CHAPTER 1

INTRODUCTION

1.1 SURVEYING

Surveying is the art of determining the relative positions of different objects on the surface of the earth by means of measurements of distances, directions and elevations and then preparing a map to any suitable scale.

TYPES OF MAPS

(i) **Plan:** A plan is a geographical representation of the features on the earth surface or below the earth surface as projected on horizontal plane. The maps are necessarily drawn to geographical sources on the globe. On a plan horizontal distances and directions are shown.

(ii) **Map:** The representation of earth surface on a small scale is called a map. The map exhibits to geographical positions on the globe.

(iii) **Topographical map:** The maps which are on sufficiently large scale to exhibit the individual features shown on the map or to be identified on the ground by their shapes and positions are called topographical maps.

(iv) **Photographical map:** The maps which are on such a small scale that the features shown on the map are entirely generalized and the map gives a picture of the country as a whole and not any exact representation of the individual features, are called photographical maps.

1.2 ART AND OBJECTIVE OF SURVEYING

The aim of surveying is to prepare a map to show the relative positions, horizontal distances and elevations of the objects on the surface of the earth. The map is drawn to some suitable scale. It shows the natural features of a country, such as rivers, villages, roads, railways, etc. The objects of surveying can be stated as follows.

(i) To collect such information as the relative positions of points on the surface of the earth.

(ii) To prepare a map showing the features required for various purposes.

(iii) To prepare the plans and maps required for various activities.

(iv) To collect such information as may be necessary for designing various engineering projects.

(ii) Check that accuracy of work is not less than that of accuracy

1.1 [illegible]

(1) PRIMARY CLASSIFICATION

Surveying is primarily classified as:

(a) Plane surveying

(b) Geodetic surveying

(2) [illegible]

Geodetic surveying takes into account the curvature of the earth & is not taken into consideration

while in plane surveying it is assumed that the earth is flat & curvature is neglected.

Plane surveying is done on an area of less than 250 sq.km

(3) [illegible]

Topographic surveying takes into account the relief features of the earth & is taken into consideration

while in cadastral surveying it is not taken into consideration.

(4) [illegible]

(a) Chain surveying

(b) Compass surveying

(c) [illegible] surveying

(d) Plane table surveying

(e) Tacheometric surveying

1.2 [illegible]

The two basic principle of surveying need to be followed for accurately locating

points on earth

(a) [illegible]

The basic principle of surveying is to work from whole to part whether it is plane or

geodetic surveying. To achieve this a suitable minimum sufficient number of primary

control points are established over the area to be surveyed. These control points are then

established with less precise methods so that details can be surveyed with the help of these

control points by adopting any of the survey methods. The main idea of working

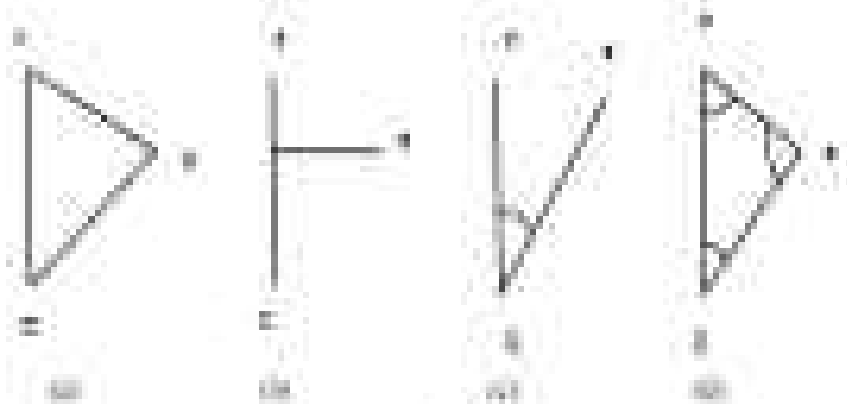
[illegible] to provide a continuous resolution of errors and to eliminate errors arising due to the large number of control points. On the other hand if survey is carried out for small part or whole, the errors would be small in general magnitudes and the scale of the survey will be observed beyond control.

In general practice the area is divided into a number of large triangles and the sides of these triangles are surveyed with greater accuracy using sophisticated instruments. These triangles are further divided into smaller triangles and their stations are fixed with less accuracy.

(ii) **To locate a new station by at least two measurements from fixed reference points / stations/points.**

By reference points / control points are selected in the area and known to us from a previous survey. We have the privilege to communicate with or reference them. In case the control points are not available then stations may be located with the system of coordinates of stations or referencing. The location of the required point may then be plotted by making two measurements from the given control points or stations/points.

Let P and Q be two given control points. Any other point R can be located with reference to these points by any of the following methods.



(a) (b) (c) (d)

Fig.1

(i) By measuring distances PR and QR:- The distances PR and QR may be measured and the location of R may be plotted by drawing arcs in the same scale in which the Fig.1(a) have been drawn as shown in Fig 1(a).

(i) **By dropping a perpendicular from A on XY:** A perpendicular AD is dropped on the line XY. Distances PD, YD and AD are measured and the location of A may be plotted by choosing the perpendicular AD to the same side as that in which P lies, from point D (Fig. 1.1(i)).

The above two principles **are generally used in "Data surveying".**

(ii) **By measuring the distance PA and angle PAX:-** The distance PA and the angle PAX, equal to α are measured and location of A may be plotted either by means of a protractor or trigonometrically (Fig 1.1(ii)).

The principle involved in **"Trigonometrical surveying".**

(iii) **By measuring the interior angles of the triangle PQA:-** The interior angles P (β) and Q of the triangle PQA are measured with an angle measuring instrument such as theodolite. The length of sides PA and QA are calculated by solving the triangle PQA and coordinates of A are calculated in the same manner as those of P and Q. From coordinate calculations, the coordinates of A can be measured by plotting the angles PQA and QPA (Fig. 1.1(iii)).

The principle involved in the method of "Triangulation".

CHAPTER-2

LINEAR MEASUREMENTS

2.1 **INTRODUCTION**

There are two main methods of determining the distances between points on the surface of earth:

(i) **Plane Measurement**: In this method, distances are usually measured on the small surface by means of **chains, ropes** etc.

(ii) **Geographical Measurement**: In this method, distances are determined by calculations as in Astronomy and Geographers.

[ ] DISTRIBUTION OF MEASURING INSTRUMENTS

(i) Ropes

(ii) Steel bands

(iii) Chains

(iv) Arrows

(v) Pegs

(vi) Ranging Rods

(vii) Ranging Poles

(viii) Offset Rods

(ix) Plumb Bobs

[ ] **TAPES**: Depending upon the material tapes are classified as

(i) Cloth or linen tape

(ii) Metallic tape

(iii) Steel tape

(iv) Invar tape

(i) **Cloth or linen tape**: Linen tapes are closely woven cloth and graduated to read in meters. They are generally 10 meters or 30 meters in length and 15mm to 19mm in width. Cloth tapes are generally used for measuring offset measurements only due to following reasons:

(i) It is easily affected by moisture and shrinks

(ii) Its length gets stretched by continuous

(iii) It is likely to break and tangle

(iv) It is not strong as metallic or steel tapes

(v) It is light and flexible and it does not smear weights in windy wind.

(vi) Has no continuous use, its figures get re-written.

(vii) **Metallic Tape:** A linear tape reinforced with fibres or copper wires to prevent stretching or breaking of fibres so called a metallic tape. As the wires are interwoven and the tape is concluded, these wires are not visible to naked eyes. These tapes are available in different lengths like tapes of 30m and 50m lengths are very common. These are supplied as further case with mending machines. Used mainly to checked size dimensions and such documents to add extended into construction.

(viii) **Glass Tape:** These tapes are available with different accuracy of graduations. Steel tapes are available in different lengths like 10m, 15m, 30m and 50m tapes are widely used in survey measurements. In this case of the tape a linear ring is provided. The length of second ring is equivalent to the length of tape. A second type of tape is degree of accuracy is generally required in a metallic or a cloth tape for linear measurements.

(ix) **Steel Tape:** Steel tapes are usually of an alloy of carbon (4%) and steel (96%) having very low co-efficient of thermal expansion (0.000012 per 1°C). These are 6mm wide and are available in length of 1cm, 30m and 50m. The tapes are used for high degree of precision required for linear measurements.

2. **Chains:** The different types of chains are used in surveying and are given below:

(1) **Gunter's chain** – It is 66ft. long and divided into 100 links. Each link measures 0.66 m.

(2) **Engineer's chain** – It is 100ft. long and divided into 100 links. Used like Gunter's ch.

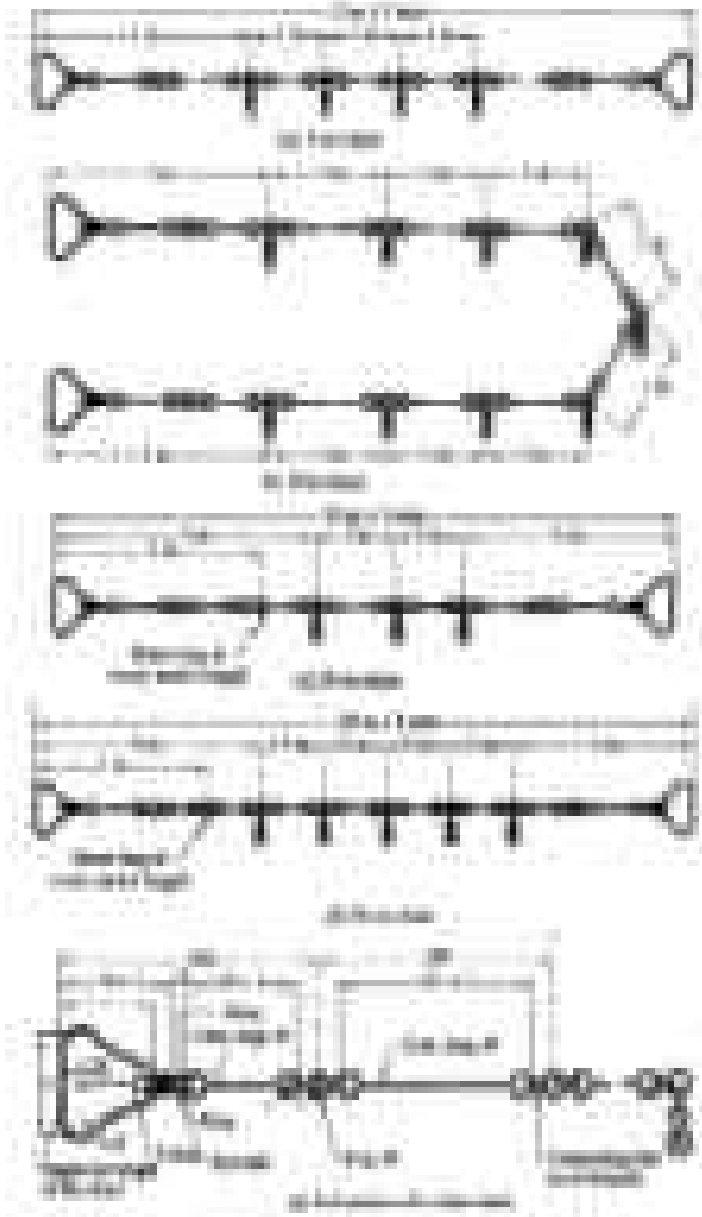


Fig. 4.1.

(1) **Swivel Chair:** A swivel chair is prepared with 150 or 140 pieces links of galvanized mild steel wire of standard gauge. The ends of the pieces are bent to form loops and connected together by means of three oval shaped rings which gives flexibility to the chair. Two arms handles are provided at the two ends of the frame with swivel joints so that chair can be turned round about its ring. The outside of the handle is the axis point or the end point of the chair. The length of the chair is measured from the outside of one handle to the outside of the other. The height of a link is the distance between the centres of the two consecutive middle rings as shown in the Fig. 1.1. The end links include the height of handle. Cushion are provided for sitting two chairs are marked with letter **"A" to distinguish the master chair from** the remaining chairs. The length of chair including the two arms and the handle are easy identification.

Suitability of Chairs: The chairs are suitable for the following uses.

(i) It is suitable for ordinary as well as prominent persons as its height allow due to continuous use.

(ii) Its length gets increased due to stretching of links and gets lengthened by fastening of the rings.

(iii) Rings have to be kept quite regular considerably when suspended in the work.

(iv) It can be easily repaired in the field.

(v) Measurements readings can be taken very easily.

(vi) It is only suitable for weight works.

Merits of Chairs:

(i) They are to read easily and quickly.

(ii) They are withstand wear and tear.

(iii) They can be easily repaired at any time in the field.

Demerits of Chairs:

(i) They are heavy and laborious work (one to operate it fully).

(ii) They require longer time to observe due to continuous use.

(iii) And the measurement is taken in progress the chain rings incorrectly giving incorrect measurements.

ARROWS: Arrows are made of tempered steel wire of diameter 4mm. One end of the arrow is bent into a ring of diameter 50 mm and the other end is pointed. Its overall length is 400mm. Arrows are used for counting the number of chains while measuring a chain line. Generally 10 arrows accompany a chain.

RANGING RODS: Rods, which are used for ranging a line are known as ranging rods. These rods are made of seasoned timber or seasoned bamboo. Sometimes GI pipes of 25mm diameter are also used as ranging rods. They are generally circular in section of diameter 25mm/30mm and length 2m / 3m. The rod is divided into equal parts of 200mm each and the divisions are painted black and white or red and white alternatively so that the rod is visible from a long distance. The lower end of the rod is provided in pointed with an iron shoe.

RANGING POLES: These are similar to ranging rods except that they are heavier in section of length 4m to 6m. They are used for ranging very long lines in undulating ground.

OFFSET RODS: These are similar to ranging rods and is 3m long. The top is provided with an open hook for pulling or pushing a chain through obstruction like hedges etc. It is used for aligning the offset line and measuring short offsets.

PLUMB BOB: It is used to transfer the end points of the chain onto ground while measuring distances on hilly terrain. It is also used for testing verticality of ranging poles, ranging rods.

PEGS: Wooden pegs usually 25mm square and 15cm long are used to mark the position of survey stations.

ADJUSTMENT OF CHAIN: Chains are adjusted in the following ways—

(1) When the chain is too long, it is adjusted by

(a) Closing up the joints of the rings

(b) Hammering the elongated rings

(c) Replacing some old rings by new rings

(2) When the chain is too short, it is adjusted by

(a) Straightening the bent links

(b) Opening the joints of the rings

(c) Replacing the old map by new longer map.

3.3 ERRORS IN LINEAR MEASUREMENTS / CHAINING

Errors in chaining may be caused due to mistakes or omissions and will differ in nature. They may be classified into two categories:

i) Compensating errors

ii) Cumulative error

(a) **COMPENSATING ERRORS**: Errors, which may occur in both directions (that is both positive and negative) and which finally tend to compensate (or balance or compensating errors.

(b) **CUMULATIVE ERRORS**: Errors which that occur in the same direction and that finally tend to accumulate are said to be cumulative. They seriously affect the accuracy of the work and are proportional to the length of the line (L) this error may be positive or negative.

i. **Positive Cumulative Error**: The error which make the measured length more than the actual is termed as positive cumulative error.

Sources: (a) The length of chain / tape is shorter than its standard length due to

- Bending of links
- Stretching of the metallic tape due to application of the tension
- Errors in connecting links
- The initial adjustment is done that is at which the tape was calibrated.
- Straightening of tape when used
- Clogging of rings with mud

(b) The tape correction is ignored while measuring along sloping ground.

(c) Not tag horizontal, if not applied when slope / tape is suspended in the air.

(d) Incorrect alignment.

ii. Negative Cumulative Error: The error which make the measured length (or) than the actual is known as negative cumulative error.

Sources: (a) The length of chain / tape is longer than its standard length due to

- Stretching of connecting rings.
- Opening of the ring joints.
- The field temperature is higher than that at which the tape was calibrated.

MISTAKES: Errors occurring due to the carelessness of the chainman are called mistakes. Following are a few common mistakes:

(1) If an arrow is withdrawn from the ground during chaining it may not be replaced in proper position if required due to some reason.

(2) A full chain length may be omitted or added. This happens when arrows are lost or wrongly counted.

(3) The numbers may be read from the wrong direction; for example a [illegible] may be read as a [illegible] and some numbers may be called wrongly. For example [illegible] may be called as [illegible] [illegible] the last point being mentioned.

PRECAUTIONS AGAINST ERRORS AND MISTAKES

(1) The point where the arrow is fixed on the ground should be marked with a cross (x).

(2) The zero end of the chain or tape should be properly held.

(3) Having counting the number of arrows carried by the follower and leader should always tally with the total number of arrows taken.

(4) The chainman should call the measurement loudly and distinctly and the surveyor should repeat them while booking.

(5) Ranging should be done accurately.

(6) The measurement should be taken with the chain in suspension.

ERRORS IN MEASUREMENT DUE TO INCORRECT CHAIN / TAPE LENGTH

Due to usage of chain over rough ground, the oval shaped rings get elongated and thus the length of chain gets increased. On the other hand, sometimes some of the links get bent and consequently the length of the chain gets decreased. Thus, the lengths obtained by chaining with a faulty chain are either too long or too short than the length which would be obtained with a chain of standard length. If the chain is too long the measured distance will be less and if the chain is too short the measured distance will be more.

Let L be the true length of chain and L' be the faulty length of chain.

Thus, the true length of a line = $\frac{\text{Standard length}}{\text{Measured length}}$ × measured length

2.2 CORRECTIONS IN LINEAR MEASUREMENTS

2.2.1 Correction for standard length

2.2.2 Correction for alignment

2.2.3 Correction for slope

2.2.4 Correction for sag

2.2.5 Correction for temperature

2.2.6 Correction for pull

(i) **Correction for standard length.** Before using a tape, its actual length is ascertained by comparing it with a standard tape of known length. The designated nominal length of a tape is the designated length e.g. 30m or 100m. The absolute length of a tape is its actual length under a specified conditions.

Let L = nominal length of a line

C_a = correction for absolute length

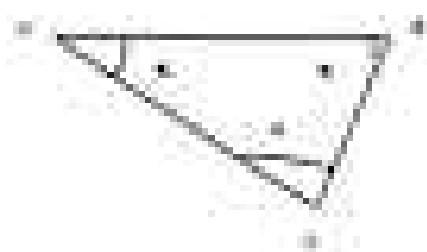
l = nominal designated length of tape

T = correction to be applied for tape

Then, $C_a = \frac{L \times T}{l}$

The sign of the correction C_a will be the same as that of T.

(ii) **Correction for alignment.** Theoretically a survey line is set out to be a continuous straight line. Sometimes, it becomes necessary due to obstructions to deflect a chain line which may be compared of two or more straight portions subtending an angle rather than 180° as shown in Fig 2.2



[illegible]

(a) [illegible]

Angle of slope: θ; Angle of slope: θ

Length [illegible] $\sin\theta$, $L\cos\theta$

No required correction [illegible] $\sin\theta$, $L(1-\cos\theta)$

(ii) **Correction for slope:** The distance measured along the slope between two stations is always greater than the horizontal distance between them. The difference is more obvious and horizontal distance is known as slope correction which is always subtractive.

Fig. 3.2 Slope Correction

Let: L = slope distance AB

D = horizontal distance AC

h= difference in elevation of A and B

$D = \sqrt{L^2 - h^2}$

Slope correction $= L - D = \frac{h^2}{2L}$

(iii) **Correction for pull (tension C_p):**

During measurement the applied pull may be either more or less than the pull at which the chain or tape was standardized. Due to the elastic property of materials the steel will vary according to the variation of applied pull and hence necessary correction should be applied. This correction is given by the expression

$C_p = \frac{(P - P_s)L}{AE}$

where: F - Pull or tension applied during measurement in Newtons

A - Cross-sectional area of the rope in square cm

L - Length of the measured line

ΔL - Stretched length

E - Modulus of Elasticity of the rope

If the applied pull is more, should correction is positive and if it is less, the correction is negative.

(ii) Temperature correction (C_2)

This correction is necessary because the length of the rope is slightly increased or decreased due to rise or fall of temperature during measurements. The correction is given by the expression as mentioned below:

$$C_2 = \alpha L(T_2 - T_1)$$

where: α - coefficient for temperature

α - coefficient of thermal expansion

T_2 - temperature during measurement in degree centigrade

T_1 - temperature at which the rope was standardized in degree centigrade

L - length of rope

(iii) Correction for sag (C_3)

This correction is necessary when the measurement is taken in the rope is suspension. It is given by the expression as mentioned below.

$$C_3 = -\frac{L}{24}\left(\frac{W}{P}\right)^2$$

where: W - weight of the rope, L - horizontal distance between the supports,

P - pull applied during measurement

Problem 1. *The length of a survey line measured with a 20m chain was found to be 485.5m. When the chain was compared with a standard chain, it was found to be 0.1m too long. Find the true length of the survey line.*

Solution.

$$\text{True length of a line} = \frac{\text{Erroneous length}}{\text{Correct length of chain}} \times \text{measured length}$$

$L' = 1.35\,\text{km},\ L = 1.5\,\text{km}$

and measured length of the survey line = 4.4 cm

Then, true length of the survey line $= \frac{1.5}{1.35} \times 4.4 = 4.89\,\text{cm}$ Ans.

Problem 2. A 30-m chain was found to be 4 cm too long after chaining 1600 m. It was 2 cm too long at the end of day's work after chaining a total distance of 2420 m. If the chain was correct before commencement of the work, find the two distances.

Solution.

Let normal length of the chain be x centimetres $= 30x$ cm.

Part length of the chain after chaining 1600 m $= \frac{1600}{30x} \times 100$ cm

Part wear length of the chain after chaining $= \frac{(30x - 4)}{30x} \times \frac{1600}{30x} \times 100$ cm

Thus the distance for the wrong chainage of 1600 m $= \frac{(30x - 4)}{30x} \times \frac{1600}{30x} \times 100 = 1611.1$ m

Thus remaining distance $= 2420 - 1600 = 820$ m

Part wear length of chain after measuring the remaining distance $= \frac{(30x - 2)}{30x} \times \frac{820}{30x} \times 100$ cm

Part true length of remaining 820 m $= \frac{820 \times 30x}{30x - 2} = 827.1$ cm

Hence, the total true distance $= 1611.1 + 827.1 = 2438.2$ m Ans.

Problem 3. A bar was measured with a steel tape which was exactly 30 metres at 20°C and a pull of 100 N. It was 30.01 m between the end marks. The temperature during measurement was 40°C and the pull applied was 150 N. Find the length of the bar, if the cross-sectional area of the bar was 2.22 sq cm. Take coefficient of expansion of the material of the tape per °C $= 0.0000116$ and the modulus of elasticity of the material of the tape $= 2.1 \times 10^6$ kg/cm^2 $= 2.1 \times 10^7$ kg/m^2.

Solution.

(*a*) *Correction for temperature per tape length.*

$= \alpha (T_2 - T_1) L$

$= 0.0000116 \times (40 - 20) \times 30$

$= 0.00696$ m ...(*i*)

(*b*) *Correction for pull per tape length.*

[illegible]

EXERCISE

1. [illegible]

2. [illegible]

3. [illegible]

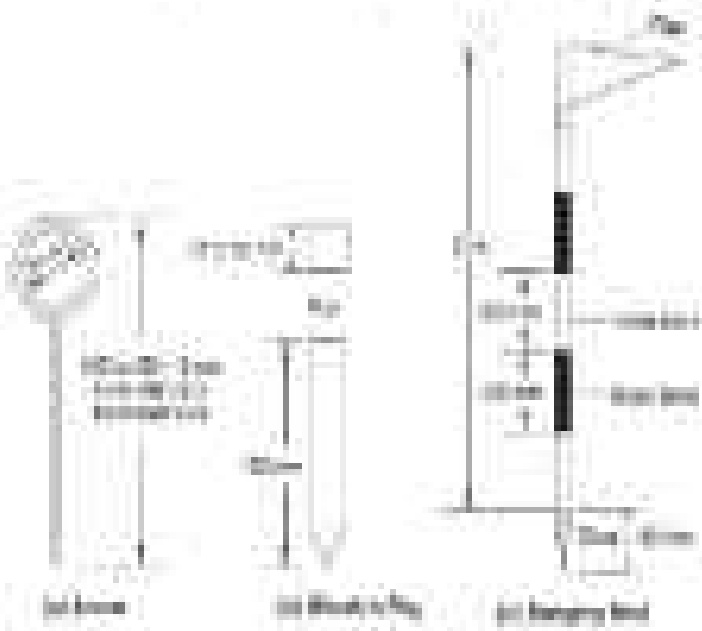
to platforms to drive or rigs, anchor other tow-boy equipment are required to a chain-carrying ring. These are linked to subsequent paragraphs.

Screens

Screens are driven pegs, sections are called screwmen, are made of wood each 4cm x 4cm in diameter, 800 to 1100 mm long and black galvanized. Screws are made to reach the end of each driven length as shown in Figure 3.0.

