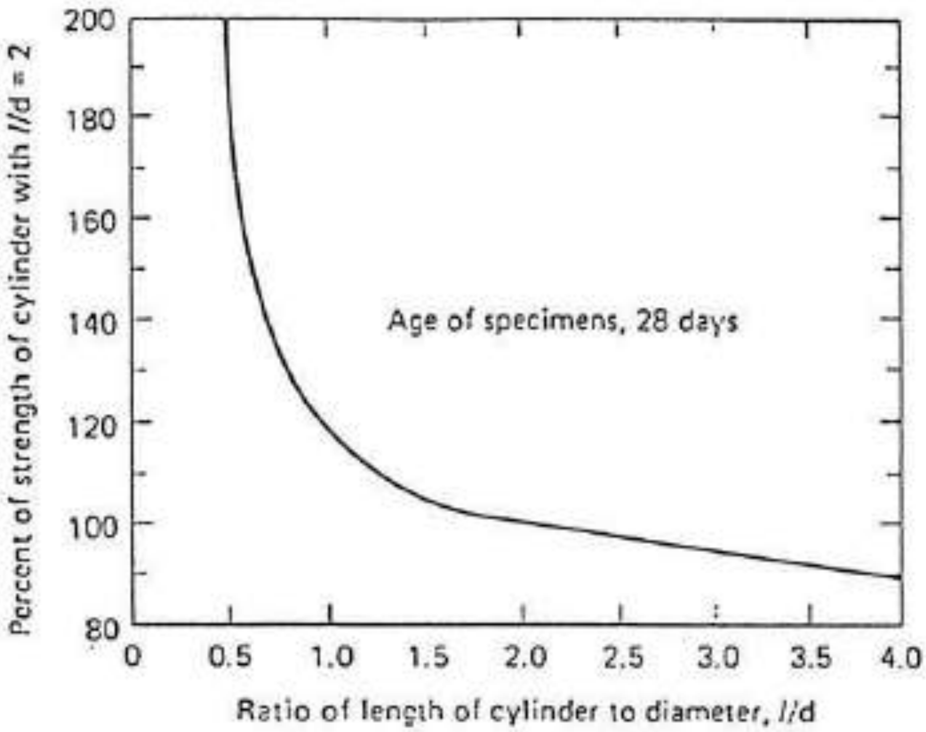


a. b. c. d.

a. At about 25-30% of the ultimate strength, random cracking (usually in transition zone around large aggregates) are observed
b. At about 50% of ultimate strength, cracks grow stably from transition zone into paste. Also, microcracks start to develop in the paste.
c. At about 75% of the ultimate strength, paste cracks and bond cracks start to join together, forming major cracks. The major cracks keep growing while smaller cracks tend to close.
d. At the ultimate load, failure occurs when the major cracks link up along the vertical direction and split the specimen

The development of the vertical cracks results in expansion of concrete in the lateral directions. If concrete is confined (i.e., it is not allow to expand freely in the lateral directions), growth of the vertical cracks will be resisted. The strength is hence increased, together with an increase in failure strain. In the design of concrete columns, steel stirrups are placed around the vertical reinforcing steel. They serve to prevent the lateral displacement of the interior concrete and hence increase the concrete strength. In composite construction (steel + reinforced concrete), steel tubes are often used to encase reinforced concrete columns. The tube is very effective in providing the confinement.

The above figure illustrates the case when the concrete member is under ideal uniaxial loading. In reality, when we are running a compressive test, friction exists at the top and bottom surfaces of a concrete specimen, to prevent the lateral movement of the specimen. As a result, confining stresses are generated around the two ends of the specimen. If the specimen has a low aspect ratio (in terms of height vs width), such as a cube (aspect ratio = 1.0), the confining stresses will increase the apparent strength of the material. For a cylinder with aspect ratio beyond 2.0, the confining effect is not too significant at the middle of the specimen (where failure occurs). The strength obtained from a cylinder is hence closer to the actual uniaxial strength of concrete. Note that in a cylinder test, the cracks propagate vertically in the middle of the specimen. When they get close to the ends, due to the confining stresses, they propagate in an inclined direction, leading to the formation of two cones at the ends.