Wooden Pegs

These are made of wood known generally 11 to 15 cm square in circular size and 1.8 mm long, as shown in Figure 3.1. Wooden pegs are normally used to mark various positions on ground on a construction sites. These are tapered on one end so that they can be driven in the ground with a hammer. These are large at about 30 mm x centimeter projecting above the ground.



Sampling Rods

Chairs are categorized as an aspect to their commodity. Of the 40 chairs documented, eight chairs in particular stand out. Each is bought and provided with an accompanying chair stand as shown in Figure 3.3. These are planned to blend well within different houses and necessarily have a flag at the top. For many occupations and identifications, there is distinction. In the company trade are graduated in colours and size levels of a ranks, they are called officer rank and are used for measurement of chief officers.

Phase 1: Bolt

It is usually heavy upholstered or cushioned built, as shown in Figure 3.3, of metal and is used to provide access on ground by responding to the first sign of a coming threats. It is used to transporting the bolt on sloping ground by dragging. Compass, strength, for our work. Considerations are also given based on the weight is given as exactly as with the help of physical terms.

Line Hanger

A line hanger consists of either two plate members or two right angled members placed one above the other as depicted in Figure 3.3. The diagonals of both the plates are inclined so as to offset the incident light. Line hangers are provided with a handle to hold by maintenance. A line hanger can also be used to show offset on surface line.

Use of chain

Fabricating Of Chain: It is open chain for strap is cushioned and the two chain handles are held in the left hand and the hands is the one clenched with the right hand. Then on downward stroke of the working manner by holding one handle and another moving from and by holding the other handle and the chain is completely controlled.

Folding of Chain: After the completion of the work the chain should be folded in a handle and fastened with a leather strap. It is to that the handles of the chain should be brought together by folding the chain in the middle, commencing from the middle step two pairs of folds at a time with the right hand and place them compactly and see that either in the left hand. When the chain is collected in a handle, it is tied with a leather strap. The process is called the folding of chain.

Reading a chain:

A survey chain is generally comprised of 100 or 150 links that are by the process of galvanized mild steel wire of 3 mm diameter. The ends of each link are looped and connected together by means of the connecting rings which helps to provide flexibility in chain. The length of each link is measured as the distance between the centre of two consecutive middle rings.

The ends of chain are provided with brass handles with a swivel joint. The end link, length including the length of handle and is measured from the outside of the handle, which is considered as zero point for the chain end. Tallies, which are metallic tags of different patterns are provided at suitably specified points in the chain to facilitate quick and easy reading. A metal circular plate is provided to the centre on the same principle of handle of chain link being the initial point or the end of one chain length. The number of links in a chain could be 100 in a 20 m chain and 150 in a 30 m chain. The details of a metric chain are as shown in Figure

Testing of a chain:

Due to continuous use, a chain may be elongated or distorted. So, the chain should be tested and adjusted accordingly. If full adjustment is not possible, then the amount of elongation (called as "test chain") **and elongation (known as "testing") should be noted clearly. The necessary corrections** applicable to the chain.

For testing the chain, a test gauge is established on a level platform with the help of a welded steel rigid. The said rigid is standardized at 200 mm under a tension of 9 kg. The test gauge consist of two gauge forming rods at the top and fitted on a curved platform comprised of semi circular rigid ring. To the first [illegible] the chain is fully stretched by pulling it under a load known during the test gauge. If the length of the chain does not tally with standard length, then the amount should be noted to rectify the error. Actually, the amount of elongation or shortening should be noted.

Details of Work Chain

The allowable error is about 2mm per 1 m length of the chain. The overall length of the chain should be within the following permissible limits :

[illegible]

[illegible]

Adjustment of a chain :

Chains are adjusted in the following ways :

- Where the chain is too long, it is adjusted by
  - Closing the opened joint of the rings
  - Removing the unrequired rings
  - Removing one or more connected rings
  - Replacing the worn-out rings

- Where the ring is too close, it is adjusted by
  - Straightening the fused links
  - Removing the unusable rings
  - Inserting the open rings in the necessary
  - Replacing the old rings by correct larger rings

Hanging

The process of transferring a correct load position into a sling for lifting or to put it down is known as slinging.

Purpose of slinging

The purpose of slinging is to enable a number of load-handling points on a load to be joined to the hook so that the weight can be supported correctly.

If the load is slung in an unsafe manner, a slack rope, the load may fall out of alignment. But if the load is slung in an unsafe manner, it can create also an unbalance ground. It is important to check a number of points with hanging work.

Code of Signals for Hanging

S.No.	Signal by the Banksman	Action by the Assistant
1	Raise/ swing with right hand	When considered (-) to the right
2	Move/ swing with right hand	Move down to the right
3	Right arm extended	Crossing an enemy to my right
4	Right arm up and bent to the right	Pinch the rope on the right
5	Raise/ swing with left hand	Move considerably to the left
6	Move/ swing with left hand	Move slowly to the left
7	Left arm extended	Continue to move to the left
8	Left arm up and bent to the left	Pinch the rope to the left
9	Both hands down/ hand and then brought down	Lower
10	Both arms extended forward, horizontally, and the hands folded	Hold the load

Slinging angles

When intermediate staging rods are fixed along the datum line, by direct observation from either **end station, the process is known as "Direct Ranging". Direct ranging is possible when the end** stations are in sight. The following procedure is adopted for direct ranging.

- Erect ranging rods at points, vertically behind each end at the line.
- Erect a third rod at the end of the ranging rod at the beginning of the line.
- **Direct the assistant to hold a ranging rod vertically at any convenient point in the proximity of the** intermediate station is to be established.
- Direct the assistant to move him end to the right or left, until the ranging rods appear to be exactly in a straight line.
- Then direct and check the position of the rod by sighting over the three ranging rods as earlier as several times to ensure verticality of the ranging rods.
- After ascertaining that the ranging rods are in a straight line, signal the assistant to fix the ranging rod.

Indirect ranging

When the end stations are not intervisible due to many living high ground between them, intermediate ranging rods are fixed in the line by an indirect way. This method is known as indirect ranging or reciprocal ranging. The following procedure is adopted for indirect ranging.

Suppose A and B are two end stations which are not intervisible due to high ground existing between them. Suppose it is required to fix intermediate points between A and B. Two chainmen take up positions at A and B, with ranging rods in their hands. The chainmen at B, provide with his ranging rod so that he can see the ranging rods at A and B. Again the chainmen at A, should with his ranging rod so that he can see the ranging rods at B and C. Now the chainmen proceed to range the line by observing each other alternately. The chainmen at B_1 direct the chainmen at A_1 to proceed to a point C_1 so that B_1, C_1 and B are in the same straight line. Again the chainmen at C_1 observe the chainmen at B_1 to move his position to B_2 so that A_1, B_2 and C are in the same straight line. By observing each other alternately in this manner they change their positions every time until they finally come to the positions B and A and are in the straight line AB. The ranging the points A_1, B_1, C_1 and B are in the same straight line.

Role of Leader and Follower :

The foremost at forward (tail of the chain, who drag the chain forward, is known as leader. The duties of the leader are as follows :

a. [illegible]

b. [illegible]

c. [illegible]

The foremost at the rear end of the chain, who holds the rear end of the chain at the station, is known as the follower. The duties of the follower are :

a. [illegible]

b. [illegible]

c. [illegible]

Changing of Lead Ground :

[illegible]

[illegible]

[illegible]

[illegible]

Chaining on Sloping Ground

Chaining on the surface of a sloping ground gives the sloping distance. For plotting the survey, horizontal distances are required. If a correction necessary either to reduce the sloping distance to horizontal equivalent or to measure the horizontal distance between the stations directly. The following are the different methods that are generally employed.

(a) Direct Method or Stepping Method

(b) Indirect Method

Direct Method

This method is applied when slope of the ground is very steep. In this method, the sloping ground is divided into a number of horizontal and vertical steps like steps. In this method is also known as stepping method. The length of the horizontal portions are measured and added to get the total horizontal distance between the points. The steps may not be uniform and exactly depend on the nature of the ground.

Procedure:

Suppose the horizontal distance between two points A and B is to be measured.

Hold the chain at A in proper direction.

Hold the chain at the other end of the chain at A.

Hold bottom end of another length AP1 as plumb P1 is at short length and AP1 is perpendicular.

Hold horizontal measurement by eye estimation by an assistant at the intermediate stations.

Hold point P1 is marked on the ground by plumb bob so that P1 is perpendicular.

Hold horizontal length AP1 is noted then the following steps as for the previous P1 and finally the other end of the chain at that point.

Repeat the above process a number of times so that P2 is horizontal and P2 is vertical.

Hence the horizontal lengths P1P2 and P2P3 are measured.

Hence the total horizontal length = AB = AP1 + P1P2 + P2P3.

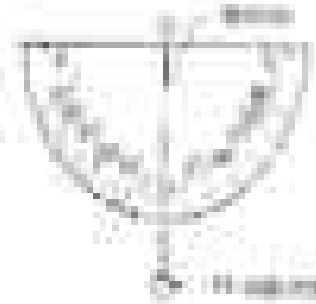
Indirect Method

When the slope of the ground between two points and points that engineering methods are used to find a value, the horizontal distance may be obtained by the indirect methods. Here are of following types

a. By measuring the slope with clinometer.
b. By applying trigonometrical ratio rules.
c. By knowing the difference of level between the points.

- **Measuring slope with a clinometer :**

A clinometer is a graduated semi-circular protractor. It consists of two pins P and Q, for sighting the object. A plumb bob is suspended from point O with a thread. When the straight edge is just horizontal, the thread passes through 0^0. When the straight edge is tilted, the thread remains vertical, but passes through a graduation on the arc which shows the angle of slope.



Suppose C and D are two points on sloping ground. Two ranging rods are fixed at these points. Observers at these points C1 and D1 are marked as the ranging rods as fixed C1 D1 = AB.

An observer at point C1 looks at the top of the ranging rod at D1. The clinometer is then turned gradually and the points P1, P2, and P3 are at the same straight line. In this position the thread of the clinometer will show an angle which is the angle of slope of the ground. Suppose this angle is α. The sloping distance CD is can measured.

The required horizontal distance = CD $\cos\alpha$ Units

b. Applying trigonometrical ratios

In this method, the slope of the ground is measured using the clinometer. A horizontal distance is then made for each step length.

Let θ = angle of slope measured by clinometer

$\sin\theta$ = [illegible]

$\cos\theta$ = [illegible]

$\tan\theta$ = [illegible]

[illegible]

[illegible]

[illegible]

Obstacles

Obstacles that may be encountered during clinometer measurements

1. Where choosing an [illegible] line cannot be observed.
2. Where choosing an obstacle(s), but vision is [illegible]
3. Where choosing each staircase looks impractical.

3. Choosing the horizontal distance:

Recall a problem occurs when a strong ground or a people wish to navigate the vision line from the one staircase to the next staircase.

Case (i)

The vital question was to create the line using intermediate points on the strong ground. In this case, the person stepping is instructed to avoid the [illegible] a times by stepping method

Case (ii)

The vital question was to create from intermediate points where people are cannot access the check line.

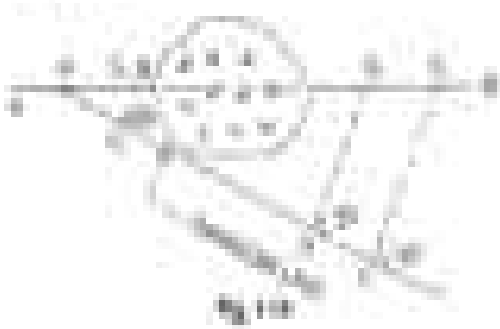


Fig 1.0

Let AB line be the curved choke line which connects the hanging wall and footwall portions of hemisphere to a straight line and intersects up on AC. A point P is selected on the choke line and a random line PT is drawn as a suitable direction. Points C_1, D and E are selected on the footwall line and perpendiculars are projected from them. The perpendicular at P meets the line at P_1.

Now in $\triangle PP_1C$

$$\frac{PP_1}{CP} = \frac{P_1C}{CP}$$

$$PP_1 = \frac{P_1C}{CP} \times PC \quad \text{..... (1)}$$

Again from triangle P_1EC_1 and PCC_1

$$\frac{P_1C_1}{EC_1} = \frac{PC_1}{DC_1}$$

$$PP_1 = \frac{P_1C_1}{EC_1} \times PD \quad \text{..... (2)}$$

From eq 1 and 2, the lengths EC_1 and DC_1 are calculated. The distance or movement along the perpendiculars at D and E. Points P_1 and C_1 should lie on the choke line AB

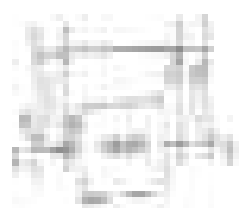
$$\text{Distance } PC_1 = \sqrt{PP_1^2 + P_1C_1^2}$$

I. Choking downward horizontal line:

Such a problem arises when a portal is cross cutting across the choke line. The solution can be resolved in the following steps.

Case—I

When a small rectangle like shown here, it is possible to get around the obstruction.



$CD = AB$

$CD = \sqrt{AD^2 + CD^2}$

3. Choosing and using basic theorems:

Teach a problem where a building comes across the distance. It is solved by the following method.

Suppose AB is the shore line. Two points C and D are selected on a same side of the building. Equal perpendicular CE and DF are erected. The line CD, a convenient part of the building is surveyed. On the extended line, two points A and B are selected. From perpendiculars, AB and EF are to be measured.

$\Delta ABC \cong \Delta EFD \cong \Delta CED$

Thus, the points C, D, A and B will lie on the same straight line. We

Here, $CD = EF$,

The distance EF is measured, and is equal to the required distance CD.

Problem:

A shore line ABC contains a river, B and C being on the near and distant banks respectively. The line BD of length x m is set out at right angles to the shore line AB. If the bearings of DB and DC are 24° 12' and 62° 12' respectively, find the width of the river.

Solution:

$\angle BDC = 90 + \angle DBA = 114°$ (ext $\angle$)

$\angle A = 180 - (24°12' + 114°) = 41°48'$

From triangle ABD, $\frac{AB}{\sin 114°} = \frac{x}{\sin 41°48'}$

$AB = \frac{x \sin 114°}{\sin 41°48'} = 1.36x$.

So the width of river is 1.7 m.

[illegible]

Definition:

[illegible] is one of the methods of land surveying. It is the system of surface in which sides of different triangles are measured directly in the field and no angular measurements are taken.

Principle of Chain Surveying:

The principle of chain surveying is triangulation. It is based upon the fact that a field to be surveyed is divided in to a number of small triangles which should be well conditioned. In chain surveying the sides are directly measured by chain or tape.

Chain surveying is recommended when:

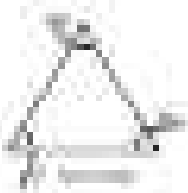
1. The ground surface is more or less even.
2. A small area is to be surveyed.
3. A rough sketch map is to be prepared and
4. The formation of well conditioned triangles is easy.

Chain surveying is unsuitable when:

1. The area is covered with many details.
2. The area is full of too many details.
3. The area is very large.
4. The formation of well-conditioned triangles becomes difficult due to obstacles.

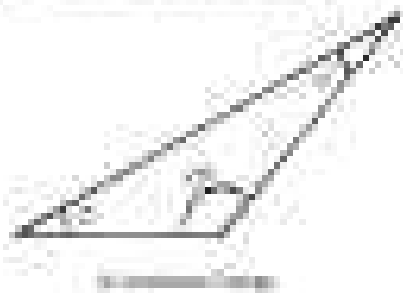
Well Conditioned Triangle:

1. A triangle is said to be well – conditioned when no angle is less than 30° or greater than 120°. An ideal triangle is considered to be best conditioned or ideal triangle.
2. Well conditioned triangles are preferred because their apex points are very sharp and can be located by ranges "well".



III. – Undefined Triangle

1. A triangle in which an angle is less than 30° and greater than 150° is said to be an undefined triangle.
2. [illegible] triangle is not used in [illegible]



[illegible] Undefined Triangle

Accessories in chain survey

The following equipments are required for conducting chain survey

1. [illegible]	= 1 no.
2. [illegible]	= 30 nos.
3. [illegible]	= 1 no.
4. [illegible]	= 1 no.
5. [illegible]	= 1 no.
6. [illegible]	= 1 no.
7. [illegible]	= 1 no.
8. [illegible]	= 1 no.
9. [illegible]	= 1 no.
10. [illegible]	= 30 nos.
11. [illegible]	= 1 no.
12. [illegible]	= 1 no.
13. [illegible]	= 1 no.
14. [illegible]	= 1 no.
15. [illegible]	= 1 no.

Reconnaissance Survey and Index Sketch:

During reconnaissance survey, the surveyor should walk over the area and note the various obstacles and lengths of sure lines wherever possible. The index sketch should

be so selected that they enclose the whole area. The surveyor should be also care that the triangles formed are well conditioned.

The neat hand sketch of the area which is prepared during reconnaissance survey is termed as "index sketch" or "key plan". The index sketch shows the skeleton of survey work.

Selection of Surveying Stations:

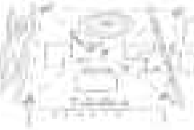
Survey stations are the points at the beginning and the ending of a chain line. The stations are classified under 3 categories:

i.e.- (a) Main Station
(b) Subsidiary Station
(c) Tie Station

1. Main survey station at the end of main line should be inter visible.
2. Survey line should be minimum as possible.
3. The main principle of surveying such as working from whole to part and from part to whole.
4. The stations should be well conditioned triangle.
5. Every triangle should be provided with a check line.
6. Tie line should be provided to avoid too long offsets.
7. Obstacles to ranging and chaining if any should be avoided.

The longer side of the triangle should be placed parallel to the boundaries, roads, buildings, etc. to have short offsets.

1. Chain line should be on even leveled ground.
2. Line should be laid on one side of the road to avoid disturbance of chaining by passing of traffic.



INDEX SKETCH

Base line:

The line on which the measurements are taken is called a base line or the "Base line". It is the most important line of the survey work. Generally, the longest of the main survey lines is considered as base line.

Tie line:

The tie line is a line which gives additional control on the main line.

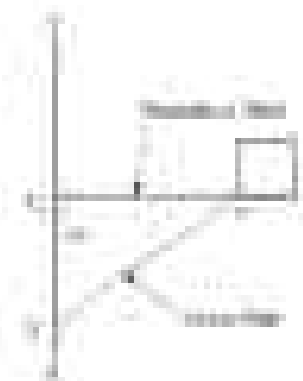
Check line:

The line joining the apex point of triangle or any two fixed points on the base is known as check line. It is taken to check the accuracy of the triangle.

Offsets:

The lateral measurements taken from the object to the chain line or base is known as offset. Offsets are taken to locate objects with reference to the chain line. They are two types:

i. Perpendicular offsets
ii. Oblique offsets



Perpendicular Offsets:

When the lateral measurements for fixing the details points are made perpendicular to the chain line. The offsets are known as perpendicular offset.

Oblique Offset:

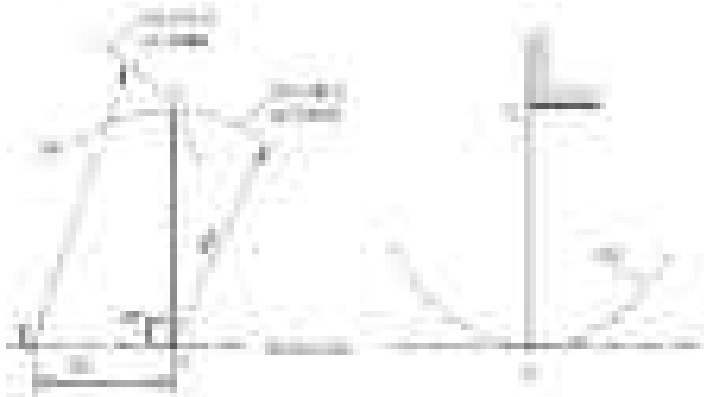
When the lateral measurements for fixing the details points are made at any angle to the chain line. The offsets are known as oblique offset. It can be done by following two Chain rule as :

i. Long offset
ii. Short offset

Setting offset with chain and tape (Manual method):

1-4-3 Offset

Perpendicular offset of chain line at any point A is measured using the following mathematical expression $AP = \frac{AB \times CA}{CB}$. A point B is located on chain line at a distance of



(a) Line Offset (b) Swing Offset

) to chain A such that AB =) m. Now, an arc is drawn with centre at A and radius equal to 4 m. Another arc is drawn with centre at B and radius equal to 5 m intersecting the previous arc at C. In triangle ABC, the sides AB, BC and CA are known as perpendicular to the AB.

Swing Offset

The perpendicular distance of an important feature, e.g. building corner, from the chain line is measured using swing offset method. The one end of tape is kept at point of interest (figure) and point at the other end, normal from C on chain line is located by swinging the tape with C as centre. The point B is determined by a point at which the arc intersected by swing a segment to survey line and the distance of C from any point on chain line is minimum.

It may be noted that usually only small offsets are to be by swinged method.

Optical Square:

1. It is a very versatile instrument for taking set of lines or a right angle is needed here.
2. It consists of a circular metal box about 4 to 5 cm in diameter and 2 cm in depth. It consists of two mutually plane at an angle of 45°.

1. The upper plate is known as **the ground** plate and the lower one plate is known as **index** plate.

Principle:

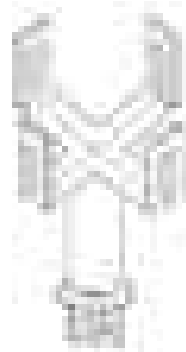
If the two mirrors are inclined with the vertical at an angle of θ, the plane of reflection is inclined with the vertical at 2θ.

Uses:

1. It is used to find out the perpendicular to the plane mirror.
2. It can use as perpendicular to surface line.

Cross staff:

The cross-staff consists of four equal arms with vertical slits. The two pairs of arms are at right angles to each other. The vertical slits are meant for sighting the ranging rods. The cross-staff is mounted on a wooden pole through a hole and pointed at its end. The pole is fitted with an iron shoe.



Cross staff

Working Length of Offset:

The maximum length of the offset should not exceed about the length of the perpendicular to the line to be chained. The maximum length of offset is limited to 15 m. However, this length also depends upon the following factors:

(a) The desired accuracy of the map
(b) The scale of the map
(c) The nature of the ground adjacent to the offset line in the direction
(d) The nature of ground

Sources of Errors::

Errors may arise from three sources:

(i) **Instrumental**
Errors may arise due to imperfect or faulty adjustment of the instrument with which measurements are being taken. For example, a tape may be too long or an angle measuring instrument may be out of adjustment. Such errors are likely to be systematic errors.

(2) **Personal**

(3) **Natural**

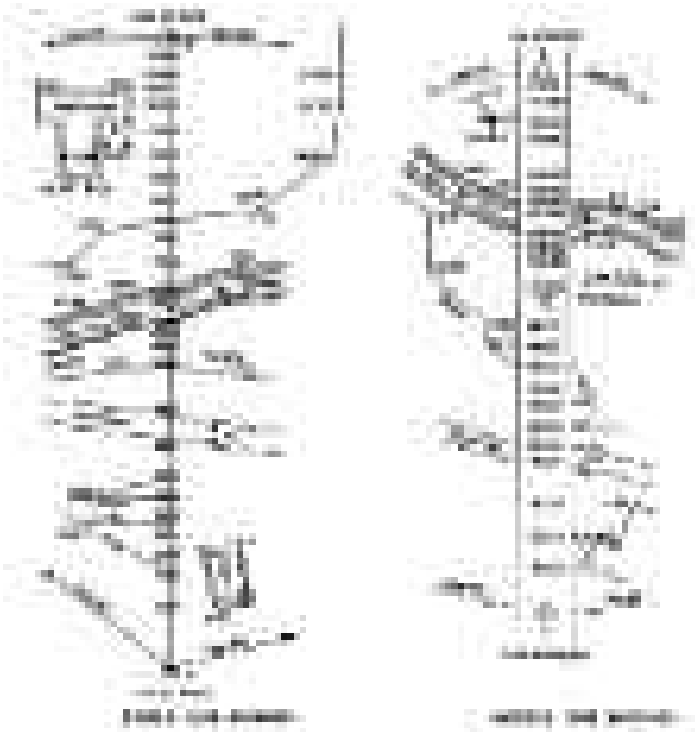
Field Book

1.
2.
3.
4.
5.
6.
7.
8.
9.
    i.
    ii.

Single Line Field Book

Double-Line Field Book

In this type of field book, two vertical lines, 1/4 inch apart, are drawn through the middle of each page. The column right of the first line, and the distances and notes in it. The offsets are recorded with chainage in the left or right of the column.



(A) METHODS OF PLOTTING.

Referring to the equipments of plotting

1. Drawing board (normal size — 600 mm × 750 mm)

1. Item [illegible]
2. Item [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]

Procedure for plotting:

1. A suitable scale is chosen so that the area can be accommodated in the given dimensions in the map.
2. A margin of about 2 cm from the edge of the sheet is drawn around the sheet.
3. The north line marked on the right-hand corner, and should perfectly be vertical. When a [illegible] is not convenient to be put without north line, [illegible] is confined to accommodate the whole area within the map.
4. The [illegible] is completed with all survey lines, check lines and tie lines. Where a cross plotting error which exceeds the permissible limits, the necessary lines should be [illegible].
5. The plotting of others should be continued according to the sequence mentioned in the field book.
6. The administrative [illegible] required in the map should be shown on the right-hand side.
7. The scale of the map is shown below the lettering on a more suitable place. The lettering should be [illegible] of the map.
8. [illegible]
9. The map should not contain any [illegible].

The commonly used scale for some of the types of map could be

(a) **Geographical Map:** [illegible] and is as smaller. Atlas maps are such maps.

[illegible]

(b) **Topographical Map:** [illegible] showing natural and man-made features.

[illegible]

(c) **Cadastral or Land Revenue Map:** [illegible] showing ranges number [illegible]

[illegible]

(d) **Building Site, Town Planning Schemes etc.** [illegible] for building sites [illegible] scale, e.g. 1:100 can be used.

(iv) **Roads, Railway Lines, or Canal Bridge:** [illegible]

[illegible] Some conventional signs or symbols, which are commonly used, are given in Fig. 2.

Some of the conventional symbols approved by Bureau of Indian Standard (BIS) are as shown in Figure.

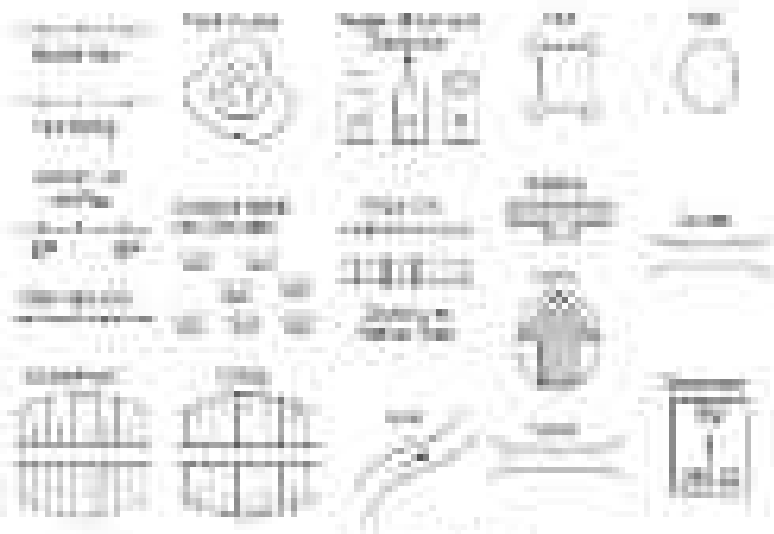


Fig. Conventional Signs and Symbols

ERRORS IN CHAIN SURVEYING:

Errors in chaining may be caused due to mistakes in compensation and [illegible] errors in measurement, etc. They may be either

1. Compensating errors
2. Cumulative errors.

Compensating Errors:

Compensating errors occur in the both directions i.e. both positive and negative and they are usually small. Compensating errors are known as compensating errors. They are proportional to $\sqrt{L}$, where L is the length of the line. Such errors may be caused by:

1. Incorrect Marking of the chain

2. Inaccurate measurement of right angle with chalk, tape
3. Horizontality and verticality of steps are being projected, maintained during the sighting operations.
4. Horizontal parts of the chain or tape not being written throughout its length

Constant Error:

Error which can occur in the same direction and which finally add to accumulative (may seriously affect the accuracy of work) the length of the line e.g.

Positive Error: when the measured length is greater than the actual length (the chain length is over-stretch) the error is said to be positive error. There error occur due to:

(a) The length of chain or tape being shorter than the standard length.
(b) Sloppy completion not being applied.
(c) Carelessness by ugly and long marks.
(d) Measurement being taken while faulty engrossed.
(e) Measurement being taken in high wind with the tape in suspension.

Negative Error: When the measured length is less than the actual length (the chain length is over-stretch), the error is said to be negative. There error occur when length of chain or tape is greater than the standard length due to following reasons:

(a) The opening of ring zones
(b) The applied pull being much greater than the standard
(c) The temperature during measurement is being much higher than standard
(d) Kinking of connecting rings.
(e) Elongation of the links due to heavy pull

Precautions against Error:

Following are the precautions should be taken to guard against errors and mistakes:

1. The point where the arrows or chains on the ground should be marked with a cross (x).
2. The back end of the chain or tape should be properly held.
3. The chain man should call the measurements loudly and distinctly and the recorder should repeat them while booking.
4. During booking, the number of arrows used by the follower and holder should always tally with the total numbers of arrows taken.
5. Measurements should not be taken with tape in suspension in high wind.
6. In sloping ground, horizontality and verticality should be properly maintained.
7. Plunging should be done accurately.
8. No measurement should be taken with the chain in entanglement.
9. Care should be taken so that the chain is properly straightened.

CHAPTER-5

5.0 ANGULAR MEASUREMENT:

Compass:

The compass works on the principle that a freely suspended magnetic needle takes the direction of the magnetic lines of force at a place. Any prismatic box with a pivoted magnetic needle to which alidhade can be mounted

There are two types of compasses

1. The prismatic compass.
2. The surveyor's compass

The principal **compass is mainly used** in **traverse** projects. The principles of the operation of both the compass is the same but they are made differently used in the field

1) The prismatic compass.

It is the most suitable type of surveying compass which consists of a circular box about 150 mm in diameter.

It is used to measure the bearing of a line.

It can be mounted on tripod stand or ranging rods.

The major parts of a prismatic compass are as follows

Magnetic Needle

The magnetic needle is the most important of the measurements. It is usually generally of the pivoted type, is supported on a hard, steel point with an agate cap. When not in use, the needle can be lifted off the point by a lifting needle connected to the folding of the object vane. This is done to prevent the point from becoming blunt or needle worn. The magnetic needle should be perfectly symmetrical and balanced so as to be horizontal when freely pivoted for use. It should be weighted with an adjustable weight to compensate for the dip angle. The needle should be straight and have up the north south direction correctly. The needle should be in the same horizontal plane as the object probe and a vertical plane should be made to such a way that the centre of gravity of the needle lies as much below the pivot point as possible

Graduated ring:

The aluminum graduated ring 90 to 110 mm diameter is attached to the needle so as to be a downward as to of the ring. Sometimes, being a non- magnetic substance is used to ensure that the ring does not influence the behavior of the needle. The

graduations of the ring is from 0 to 360°. 0° "north" is marked on the north point of the needle and the graduations go in a clockwise direction, with 90° marked at the east, 180 at the south, and 270° at the west direction. The graduations are marked at half degrees, so it is possible to read the angle to one half degree. The graduations on the ring are in relation to the direction that you are facing at the time.

For your prac:

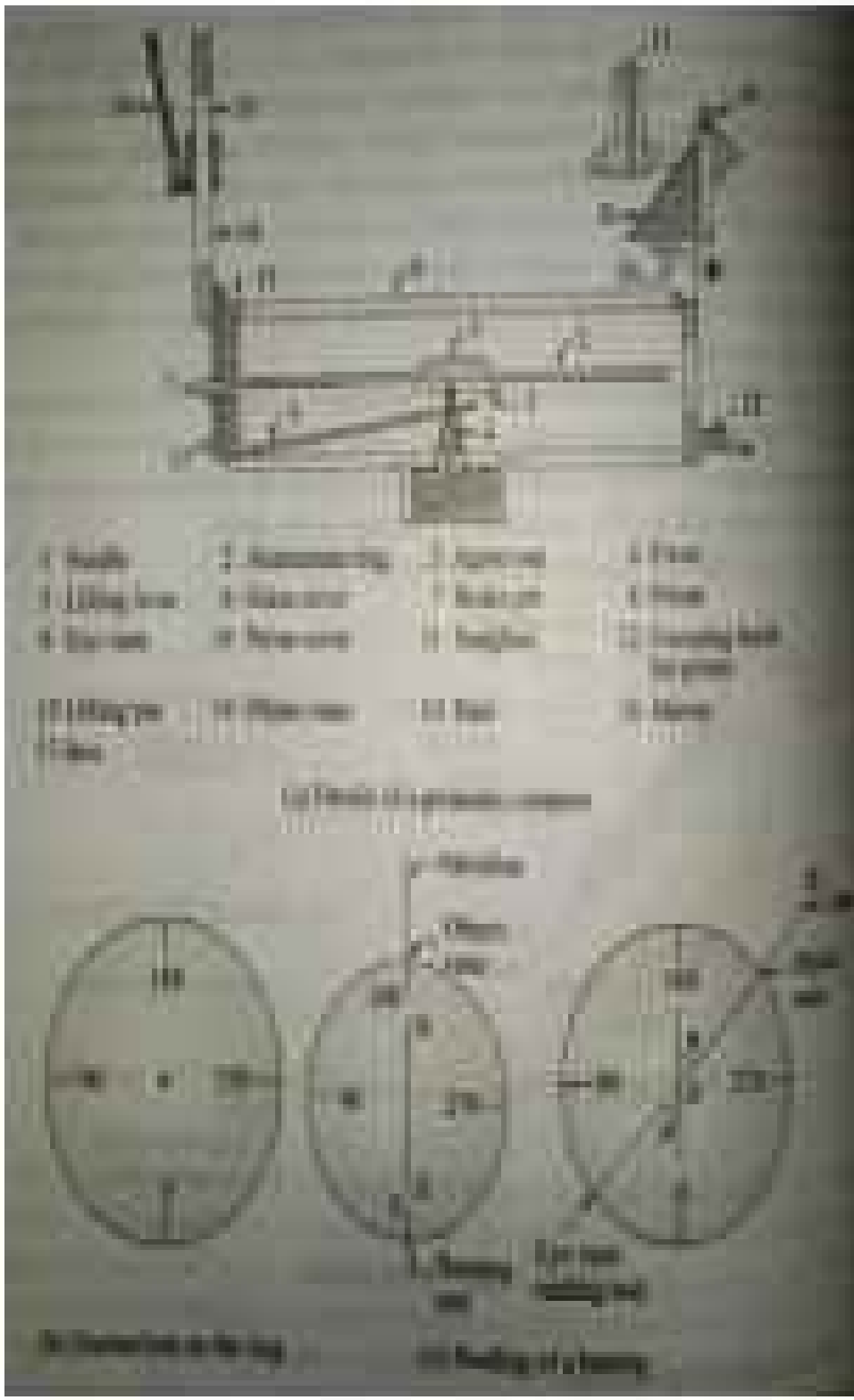
The prism in the prismatic compass folds down when the magnifying lens is in use. It is held up by a small piece of metal which is attached to the graduated ring when it is folded over the glass cover of the compass. The prism has a mirror surface, which magnifies the graduations on the ring. A small mirror is used to view the reading from the prism when it is in use. The prism can be viewed or reversed by the metal frame that is attached to the cover which also has a magnifying lens. Both prism and mirror can be brought in over the sighting hole to look at the sighting plate.

Object case:

Diametrically opposite the eye view the object vane, which is a metal frame hinged at the bottom and folding over the glass cover when it is not in use. A fine slit through a bar is attached to the frame vertically, which can be used to mount a magnifying lens on the back of it that on the frame vertically, which can be used to mount a magnifying lens or other objects. When the frame is folded over the glass cover, it prevents light from entering the compass through the sighting hole and the needle. When the prism is in use the frame is held by a hook, which, when gently pressed, engages the two flanges of the needle by pressing against the graduated circumference ring. The object vane may be provided with a mirror, which can be removed when the frame for sighting objects at a height is to be taken.

Compass Box:

The needle and other fittings are mounted in a metal box with a glass cover to protect dust. The two vanes are also attached to the box at diametrically opposite ends. The box is attached to a metal plate through a ball and socket arrangement for leveling the compass. While the compass case can be held in the hand, it is preferable to use it with a tripod, for which the metal plate has a universal joint that can be attached to a tripod. The compass box can be carried in a leather pouch when not in use.



Use of Prismatic Compass:

Use follow tips must be supposed to using prismatic compass.

1. Holding up and removing a box the prismatic compass note the object and place the object over the station. It is connected over the object. Centering is done by adjusting the object legs.
2. Level the compass using the ball and socket arrangement. Levelling is done approximately so that the needle can move freely in it plate after opening the object lid and eye vane.
3. Object the object vane and eye vane so that needle remain freely. Observe the object vane towards the ranging rod or any other objects at the next station. Sighting is done by orienting the object with the vane slide so the object looks while looking through the slit vane. The prism of the eye vane has to be adjusted for a clear view of the graduations by moving it up or down. It is done that the graduated ring along with the magnetic needle always comes in the north direction which we have to consider it as the vane. The line of straight between the vanes is through the eye vane and the vane face of the object vane and should pass through the centre of the prism.
4. Hence that object has been clearly sighted, along the coincidence of the needle with the breaking part of engraved. Once the object has been pin it engraved. Check the needle vibrate or not. Looking through the prism, record the reading at the point on the ring corresponding to the vertical hair seen directly through the slit in the prism holder.

Conclusion in day:

From above from the explanation that the prismatic compass gives the WCBs of the lines. The reading taken through the prism has to be zero when the black. The reading taken through the prism has to be zero when the line of sight is pointing to the north. The reading will be zero when the needle. Therefore, the zero graduations is marked on the south end.

Temporary adjustment:

In every station while prismatic compass is placed. The following adjustments as described above, have to be made centering, levelling and focusing the prism. The prism has to be focused such that same prism has to take the prism. The prism has to be focused only when the same prism has to take the readings. Centering is done by adjusting only the legs not using the

compass, usually in an alternative. Levelling is always necessary as the compass is not used. A sighting vane may be used, in a horizontal plane and the bearing read on the ring.

Surveyor's Compass

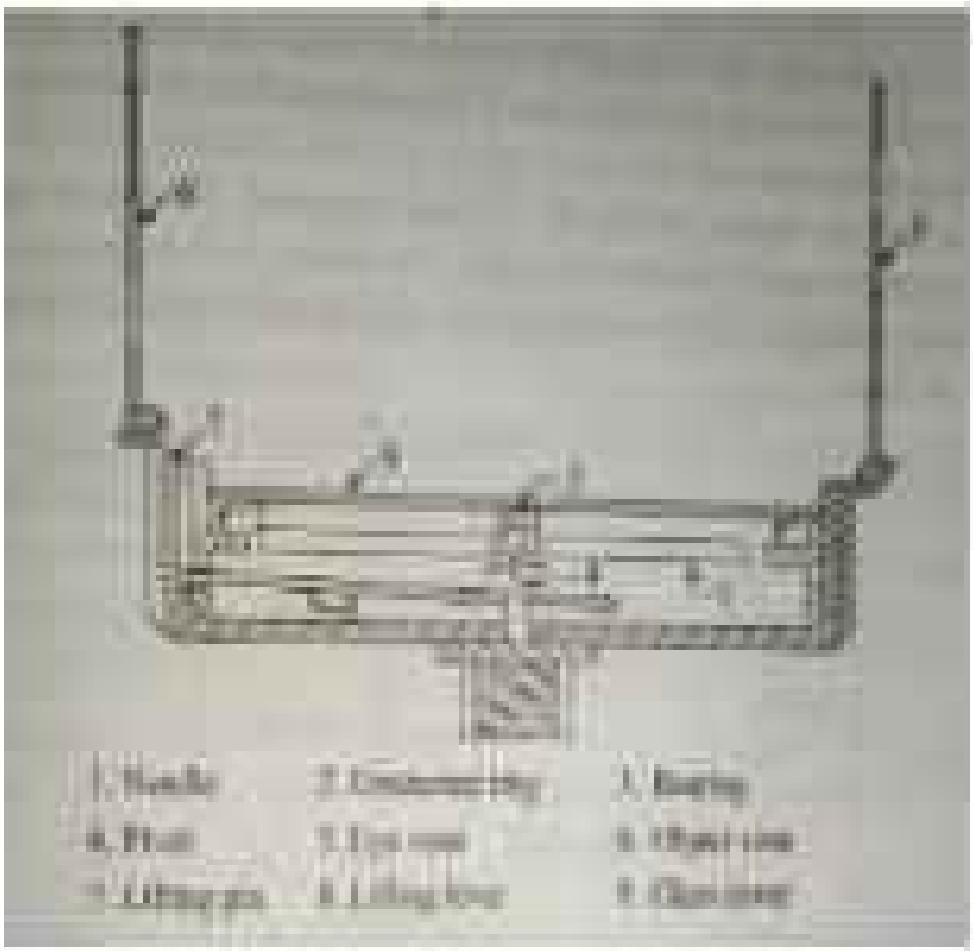


Fig. surveyor's compass is the old type of instrument having now (see text). A brief description of the instrument is given below. The surveyor's compass has the following components:

Magnetic needle: It is edge on magnetic needle, now on a pivot at hard metal and floats freely.

Graduation ring:

The graduated ring is rim attached to the needle, that is, the centre of the compass and needle is. The graduations are in the quadrantal system. The letters N, W, S and E are marked on the ring along with graduations, known as the cardinal points. The graduations are marked in half degrees and can be read to one-fourth of a degree by

(alignment) the A and B full diopters, but can be read on the ring. The zero is with the compass at the left. A mutual for sighting, the handle pointing to the south, all right.

Object case and eye case

The object case consists of a flat circular box, fitted onto a metal frame for sighting objects. The eye case is a similar frame with a flat slit but has no pivots to read the graduations.

Recorder's report

The surveyor's compass consists of a circular box, 3 inches in diameter, mounted on a tripod and is surveying rod for the object case.

The arrangement for fitting the needle off the pivot is convenient. The object case is folded over the eye glass.

Using surveyor's compass:

The following steps are required:

1. Attach the compass box to the tripod. Place the tripod over the station and center and level the instrument.
2. Release the instrument so that the object case is in line with the ranging rod at the adjacent station. Looking through the eye case, clearly bisect the ranging rod.
3. Note the reading the pointer is pointing nearest to the object case number, at the north end of the needle by looking through the glass. Take the reading along with the quadrant by reading across the bearing on either side of the reading.

Conclusion on ring:

Fig. explains the graduations on the ring. N and E are marked along the north-south direction. S and W are marked along the east-west direction on two fixed positions, are interchanged with E marked on the left of N and W on the right of the N. This is done to ensure that the readers question to orient when the reading is taken at the north end of the needle.

Fig. shows the bearing of this. All bearing are noted. The compass is at A and the line of sight is oriented B. The needle points to the north direction. After sighting B, the compass to the north end of the needle to read the bearing angle and the quadrant. It is clear from the figure that if the right quadrant (N-E) is correct, it should be marked on the left N.

At first the bearing of line BC is being measured. The line of sight is along BC while the needle points to the north. The bearing is to read at N. B, and N. (Read in clockwise direction) to give the correct reading quadrant as can be seen from the figure

Comparison Between Prismatic and Surveyor's Compass:

The prismatic compass and the surveyor's compass are both based on the same principle of orientation of a magnetic needle along the north-south direction. Both the instruments are known as magnetic bearings.

Differences between the prismatic compass and surveyor's compass

Sno		Prismatic Compass	Surveyor's Compass
1	Magnetic needle	It has a broad needle in the form of a V or an inverted V.	It has an edge but needle and are in an inverted V.
2		The graduated ring is attached with the needle. This does not rotate along with the line of sight.	The graduated ring is fixed to the box and is independent of needle.
3		The graduations are in WCB. It is clockwise from zero at the north end. In ranges from 0° to 360° in the clockwise direction. The graduations are engraved on metal.	The graduations are in QB system. Starting North and south are marked with 0° where as east and west are marked with 90°. In ranges from 0 to 90, but not in the anticlockwise. The graduations are engraved on ivory.
		The eye vane has a prism to read the graduated ring.	The eye vane has no prism and is not used for reading.
		Can be used in the horizontal position also.	Has to be used in a vertical only.
		Sighting and reading are done simultaneously due to the position of the observer.	Sighting and reading cannot done simultaneously due to the position of the observer.

Introduction:

The first direction to the surface of the earth with reference to which readings of the dip may be expressed is called as the dip plane.

Bearing:-

The horizontal angle between the reference meridian and the strike line measured in a clockwise direction is called bearing.

There are five different types of meridians which can be used as reference directions.

True meridian:

The line in geographic meridian as a point in the line of intersection of a plane passing through the earth and south poles and the point with the surface of the earth. From the earth is approximately a sphere it is clear that the meridians through different points meet at the north and south poles. The true meridians through different points are not parallel. The true meridian at a place can be established through astronomical observations. The direction of the true meridian remains constant. If the magnetic bearing of the sun is taken at noon, the bearing will be true east-west at the point and it is found. The sun is taken as north or on a plane passing through the north and south poles at a place. The time bearing of an ore body from the horizontal angle that the radius with the true meridian passing through one of its ends.

Magnetic meridian.

The magnetic meridian through a point on the ground is the direction taken by a freely suspended magnetic needle placed at that point. The magnetic meridians can be affected by any external magnetic interference. Such as mineralized veins, rails or the presence of magnetic substances, such as magnetized keys. The magnetic bearing of a survey line is the horizontal angle which it makes measured from magnetic bearing of a line.

Grid Meridian

Grid survey maps are based on two or more true meridians of places on their long parallel. The meridian lines of the grid are parallel to the line representing the central meridian. The distances of the grid lines along the meridian direction is known as Grid Meridian. The bearing of survey lines referred to grid lines are called Grid Bearing.

Arbitrary meridian:

The arbitrary meridian at a point is any north direction assumed to any true point, such as the axis of a church, a well defined point on the ground, or a corner. Such meridians can be used for local surveys as they will serve the purpose of a reference direction and the required computations are possible with such data. The arbitrary bearing of a line is the horizontal angle between the line direction of the direction of the arbitrary meridian through one end of the line.

Designation of Bearing:

The bearing of survey lines are designated in the following systems

1. Whole Circle bearing system (W.C.B)
2. Quadrantal bearing system (Q.B)

1.Whole circle bearing system (WCB):

In this system of bearing of a line measured from the true north in clockwise direction. The value of bearing may vary from 0 to 360. It is also known as Azimuthal bearing.

2.Quadrantal Bearing system (WCB):

In this system of bearing of a line measured in two local lines the north or south which ever is nearer to the center both North and South direction are used as reference meridians the bearings are measured either clockwise or anticlockwise depending upon the position of the survey line. It is also called Reduced bearing.

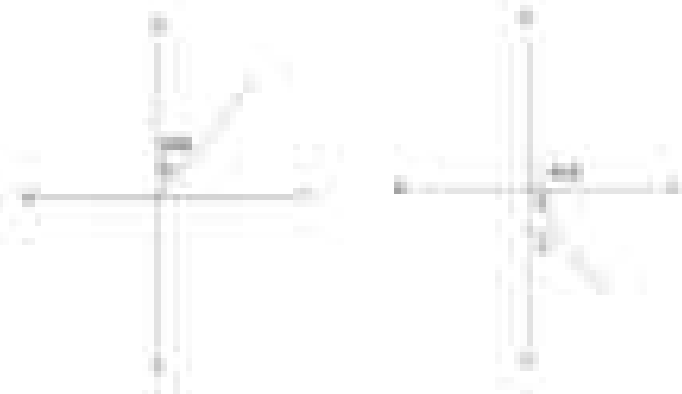
Conversion of bearing:

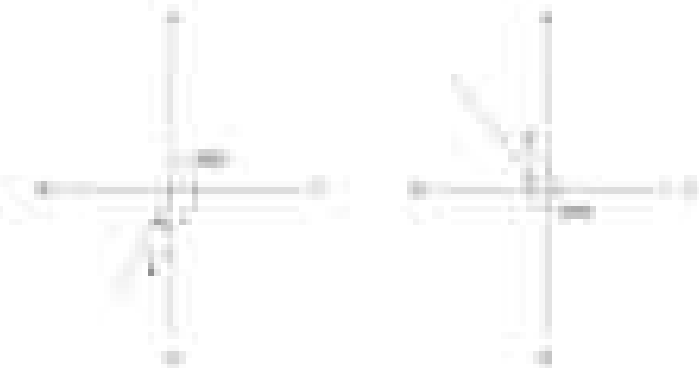
If the W.C.B. of any given survey line is known it is required to calculate the bearing of the line also be converted to W.C.B.

Whole circle bearing to reduced bearing:

In a survey, 90 people were asked to choose their favourite drink from tea, coffee or milk. The following results were recorded.

- (a) If the 40 people who chose tea are represented by a sector of angle 144°, find the angle that represents the people who chose coffee.
- (b) If the 90 people are represented by a pie chart, a sector with angle 72° represents the people who chose milk. How many people chose milk?
- (c) If the 90 people are represented by a pie chart, a sector with angle 100° represents the people who chose coffee. How many people chose tea?
- (d) If the 90 people are represented by a pie chart, a sector with angle 54° represents the people who chose tea. How many people chose coffee?