(b) Specimen for compressive strength determination

The cube specimen is popular in U.K. and Europe while the cylinder specimen is commonly used in the U.S.

i. Cube specimen

BS 1881: Part 108: 1983. Filling in 3 layers with 50 mm for each layer (2 layers for 100 mm cube). Strokes 35 times for 150 mm cube and 25 times for 100 mm cube. Curing at 20±5 ^{0}C and 90% relative humility.

ii. Cylinder specimen

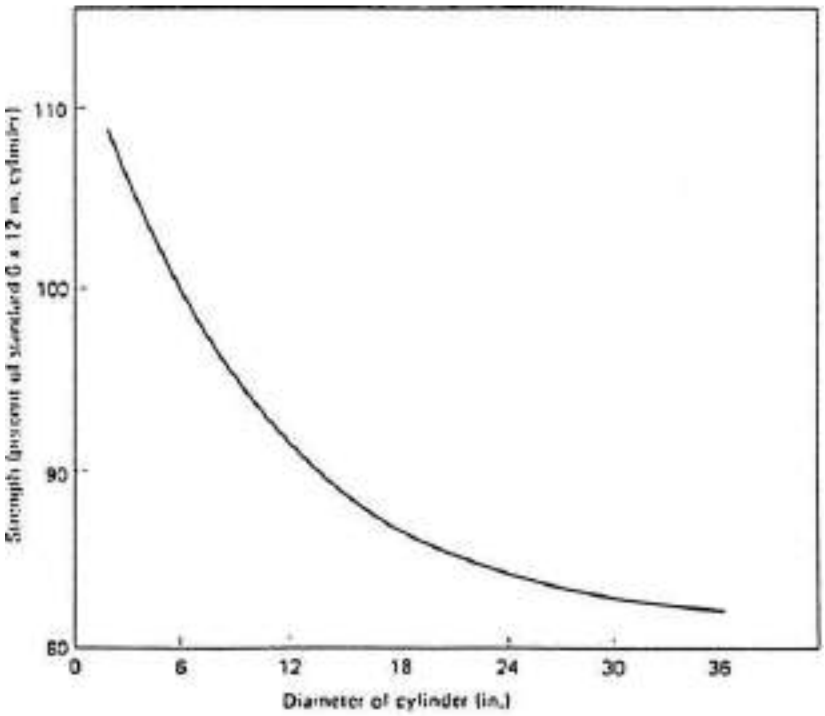
ASTM C470-81. Standard cylinder size is 150 x 300 mm. Curing condition is temperature of 23±1.7 ^{0}C and moist condition. Grinding or capping is needed to provide level and smooth compression surface.

(c) Factors influencing experiment results

(i) End condition. Due to influence of platen restraint, cube's apparent strength is about 1.15 times of cylinders. In assessing report on concrete strength, it is IMPORTANT to know which type of specimen has been employed.

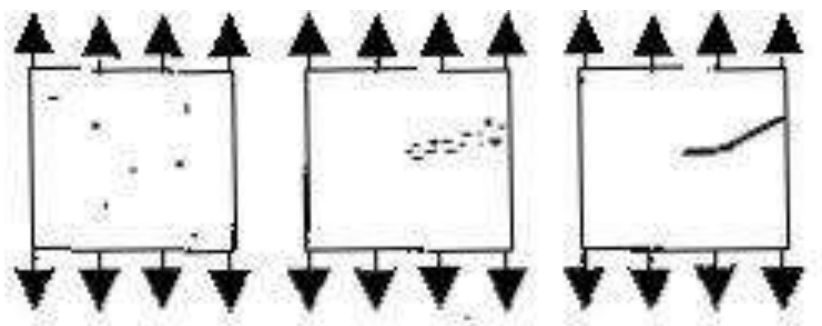
(ii) Loading rate. The faster the load rate, the higher the ultimate load obtained. The standard load rate is 0.15 -0.34 MPa / s for ASTM and 0.2-0.4 MPa/s for BS.

(iii)Size effect: The probability of having larger defects (such as voids and cracks) increases with size. Thus smaller size specimen will give higher apparent strength. Standard specimen size is mentioned above. Test results for small size specimen needs to be modified.



3.3 Tensile strength and corresponding tests

(a) Failure mechanism



a. b. c.

a. Random crack development (microcracks usually form at transition zone)
b. Localization of microcracks
c. Major crack propagation

It is important to notice that cracks form and propagate a lot easier in tension than in compression. The tensile strength is hence much lower than the compressive strength. An empirical relation between f_t and f_c is given by:

$$f_t = 0.615 (f_c)^{0.5} \quad \text{(for 21 MPa < } f_c \text{ < 83 MPa)}$$

Substituting numerical values for f_c, f_t is found to be around 7 to 13% of the compressive strength, with a lower f_t/f_c ratio for higher concrete strength. In the above formula, f_c is obtained from the direct compression of cylinders while f_t is measured with the splitting tensile test, to be described below.

(b)Direct tension test methods

Direct tension tests of concrete are seldom carried out because it is very difficult to control. Also, perfect alignment is difficult to ensure and the specimen holding devices introduce secondary stress that cannot be ignored. In practice, it is common to carry out the splitting tensile test or flexural test.

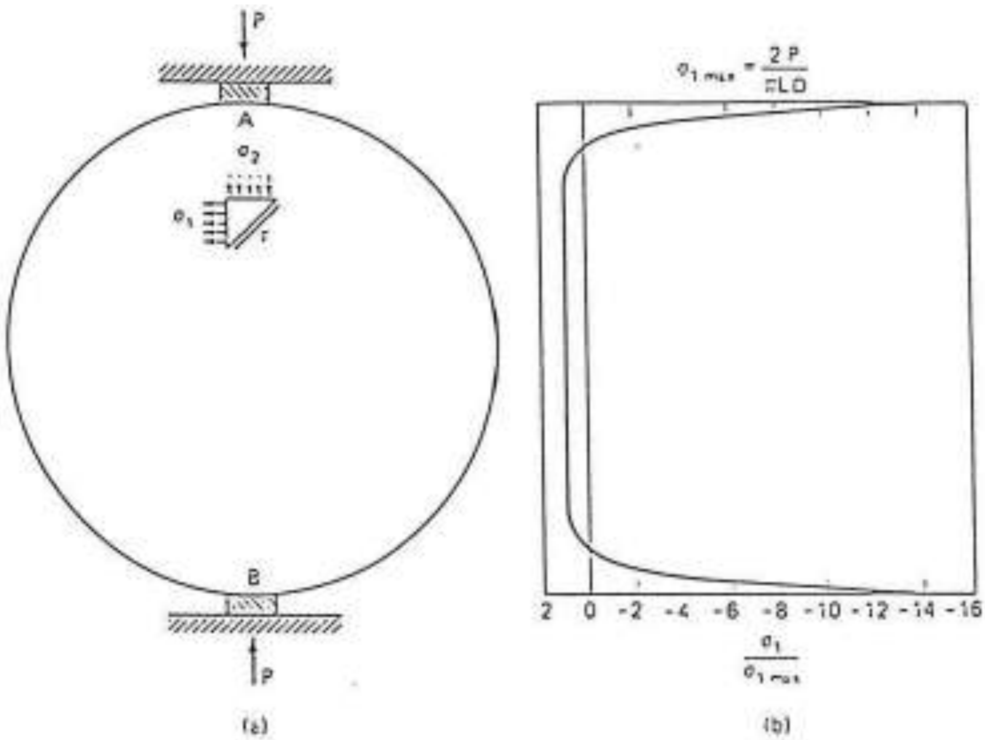
(c) Indirect tension test (split cylinder test or Brazilian test) BS 1881: Part 117:1983.

Specimen 150 x 300 mm cylinder. Loading rate 0.02 to 0.04 MPa/s

ASTM C496-71:

Specimen 150 x 300 mm cylinder. Loading rate 0.011 to 0.023 MPa/s

The splitting test is carried out by applying compression loads along two axial lines that are diametrically opposite. This test is based on the following observation from elastic analysis. Under vertical loading acting on the two ends of the vertical diametrical line, uniform tension is introduced along the central part of the specimen.

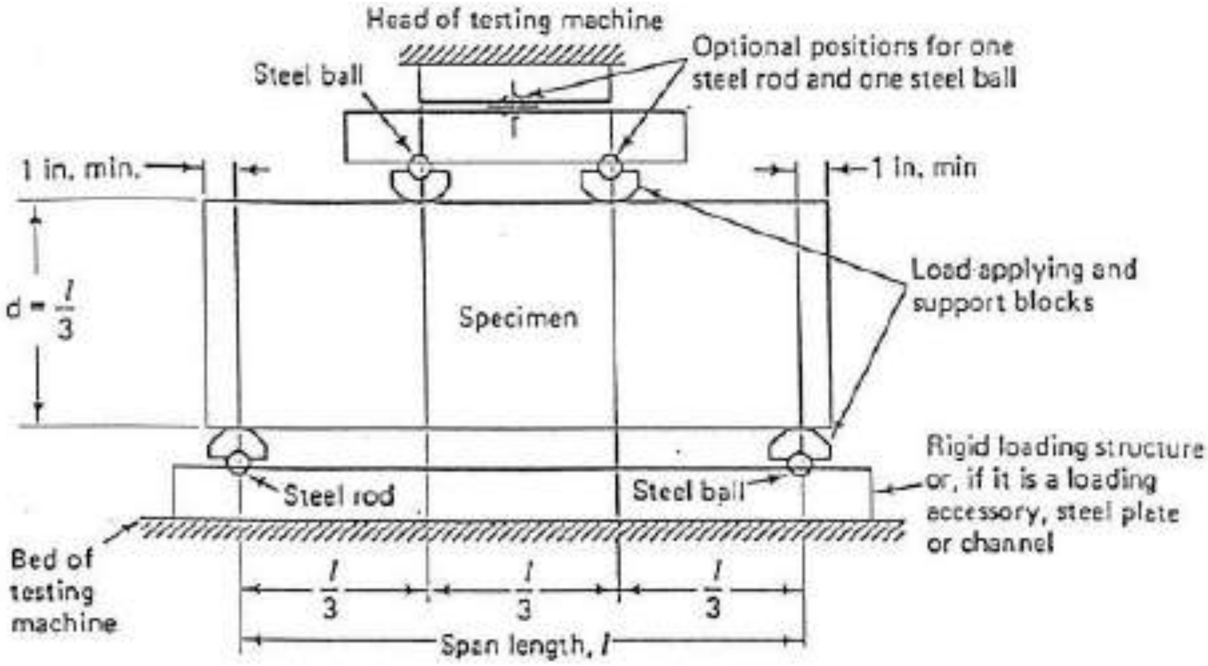


The splitting tensile strength can be obtained using the following formula:

$$f_{st} = \frac{2P}{\pi LD}$$

According to the comparison of test results on the same concrete, f_{st} is about 10-15% higher than direct tensile strength, f_t.

3.4 Flexural strength and corresponding tests



BS 1881: Part 118: 1983. Flexural test. 150 x 150 x 750 mm or 100 x 100 x 500 (Max. size of aggregate is less than 25 mm). The arrangement for modulus of rupture is shown in the above figure.

From Mechanics of Materials, we know that the maximum tension stress should occur at the bottom of the constant moment region. The modulus of rapture can be calculated as:

$$f_{bt} = \frac{Pl}{bd^2}$$

This formula is for the case of fracture taking place within the middle one third of the beam. If fracture occurs outside of the middle one-third (constant moment zone), the modulus of rupture can be computed from the moment at the crack location according to ASTM standard, with the following formula.

$$f_{bt} = \frac{3Pa}{bd^2}$$

However, according to British Standards, once fracture occurs outside of the constant moment zone, the test result should be discarded.

Although the modulus of rupture is a kind of tensile strength, it is much higher than the results obtained from a direct tension test. This is because concrete can still carry stress after a crack is formed. The maximum load in a bending test does not correspond to the start of cracking, but correspond to a situation when the crack has propagated. The stress distribution along the vertical section through the crack is no longer varying in a linear manner. The above equations are therefore not exact.

3.5 Dimensional stability--Shrinkage and creep

Dimensional stability of a construction material refers to its dimensional change over a long period of time. If the change is so small that it will not cause any structural problems, the material is dimensionally stable. For concrete, drying shrinkage and creep are two phenomena that compromise its dimensional stability.

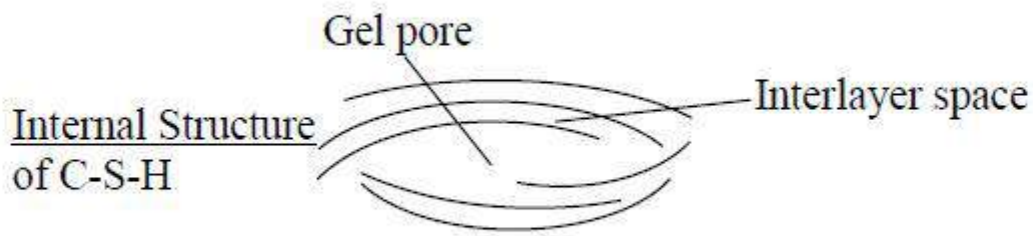
Shrinkage and creep are often discussed together because they are both governed by the deformation of hydrated cement paste within concrete. The aggregate in concrete does not shrink or creep, and they serve to restrain the deformation.

3.5.1 Drying shrinkage

After concrete has been cured and begins to dry, the excessive water that has not reacted with the cement will begin to migrate from the interior of the concrete mass to the surface. As the moisture evaporates, the concrete volume shrinks. The loss of moisture from the concrete varies with distance from the surface. The shortening per unit length associated with the reduction in volume due to moisture loss is termed the shrinkage. Shrinkage is sensitive to the relative humidity. For higher relative humidity, there is less evaporation and hence reduced shrinkage. When concrete is exposed to 100% relative humidity or submerged in water, it will actually swell slightly.

Shrinkage can create stress inside concrete. Because concrete adjacent to the surface of a member dries more rapidly than the interior, shrinkage strains are initially larger near the surface than in the interior. As a result of the differential shrinkage, a set of internal self-balancing forces, i.e. compression in the interior and tension on the outside, is set up.

In additional to the self-balancing stresses set up by differential shrinkage, the overall shrinkage creates stresses if members are restrained in the direction along which shrinkage occurs. If the tensile stress induced by restrained shrinkage exceeds the tensile strength of concrete, cracking will take place in the restrained structural element. If shrinkage cracks are not properly controlled, they permit the passage of water, expose steel reinforcements to the atmosphere, reduce shear strength of the member and are bad for appearance of the structure. Shrinkage cracking is often controlled with the incorporation of sufficient reinforcing steel, or the provision of joints to allow movement. After drying shrinkage occurs, if the concrete member is allowed to absorb water, only part of the shrinkage is reversible. This is because water is lost from the capillary pores, the gel pores (i.e., the pore within the C-S-H), as well as the space between the C-S-H layers. The water lost from the capillary and gel pores can be easily replenished. However, once water is lost from the interlayer space, the bond between the layers becomes stronger as they get closer to one another. On wetting, it is more difficult for water to re-enter. As a result, part of the shrinkage is irreversible.