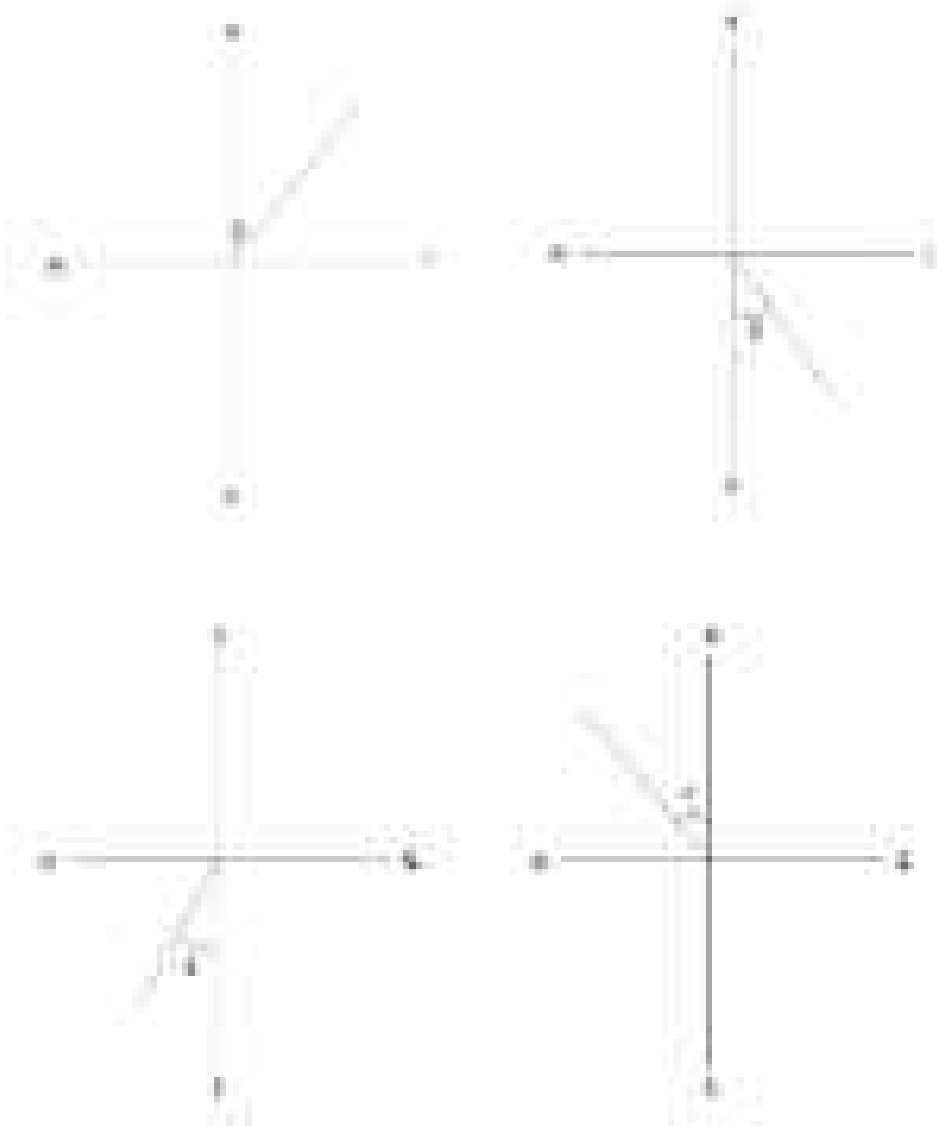




Quadrantal bearings to whole circle bearings

You are given that $\cos\theta = \frac{3}{5}$. For the following acute angles, find the value of θ.

- (a) If the quadrantal designation is N θ° E, the whole circle bearing is θ°.
- (b) If the quadrantal designation is S θ° E, the whole circle bearing is $180^\circ - \theta^\circ$.
- (c) If the quadrantal designation is S θ° W, the whole circle bearing is $180^\circ + \theta^\circ$.
- (d) If the quadrantal designation is N θ° W, the whole circle bearing is $360^\circ - \theta^\circ$.



Example: Convert the following TFCDs to SDs and SDs to TFCDs.

(a) [illegible]

(b) [illegible]

Sol:

(a)

[illegible]

5.1

[illegible]

Forward Stack Strategy:

Forwarding:

[illegible]

Back Strategy:

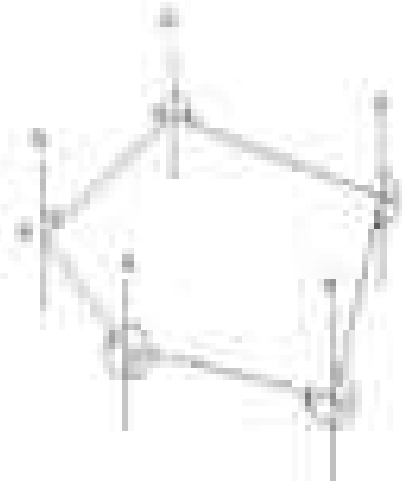
[illegible]

[illegible]

Stack Strategy: Forwarding + [illegible]

[illegible]

[illegible]



Calculation of Included Angle from Bearing:

Calculation of Bearing from Included Angle.

Bearing of AB = 060° + 180° = 240°

Bearing of AC = 060° + 180° = 240°

Since the bearing of AB = bearing of AC, the two lines are parallel.

Note:

- In a closed traverse, all the interior angles are less than 180°.
- In a closed traverse, one or more interior angles are greater than 180°.

Example 1: From the following bearings, calculate the interior angles of the traverse PQRS.

Line	Bearing	Bearing
PQ	045°	225°
QR	135°	315°
RS	225°	045°
SP	315°	135°

Bearing of QP = 225° (Reverse bearing of PQ)

Bearing of QR = 135°

Included angle PQR = Difference in the bearings = 225° − 135° = 90°

Bearing of RQ = 315° (Reverse bearing of QR)

Bearing of RS = 225°

Included angle QRS = 315° − 225° = 90°

Bearing of SR = 135° (Reverse bearing of RS)

Bearing of SP = 045°

Included angle RSP = 225° − 135° = 90°

Bearing of PS = 315° (Reverse bearing of SP)

Bearing of PQ = 045°

Included angle SPQ = 360° − (315° − 045°) = 360° − 270° = 90°

Check: Sum of interior angles = (4 − 2) × 180° = 360°

90° + 90° + 90° + 90° = 360°

Example 3

The bearings of the sides of a closed traverse ABCDE are as follows:

Side	F.B.	B.B.
AB	037° 15'	217° 15'
BC	82° 30'	262° 30'
CD	213° 45'	033° 45'
DE	151° 15'	331° 15'
EA	324° 45'	144° 45'

Compute the corrected angles of the traverse and reconcile the bearings of the sides.

Solution:

(i) The included angle A = The difference in bearings of AB and AE.

As the bearing of AE is less than that of AB, add 360°.

Included angle A = (324° 45' + 360°) − (037° 15') = 347° 30'.

The included angle at B = The difference in bearings of BC and BA.

= 262° 30' − 217° 15'

Included angle = 45° 15'.

The included angle at C = The difference in bearings of CD and CB

= 213° 45' − 082° 30' = 131° 15'

Included angle C = 194° 45'.

The included angle at D = The difference in bearings of DE and DC

= 331° 15' − 213° 45' = 117° 30'

Included angle D = 117° 30'.

The included angle at E = The difference in bearings of EA and EB

= 144° 45' − 151° 15' = 353° 30'

Included angle E = 353° 30'. Ans.

Check:

Sum of the included angles of a pentagon

= (5×4) = 8 right angles

And, sum of the included angles = A + B + C + D + E

= 347° 30' + 045° 45' + 194° 45' + 117° 30' + 353° 30'

= 1407° 30' = 8 right angles. Hence, OK.

Example

A closed compass traverse ABCDE was conducted and the following bearings were obtained. Determine which of the stations are affecting from local attraction and give the values of the corrected bearings.

Line	F.B.	B.B.
AB	150° 30'	330° 30'
BC	225° 30'	45° 30'
CD	318° 30'	138° 30'

DA	[illegible]	[illegible]

Solution:

On examination, the fore and back bearings of [illegible] differ exactly by 180°. Hence stations C and D are free from local attraction. Stations affected by local attraction are [illegible].

Calculation of included angles:

Interior angle at A = bearing of [illegible] − bearing of [illegible]

= [illegible]

Exterior angle A = 360° − [illegible] = [illegible]

Interior angle at B = bearing of BC − bearing of BA

= [illegible] = [illegible]

Exterior angle at B = 360° − [illegible] = [illegible]

Interior angle at C = bearing of CB − bearing of CD

= [illegible] = [illegible]

Exterior angle at C = 360° − [illegible] = [illegible]

Interior angle D = bearing of DC − bearing of DA

= [illegible] = [illegible]

Check : Sum of exterior angles of the quadrilateral ABCD

(2n+4) × 90 = 12 right angles. 1080°

Total sum of exterior angles

= [illegible] + [illegible] + [illegible] + [illegible]

= 1080° = 12 right angles. Ok.

Calculation of bearing:

Bearing of [illegible] = [illegible] (given)

Add angle at B = + [illegible]

Sum = [illegible]

Sum is more than 180°, subtract = [illegible]

Bearing of [illegible] = [illegible]

Add angle at [illegible] = + [illegible]

= [illegible]

Sum is more than 180°, subtract = [illegible]

Bearing of [illegible] = [illegible]

Add exterior angle at D = [illegible]

Sum = [illegible]

Sum is more than 180°, subtract = [illegible]

Bearing of [illegible] = [illegible]

Add exterior angle at C = [illegible]

Sum = [illegible]

Sum is more than 180°, subtract = [illegible]

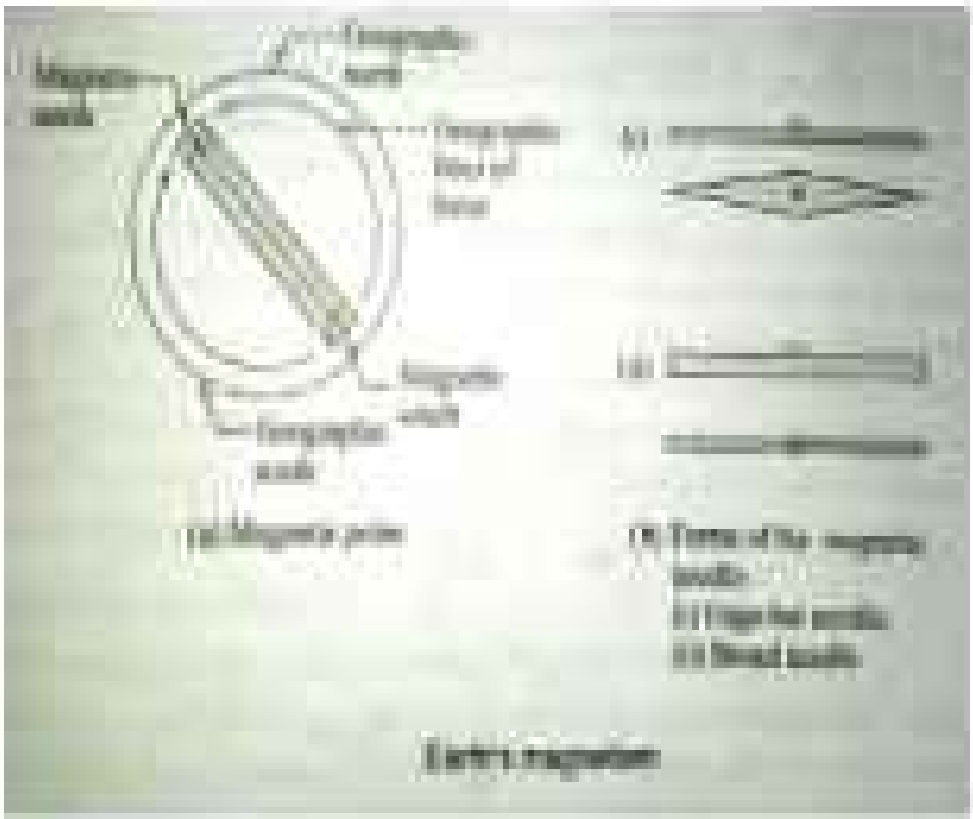
Record a compass bearing for the three cars.

Car	Bearing	Compass direction
Red	[illegible]	[illegible]
Blue	[illegible]	[illegible]
Yellow	[illegible]	[illegible]
Green	[illegible]	[illegible]

Effect of earth's magnetism

The earth behaves like a strong magnet with its poles placed near the geographic north and south poles. One pole of the earth's magnet is placed at approximately 70° north latitude and 96° west longitude in Canada and another pole exists at a diametrically opposite location in the Southern Hemisphere. A magnetic needle suspended in such a way that it can rotate in a vertical plane will align itself in a vertical position at each of these points. If one end of a magnetic needle points to the north direction and is designed as the north pole of the needle, it is clear that the magnetic magnet inside the earth has its south pole there. This is because unlike poles attract each other. The north pole of a magnet is actually the earth-seeking pole.

The magnetic lines of force that earth's magnetism generates go from one of its poles to the other pole. Such lines of force are parallel to the surface (horizontal) only near the equator. At other places, as these lines of force enter the earth, they are directed at the nearest [illegible] with the horizontal) by a small angle. This is known as the dip angle. The dip angle increases as we go from the equator to the poles.



A magnetic needle is generally made perfectly symmetrical and supported on a smooth pointed pivot. To make it dip in a horizontal position, it is generally weighted with an adjustable weight. In the north part of the earth's surface the north dip zone is in the northern hemisphere, the needle is weighted on the southern segment of the needle there. Similarly, the southern segment of the needle is weighted in the southern hemisphere. Electric or the lines and current of force of magnetic needles commonly used are with pointed ends unlike the needle and other of needles with broad flat ended. The north pole, or the north - seeking pole, of a magnetic needle when freely suspended points to the direction of the magnetic lines of the Earth and this is used as a reference in compass surveying.

Magnetic Declination

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

[illegible]

1. **[illegible]**
   - [illegible]
   - [illegible]
   - [illegible]
   - [illegible]

2. Calculation of True Bearing

True Bearing = Magnetic bearing ± magnetic declination

Add + (east) if declination is east

and − (west) if it is west.

3. Calculation of Magnetic Bearing

Magnetic bearing = True bearing ∓ magnetic declination

(− sign for eastern declination and + for western declination)

Variation and Declination

The direction of the planet does not indicate a constant but always an changing. From noon to noon there is a change in the declination of the planet.

1. Secular variation
2. Annual variation
3. Diurnal variation
4. Irregular variation

1. Secular Variation. The earth magnetic poles are continually changing their positions relatively to the geographical poles. Earth Magnetic variation also changes and affects the declination of planet. Secular variation is a slow and steady change and declination of planet. There is a cross and two eight-pointed stars in your. Due to the magnetic secular variation is the most important for land surveyors. It appears to be of periodic character and follows a wide cycle. The swing of the needle in a given area of period of centuries may be compared to a simple harmonic motion. A secular change from year to year is also not uniform for any given place. It is also different for different places. In normal magnetic bearings are the bearings of a certain amount of declination is considered magnetic. In such a case, required the surveyor to know the characteristics of declination. When observations for the declination are made in different years of a century, it is noticed that magnetic meridian varies from one side of the meridian to the other. The change produced annually by secular variation is different in different years. Some times it increases and sometimes decreases. The variations in opposite upon the geographical positions of different places. The interval between changes is generally more for middle period of a complete cycle and least at its extreme limits.

1. Annual Variation. [illegible] at a place over a period of one year, is known as annual variation. From the observations made at different places over a period of 25 years, it is found that annual variation is about 1 minute or 2 minutes, depending upon their geographical positions.

2. Diurnal Variation. The departure of declination from its mean value during a period of 24 hours at any place is called diurnal variation. The diurnal variation depends upon the following factors:

(1) **The geographical position of the place.** It is greater for the places in higher latitudes and lower near the equator.

(2) **Seasons of the year.** It is comparatively more in summer than in winter at the same place.

(3) **The time.** It is more in day and less in night.

(4) **The year of the cycle.** It is different for different years in the complete cycle of sunspot variation.

(5) **Irregular Variation.** Abrupt change of declination at places due to magnetic storms, earthquakes and other solar disturbances are called irregular variations. These disturbances may occur at any time in any place and cannot be predicted. The displacement of a needle may be as much from 1° to 2°.

Example. The true and magnetic bearings of a line are 1° 15' and 1° 45' respectively. Calculate the magnetic declination at the place.

Solution.

Magnetic declination = The bearing magnetic bearing

= 1° 45' − 1° 15'

= 2' (E)

As the right is + ve, the declination is east of true meridian.

Magnetic declination = 2' E East

6.5 Errors in compass surveying.

The following are the common errors occurring in compass

Instrumental errors.

These occur by the defective parts of the instrument. These are

(a) The needle does not be straight, giving wrong readings

(b) The pivot point may have become blunt and the needle may not move freely

(c) The line of sight may not pass through the centre of the graduated ring

(d) The ring may not move with the needle please due to the slip of the needle as a result of the wrong adjustment of the balancing weight.

(e) The zero line in the opposite direction may not be straight or may be a bit bended.

Personal errors:

(a) Reading the graduations in the wrong direction or reading the graduations wrongly

(b) Improper centering of the compass over the station

(c) Not levelling the compass properly

(d) Not clamping the needle at a convenient position.

Other errors:

(a) Variation in the declination during the day, when the survey is extended over a long duration during the day.

(b) Local attraction due to the presence of external magnetic influences as cast in heavy machines.

(c) Other variations due to magnetic storms, cloudiness etc. which affect the magnetic needle.

PRECAUTIONS TO BE TAKEN IN COLORADO TESTS

[illegible] may be [illegible] the following precautions:

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

MAINTENANCE OF MAGNETIC COMPASS:

The [illegible] compass is a fine instrument that is easy to set up and use. It is ideally suited for rough, speedy survey work. The following points are important for maintaining the compass in good condition: the compass needs to be [illegible]. The compass should be kept in the carry case [illegible].

- The compass should be read frequently, [illegible] the [illegible]. Read regularly to see whether the magnetic needle is freely moving or sluggish.
- Set up the compass at a point and take the bearing of a line connecting to a well-defined object. Release the compass and immediately bring it back to the same point, and take the bearing. The bearing should be the same. If not, the needle is not moving properly due to a [illegible].
- Check whether the needle [illegible] the graduated ring moves to a horizontal plane.
- Keep the compound free of dust and clean the glass cover with a fine cloth.

8.3 CHAIN AND COMPASS SURVEYING

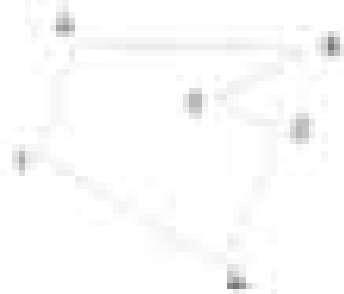
8.1 Principle of traversing

A series of connected straight lines such joining two points on the ground is called a traverse. And points are known as traverse stations and straight lines between two consecutive stations are called traverse legs.

Traverse may be either a closed traverse or open traverse.

Closed Traverse:

A traverse which either begins from a station and closes on same station or two fixed stations whose relative position are known in terms of a convenient system of co-ordinates is known as closed traverse. In closed traverse accuracy of linear as well as angular measurements may be known.



Closed Traverse

Open Traverse:

A traverse which neither returns to the starting station nor ends on another known station is known as open traverse. In open traverse no check of linear as well as angular measurements may not be checked.

Open Traverse

Difference between Chain survey and Compass Survey

Observation is performed in the above manner until a point is reached and further observation is found to be the same. If the area is comparatively large with subdivisions and later necessary, it requires compass survey or traverse.

5.3 Local Attraction.

North end of a freely suspended magnetic needle points to the magnetic north. It can be influenced by any other material known as **compass traverse** magnetic field.

The magnetic needle gets deflected from its normal position, if placed near magnetic rocks and some subsurface rocks containing iron ore known as local attraction.

Detection of local attraction:

The presence of local attraction in any traverse may be detected by observing the fore and back bearings of the lines. If the difference between fore and back bearing (+/- 180°) of the adjacent stations are not the true local attraction. It has the following may be due to:-

(i) Observation error due to faulty fore or back bearings or both.

(ii) Presence of local attraction at either stations.

(iii) Presence of local attraction at both the stations.

The correction to the observed bearing may be made according to the following methods.

i) By calculating the included angles at the affected stations.
ii) By calculating the local attraction at each station and then applying the reversed corrections resulting from the unaffected bearing.

Method of Elimination of local attraction by included angle:

i) Prepare the included angles at each station from the observed bearing in place of observed bearing.
ii) Starting from the unaffected line, run down the corrected bearing of the successive lines.

Method of elimination of local attraction by applying correction to bearing to closed:

Following steps are followed:

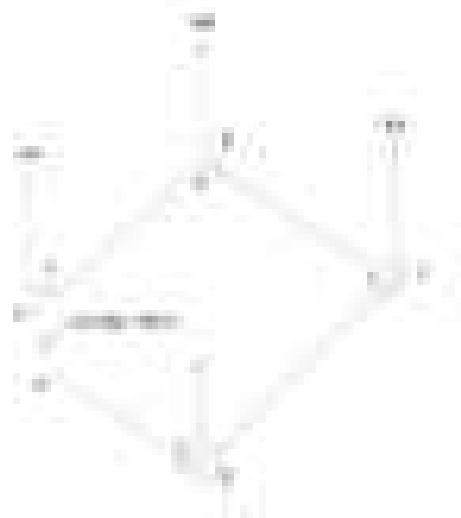
i) Calculate the magnitude and direction of the error due to local attraction at each affected station.
ii) Then observed bearing correct from the bearing unaffected by local attraction.

5.4 Methods of Plotting of Traverse

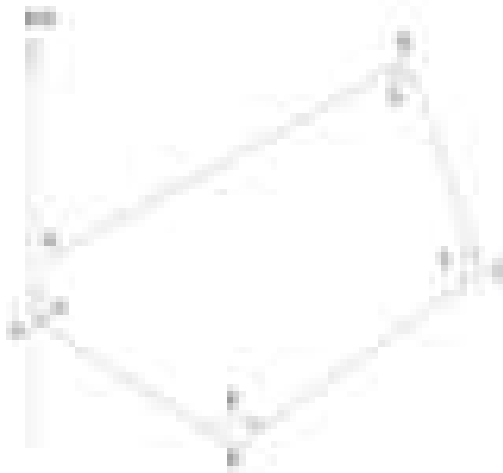
Perform practice of common curves to identify the distance between the centers of the two circles. If not then improve instruction to small learning keys for friends so that the lesson will perfect to the geometrical figure based on field data.

Use appropriate ways to present the results of this method.

LO: Threefold Worldview: After deciding the layout of the entrance a line representing the respective radius through the location of the station is drawn on the paper. The bearing of the line AB is pursued with the ordinary protractor and its length duly reduced to scale. A station off is got the location of station A is drawn. The bearing of BC is plotted and length BC is produced to scale. The process is continued till last station is plotted. In a close traverse the last line should fix and on the existing station A. In case of a closed traverse at any other known station in case of these closed traverse. If does not the discrepancy between the locations of the same station is termed as closing error.



LO: Included Angles:



Drawing Perpendicular

(b) Deflection angles of the successive stations have the positions of pointing as checked by the following formulae.

1. If the included angle between adjacent lines is between 0° and 90°, deflection angle is equal to the included angle.
2. If the included angle is between 90° and 180°, subtract the given included angle from 180° to get the deflection angle.
3. If the included angle is between 180° and 270°, subtract 180° from the given included angle.
4. If the included angle is between 270° and 360°, subtract the given included angle from 540° to get the deflection angle.

Continue the process till all the stations are checked.

Adjustment of Closing Error:

When a closed traverse is plotted from the field measurements, the misclosure of a traverse generally does not coincide exactly with its starting station. This discrepancy is due to the errors in field observations i.e. in angular bearings and linear distances. Such an error of the traverse is known as **closing error in traverse of closure**.

If both the angular and linear measurements are of equal precision, graphical adjustment of the traverse may be made. **The method is based on the Bowditch's rule. Corrections are applied** to lengths as well as to bearings of the lines in proportion to their lengths. Graphical method is also sometimes known as proportionate method or adjustment

Method. The adjustment of a traverse is done graphically as under :

Let ABCDEA' be a closed traverse as plotted that the closing error AA' has been calculated by the following methods. Let **distance** d_1 **and** θ_1 be the length of the station A as plotted. Hence, A'A is the closing error.

Adjustment. Following procedure may be adopted :

- Draw a straight line AA_1' equal to the perimeter of the traverse to any suitable scale.
- Set off the distances AB, BC, CD, DE, and EA' equal to the lengths of the sides of the traverse.
- Draw $A'A''$ parallel and equal to the closing error A'A.
- Draw parallel lines through points B, C, D, and E to meet AA_1' in B_1', C_1', D_1' and E_1'.
- Draw parallel lines through the plotted stations B, C, D, E and plot the errors equal to BB_1', CC_1', DD_1' to the traverse in A, B, C, D, E.
- Join the points $AB_1'C_1'D_1'E_1'A''$ to get the adjusted traverse.