The magnitude of the ultimate shrinkage is primarily a function of initial water content of the concrete and the relative humidity of the surrounding environment. For the same w/c ratio, with increasing aggregate content, shrinkage is reduced. For concrete with fixed aggregate/cement ratio, as the w/c ratio increases, the cement becomes more porous and can hold more water. Its ultimate shrinkage is hence also higher. If a stiffer aggregate is used, shrinkage is reduced.

The shrinkage strain, ε_{sh}, is time dependent. Approximately 90% of the ultimate shrinkage occurs during the first year.

Both the rate at which shrinkage occurs and the magnitude of the total shrinkage increase as the ratio of surface to volume increases. This is because the larger the surface area, the more rapidly moisture can evaporate.

Based on a number of local investigations in Hong Kong, the value of shrinkage strain (after one year) for plain concrete members appears to lie between 0.0004 and 0.0007 (although value as high as 0.0009 has been reported). For reinforced concrete members, the shrinkage strain values are reduced, as reinforcement is helpful in reducing shrinkage.

3.5.2 Creep

Creep is defined as the time-dependent deformation under a constant load. Water movement under stress is a major mechanism leading to creeping of concrete. As a result, factors affecting shrinkage also affect creep in a similar way. Besides moisture movement, there is evidence that creep may also be due to time-dependent formation and propagation of microcracks, as well as microstructural adjustment under high stresses (where stress concentration exists). These mechanisms, together with water loss from the gel interlayer, lead to irreversible creep. Creeping develops rapidly at the beginning and gradually decreases with time. Approximately 75% of ultimate creep occurs during the first year. The ultimate creep strain (after 20 years) can be 3-6 times the elastic strain.

Creep can influence reinforced concrete in the following aspects.

i). Due to the delayed effects of creep, the long-term deflection of a beam can be 2-3 times larger than the initial deflection.

ii). Creeping results in the reduction of stress in pre-stressed concrete which can lead to increased cracking and deflection under service load.

iii). In a R.C column supporting a constant load, creep can cause the initial stress in the steel to double or triple with time because steel is non-creeping and thus take over the force reduced in concrete due to creep.

Creep is significantly influenced by the stress level. For concrete stress less than 50% of its strength, creep is linear with stress. In this case, the burger's body, which is a combination of Maxwell and Kelvin models, is a reasonable representation of creep behaviour. For stress more than 50% of the strength, the creep is a nonlinear function of stress, and linear viscoelastic models are no longer applicable. For stress level higher than 75-80% of strength, creep rupture can occur. It is therefore very important to keep in mind that in the design of concrete column, 0.8 f_c is taken to be the strength limit.

Factors affecting Creep of concrete

a) w/c ratio: The higher the w/c ratio, the higher is the creep.
b) Aggregate stiffness (elastic modulus): The stiffer the aggregate, the smaller the creep.

c) Aggregate fraction: higher aggregate fraction leads to reduced creep.

d) Theoretical thickness: The theoretical thickness is defined as the ratio of section area to the semi-perimeter in contact with the atmosphere. Higher the theoretical thickness, smaller the creep and shrinkage.

e) Temperature: with increasing temperature, both the rate of creep and the ultimate creep increase. This is due to the increase in diffusion rate with temperature, as well as the removal of more water at a higher temperature.

f) Humidity: with higher humidity in the air, there is less exchange of moisture between the concrete and the surrounding environment. The amount of creep is hence reduced.

g) Age of concrete at loading: The creep strain at a given time after the application of loading is lower if loading is applied to concrete at a higher age. For example, if the same loading is applied to 14 day and 56 day concrete (of the same mix), and creep strain is measured at 28 and 70 days respectively (i.e., 14 days after load application), the 56 day concrete is found to creep less. This is because the hydration reaction has progressed to a greater extent in the 56 day concrete. With less capillary pores to hold water, creep is reduced.

UNIT 4

Mix Design

4.1 INTRODUCTION

The common method of expressing the proportions of ingredients of a concrete mix is in the terms of parts or ratios of cement, fine and coarse aggregates. For e.g., a concrete mix of proportions 1:2:4 means that cement, fine and coarse aggregate are in the ratio 1:2:4 or the mix contains one part of cement, two parts of fine aggregate and four parts of coarse aggregate. The proportions are either by volume or by mass. The water-cement ratio is usually expressed in mass.

4.2 Factors to be considered for mix design

- The grade designation giving the characteristic strength requirement of concrete.
- The type of cement influences the rate of development of compressive strength of concrete.
- Maximum nominal size of aggregates to be used in concrete may be as large as possible within the limits prescribed by IS 456:2000.
- The cement content is to be limited from shrinkage, cracking and creep.
- The workability of concrete for satisfactory placing and compaction is related to the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.

4.3 Procedure for Concrete Mix Design – IS456:2000

1. Determine the mean target strength ft from the specified characteristic compressive strength at 28-day f_{ck} and the level of quality control.

$$f_t = f_{ck} + 1.65\ S$$

   Where, S is the standard deviation obtained from the Table of approximate contents given after the design mix.

2. Obtain the water cement ratio for the desired mean target using the empirical relationship between compressive strength and water cement ratio so chosen is checked against the limiting water cement ratio. The water cement ratio so chosen is checked against the limiting water cement ratio for the requirements of durability given in table and adopts the lower of the two values.

3. Estimate the amount of entrapped air for maximum nominal size of the aggregate from the table.

4. Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) from table.

5. Determine the percentage of fine aggregate in total aggregate by absolute volume from table for the concrete using crushed coarse aggregate.

6. Adjust the values of water content and percentage of sand as provided in the table for any difference in workability, water cement ratio, grading of fine aggregate and for rounded aggregate the values are given in table.

7. Calculate the cement content form the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.

8. From the quantities of water and cement per unit volume of concrete and the percentage of sand already determined in steps 6 and 7 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations:

$$V = \left[W + \frac{C}{S_c} + \frac{1}{p}\frac{f_a}{S_{fa}}\right] \times \frac{1}{1000}$$

$$V = \left[W + \frac{C}{S_c} + \frac{1}{1-p}\frac{C_a}{S_{ca}}\right] \times \frac{1}{1000}$$

Where, V = absolute volume of concrete = gross volume ($1m^3$) minus the volume of entrapped air

S_c = specific gravity of cement

W = Mass of water per cubic metre of concrete, kg

C = mass of cement per cubic metre of concrete, kg

p = ratio of fine aggregate to total aggregate by absolute volume

fa, Ca = total masses of fine and coarse aggregates, per cubic metre of concrete, respectively, kg, and

S_{fa}, S_{ca} = specific gravities of saturated surface dry fine and coarse aggregates, respectively

9. Determine the concrete mix proportions for the first trial mix.

10. Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size and test them wet after 28-days moist curing and check for the strength.

11. Prepare trial mixes with suitable adjustments till the final mix proportions are arrived at.

4.4 CONCRETE MIX DESIGN EXAMPLE – M50 GRADE CONCRETE

Grade Designation = M-50
Type of cement = O.P.C-43 grade
Brand of cement = Vikram (Grasim)
Admixture = Sika [Sikament 170 (H)]
Fine Aggregate = Zone-II

Sp. Gravity
Cement = 3.15
Fine Aggregate = 2.61
Coarse Aggregate (20mm) = 2.65
Coarse Aggregate (10mm) = 2.66

Minimum Cement (As per contract) =400 kg / m3
Maximum water cement ratio (As per contract) = 0.45

Mix Calculation: –

1. Target Mean Strength = 50 + (5 X 1.65) = 58.25 Mpa

2. Selection of water cement ratio:-

Assume water cement ratio = 0.35

3. Calculation of water: –

Approximate water content for 20mm max. Size of aggregate = 180 kg /m^3 (As per Table No. 5, IS : 10262). As plasticizer is proposed we can reduce water content by 20%.

Now water content = 180 X 0.8 = 144 kg /m^3

4. Calculation of cement content:-

Water cement ratio = 0.35
Water content per cum of concrete = 144 kg
Cement content = 144/0.35 = 411.4 kg / m^3
Say cement content = 412 kg / m^3 (As per contract Minimum cement content 400 kg / m^3) Hence O.K.

5. Calculation for C.A. & F.A.: –

Volume of concrete = 1 m^3
Volume of cement = 412 / (3.15 X 1000) = 0.1308 m^3
Volume of water = 144 / (1 X 1000) = 0.1440 m^3
Volume of Admixture = 4.994 / (1.145 X 1000) = 0.0043 m^3
Total weight of other materials except coarse aggregate = 0.1308 + 0.1440 +0.0043 = 0.2791 m^3

Volume of coarse and fine aggregate = 1 – 0.2791 = 0.7209 m^3
Volume of F.A. = 0.7209 X 0.33 = 0.2379 m3 (Assuming 33% by volume of total aggregate)

Volume of C.A. = 0.7209 – 0.2379 = 0.4830 m^3

Therefore weight of F.A. = 0.2379 X 2.61 X 1000 = 620.919 kg/ m^3

Say weight of F.A. = 621 kg/ m^3

Therefore weight of C.A. = 0.4830 X 2.655 X 1000 = 1282.365 kg/ m^3

Say weight of C.A. = 1284 kg/ m^3

Considering, 20 mm: 10mm = 0.55: 0.45
20mm = 706 kg.
10mm = 578 kg.
Hence Mix details per m^3
Increasing cement, water, admixture by 2.5% for this trial

Cement = 412 X 1.025 = 422 kg
Water = 144 X 1.025 = 147.6 kg
Fine aggregate = 621 kg
Coarse aggregate 20 mm = 706 kg
Coarse aggregate 10 mm = 578 kg
Admixture = 1.2 % by weight of cement = 5.064 kg.