5.5 Errors in chain and compass surveying:

Errors in Chaining:

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]
5. [illegible]
6. [illegible]
7. [illegible]
8. [illegible]

[illegible]

Instrumental errors:

[illegible]

(a) [illegible]

(b) [illegible]

(c) [illegible]

(d) [illegible]

(e) [illegible]

Personal errors:

(a) [illegible]

(b) [illegible]

(c) [illegible]

(d) [illegible]

Other errors.

(i) Variation in declination during the day: when the survey is carried out over a long duration during the day.

(ii) Local attraction due to the presence of magnetic substances near the compass.

(iii) Other reasons due to magnetic storms, cloud cover, etc. which affect the magnetic needle.

PRECAUTIONS TO BE TAKEN IN COMPASS SURVEY

The instrumental and observational errors during a compass survey may be minimized by taking the following precautions:

- Set up and level the compass carefully.
- Keep the vicinities of the needle by gently pressing the knife-rest so that it may come to rest easily.
- Make a final sighting the needle and note its reading as the second pointer.
- To find the instrument is not to use, the magnetic needle should be kept off the pivot. It is not done, the pivot is subjected to unnecessary wear which may cause displacement of the magnetic needle.
- Before taking a reading, the compass box should be gently tapped to ensure that the magnetic needle is freely swinging and has not come to rest due to friction of the pivot.
- Windows should be selected such that there are away from the sources of local attraction.
- Rod person should never carry knife, spade, metal tape or bundle of lathe which may cause local attraction.
- Care and back bearings of each line should be taken a good agreement. If the compass is out of the case of a line, the bearings may be taken from any intermediate point along that line.
- Two sets of readings should be taken at each station for important details by displacing the magnetic needle after taking one reading.
- Avoid taking a reading in swampy area since it will be difficult to keep the ranging rod vertical.
- If the glass cover has been cleaned with a handkerchief, the glass gets charged with electricity and the needle adheres to the glass cover. This can be rectified by tapping a metallic object on the glass.
- Figure now and go over once to strengthen it before making observations.

7.Computation of Area

Introduction.

Methods for computation of area:

There are two methods of computation of the area:

a) Graphical method

b) Analytical method

Calculation of area from Graphical method:

The area may be calculated in two following ways:

- From Field Notes
- From Plotted plan

Computation of Area from Field notes:

In this method the computation of the area is done in two steps.

a) Accurately make the whole area divided into number of triangles as far as triangles, rectangles, squares, trapeziums and then the area is calculated.
b) Then the areas of the geometrical fig. added up to get the required area.

Calculation of the area from Plotted plan:

The area may be calculated by two following ways:

a) By dividing the whole area

b) By dividing the boundary area

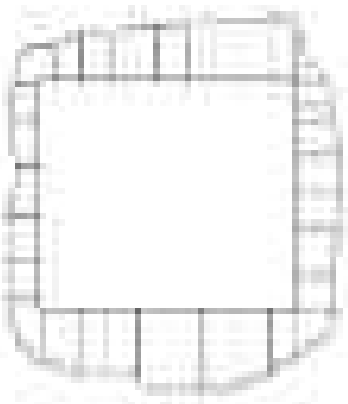
Considering the Entire area: The entire area is divided into a group of convenient shape and they are calculated by

a) By dividing the area into triangles: The triangles are so chosen as to include the irregular boundary line. Then the lengths and altitude of the triangles are determined according to the scale to which plan is drawn. After this the areas of these triangles are calculated (Fig 1)

i. **By dividing the area into squares.** [illegible] 

ii. **By drawing parallel lines and converting them into rectangles.** [illegible] 

Empirical formula: [illegible]

Graphical Method: [illegible] 

i. [illegible]

ii. [illegible]

iii. [illegible]

Engineer's rule

Mid-Ordinate rule.

Let

[illegible] = ordinates at equal intervals

L = length of the base line

d = Common distance between ordinates

[illegible] = mid ordinates

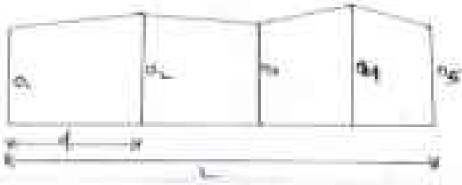
Area of the plot = [illegible]

= [illegible]

Where [illegible] and so on.

Therefore the required area = common distance × sum of the mid ordinates.

Average ordinate rule.



[illegible] ..... offsets or offset is equal distance

[illegible] length of the base line

[illegible] number of offsets

Area = $\frac{[illegible]}{[illegible]}$ ..... sq. u.

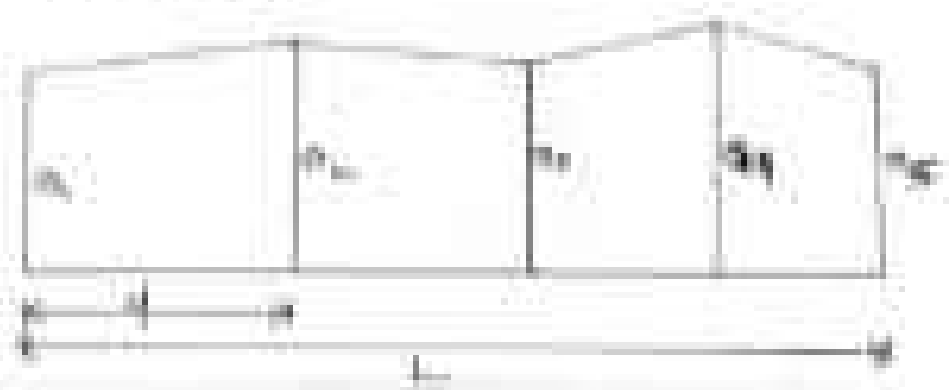
Trapezoidal rule:

This rule applying the trapezoidal rule formula to find out the area of the offsets are assumed at no straight line between each pair of the base line and the irregular boundary lines are to be a straight line segments.

[illegible] ..... offsets or right

[illegible] Common distance between offsets

[illegible] length of the base line



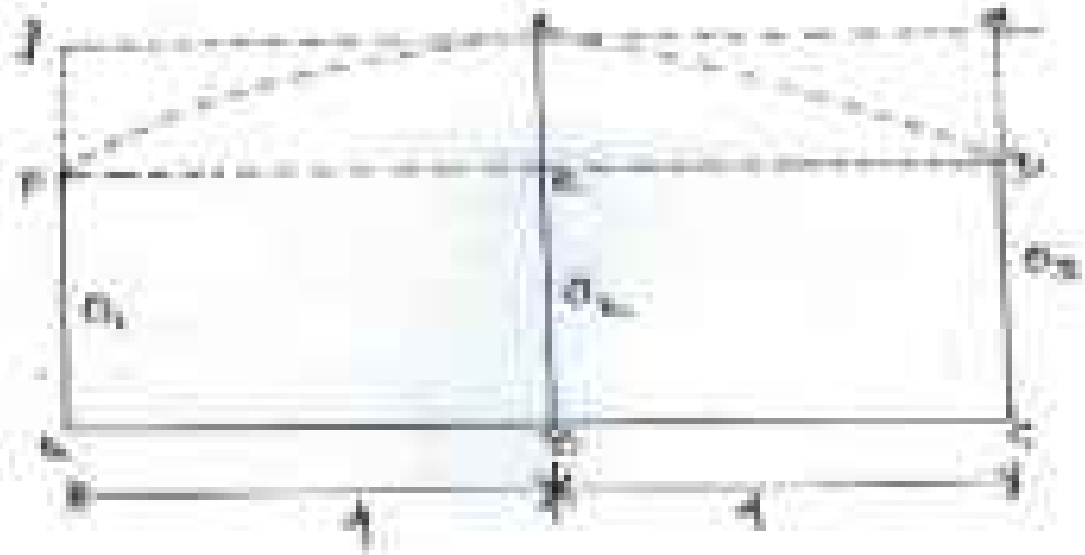
Then the,

1st area = $\frac{[illegible]}{2}$ sq.u

2nd area = $\frac{[illegible]}{2}$ sq.u

3rd area = $\frac{[illegible]}{2}$ sq.u

4th area = $\frac{[illegible]}{2}$ sq.u



Let (x,y,z) = three consecutive numbers

S = Common distance between the arithmetic

Therefore the required sum $S=A+B$ ... (i) sum of the progression (1) to n terms + sum of the progression (2) to (n) terms

Sum of the progression (1) to (n) terms $=\frac{n}{2}[2a+(n-1)d]$

$=\frac{n}{2}[2\times 1+(n-1)\times 1]=\frac{n}{2}[2+n-1]=\frac{n}{2}(n+1)$

Sum of the progression (2) to (n) terms $=\frac{n-1}{2}[2a+(n-2)d]$

$=\frac{n-1}{2}[2\times 2+(n-2)\times 1]=\frac{n-1}{2}(n+2)$

So, the sum becomes the form as we discussed as

$S=\frac{n}{2}(n+1)+\frac{n-1}{2}(n+2)=\frac{n^2+n+n^2+2n-n-2}{2}$

$=\frac{2n^2+2n-2}{2}=n^2+n-1$

Conclusion: the sum becomes two equal terms as consecutive

$S=n^2+n-1$ ... (i)

$S_1=n^2+n-1$ ... (ii) and so on

Required sum $=S_1+S_2+S_3$ ... $+S_n$

$=[n(n)+n(n+1)+1]+[n(n)+n(n+1)+1]+[n(n)+n(n+1)+1]+$ ... $+[n^2+n(n-1)+1]$

7. Plane Table Survey

Definition:

A **plane table** is a device used in surveying and related disciplines to provide a solid and level surface on which to make field drawings, sketch and maps. The early use of the term plane table refers to graphical or mechanical methods, as opposed to analytical methods.

Objectives:

- It is suitable for location of details as well as contouring for large scale maps directly in the field.
- As surveying and plotting are done simultaneously in the field, chances of getting omission of any detail are less.
- The plotting details can immediately get compared with the actual ground details in the field. This serves as well as a check on the plot and the accuracy of the work progresses in the field.
- Unknown and specific features can be represented and checked conveniently on the sheet and it is open to the choice of plotting.
- Only one operation is involved because the map is drawn as the survey progresses. Therefore details get omitted in the final field.
- The plane table survey is generally more rapid and less costly than most other types of survey.
- As the instruments used are simple, one need not be an expert in operation of instruments to operate. The method of survey requires no field books.

Disadvantages:

- The plane table survey is not possible in rainy weather, cloudy and in windy day etc.
- The method of survey is not very accurate and thus unsuitable for large scale or precise work.
- As no field book is maintained, plotting is difficult work requires full exercise.
- The method requires large amount of space in the field.
- Quality of the final map depends largely on the drafting aptitude of the surveyor.
- The method is effective in relatively open country where sighting can be taken easily.

Principle:

The principle of plane table survey is **Parallelism**. It means that the ray drawn from station to object on the paper are parallel to the rays from the station to the object on the ground.

Accessories of plane table:

a. Plane table

b. Alidade

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

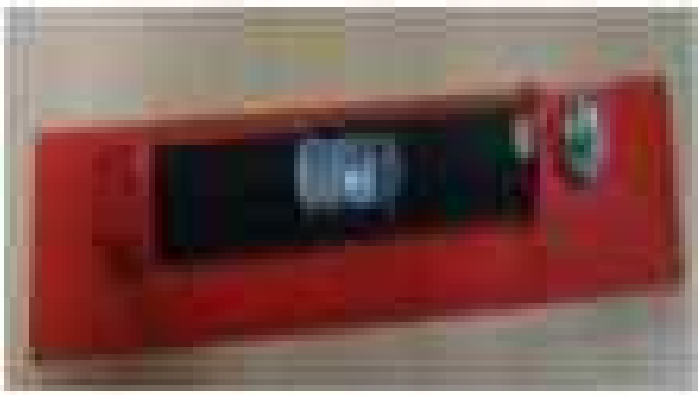
[illegible]

[illegible]

[illegible]

The function of the module is to right original. The very detail for determining the balanced edge

- **The Spirit level.** It is a sturdy metal case containing a small bubble of space. The bubble is visible on the top along a graduated glass tube. The spirit level is tested by leveling the plane table.



- **The compass.** There are two types of compass

  - The trough compass

  - The circular box compass

- **The trough compass.** It is rectangular box made of brass magnetic needle containing a magnetic needle pivoted at the centre. The compass consists of "S" mark at both the ends to locate N-S directions.

- **The Circular box compass.** It consists a pivoted magnetic needle at the centre. The circular box is fitted of square brass plate. Sometimes two needles are also fixed at the right angles to each other on the brass plate. The compass is pivoted like making the north direction of the ring.

: The L- Fork or
with plane table.
...

...

...

plane table Fork
The L- fork is a ... **object** a "D" ...
...
...
...

...

Procedure of setting up plane table over a station

The following ... A ... should be followed while setting up a plane table over a station:-

1. **Fixing the table to the tripod stand:** The tripod stand is placed over the required station with its legs well apart. Then the table is fixed on to it by using one of the methods

2. **Levelling the Table:** The table is levelled by placing the open box at a different position and ... of the table. The bubble ... brought to the centre of its run in every position of the table by adjusting the legs.

3. **Centering the table:** ... the plumbing fork is fixed on the table. A suitable point is selected **on the sheet to represent the station "A" on the ground.**

A pin is then placed at this selected point.

The open end of the L-fork is made to coincide with the station pin and the plumb bob is suspended from the hook at the lower end is brought over the station **"A" by moving the table** ... slowly in any desired direction or slightly adjusting the table legs.

This operation is called ' Centering ' and the table is centered ... and should be taken that this operation should not in any ... affecting the ... levelling.

4. **Marking the North line:** The magnetic compass is placed on the right hand top corner of the ... sheet with its north and ... approximately towards the north. With the compass in ... fork is set on the plane table so that the needle ... coincides with the ... line. Now a line representing the north line is drawn through the edge of the compass. It should be ... and is ...

1. **Determination.** Where the physical address is unknown, or when the employee is concealing correct location, the determination must be performed in succession. Location can be done by two methods.

a. Electromagnetic method or magnetic needle method

a. Block sighting (Alidade)

This method is accurate and is always preferred. The following steps are followed during the block sighting method:

i. Suppose A and B are two stations. Set plane table at station A and level it. Select a point P on the sheet and mark it as a station point. Place the alidade with the fiducial edge touching the point P and the ruler pointing towards A. Draw the ray PA.

ii. With the help of the alidade, sighting the point B. Draw ranging rod at B. Measure the distance AB by chain or tape. Mark a point b on the ray PA such that Pb represents the distance AB to the scale chosen.

iii. Shift the table to station B and set up over B. Level it and orient it such that the ray PA is towards A. This is done by placing the alidade along the line ba and the ranging rod at A. Rotate the table until the ranging rod is bisected in the sighting vane. Clamp the table in this position. Select a point Q on the sheet such that the angle PBQ is equal to the angle PBA and the distance BQ is equal to the distance BA to the scale chosen. Draw the ray BQ. Repeat the procedure at station C such that the angle QCR is equal to the angle QBA and the distance CR is equal to the distance CB to the scale chosen. Join PR. PR represents the distance AC to the scale chosen.

b. **Magnetic needle Method.** This method is used when the local attraction at each station is not known. The following steps are followed during the magnetic needle method:

i. Suppose A and B are two stations. Set plane table at station A and level it. Place the needle in the box and bring the edge of the box against the pin. Rotate the box until the north end of the needle points towards the mark on the box. Clamp the box in this position. Select a point P on the sheet such that the angle between the edge of the box and the line PA is equal to the bearing of A from B. Draw the ray PA.

ii. With the help of the alidade, sighting the point B. Draw ranging rod at B. Measure the distance AB by chain or tape. Mark a point b on the ray PA such that Pb represents the distance AB to the scale chosen.

iii. Shift the table to station B and set up over B. Level it and orient it such that the ray PA is towards A. This is done by placing the alidade along the line ba and the ranging rod at A. Rotate the table until the ranging rod is bisected in the sighting vane. Clamp the table in this position. Select a point Q on the sheet such that the angle PBQ is equal to the angle PBA and the distance BQ is equal to the distance BA to the scale chosen. Draw the ray BQ. Repeat the procedure at station C such that the angle QCR is equal to the angle QBA and the distance CR is equal to the distance CB to the scale chosen. Join PR. PR represents the distance AC to the scale chosen.

iv. When the crossing and leveling are perfect and the readings are all 0.0 mark, the elevations are said to be perfect.

Methods of Plane Table

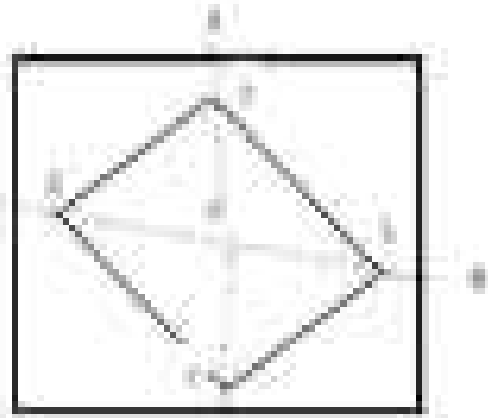
There are five methods of plane table. They are:-

- Radiation
- Intersection
- Traversing
- Resection

Radiation:-

This method is suitable for locating the stations from a single station.

In this method you are drawn from the station to the objects and the distances from the station to the objects are measured. Suitable scale should be chosen to represent the distances.



Procedure:-

i. Suppose it is a station on the ground from where the objects A, B, C, ... & D are visible.

ii. The plane table is set up over at P. A drawing sheet is fixed on the table and a suitable horizontal scale is chosen. A point a is selected on the sheet to represent the point A.

iii. The North line is marked on the right hand top corner of the drawing sheet with the help of compass.

iv. With the alidade touching the point a, ranging rod at A, B, C, D, E, & other features are sighted one by one.

v. The distances PA, PB, PC, & PD are measured and plotted to an suitable scale to mark the points a, b, c, & d representing A, B, C, & D on the paper.

Introduction

This method is suitable for locating (successively) points by the construction of the ray drawn from two known coordinate stations.

Procedure:

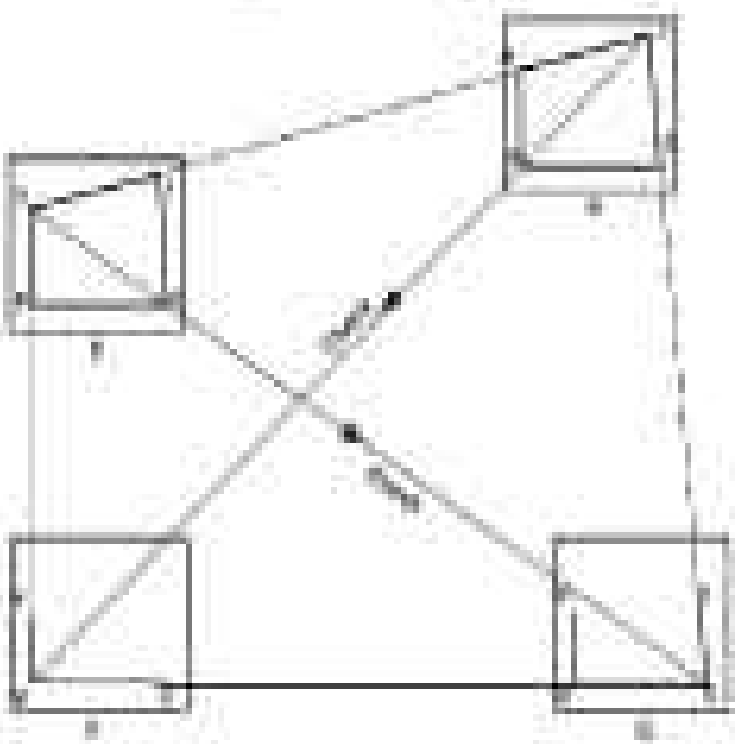
1. Suppose A & B are two stations and P is an inaccessible point. It is required to locate the position of P on the sheet by the intersection of the rays drawn from A and B.
2. The plane is set up on A i.e. it is levelled and centered on the ground and the sheet is pinned down. The North line is marked on the light hand top corner of the drawing sheet with the magnetic compass.
3. With the alidade touching the point a the sheet P and the sighting vane at the other terminal end open and closed towards the fiducial edge of the alidade.
4. The drawing bit is sharpened and pinched to very accurate point to enable the point a.
5. The table is clamped and centered over A and levelled properly. Now the alidade is placed along the line ba and orientated is done by hand sighting. While backsighting it should be kept in contact that the centering and the sighting is not disturbed. In case it is disturbed it should be adjusted accordingly.
6. With the alidade touching b the ruler P is traversed across the sheet. Suppose the ray intersects the previous ray at point p. This point p is the desired position of P.

Resection

This method is suitable for locating the position of the station.

Procedure

1. Suppose the P (A B C) are the known stations.

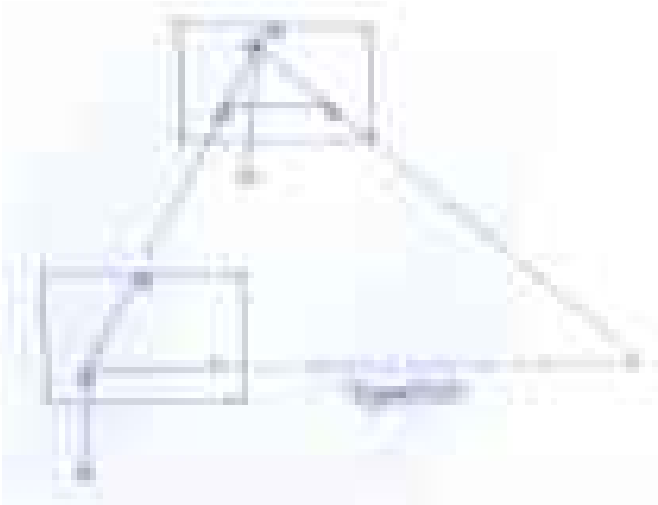


(d) [illegible]

(e) [illegible]

Inverse method:

This method is suitable for constructing accurate [illegible] in order to locate missing details.



Procedure

(a) Suppose it is required to [illegible] a station at position on P. Let us embed two pointers A and B on the ground. The distance AB is measured and plotted as any suitable scale. The line AB is [illegible] as the "base line".

(b) The table is set up at A, it is levelled, centered and oriented by [illegible] ranging rod at B. the table is then clamped.

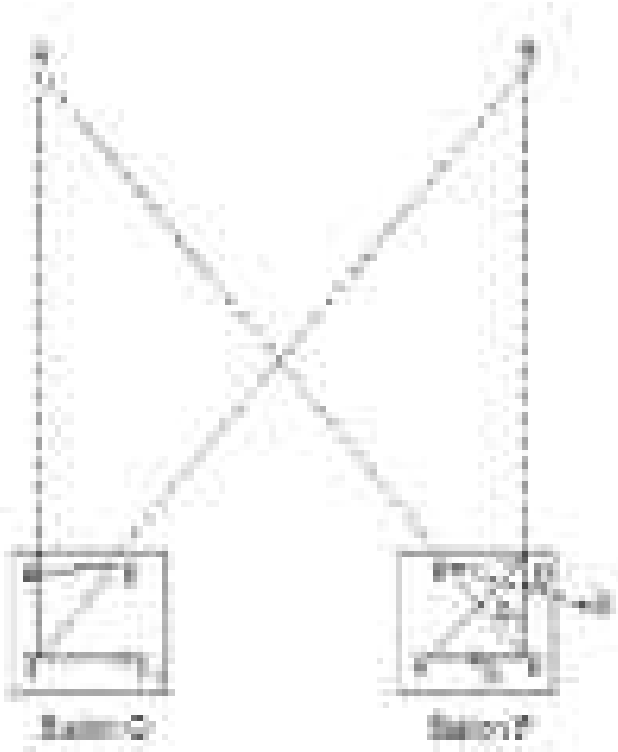
(c) With the alidade sighting point a, the ranging rod at P is [illegible] and a ray is drawn. Let a point P' is marked on this ray by measuring to it the [illegible]

(d) The table is shifted and centered to such a way that P' is now over P' it is then immediately have sighting the ranging rod at a

(e) With the alidade sighting point A, the ranging rod at B is [illegible] and a ray is drawn. Suppose the ray intersects the previous ray at a point P. This point represents the position of the station P on the sheet. Once the actual position of the station P is marked on the ground by a [illegible] [illegible].

[illegible] [illegible] [illegible] [illegible]

[illegible]



: The Three-mast problem

The problem can be solved by three methods: (a) the graphical, (b) Bow's method, (c) the mechanical method, such as the slide and error method.

(a) The Graphical method

(b) Suppose A, B and C are three such stations on which three masts are placed as A, B and C. Now, it is required to locate a station at P.

(c) The station is placed at the required station P and the slide is placed along the line AB and the power is connected and energy drawn.

(d) Again the slide is placed along the line AC and the power is connected and the station is changed. In this the slide touching at the point P we have connected a key is drawn. Suppose this slip movement the previous slip at a given A.

The slide is placed along AB and the power is connected. In this position the slide is said to be perfectly matched. Now the lays Aa, Bb and Cc are drawn. These three lays must meet at a point p which is the required point on the map. This point is unaffected as the ground by (c) (d) and above lines.

Errors and Precautions:

A. **Instrumental Errors:**

1. The needles of table may not be perfectly sharp.
2. The ring and ring like obstacle might not be straight.
3. The compass may not be vertical.
4. The boundaries may be loose and unequal.
5. The table may be heavily pressed with the hand while
6. The needle of the drawing compass may not be perfectly balanced. This is very and by this to move thereby shows a suggestion of the given point.

B. **Personal Errors:**

1. For focusing of the object-glass, and its perfectly.
2. The table may not be centred properly.
3. The orientation of the table may not be proper.
4. The table might not be perfectly clamped.
5. The objects may not be focussed properly.
6. The obstacle may not be correctly centered on the station point.
7. The open weights not be chosen accurately.
8. The plotting may not be centered on the same side of the station point throughout that work.

C. **Plotting Errors:**

1. A good quality pencil with a very fine pointed lead may not have been used.
2. An incorrect scale may be used for plotting.
3. Errors may result from failure to observe the correct measurements from the scale.
4. Inaccuracy due to the loss of plotting may lead to plotting errors.

The following precautions should be taken while using the plane table.

1. Before starting the work the equipments for survey work should be verified. Defective or unserviceable should be replaced by perfect equipments.
2. The centering should be perfect.
3. The levelling should be proper.
4. The orientation should be accurate.
5. The obstacle should be centred on the same side of the station per until the work is completed.
6. While shifting the plane table from one station to another, the tripod stand should be kept vertical to avoid damages to the fitting arrangement.
7. Field book entries should be up to date.
8. Measurements should be taken carefully from the scale while plotting.
9. The stations on the ground are marked A, B, C, D etc. while their corresponding points on the map are marked a, b, c, d etc.

Procedure of book work:

1) **Assessment:**

The assessment is done periodically. Assessment is done by the most appropriate way for the learning. The learning outcomes should cover the whole course and should be achievable. The percentage for each lesson should be approximate.

2) **Marking the exams:**

The allocated marks are marked on the ground of a wonderful page. Reflective questions should be prepared for the learners so that they can be readily discussed in case the survey page is answered.

WATER SUPPLY ENGINEERING

CHAPTER-1

INTRODUCTION

The branch of civil engineering which deals with the supply of water for various purposes e.g. domestic, industrial, commercial & public is called **Water Supply Engineering**

Necessity:-

Water is the most essential commodity for the continuation of life. An adequate & clean water supply is the most requirement for domestic use for various purposes like:-

(i) for drinking & cooking

(ii) for bathing & washing

(iii) for watering of lawns & gardens

(iv) for air-conditioning system

(v) for sewer washing etc.

Water is also required for various types of industrial & commercial purposes.

Historical Development:-

Having known that water is necessary for existence of human beings in the most basics of the needs. The local bodies took those works, but due to lack of technical staff with them, they could not do satisfactory progress. In 1941 Union Government appointed the Environmental Hygiene Committee which put up their recommendations in the broader field of environmental hygiene. The committee also recommended a comprehensive plan for providing water supply & sanitation facilities to 90% population within 40 years. But no special measures were taken to implement these recommendations.

In first five year plan (1951-1956) provision of water supply & sanitation schemes in the states were made in the community Development Works & Local development works. In 1951, the Union Health Ministry issued first enquiry that the state governments could not do satisfactory progress in this matter from their own resources. With the result, the Union Health Ministry announced in 1954 first National Water Supply & Sanitation programme as a part of the Health schemes. & also made specific provisions to assist the states in this matter. Under this scheme approved urban schemes got loans, which rural schemes up to 1000 population got 33% grant-in-aid by central government & part of

remaining 20% was provided by State Governments & part as contributions from the villagers either in cash or in kind or in shramdan.

Having lived histories of health & social historical water supply & sanitation committees for increasing the proportion of rural & National water supply & sanitation programme & for concrete examination of urban & rural improvements. The report of this committee shows that 66% towns of India cover only 6.5% of total population. Out of this only 48.9% population was supplied with safe water that was 1/3 to 1/4th litres capita/day.

We found that one plan Rs.149 crores was arranged for water supply and sewerage. A number of water supply & sewerage schemes were completed. For assessing water borne diseases number of scholars were completed. Previous of Rs. 1.98 crores was done, the scholars supplying water to the rural areas of each country. In India, there are many shortage of funds for the various projects, due to lack of all efforts the expenditure in water supply & sanitation remains within 1% of total plan outlay, which may be considered as good amount. After spending such amounts, in India, 66.5% urban population gets safe drinking water, but in rural areas, major work is to be taken to arrange safe water is not published.

QUANTITY OF WATER

Introduction:-

[illegible] planning a water supply scheme, it is the duty of the engineer to carefully examine the various types of water demand of the town & also to find out the quantity of water from which the demand can be met.

The various types of water demand of a city or town are:-

(i) Domestic Water Demand

(ii) Commercial & Industrial Demand

(iii) Demand for public use

(iv) Fire Demand

Domestic Water Demand:- This demand includes the quantity of water required in the houses for drinking, cooking, bathing, washing, gardening, sanitary purposes etc. It mainly depends upon the living conditions of the consumers. As per IS 1172-1963 water required for domestic purposes for average Indian conditions per head per day may be taken as 135 litres, in developed countries this may be as high as 400 litres. The total domestic water consumption may amount to 50 to 60% of the total water consumption. **Detail of water requirement for Domestic purpose:-**

Sl No.	Description	Consumption of water per head per day in litres
1.	Drinking	5
2.	Cooking	5
3.	Bathing	55
4.	Washing of clothes	20
5.	Washing of utensils	10
6.	Washing of house	10
7.	Flushing of Latrines etc.	30
	Total	135

Commercial & Industrial Water Demand :- This includes offices, hotels, restaurants, schools, stores, shopping centers etc. The demand depends upon the nature of the city, number and types of industries. On an average 20 to 25% of the total water demand may be allowed for the type of demand in the design.

Demand for public use :- Public demand includes the quantity of water required for public utility purposes such as watering of public parks, gardening, sprinkling on roads, use in public fountains etc. In many water supply schemes these demands are not fulfilled as an entitled and exceptional amounts not exceeding 2% of the total demand is kept as allowance basis.

Fire Demand :- It is the quantity of water required for fighting a fire outbreak. For right value of fire demand requirements for this purpose is particularly essential. The quantity of water required for fire purpose can be found out by applying certain empirical formulas. There are :

(i) National Board of Fire Underwriters Formula

$Q = 4637\sqrt{P}\,(1 - 0.01\sqrt{P})$

Where Q = Quantity of water required in litres per minute

P = Population of the area in thousands

(ii) Freeman Formula :-

$Q = 1136\,(P/5 + 10)$

(iii) Kuichling's Formula

$Q = 3182\sqrt{P}$

Per capita Demand :-

It is the annual average amount of daily water required per person and includes the domestic, industrial, and public use.

If Q = total quantity of water required in a city per year in litres &

P = Population of the city

Then the Capita demand in litre per day = $Q/(P \times 365)$

Variations in Demand :-

It has been seen that the demand does not remain uniform throughout the year, but it varies from season to season, even from hour to hour. The variation in rate of demand may be treated as :-

(i) Seasonal variations.

(ii) Daily variations.

(iii) Hourly variations.

Seasonal Variation:- In Summer the water demand is more as compare, Because people will use more water in bathing , washing, lawn watering, water sprinkling etc. This demand goes on reducing as in winter it becomes minimum. Because then water will be used in bathing & there will be no lawn watering.

Daily Variation:- The rate of demand may vary from day to day also. This is due to habits of the consumer, climatic conditions, holidays etc. On hot and dry day water requirements will be more as compared to a rainy day.

Hourly Variation:- The rate of demand during 24 hours does not remain uniform & it varies according to hours of the day. On Sundays & other holidays the peak hours may be about 8 to 10 hrs in the morning whereas it may be 6 to 8 hrs on the other working days. Various variations may be working as day & night shifts & consuming more water.

Factors affecting Per Capita Demand :-

The various factors which affect the per capita demand are :-

1. **Climatic condition :-** In hot regions/areas, during summer one uses more water. During summer water is used for bathing , drinking & also more water is consumed in washing woollen etc. Hence water consumption is much more in summer than that in winter.
2. **Size of city :-** Generally the demand of water per head is bit more in big cities than in small ones. In big cities lot of water is required for maintaining sewage & sanitary arrangements while in small towns it is not required.
3. **Habits of people :-** People from community uses more water due to their better standard of living & higher economic status. Middle class people use moderate amount of water and the poor people use water sparingly as they can't afford the costly facilities.
4. **Industries :-** Water is required in highly industrialized city.
5. **Cost of water :-** More costly is the water, less will be use of demand. Hence the cost of water is regulated so the consumer must also reflect the rate of demand.

6. **Quality of water** :- A water supply system having a protected & good quality of water supply would always be more popular with consumers. Hence more quantity of water will be consumed if the quality is good.

7. **Provision in the distribution system** :- Some overall loss of great importance is the case of distribution having a number of loss in form of leakages. Adequate provision should always be provided for continuous supply of water.

8. **System of supply** :- The system of supply may be continuous or intermittent. In continuous system water is supplied all the 24 hours while in case of intermittent system water is supplied for certain fixed hours of the day only, result in water reduction in the consumption. This may be due to decrease in losses & other wastage etc.

Methods of forecasting populations :-

The following are the methods used for forecasting populations :-

1. **Arithmetical Increase Method** :- In this method, the increase in population is assumed to be constant and an average increase of the last 3 or 4 decades is calculated and added to the present population to determine population of the next future decade. The population can be found out at the end of 'n' year as follows :-

$P_n = P + n^{th}$ (where P = Present population , i = Yearly or per decade increase in population).

2. **Geometrical Increase Method** :- In this method the average % age of growth of last few decades is determined. The population forecasting is done on the basis that % age increase per decade will be the same. Thus population at the end of 'n' years or decades is given by :

$$P_n = P\left(1+\frac{i}{100}\right)^n$$

Where i = % age increase per decade.

3. **Incremental Increase Method** :- This method is improvement over the above two methods. The average increase in the population is determined by the arithmetical method and to this is added the average of the incremental increase once for each future decade. Thus population at the end of 'n' years is given by :

$$P_n = P + n\left(i_1 + \frac{n-1}{2}j\right)$$

Where I_1 = Average arithmetical increase &

I_2 = Average incremental increase

i **Decreasing Rate Method** :- in this method the average decrease in the huge increase is worked out and is then subtracted from the most huge increased for each successive decade.

Problem :-

The following data have been noted from the census department:

Year	Population
1961	8,000
1971	12,000
1981	13,000
1991	12,500

Calculate the probable population for the year 1901, 1951 & 2001.

Increase by using, Arithmetical increase method :-

Year	Population	Increase in population
1961	8,000	----------
1971	12,000	4000
1981	13,000	1000
1991	12,500	-500
	Total	44,500
	Average	1411

Solution:

Year	Population
1901	12,500 – 14 (411) = 7,246
1951	12,500 – 5 (411) = 10,445
2001	12,500 + 1 (411) = 12,911

Answer by using Geometrical Increase Method :

Year	Population	Increase in	Percentage increase

1981	1,000	———	———
1991	1,400	400	(400/1000)*100 = 40.0%
2001	1,800	400	(400/1400)*100 = 28.6%
2011	2,200	400	(400/1800)*100 = 22.2%
Total		1,200	120%
Average per decade		400	40%

The population at the end of various decade will be as follows:-

Year	Expected population
2021	2,200 + (40% of 400) = 2,360
2031	2,360 + (40% of 400) = 2,520
2041	2,520 + (40% of 400) = 2,680

Answer by using Incremental Increase Method :

Year	Population	Increase in Population	Incremental Increase
1981	1,000	———	———
1991	1,400	400	———
2001	1,800	400	0
2011	2,200	400	0
Total		1,200	0
Average		400	0

The population at the end of various decade will be as follows:-

Year	Expected population
2021	2,200 + 1 (400) + 0 = 2,600
2031	2,600 + 2 (400) + 0 = 3,400
2041	3,400 + 3 (400) + 0 = 4,600

Answer by using Decreasing Rate Method :

Year	Population	Increase in Population	Percentage increase in population	Increase in the % age increase
1940	8000	———	———	———
1950	12000	4000	(4000/8000) * 100 = 50	———
1960	17000	5000	(5000-12000) * 100= 41.7	- 8.3
1970	22100	5100	(5100 / 17000) * 100= 12.8	- 4.2
1940		14100		17.6
Average		4033		8.8

The population at the end of recent decade will be as follows :

Year	Last % age increase in population	Estimated Population
1940	22.1 - 4.2 = 17.9	22,100 + (22,100 * 17.9) = 26,054
1960	17.9 - 4.2 = 13.7	26,054 + (26,054 * 13.7) = 29,623
2000	13.7 - 4.2 = 9.5	29,623 + (29,623 * 9.5) = 32,437

QUALITY OF WATER

Impurities in water:-

For the purpose of classification the impurities present in water may be divided in to the following three categories

1. Physical impurities
2. Chemical impurities
3. Bacteriological impurities

1) Physical impurities:-

i) **Colour:-** The water in lakes may be coloured by organic matter from vegetable and animal sources. The discharge from many industries may be coloured and such discharges in to natural water bodies impart colour to the water of such water bodies.

It may be stated that pollution of water due to colour is mostly an aesthetic one and in many cases, it does not develop any threat to the public health.

The measurement of colour in water is carried out by means of a instrument. Two **petco nessler tubes** are used for this purpose. **The matter in water which should not be removed** by this method is generally less than 10.

ii) **Taste and odour:-** The watery vegetable matter and odorous gases in various amount and thus make the water unpleasant for drinking. The industrial wastes contain many strong smelling chemical compounds and when such waste waters are discharged in to rivers or streams, the water of such rivers or streams gets unpleasant taste and odours. The taste and odour in water is general have no real public health significance. But the pollutants of water by taste and odour has the following effects.

(i) Such waters may prove detrimental to fish life and may damage the value of fisheries.

(ii) Such waters are not liked by public and they are rejected even though there is no health risk and subjective nature of poor quality.

(iii) If taste and odour in water are due to certain toxic chemical gases, the use of such water may seriously injure the public health.

The test to control can be by having thorough taste of an water supply. The taste and odour of water may also be tested by threshold number. For potable water supply the threshold number should not be more than

ii) **Temperature** – If the temperature of water is not within an acceptable range, it can cause a health problem. For instance, the cooling water from thermal and nuclear power stations is considerably warm and if such warm water is discharged in to normal water bodies, it will result in the rise of temperature of water of such natural bodies.

The ambient temperature of water has an practical meaning in the sense that it is not possible to give any limitation to control the temperature in any water supply project. The temperature of water to be supplied from single source depends on the depth from which it is drawn. The desirable temperature of potable water is 10°c. While temperature of 25°c is unobjectionable.

The measurement of temperature of water is done with the help of ordinary thermometers. From the study of temperature the characteristics of water such as density, viscosity, vapour pressure and surface tension can be determined. It also helps in determining the saturation values of solids and gases which are beneficial to water and also the rate of chemical, biochemical and biological activity.

iii) **Turbidity**:- The colloidal matter present in water interferes with passage of light and thus imparts turbidity to the water. The turbidity in water may also be due to clay and silt particles, discharge of sewage or industrial wastes, presence of large numbers of microorganisms etc. And this visual appearance developed in water due to turbidity is undoubtedly undesirable and in many ways be harmful to the consumers. Turbidity slows the disinfection process because the solids may physically shield the organisms from the disinfectants.

The turbidity is expressed in terms of parts of suspended matter per million parts of water or mostly written as P.P.M. It is to be noted that the expression p.p.m is also equivalent to mg per liter or mg/lit. The standard name of turbidity are the turbidity produced by one part of fullers earth when it is the form of finely divided silica in a million parts of distilled water. The instrument by which turbidity of water is measured is

The measurement of turbidity in the field is done by means of turbidity rod and a
is referred to as the visual method of turbidity measurement the jar, turbidity meters are
used for to measure the turbidity of water.

The data obtained from turbidity measurement are helpful in the following ways:

i. It assists in deciding whether turbidity reduction and the photosynthesis reaction is
chemical likes.

ii. It gives indication of the quantity of chemicals required for day to day operations of water
treatment works. The excess turbidity may seriously affect the functioning of water treatment
filters.

Chemical impurities and chemical tests:-

1. **Chlorides:-** The chlorides contents especially of sodium chloride is salt are evidence for
a sample of water. The present presence of sodium chloride in natural water indicates
pollution of water due to sewage, domestic, saline oil, and wastewater, ion, steam plant
effluents, chemical industries, sea water intrusion in which reports also, iron in drinking
water. An highest desirable level of chloride content is 250mg/lit. And its maximum
permissible limit is 600mg/lit.

The presence of chlorides salts in rivers and lakes cannot be used for
human because of corrosion (RC) due to presence of magnesium chloride in water.

2. **Dissolved gases:-** The water contains various gases from its contact with the
atmosphere and ground surfaces. The usual gases are nitrogen, methyl hydrogen
sulphide, CO_2 and oxygen. The contents of these dissolved gases in a sample of water
are valuably evaluated.

The hydrogen is very very important for evaluation of corrosion in water method
for its significance property. The hydrogen sulphide gives disagreeable odour to the water
even if its amount is very small. The carbon dioxide creates saturation, biological
activities, sewage corrosion, increase the solubility of many minerals in the soil giving an
acidic to the water.

The oxygen in the dissolved state is obtained from atmosphere and plant
material. Surface water is usually saturated with it. The simple test to determine the
amount of dissolved oxygen present in a sample of water is to measure for 4 hours
at a temperature of 27°C with 30% acid solution of potassium permanganate.

[illegible] quantity of oxygen that soil can store for use by plants. This amount for potable water should be about 5 to 10 p.p.m.

3) **Hardness:** The term hardness is defined as the ability of the water to cause precipitation of soap by the calcium and magnesium salts. (Higher fatty acids from soap.

The hardness in soap destroying power of water is of two types- temporary hardness and permanent hardness.

The temporary hardness is also known as the carbonate hardness and it is mainly due to the presence of bicarbonates of calcium and magnesium. It can be removed by boiling or by adding lime to the water.

The permanent hardness is also known as the non-carbonate hardness and it is due to the presence of sulphates, chlorides and nitrates of calcium and magnesium. It cannot be removed by simply boiling the water. It requires special treatment of water softening.

The economic hardness of water is quite serious because of it causes serious wastage as it causes excess consumption of soap, affects the working of dyeing systems, provides scales on boilers, causes corrosion and other troubles of pipes, makes food tasteless etc.

The hardness is expressed in terms of CaCO$_3$ which is known as degree of hardness.

One unit grain of $CaCO_3$ dissolved in one gallon of water will produce one degree of hardness. The expression grain is used to measuring grains here and in this case, one degree of hardness will be equal to 14.3 p.p.m. It is found that each degree of hardness causes wastage of about 0.65 grain of soap.

The water having hardness of about 5 degrees is reasonably soft water and is very soft water is sensitive. Usually for potable water, the hardness should probably be more than 3 degrees and less than 8 degrees or so.

4) **Hydrogen ion concentration (pH value) -**

The acidity or alkalinity of water is measured in terms of its pH value or Hydrogen ion [illegible]

The pure water (H_2O) consists of positively charged hydrogen ions and negatively charged hydroxyl or hydroxide ions. But the process of dissociation takes place in pure water and hence it contains some unionized positively charged H_3O^+ ions and unionized negatively charged OH^- ions. The water becomes acidic when positively charged H_3O^+ ions are in excess than negatively charged OH^- ions and it becomes alkaline when reverse is the case.

Fig 5.1

Fig. (5.1) shows pH scale. Neutral water has pH value of 7. At pH value less than seven, the water becomes acidic and what pH value it can't it indicates maximum acidity reached. So water becomes alkaline as pH value increases and maximum alkalinity is indicated when pH value is equal to 14.

- It is theoretically impossible for pH value of water not close to 7. The acidic water causes atherosclerosis and the alkaline water causes hypertension.
- Any possible water, the pH value should be between 0.1 and 14.

3. **Alkalinity :** The term alkalinity with reference to the water and waste water is defined as the capacity of substances contained in the water to take up hydrogen ions (H_3O^+) to reach a defined pH value. It is to say ,

- The alkalinity is due to the presence of bicarbonate (HCO_3^-), carbonate (CO_3^{2-}) or hydroxide (OH^-).
- The alkalinity is usually divided into the following two parts:
  1. Total alkalinity i.e. above pH 4.5
  2. Caustic alkalinity i.e. above pH 8.2
- The alkalinity is measured by the volumetric analysis. The various types of indicators are available for the purpose for commonly adopted two indicators are as follows:

1. Phenolphthalein pink above pH 8.2 and colorless below pH 8.2.
2. Methyl orange that below pH 4.4 and yellow orange above pH 4.4

- The excess alkalinity is harmful for irrigation which leads to the soil damage and makes crop unfit.
- The highly alkaline water is usually unpotable.
- The large amount of alkalinity requires a more caustic chemicals.
- The water having alkalinity less than 200 mg/lit. is desirable for domestic consumption and for B.T.( ) construction.

5) Acidity:- The term acidity is the reference to the water and means water is attributed to the capacity of substance contained in water to take up hydroxyl ions (OH⁻) or more precisely the solution pH value (≤ 8.3).

- The acidity are of the following two types:
  1. Carbon dioxide acidity:- This acidity is due to the presence of CO_2 in ground water and surface water.
  2. Mineral acidity:- This mineral acidity is due to the presence of HCl, H_2SO_4, HNO_3 and strong organic acids.
- Total acidity = $CaCO_3$ + Mineral acidity + CO_2 acidity.
- The determination of acidity of natural and agricultural becomes of the following reasons:
  1. It affects the aquatic life.
  2. It affects the biological treatment of sewage.
  3. It corrodes pipes.
  4. The water having acidity more than 200mg/ lit. cannot be used for B.T.( ) construction.

7) Metal and other chemical substance:- Various ions are present in water the presence of different metals and other chemical substance is a sample of water.

Name of metal	Maximum permissible concentration in mg/ lit.
Arsenic (As)	0.05
Copper (Cu)	1.50
Fluoride (F^-)	1.50
Iron (Fe)	0.30
Lead (Pb)	0.05

3. Biological oxygen demand: The complete procedure to follow in the following four steps:

i. [illegible]

ii. [illegible]

iii. [illegible]

iv. [illegible]

- The amount of free ammonia in portable water should not be exceeded 0.15 p.p.m. and that of albuminoid ammonia should not exceed 0.3 p.p.m.
- The term albuminoid ammonia is used to represent the quantity of nitrogen present in water before the decomposition of organic matter has started.
- The presence of nitrite indicates that the organic matter present in water is not fully oxidized as in other words, it indicates an intermediate oxidation stage. The amount of nitrites in portable water should be nil.
- The presence of nitrates indicates that the organic matter present in water is fully oxidized and the water is not longer harmful. For portable water, the highest desirable level of nitrates is 45 mg/lit.

4. Total solids: The term solids, with reference to the environmental engineering is defined as the residue remaining after evaporation and drying in oven at 103 C. The total solids consist of dissolved and suspended matter.

1. **Dissolved solids:** In natural water the dissolved solids mainly consists of inorganic salts like carbonates, bicarbonates, chlorides, sulphates etc. together with small amounts of organic matter and dissolved gases.

- For measuring the total dissolved solids, the sample of water is placed in a china/porcelain dish and it is ignited in muffle furnace. After partial cooling in the air, it is cooled in a dessicator and re-weighed. Then, total dissolved solids

$$\text{solids in mg/lit} = \frac{A-B}{V} \times 1000$$

Where

A = Final weight of the dish

B = Initial weight of the dish in mg

V = volume of sample in ml

- Many chemical substances are undesirable in water and they impart displeasing odour, taste and colour.
- The water with higher content of dissolved solids has harmful or unwelcome effect on the human body and it also limits its possible domestic and industrial uses.
- Excessive use of inorganic fertilizers [illegible] can [illegible] also produce disorders in livestock and many lead to ecological problems, etc.
- The estimation of total dissolved solids is useful in determining the suitability of water for drinking purposes as well as for agriculture and industrial processes.
- The permissible total dissolved solids for drinking water according to BIS is 500 mg/lit. It can sometimes extend up to 1500 mg/lit.

2. Suspended solids: It refers to the portion of the total solids retained on a specified filter through which a sample of water has been passed. It includes the settleable solids, floating materials and substances which are neither settleable nor floatable.

- For measuring suspended solids the water is filtered through a glass fibre and dry material retained on the filter is weighed. The drying is carried out for the water to evaporate at 103°C.

  The suspended solids in mg/lit = $\frac{[W_2 - W_1] \times 1000}{V}$

  Where, W_1 = initial weight in mg

  W_2 = Weight of dry material retained on filter in mg

  V = Volume of sample in ml.