Water: cement: F.A.: C.A. = 0.35: 1: 1.472: 3.043

Observations from Concrete Mix Design: –

A. Mix was cohesive and homogeneous.
B. Slump = 120 mm
C. No. of cube casted = 9 Nos.
7 days average compressive strength = 52.07 MPa.
28 days average compressive strength = 62.52 MPa which is greater than 58.25MPa Hence the mix accepted.

Percentage strength of concrete at various ages:

The strength of concrete increases with age. Table shows the strength of concrete different ages in comparison with the strength at 28 days.

Age	**Strength per cent**
1 day	16%
3 days	40%
7 days	65%
14 days	90%
28 days	99%

UNIT 5

Special Concrete

5.1 Introduction

- Special types of concrete are those with out-of-the-ordinary properties or those produced by unusual techniques. Concrete is by definition a composite material consisting essentially of a binding medium and aggregate particles, and it can take many forms.

- These concretes do have advantages as well as disadvantages.

5.2 Types of special concrete

1. High Volume Fly Ash Concrete.
2. Silica fumes concrete.
3. GGBS, Slag based concrete.
4. Ternary blend concrete.
5. Light weight concrete.
6. Polymer concrete.
7. Self-Compacting Concrete.
8. Coloured Concrete.
9. Fibre-reinforced Concrete.
10. Pervious Concrete.
11. Water-proof Concrete.
12. Temperature Controlled Concrete.

5.3 High Volume Fly Ash Concrete.

- Is used to replace a portion of the Portland cement used in the mix.
- According to IS: 456 – 2000 replacement of OPC by Fly-ash up to 35% as binding material is permitted.
- HVFAC is a concrete where excess of 35% of fly-ash is used as replacement.
- Use of fly ash is because of many factors such as
    a) Abundance of fly ash i.e. 110million tons of fly ash is produced in India every year.
    b) Fly ashes from major TPP are of very high quality i.e. quality of fly ash.
    c) Economic factor i.e. Cost of fly ash within 200 km from a TPP is as low as 10% to 20% of the cost of cement.
    d) Environmental factors i.e. reduction in CO_2 emission.

5.4 Silica fume concrete

- Very fine non-crystalline silica produced in electric arc furnaces as a by-product.
- Highly reactive pozzolana used to improve mortar and concrete.
- Silica fume in concrete produces two types of effect viz.
    - Physical effect
    - Chemical effect
- The transition zone is a thin layer between the bulk hydrated cement paste and the aggregate particles in concrete. This zone is the weakest component in concrete, and it is also the most permeable area. Silica fume plays a significant role in the transition zone through both its physical and chemical effects.

5.4.1 Physical Effect

- The presence of any type of very small particles will improve concrete properties. This effect is termed either “particle packing” or “micro filling”.
- Physical mechanisms do play a significant role, particularly at early ages.

5.4.2 Chemical Effect

- Silica fume is simply a very effective pozzolanic material.
- Pozzolanic means a siliceous or siliceous and aluminous material, which in itself possess little or no cementious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementious properties.

5.5 GGBS, Slag based concrete

- By-product of the iron manufacturing industry, replacement of Portland cement with GGBS will lead to significant reduction of carbon dioxide gas emission.
- GGBS powder is almost white in colour in the dry state Fresh GGBS concrete may show mottled green or bluish-green areas on the surface mainly due to the presence of a small amount of sulphide.
- GGBS concrete requires longer setting times than Portland cement concrete, probably due to the smooth and glassy particle forms of GGBS. If the temperature is 23oC or replacement level of portland cement by GGBS is less than 30%, the setting times will not significantly be affected.

  When GGBS replacement level is less than 40%, bleeding is generally unaffected. At higher replacement levels, bleeding rates may be higher.
- GGBS concrete has lower early strengths because the rate of initial reaction of GGBS is slower than that of Portland cement. GGBS is therefore generally grounded to a finer state than Portland cement i.e. from around 4000 cm2/g to 6000 cm2/g resulting in significant increase in 28-day strength.
- It was also reported that the early strengths (up to 28 days) of concrete mixes (with 25%, 35%, 50%, and 60% GGBS replacements) were lower than that of Portland cement concrete mixes. By 56 days, the strength of 50% and 60% GGBS mixes exceeded that of

the Portland cement mix, and by one year all GGBS mixes were stronger than the Portland cement mixes.