- The suspended matter is objectionable in water for following reasons:
  1. It is aesthetically displeasing.
  2. It may include disease causing organisms.
  3. It may cause sludge deposits.
  4. It provides adsorption sites for chemicals and biological agents.
- The estimation of total suspended solids is commonly useful in the analysis of polluted waters and for evaluating the efficiency of treatment units.

SAMPLING: Sampling is the most important part of any analysis because the final result obtained even from the most accurate analysis will be misleading if the sample on which such analysis is carried out are not representative even of the liquid to be tested. As a matter of fact it will be able to carry out all the analysis immediately after the collection of samples and the quicker the analysis the more representative it will be the results of analysis of the liquid.

Precautions to be taken while collecting the samples of water to be analysed:-

i. The water should be collected in bottles, especially of white glass having well fitted stoppers. The bottles having holding capacity of about 2 litres of water are necessary for the chemical analysis.

ii. The bottle should be thoroughly cleaned. Wash thrice with water and thrice with original to be collecting the sample. However it will not be necessary to carry out such process if the added bottles are already cleaned from the laboratory.

iii. When the sample of water is to be collected from a pipe the water tap should be turn on and the water should be allow to go waste for at least two minutes to prevent the entry of impurities of the pipe in the sample of water.

iv. For collecting the sample of water from lake, stream, spring or well, the whole bottle with stopper enclosed should be suspended well under the surface of water and then only the stopper of bottle should be removed by means of a cross piece of string and the bottle is filled from the entry of floating impurity will be prevented in the bottle.

v. The bottle should be held as far away from us such as possible. In no case the water coming by hands should come in contact with the bottle.

vi. After collecting the sample the stopper of the bottle should be well secured and the bottle containing samples of water should be kept during the entire time permitted of collection.

BACTERIOLOGICAL TESTS:-

- The examination of water for the presence of bacteria is very important. The bacteria are very small organisms and it is not possible to detect them by microscope, hence they are detected by conventional methods or chemical reactions.
- The bacteria may be harmless or moderately harmful or beneficial. The former category is known as the non-pathogenic bacteria and the other category is known as pathogenic bacteria.

- The commercial group of pathogenic and non pathogenic bacteria is designated by healthful soils. Bacillus Subtilus and ... determinant of Azotic group. The group of bacteria is known as transformer of living matter liberated minerals.

Following are the two standard bacteriological tests for the bacteriological examination:

of water

(1) Total count on agar plate count test.

(2) Fecal test.

(1) Total count on agar plate count test:

*****In this test, the bacteria are cultivated on specially prepared medium of agar for different dilutions of sample of water with sterilized water.

***The standard sample is plated in an incubator for 24 hours at 37° C (24 Hours later) or 48hours at 20°C.These represent the air which has come and still remain suspended. The bacterial colonies which are formed, are then counted and their results are computed for an ml of potable water, the total count should not exceed 100 per c.c.**

(2) E coli test: The test is divided into the following three parts.

(a)Presumptive test.

(c) Confirmed test.

(d) Completed test.

Presumptive test: Following procedure is adopted in this test.

a) The definite amount of known sample of water are taken in sterilized tubes, such as c.c. 10 c.c., 1 c.c. etc.

b) The tubes placed in standard fermentation tubes containing lactose broth.

c) The tube is examined at a temperature of 37°C for a period of 48hr.

(d)If gas is seen in the tube after this period is over, it indicates presence of B –coli group and the result of the test is marked as +ve. If no gas in this case, it indicates absence of B-coli group and the result of the test is marked as negative.

(e)A negative result of bacteriological test indicates that water is fit for drinking.

Combined test:

This test is carried out in the following steps:

ex: A small portion of material showing positive precipitin test is carefully transferred to another Florentine tube containing fertilizer gram solution. Ring is seen in the precipitin test becomes essential.

ex: A small portion of material showing positive precipitin test is taken on the plate containing broth or meat confection. **Blue agar: the plates are kept at 37°C for 24 hrs.** A colonies of bacteria are seen after this period. A cultural positive result and the competitive test becomes essential. the colonies are processed by complex reagents and dark spots.

(iv) **Completed test:**

This test is made by introducing or inoculating bacteria colonies into various biochemicals tubes and agar tubes. The **incubation is carried out at 37°C for 24 to 48 hours. If gas is seen** after this period of incubation provides broad and further detailed test are carried out to detect the particular type of bacteria present in tubes. the colonies of gas indicates negative result and the tubes the considered case for shedding.

Self-assessment tools:

- Serology is a science the quality of serum like of Haemophilus is not recommended for organic matter to conduct a positive of B for shedding purpose.
- The first stage of investigation is the preparation of serum and is necessary precautions of administration rules in making study or else like. Drug, tube, reagents, organisms and tools used (B for the used process of Medicine).
- The laboratory tests are to determine one or the following main indications in Blue as a real time schools. The small amount of serum reserve for administration under dispersion as a small fraction and as the type of tank. A diffusion process of organic particles, colonies of the Blue, etc...

It is recorded that plate isolation is then made out in every about 99% of suspected cases and about 70% of bacteria had been found. Serum is made the administration basic effects of a organism can in the many to day to hospital in the administration work. The administration tests are found in a blue, acute and in cases of emergency is increased. Any case can be called upon to work in emergency cases with a Medicine of 24 hr weight of it is essential to provide the administration work.

CHAPTER 2

SOURCES OF WATER

Surface sources:-

the watercourse which the water flows over the rocks surface are called surface sources.

The surface sources are mainly classified as :- River, Stream & Lakes, Impounding reservoir.

River, Stream & Lake: :- They are formed by rainfall i.e. rain water flowing along the ground into these natural drainage depressions. Quantity varies depending on the catchments.

River: Rivers are more or less fully, natural drainage of large number of springs and streams combined together. Rivers are the only surface sources of water which have maximum quantity of water which can be easily taken. **Streams:** In mountainous regions streams are formed by the run off. The drainage in streams is much in many seasons than other streams. The quality of water in streams is normally good except the water of first rainfall.

Lakes :- In mountains or some places natural basins are formed with impervious beds. Water from springs & streams gradually flows towards these basins and Lakes are formed. The quantity of water in the lakes depends on its basin capacity, catchment area, annual rainfall & porosity of the ground etc.

Impounded Reservoir :- A dam is defined as an artificial bar created for the construction of a dam across a valley containing a water course. The object is to store a portion of the stream flow so that it may be used for water supply. The reservoir consists of three parts

(i) A dam or bund bank, dam.

(ii) A spillway through which excess stream flow may discharge.

(iii) A gate chamber containing the necessary valves for regulating the flow of water from the reservoir.

Underground Sources :-

These are the sources of water which supply water from below the earth surface. They include springs, wells & galleries.

Springs :- Ground water reappears on the ground in the form of springs. Springs are brought about under the following conditions:-

(i) When the surface of earth drops steeply below the normal ground water table, the

[illegible] bearing material is exposed to the atmosphere and the spring gets created. The formation of such springs results from an overflow of the ground water table. This type of spring is also called as **Overflow** or **Shallow spring** (Refer Fig. 2.3) and the water temperature of such springs varies with the seasons.

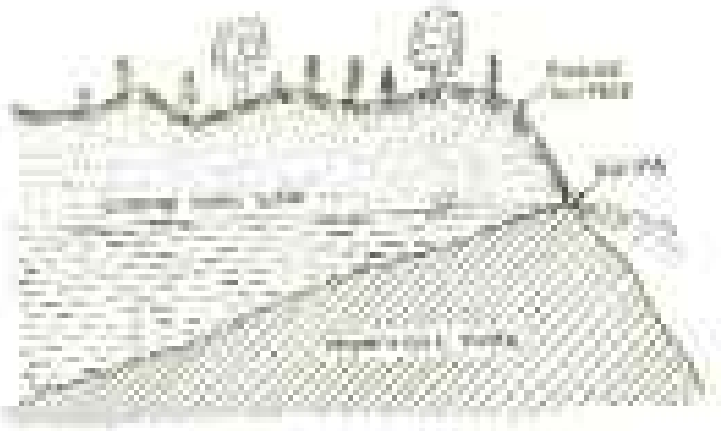


Fig. 1 (Shallow Spring)

(ii) When the water from ground water is moved in the form of a stream or a river, it flows under pressure to overflow at the surface. Springs of this type are the most common. These are formed when an impervious stratum, which is supporting the ground water, [illegible] (Refer Fig. 2.2).

Fig. 2.2 (Spring)

(iii) When the flowing water under pressure [illegible] a fissure, crack or fault in the form of spring, such types of springs occur are known as fissure spring.

through a fissure in the upper impervious stratum. There are also known as **fissure springs** (refer Fig. 1.11). The amount of water available is large & the [illegible] case of flow of water is constant because it is not controlled by a restricted percolation.

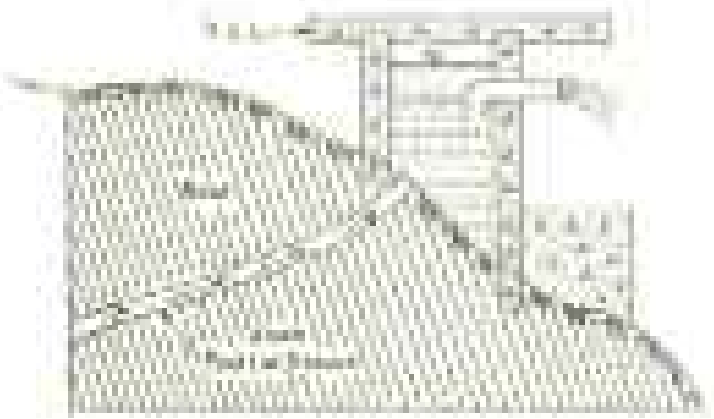


Fig. 1.11 Formation of spring due to a fault in a rock

Artesian Wells or Bore Wells. (refer Fig. 1.12) – A gallery is a horizontal or approximately horizontal excavation formed through water bearing material in a direction approximately normal to the direction of flow of the underground water. As we know that sub-surface water always flows in layer (strata) & lines or channels. Any boring which can be represented by digging a trench or by constructing a tunnel in the strata in order at right angles to the direction of flow of underground water. Open underground tunnel is used for tapping underground water such tubes, which are called infiltration Galleries.

Fig. 1.12

Infiltration Well :- An infiltration gallery may be a line of wells closely spaced & placed across a normal to the direction of underground flow or an aquifer. The water is intercepted, placed close to the bank of a river or a lake to intercept the underground flow towards the body of surface water. Wells so placed are called infiltration wells. It may be more economical to draw ground water from beneath a river by such means than to pump the surface water taken directly from the river.

Well :-

The vertical hole dug into the ground to get sub-surface water is called a well. Wells are generally classified as : Shallow well & Deep Well (Refer Fig. 1.1)

- A shallow well is that well in which the water is obtained from the upper most water bearing stratum without encountering any impervious stratum. The yield of the shallow well is appreciable due to large catchment in the ground water source throughout the year.
- A deep well is that well in which the water is obtained from the underneath of an impervious layer. The yield of a deep well is greater & constant as there is no quick fluctuation of the water level.

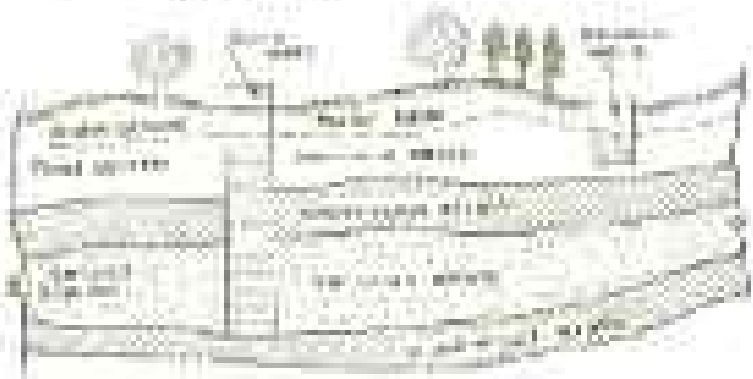


Fig. 1.1 Shallow & deep well

Types of Well :-

- According to condition of flow, wells may be classified as Gravity wells & Pressure wells.

When the surface of the water in the water bearing stratum surrounding the well is at atmospheric pressure, the well is called **gravity well.**

When the aquifer is confined between two impervious layers, one above & other below, & the water in the aquifer is at a pressure greater than atmospheric, the well is called **artesian well**.

- According to the type of construction, wells may be classified as: Dug Wells, Bored Wells or Tube Wells & Driven Wells.

Dug Wells – Small dug wells are generally excavated by hand. At lower ends, they are lined with brick, rubble or concrete. In rock, they are commonly left unlined. The lining is termed as **"Curb"**. In the case of a well used for domestic purposes, the upper portion of the curb is made impervious for a depth of 1.00m to 3.00m. Dug wells should be completed when the water table is at its lowest level.

Bored Wells or Tube Wells (Refer Fig. 3.6): This type of well can be bored by using hand or power augers into cohesive soils. Above the water table, the excavated soil is collected in the auger which is raised from time to time to remove the collected soil. When the boring is done below the water table, sand may wash out of the auger and have to be removed from the bore hole by sand auger. The holes varying from 5 to 15 cm in diameter & 9 to 12m depth can be bored by hand auger & larger power augers will drill holes of diameter ranging from 20 to 75 cm and depth 15 to 30m.

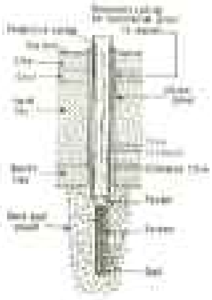


Fig. 3.6 (Bored or Tube well)

Drive Well (Peizometer Well): It is domestic and piezometric type of tubular wells develop shallow water supplies. The reasons for this is that drive wells are shallow and of smaller diameter. This is because of the difficulty in driving a large pipe in greater depths. All such wells will be located where a cultivating well with a suction pump at a distance not exceeding ten. Drive wells are adapted to soft granular formation. Peizometer well consists of a drive point & a pipe as shown in Fig. 11. A piece of pipe pierced at one end & perforated for remaining length is driven into a water bearing formation by a wooden hammer or hydraulic ram. The diameter of the casing varies from 2.5 cm to 10 cm. The whole pipe should be driven perfectly vertical as far as possible.

Fig. 11 (Peizometer Well)

Yield from Well :-

Yield has been defined as the amount of water flowing into the well per unit time. It is expressed in litres per second or sometimes in cubic metre per day.

Methods of determination of Yield of the well :-

(1) (i) the vertical distance from the water table to the bottom of the well.

d = the depth of water in the well

R = the radius of the zone of influence

r = the radius of the well

g = gravity rate

Yield of the well () = $K_v \cdot (H^2 - h^2) / \log_{10}(R/r)$ litre per minute.

Where transmissibility constant K_v = ( ) x ( ) x 1000 x ( ) x ( ) = ( )

Problem :

The following observations were made on a 30 cm diameter tube well —

(i) Rate of pumping = 1400 litre / minute.

(ii) Draw down in a nearby well after pump = 1 m.

(iii) Draw down in another nearby well after pump = 0.6 m.

(iv) Depth of water in the well before pumping = 4m.

Determine the radius of the circle of influence & the transmissibility constant.

Soln. ( ) = 4m. h / = 4 - 1 = 3 m

Formula () = $K_v \cdot (H^2 - h^2) / \log_{10}(R/r)$ litre per minute

$= K_v \cdot (4^2 - 3^2) / \log_{10}(R/0.15) = K_v \cdot (16 - 9) / \log_{10}(R/0.15)$

Solving for R by trial & error, we get R = 54m.

Now solving for K_v,

$1400 = K_v \cdot (4^2 - 3^2) / \log_{10}(54/0.15)$

$\therefore K_v$ = litre/min.

Measurement of specific yield :

The yield can be determined by the following two methods

(i) Actual Pumping Method

(ii) Theoretical Method

Actual Pumping Method :

The specific yield of a well can be determined by the following formula—

$C = k \times 2.303 \times T / \log_{10}(t_2 - t_1)$

Where,

C = Specific yield.

h_1 = Depression head in the well at the time immediately after the pumping was stopped.

h_2 = Depression head in the well at time t_2 after the pumping was stopped.

t_1 = Time after pumping when measurement h_1 was taken.

Knowing the value of C & ... the discharge 'Q' of the well can be determined by—

$Q = C \times A \times h$

Where, A = Cross sectional area of the well

h = depression head.

Theoretical Method :-

The approximate quantity of water entering or percolating in the well can be calculated as...

$$Q = A \times V$$

Where, A = cross sectional area of the well opening

V = Velocity of water percolating in the well & it = Permeability constant

Problem :-

The water level in an open well was depressed by pumping up to 1.5 meter. The water level was raised by 1.2meter within 30 minutes just after stopping the pumping. Determine Yield from a well, if the diameter of the well is 2.5 meter & the depression head is 1.5 meter.

Soln. Given h = 1.5m, h_1 = 1 – 1.2 = 1.5m, T = 30 minutes = 1800 sec, C

$k = (2.3 \times 1) \log_{10}(h_1/h_2)$

$= C \times k = (2.3/1800) \log_{10}(2/1.5)$

$= C \times k = 0.0001107$

$Q = k \times A = 0.0001107 \times 4.1625 = 0.0018$ m³

Thus $Q = C \times A/16 = 0.0001107 \times 4.909 \times 3$

$= 1.152 \times 10^{-3}$ litre per second = 1 lps.

CONVEYANCE OF WATER

Intake :-

A device placed in surface water source to draw water from the source for the purpose of a conduit through which water is led from the water work system, is called intake. It consists of a conduit with protective work, screen at inlet end, gate and valves to regulate the flow as shown in fig. 4.1.

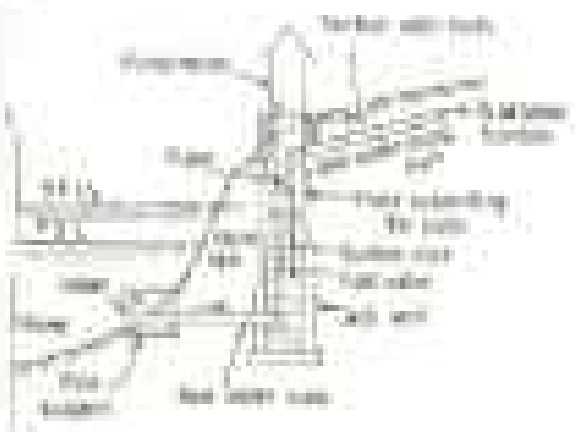


Fig. 4.1

Types of Intake :-

Intakes are used to collect water for water works from various sources. The sources may be rivers, reservoirs, canals. Common type of intakes are :

(i) River intake

(ii) Reservoir intake

(iii) Canal intake

River Intake : (refer Fig. 4.2) It is a circular masonry tower constructed along the bank of river at such place from where required quantity of water can be obtained in the dry period. The water enters in the lower portion of the intake is known as the sump well from pumped. The pumps are fitted with screens to check the entry of solid and are placed on the intermediate pile. The opening & closing of pumping valves is done with the help of wheels provided in the pump house floor.

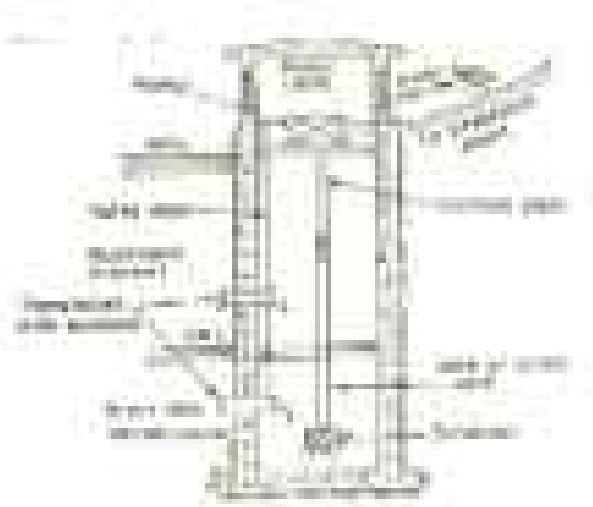


Fig. 4.2 (Service Intake)

Reservoir Intake :- These consists of intake control having an inlet, intake other than in the intake pipe. The control of the level is done inside accessible for inspection & operation. Fig. 4.3 shows a reservoir intake which is usually located either along the upstream of an earthen dam or within the body of a masonry dam. There are number of valves constructed by covers at different levels to draw water from near the reservoir.

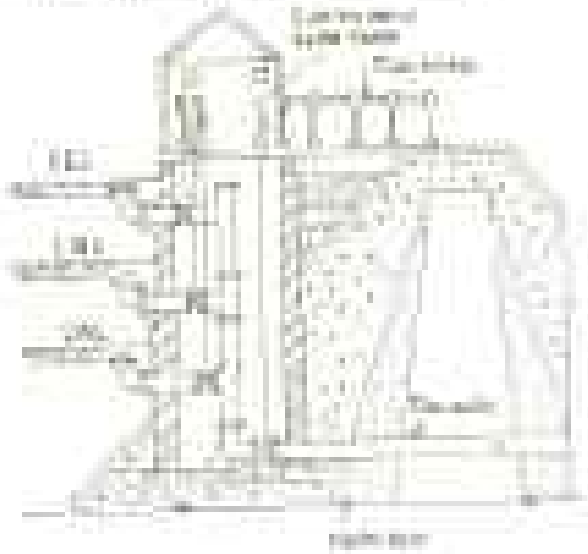


Fig. 4.3 (Reservoir Intake)

When the discharge of water over or between crossing sufficient to cover up the intended, but using these are not usually in which it cannot meet the low weather demands. In such cases reservoirs are constructed by constructing weirs or dams across the river.

Canal Intake: Canal intake is a very simple structure constructed on the bank of a canal. It consists of a RCC or brick masonry chamber built partially in the canal bank. Fig 4.4 shows fully shown a canal intake. It has a side opening fitted with coarse screen which excludes floating matter from entering the conduit. The end of pipe inside chamber is provided with a bell mouth fitted with a rectangular coarse screen. The outlet pipe connects the water to the other side of the canal bank from where it is taken to the treatment plant.

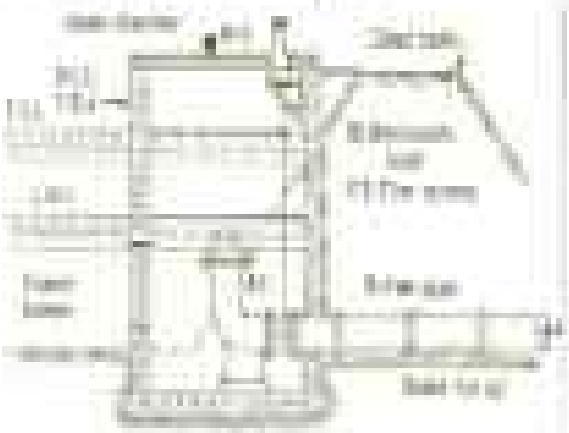


Fig. 4.4 Canal Intake

PIPES : Pipes are circular conduits in which water flows under pressure.

Most commonly the following types of pipes are available :

(i) Cast Iron Pipe

(ii) Steel Pipe & Wrought Iron Pipe

(iii) RCC Pipe

(iv) Asbestos Cement Pipe

(v) Plastic and Glazed Tile Pipe

Cast Iron Pipes : These are most commonly used in water supply schemes due to their durability, strength, resistance to corrosion, easy of laying etc. But the disadvantages of this type of pipes are :

(i) Due to its heavy weight, large diameter pipes are difficult to transport in hilly & difficult terrains.

(ii) Cutting, bends and specials of the pipe is required for carrying out the water.

Steel & Wrought Iron Pipes : These pipes are stronger than cast iron pipes. They are found to last durable for long life up to 50 years, more flexible to construct. It is necessary for the

of a couple from pipes as mentioned there are galvanized mild steel. These pipes are withstand much higher pressures but are of lighter section & hence easy to transport & use.

Advantages of Steel Pipes :-

(i) Steel Pipes are cheap.

(ii) These pipes are more durable.

(iii) These pipes are light in weight, hence easy to transport.

(iv) These pipes are available in large lengths which decreases the number of joints.

(v) Steel pipes can stand high internal pressure.

Disadvantages :-

(i) Steel pipes are likely to be rusted when subject to acid.

(ii) These pipes require more care for repair.

(iii) Its maintenance cost is more.

Reinforced Cement Concrete Pipes :- These are very durable, however it can be used up to 1.8m diameter. Transportation costs are much reduced as the pipes are come in sets. These pipes are mostly to carry sewage & especially suitable for soft & acidic water. The sections are normally used in 1:2:4.

Advantages :-

(i) These pipes have low maintenance cost.

(ii) The pipes are not corroded from inside by normal chemical in water.

(iii) These are very durable.

Disadvantages :-

(i) These pipes are difficult to repair & join.

(ii) The pipes have tendency to leak due to shrinkage cracks & porosity.