- Due to its longer setting time, it can be transported to distant places but care should be taken while casting because there are chances that bleeding may take place.

5.6 Light weight concrete

- Structural lightweight concrete is similar to normal weight concrete except that it has a lower density.
- Made with lightweight aggregates.
- Air-dry density in the range of 1350 to 1850 kg/m^3
- 28-day compressive strength in excess of 17 Mpa.
- Structural lightweight concrete is used primarily to reduce the dead-load weight in concrete members, such as floors in high-rise buildings.
- **Structural Lightweight Aggregates:**
  - Rotary kiln expanded clays, shales, and slates
  - Sintering grate expanded shales and slates
  - Pelletized or extruded fly ash
  - Expanded slags
- **Compressive Strength:**

  The compressive strength of structural lightweight concrete is usually related to the cement content at a given slump and air content, rather than to a water-to-cement ratio. This is due to the difficulty in determining how much of the total mix water is absorbed into the aggregate and thus not available for reaction with the cement.
- **Slump:**

1. Due to lower aggregate density, structural lightweight concrete does not slump as much as normal-weight concrete with the same workability.
2. A lightweight air-entrained mixture with a slump of 50 to 75 mm (2 to 3 in.) can be placed under conditions that would require a slump of 75 to 125 mm (3 to 5 in.)
3. With higher slumps, the large aggregate particles tend to float to the surface, making finishing difficult.

5.7 Polymer concrete

Polymer concrete is part of group of concretes that use polymers to supplement or replace cement as a binder. The types include polymer-impregnated concrete, polymer concrete, and polymer-Portland-cement concrete.

- In polymer concrete, thermosetting resins are used as the principal polymer component due to their high thermal stability and resistance to a wide variety of chemicals.
- Polymer concrete is also composed of aggregates that include silica, quartz, granite, limestone, and other high quality material.
- Polymer concrete may be used for new construction or repairing of old concrete.

- The low permeability and corrosive resistance of polymer concrete allows it to be used in swimming pools, sewer structure applications, drainage channels, electrolytic cells for base metal recovery, and other structures that contain liquids or corrosive chemicals.
- It is especially suited to the construction and rehabilitation of manholes due to their ability to withstand toxic and corrosive sewer gases and bacteria commonly found in sewer systems.
- It can also be used as a replacement for asphalt pavement, for higher durability and higher strength.
- Polymer concrete has historically not been widely adopted due to the high costs and difficulty associated with traditional manufacturing techniques.

5.8 Self compacting concrete

- Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement.
- The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete.
- Very close to the Kolhapur there is project of steel industry, sand used for the formation of mould when the moulds are opened the waste sand is dumped for the filling the low lying areas while doing this the agriculture areas is converted into barren area. Because there is no space for the waste other than the land filling. similar case is in case of aluminium industry where red mud is concluded to be waste, which contains lot amount of bauxite and that is why red mud is also dump in the nearby areas here it is causing big threat for the society and it is disturbing the eco system of the environment. So it is the need to use this particular otherwise waste material for the constructive in such fashion in the case of concrete so that concrete which became cost effective as well as eco-friendly.

5.8.1 Types

1. **Powder type of self-compacting concrete**: This is proportioned to give the required self-compactability by reducing the water-powder ratio and provide adequate segregation resistance.
2. **Viscosity agent type self-compacting concrete**: This type is proportioned to provide self-compaction by the use of viscosity modifying admixture to provide segregation resistance.
3. **Combination type self-compacting concrete**: This type is proportioned so as to obtain self-compactability mainly by reducing the water powder ratio.

5.8.2 Fresh SCC Properties

1. Filling ability (excellent deformability)
2. Passing ability (ability to pass reinforcement without blocking)
3. High resistance to segregation.

- It has been observed that the compressive strength of self compacting concrete produced with the combination of admixtures goes on increasing up to 2% addition of red mud.

- After 2% addition of red mud, the compressive strength starts decreasing, i.e. the compressive strength of self-compacting concrete produced is maximum when 2% red mud is added.

The percentage increase in the compressive strength at 2% addition of red mud is +9.11 .

5.9 Fibre reinforced concrete

- Fibre reinforced concrete (FRC) may be defined as a composite materials made with Portland cement, aggregate, and incorporating discrete discontinuous fibres.
- The role of randomly distributes discontinuous fibres is to bridge across the cracks that develop provides some post- cracking “ductility”.
- The real contribution of the fibres is to increase the toughness of the concrete under any type of loading.
- The fibre reinforcement may be used in the form of three – dimensionally randomly distributed fibres throughout the structural member when the added advantages of the fibre to shear resistance and crack control can be further utilised.

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THANKS