(iii) The pipes are difficult to transport.

Asbestos Cement Pipes :- These are manufactured from a mixture of pure best cement & asbestos fibre compacted under pressure into a dense homogeneous structure. These pipes are very light in weight, can be easily cut, joined & handled. They resist corrosion & are very smooth. Use of these pipes are increased in water works of distribution system, because of low resistance to flowing of water caused due to incrustation.

Advantages :-

(i) The pipes are very light in weight.

(ii) The pipes are smooth & their carrying capacities do not reduce with time.

(iii) The pipes are very suitable in small distribution system.

(iv) The pipes are flexible so much the joints are made it is tight.

Disadvantages :-

(i) The pipes are costly & less durable.

(ii) The pipes are still & brittle & do not have much strength.

(iii) The pipes are likely to be damaged during transportation.

PVC Pipes :- These pipes are widely used for cold water services, rain water system etc. These are strong & can withstand much high pressure for a given wall thickness. It is quite resistance to acid & alkali, corrosion, bacteria, corrosion & etc.

Selection of Pipe Material :-

The factors which affect the selection of pipe materials are :

(i) Internal pressure & external loads to which the pipe is subjected.

(ii) **Type of water to be conveyed & it's maintenance** as corrosion.

(iii) Maintenance cost.

(iv) Availability of funds.

(v) Expected life & safety & reliability.

PIPE JOINTS :-

The common types of pipe joints are as follows :-

(i) Socket & spigot joint.

(ii) Flanged joint.

(iii) Expansion joint.

(iv) Universal joint.

(v) Collar joint.

(vi) Screwed & socketed joint.

Spigot & Socket joint :- (Refer Fig. 4.1) :- These types of joints are commonly used in case of cast-iron pipes. For this construction of this joint the spigot or normal end of one pipe is entered into the socket of the other pipe. Some yarn is then wrapped around the spigot, leaving sufficient the required depth of socket for lead. A threaded clay ring is then placed as a mould for lead & against the face of the socket. After this molten pig lead is poured into the annular of the socket.

Fig. 4.1 (Expansion bracket joint)

Flanged Joint (Refer Fig. 4.2) :- These joints are rigid & can also be used in slightly wet trenches. In such cases cement pipes joints have to be occasionally opened out for carrying out repair work or in emergency situations. The pipes in this case have flanges cast integrally, external, machined to a required width. The pipes. A gasket of rubber, canvas or lead is introduced between the two flanges of cast iron pipes, which are then tightened with nuts & bolts.

Fig. 4.2 (Flanged Joint)

Expansion Joint (Refer Fig. 4.3) :- These joints are used on pipes exposed to considerable difference of temperature allowing for free expansion or contraction without setting up abnormal stresses in the pipes. These joints are pipes, lip, socket and spigot formed in cast iron pipe construction. A suitable length is left in the space provided for it & the clearance is filled in every position by the joint is made tight.

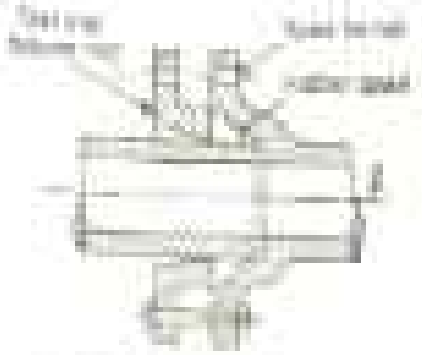


Fig. 4.7 (Expansion Joint)

Flexible Joints (Refer Fig. 4.8) a. These joints are used for pipes to let lead subsequent water mains , where the surface of the pipe is exposed with the possibility of settlement & consequent damage. If two pipes (pipes are deflected, the ball shaped portion will move inside the socket , & the joint will remain water proof to all the positions.

Fig. 4.8 (Flexible Joint)

Collar Joint (Refer Fig. 4.9) a. This joint is usually used for passing concrete & bituminous concrete pipes having bigger diameter. A cement jacket is placed between and rings at the junction after bringing the ends of the two pipes in one level. Then the collar is placed at the joint so that it should have the same clip on both the pipes. After this cement mortar (1 : 1) is filled in the gap between the pipes & the collar.

Fig. 4.9 (Valley Joint)

Screwed & Sealed Joint (Refer to Fig. 4.10) - This is a simple type of joint commonly used for jointing galvanized steel pipes and fittings. In this joint, two ends of the pipes are threaded on the outside and on these a suitable jointing compound should be used before screwing socket or coupling over the ends. Threads from inside.

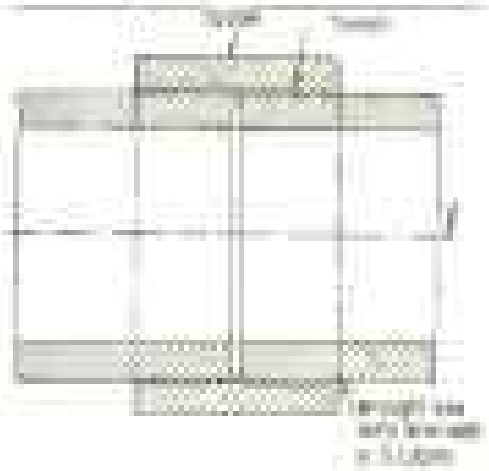


Fig. 4.10 (Screwed & Sealed Joint)

Testing of Pipes:

Pipes are generally laid with a flat slope parallel to the hydraulic gradient or sometimes as a falling gradient. Where there is steep slope laying should be done in an uphill direction so as to get proper bedding.

Testing of Pipe Lines:

After a new pipe line has been laid & jointed, it shall be subjected to the following two tests.

(a) Pressure Test

(b) Leakage Test

Pressure Test as a Pressure at least double the maximum working Pressure:

The procedure adopted for pressure testing of pipes is as follows:

(i) The pipe line is tested from section to section. At a time only one section is tested between two valves is taken up for testing.

(ii) First the downstream sluice valve of the section is closed & water is admitted in the section through the upstream sluice valve. During filling, air valve is properly operated to remove all air from the pipe.

(iii) Then the upstream valve is closed to completely isolate the section from the rest of the pipe line.

(iv) Pressure gauges are then fitted along the pipe length of the section at suitable interval (generally 180 m or so) & the water through hydraulic lift or hydraulic pumps.

(v) The pipe section is then connected to the delivery side of a pump through a sluice valve & the pump is started to increase the pressure in the pipe. The operation is continued till the pressure inside the pipe reaches a pressure at least double of the maximum working pressure.

(vi) Then the pump is stopped & the valve is closed & the pump is disconnected.

(vii) The pipe is kept as it is for 24 hours & observed for any fall of pressure. This completes the pressure testing of pipes.

Leakage Test as a Pressure to be specified by the authority:

After successfully completing the pressure test, the leakage test is carried out. Leakage test is to see maximum allowable leakage which is determined by the formula.

$$L = \frac{N D P^{0.5}}{3.3}$$

Where L = allowable leakage in cum/hr

N = number of joints in the length of pipe line

2. Gaseous stage

3. The arrangement process during the leakage and during [illegible]

Causes of corrosion in water system pipes:

Pipes used to distribute drinking water are made of plastic, concrete or metal (e.g. steel, galvanized steel, ductile iron, copper, or aluminium). Plastic and concrete pipes tend to be resistant to corrosion. Metal pipe corrosion is a continuous and natural process of iron release from the pipe into the water. Some unfavorable environmental conditions make pipes are the most vulnerable based on the properties of the pipe, the soil surrounding the pipe, the water properties, and stray electric currents. When metal pipe corrosion occurs it is a result of the electrochemical reactions occurring in making these the differential galvanic properties between metals, the ionic influences of electrolytes (aquatic backfilling), or low solution pH.

Remedies: -

- To avoid blocking of old pipes.
- To avoid placing of new pipes.
- To prevent drawing of water from water tanks to flow through the pipes.
- Must plan well so that individuals, groups, etc are ready to form a committee that is going to work.

CHAPTER-I

TREATMENT OF WATER

Flow diagram of treatment plant

Fig-1.1

TYPES OF SEDIMENTATION TANKS (CLARIFIERS):

Depending upon the manner of working, clarifiers are of the following two types:

(1) Fill and draw type clarifier.

(2) Continuous flow type clarifier.

(1) Fill & draw type clarifier:

(i) Working: These are also known also the quiescent type or intermittent type clarifiers. The working of tanks is simple. the water is filled in the tank and it is then allowed to rest for a certain time. During the period of rest the particles in suspension will settle down at the bottom of the tank. the clear water then drawn off and the tank is cleaned of silt and filled again.

The actual period of rest to cause settlement of particles is about 24 hours or so. If time is required for inlet, outlet, emptying and cleaning purpose a additional period about 10 to 12 hours is required. so use the tank again to working condition.

The inquiry that the tank two tanks will be required if an additional tank is to be provided as stand by the minimum number of tanks required under this type of working will not be less than three.

(ii) Design consideration:

- The vertical cylinder of the tanks will represent the storage capacity of the tank. the provision is made at the bottom for accumulation of silt. The inlet valve is provided at

the top of still deposit zones. Box holed and welded for 'rotten' are arranged at opposite ends as seen in plan of the tank. Fig. 1 shows the plan section of a typically fill and draw type of clarifier.

- **USE**

"These tanks are mostly use of the use is planned at their primary stage.

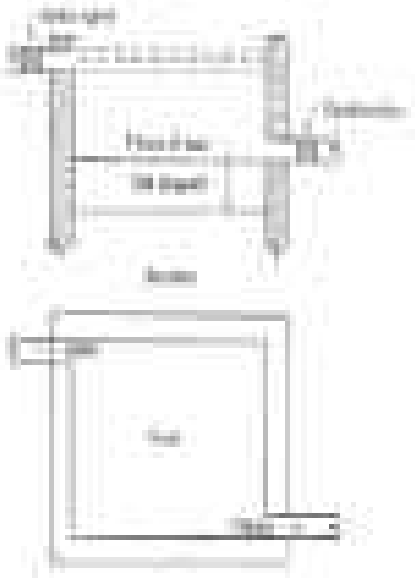


Fig. 6.2

a of velocity of the flow is reduced a large amount of suspended impurities from water can be easily removed. This is the principle on which continuous flow type of sedimentation tanks is working.

"The working operations of the tank is very simple as discussed in fig 6.1 the water enter the tank from one end at a constant velocity the top to at the other end, its velocity is reduced and solution by means of baffle walls. The outlet consist opening at different level.

"The velocity of the flow is so adjusted that the time taken by a particle of the water to move from one end to other is slightly more than that required for the settlement of suspended impurities in water.

"The entry of impure water from one end the exit of clean water from the other end are continuous. The flow of water is designed to meet the following two requirements.

(a) The velocity of flow is such that required minimum of impure size solids down at the bottom surface.

(b) A fair sized amount of flour from the main section (it forms) expects to the daily demand of the users.

- The unit is operated at the bottom of chamber and when it is accumulated in sufficient quantity, the flush valve is opened and the clarified is drained

(c) while these machines are mainly used in the modern times as they possess many advantages as mentioned below

(a) less labor & supervision :-

The action of the sedimentation tank is continuous and hence no manual labour is required except a few hours of cleaning or washing the chamber. Also only general supervision is required during the working of the chamber.

(b) **LITTLE LOSS OF HEAD**:

*The use of a situated near top of chamber, there is practically very little loss of head. Also the pure water is drawn from the top layer.

(c) **LARGE QUANTITY**:

*The continuous flows are arranged in series and hence the size of flocs that be retained for Clearly or washing per time. Thus the provision of area for water to be can be completed with ease.

(d) **TIME OF OPERATION**: As the flow of water is continuous, there is no wastage of time since the tank is put into continuous further as clean water storage tanks will be required and flow will be regulated and this will result in reduction in cost.

(f) **DISADVANTAGE**

*There is no only one inherit disadvantage of continuous flow type of chambers which the chemical the water in the tanks is to be taken out. Also there is considerable wastage of water. Hot cleaning operations are not carried out frequently. Unless such wastage of water can be to together.

SEDIMENTATION WITH COAGULATION:

*The turbidity is mainly due to the presence of very fine particles of clay silt and organic matter.

* All these impurities are in a finely divided state & it is not possible to detain them in plain sedimentation tanks as they such tanks are designed to get detention period.

*The ideal situation is easy to such particles is to increase their size so that they become unstable. The purpose of coagulation is that a stable particle of bigger size by adding certain chemicals known as coagulants to the water. The coagulants react with the impurities in water and prevent them to unstable size.

*The coagulation is to be adopted when turbidity of water exceeds about 10ppm.

PRINCIPLES OF COAGULATION

The principle of coagulation can be explained from following two considerations.

(1)**The formation:** When coagulants are dissolved in water and thoroughly mixed with it. They produced a thick gelatinous precipitate. This precipitate is known as the floc and floc has got property of entrapping the suspended impurities in water settling in downward direction towards the bottom of the tank.

(2) **Down charge:** The ions of floc are found to possess positive charge. Hence they will attract the negatively charged colloidal particles of clay and thus they caused the removal of such particles from the water.

*The surface of floc is sufficiently wide to attract colloidal and organic matter present in water. The term flocculation is used to describe the process of floc formation and thus the formation and thus the flocculation. Here the additives follows the addition of coagulants, and its efficiency depends on the

TYPICAL COAGULANTS :

Following are the most commonly coagulants which are adopted for coagulation.

(1) Aluminum sulphate

(2) Ammoniated copper

(3) Ferrous sulphate (green)

(4) Magnesium carbonate

(5) Polyelectrolytes

(6) Sodium aluminate.

(1) ALUMINUM SULPHATE:

- This is known by other name or alum only its chemical composition is $Al_2(SO_4)_3.18H_2O$.
- The alum is most commonly practiced commercially supplied and used in the form of flake/lump or powder lumps and then ignited to a solution form.

The advantages of using alum as a coagulants are as follows:

1. It does not have toxic and colour in water.

ii. It is clear.

iii. It produces a red dust cloud

Generally the fluorescein alkalinity is present in water and the chemical reaction involved between base hexane alkalinity and water is as follows:

$C_{20}H_{12}O_5 + 2NaOH \rightarrow C_{20}H_{10}Na_2O_5 + 2H_2O$

The fluorescein hydroxide formed is insoluble in water and it behaves as follows:

If metal possesses a little or no alkalinity the lime is added in water. The chemical reaction is as follows: $Ca(OH)_2 + 2H^+ \rightarrow Ca^{2+} + 2H_2O$

The magnesium is found to be efficient in hormonal PH range of 8.3 to 8.5

It practices the dosage of alum varies from 1 to 20 milligrams per litre for normal water the usual being 1 to milligrams per litre.

The should example of using alum as a coagulant are mainly two.

It is different to determine the dosage formula and further, it is necessary to laboratory efficient as it is found unsuitable for filling of living beads.

The effective PH range for coagulation with alum is found to be near neutral and in some cases, the lime or caustic soda will known to be added to adjust the PH value to a proper level. The will increase the cost of treatment of water.

(i) Disadvantages of using Aluminium sulphate

- When plumes and solutions of ferrous sulphate are mixed, the following chemical reaction takes place: $Al_2(SO_4)_3 + 3Ca(OH)_2 \rightarrow 2Al(OH)_3 + 3CaSO_4$
- The combination of ferric sulphate $Fe_2(SO_4)_3$ and ferric chloride is known as the chlorinated copperas, each one of the compound is effective as a $FeCl_3$ and the combination is also quite effective.
- The ferric sulphate and ferric chloride $FeCl_3$ both can be used independently with lime or soda as coagulant and the chemical reactions involved would be as follows: $Fe_2(SO_4)_3 + 3Ca(OH)_2 \rightarrow 2Fe(OH)_3 + 3CaSO_4$; $2FeCl_3 + 3Ca(OH)_2 \rightarrow 2Fe(OH)_3 + 3CaCl_2$

The ferric hydroxide $Fe(OH)_3$ forms the floc. For ferric sulphate the effective PH change is 4 to 7 and above 9 for ferric chloride the effective PH range is 3.8 to 6.0 and above 8.0

(3) FERROUS SULPHATE AND LIME:-

* When ferrous sulphate and lime are added to the water, the following chemical reaction takes place. [illegible]

* The ferrous hydroxide $Fe(OH)_2$ thus [illegible] oxygen in water and ferric hydroxide is formed as per the following chemical reaction. [illegible]

* The ferric hydroxide $Fe(OH)_3$ forms the floc. [illegible] ferrous sulphate [illegible] effective PH range [illegible] and above.

(4) MAGNESIUM CARBONATE:-

* When magnesium carbonate is dissolved and is mixed with water along with lime the following reaction takes place. [illegible]

* The compounds magnesium hydroxide $Mg(OH)_2$ and calcium carbonate are insoluble in water and the sludge formed in this process contains a sludge of $Mg(OH)_2$ and $CaCO_3$. This coagulant is not at present favored.

(5) Polyelectrolyte's:-

* These are special types of polymers and depending upon the charge they carry, they are classified as anionic, cationic and nonionic; only cationic polyelectrolyte's can be used effectively as independent coagulants. The other varieties can be used along with alum or other conventional coagulants.

* The use of polyelectrolytes is still in pilot stage and they may prove to be an alternative to the alum in future.

(6) SODIUM ALUMINATE:-

* The chemical composition of the coagulant is $Na_2Al_2O_4$ [illegible]

[illegible]

[illegible]

$$N_P N_1 L_1 = z_2 N_P L_2 / N_P N_2 \quad \text{.....(3)}$$

- The required transmission ratio between the impeller and the follower is equal to the ratio between the number of teeth on the follower and the number of teeth on the impeller.
- The velocity ratio between the impeller and the follower is equal to the ratio between the number of teeth on the follower and the number of teeth on the impeller.
- The velocity ratio between the impeller and the follower is equal to the ratio between the number of teeth on the follower and the number of teeth on the impeller.

FLUID MOTORS:

A fluid motor is used to obtain a positive rotation and thus the transfer of energy from the fluid motor to the main machine known as flow meter.

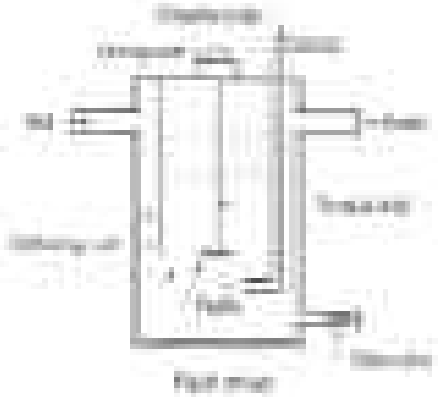


Fig.4.1

Fig.4.1 shows a typical fluid motor. The rotation is obtained by a rotating paddle situated in the lower end of the vertical shaft. The rotating water is diverted towards the rotating paddle by deflecting wall.

- The impellers are brought by supplied pipe and also the water jet over the rotating fan.
- Tail race valve is provided to remove sludge from the bottom of fluid motor.

Hydraulic motor shown is typical fluid motor. The rotor rotating is obtained by rotating paddles. The paddles usually make about 2 to 3 revolution per minute.

FILTRATION

NECESSITY:

- The sedimentation tanks remove a large percentage of the suspended solids and the organic matter present in raw water.
- The process of coagulation further assists in the removal of impurities present in the water. But even then, the resultant water is not pure and may contain some very fine suspended particles, bacteria etc.
- It is vital to remove all to reduce the chances of typhoid and diarrhea. So water is filtered through the beds of fine granular material like sand. The process of passing through the bed such granular material is known as filtration.

PRINCIPLES OF FILTRATION:

Process of filtration consists of the allowing water to pass through a thick layer of sand.

Principles of filtration are:

(1) **Mechanical straining**: The suspended particles which are unable to pass through the voids of sand grains are arrested and are removed by mechanical straining.

(2) **Sedimentation**: The voids between sand grains of filter act more or less like small sedimentation tanks. The particles of impurities arrested in these voids, as soon as the particles of sand grains and are thus removed by the action of sedimentation.

(3) **Biological activities:**

- The growth and development of the living cells is known as the biological activities.
- When the bacteria are caught in the voids of sand grains a zoological jelly or film is formed around the sand grains. This film contains large colonies of living bacteria. The bacteria feeds on the organic impurities contained in water. They convert such impurities in to harmless compounds by the complex biochemical reactions.

(4) **Electrolytic changes**: According to this theory when two substances with opposite electric charges are brought in to contact with each other the electric charges are neutralized and so strong ac ions chemical reactions are caused.

It is observed that some of the sand grains of filter are charged with electricity of some polarity. Hence, when particles of suspended and dissolved matter contact chemically

of opposite polarity arise into contact with each other gases into neutral and other and neutralize as well as the alteration of chemical characteristics of water.

CLASSIFICATION OF FILTERS :

Filters are classified in to the following

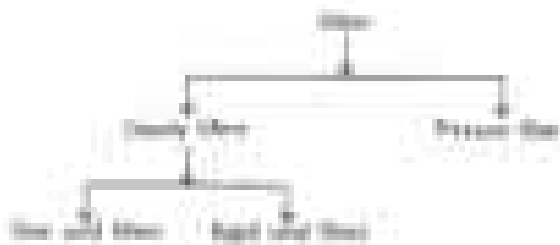
(1) Slow sand filter

(2) Rapid sand filters

The rapid sand filters are further subdivided into the following two categories

- Gravity type rapid sand filter
- Pressure type rapid sand filter

The above classification is based on the rate of filtration. On the consideration of the gravity and pressure the filters may be classified as follows.



Considering the above classification, there are following three types of filters

1) slow sand filter
2) Rapid sand filter
3) pressure filter

SLOW SAND FILTER:

- **(LIFE SPAN) :** In case of slow sand filtration, the water is allowed to pass slowly through a layer of sand placed over the base of the material and then the purification process are is simultaneously removing the biological ,chemical and physical characteristics of water.
- The slow sand filtration is very well suited for rural area as well as developing countries because of its simple operation and maintenance procedures. It does provide safe drinking water at low treatment cost.

ESSENTIAL PARTS : A slow sand filter consists of the following five parts.

(1) Inlet chamber walls.

(2) Outlet drainage system

(3) Main material

(4) Filter media or sand

(5) Appurtenances.

- **ENCLOSURE TANK:** A water tight tank is constructed either in stone masonry or brick masonry. The sides & floor are also coated with water proof material. The end slope is given as 1V in 3H or 1 in 3H formula. The central drain. The depth of tank is about 2.50m to 3.00m. The surface area of a clear sand filter may vary from 40m to 2000m or more.

- **UNDER DRAINAGE SYSTEM:** The under drainage system consists of a central drain and lateral drain as shown in the fig 3.4

The lateral drain is placed at a distance of about 2.5 m to 3.0m and they are supplied at a distance of about 3000mm to 4000mm from the walls of the tanks. The drains may be pipe drain are tank with open joint.

Fig 3.4

(3) **MAIN MATERIAL:** The base material is generally put in place on the top of under drainage system.

Its depth varies from 40cm to 70cm. It is usually graded and laid in layers of 150mm. The topmost layer should be small size gravel and the bottom layer should be of bigger size gravel. Following is a typical section of base material

Top most layer 150mm depth varies from to

150mm depth size varies from 3mm to

150mm depth varies 25mm to

—Three depth— one three in three.

Inspections depth.

(b) FILTER MEDIA OF SAND

- A layer of sand placed above the gravels.
- The depth of sand layer varies from 600mm to 900mm.
- The effective size of sand varies from 0.35 mm to 0.45mm & the uniformity coefficient varies 2 to 3.
- The finer the sand, the better will be the efficiency of filter regarding the removal of bacteria, but in that case, the output from the filter is lessened.

(c) APPURTENANCE

- The various appurtenances are to be provided for the efficient working of slow sand filter.
- The devices for measuring loss of head for ascertaining depth of scrapping sand layer, head for cleaning rate of flow through filter are to be suitably installed.
- The method of inlet passing through layer of sand help in proper function of filtering media.

(1) WORKING & CLEANING

- The water allowed to enter the filter through the inlet chamber to descends through the filter media and during this process is gets purified.
- Water is then collected in the outlet chamber and taken to the clear water reservoir tank.
- The depth of water filter is to be carefully decided, it should neither be too much nor too high. Generally it is kept as equal to the height of filter media of sand.
- For the purpose of cleaning the top layer of sand is scrapped or removed through a depth of about 3 mm to 25mm. The water in the outlet valve in the filter that the particular water is not taken into use and for increase the water sand gets cleaned.

(2) RATE OF FILTRATION :- The rate of filtration of a normal slow sand filter varies from 100 to 200 litres/ hours/ m^2 of filter area.

RAPID SAND FILTERS (GRAVITY TYPE):

1) **Purpose :** The pore dimensions of a slow sand filter are such that it requires considerable space for its installation. This requirement makes it uneconomical for places where land values are high.

The difficulty of requiring more space for slow sand filters can be eliminated by increasing the rate of filtration which is accomplished in rapid sand filter by increasing the size of sand.

2) **Essential parts :** Fig shows the layout of a typical rapid sand filter (gravity type). It consists of the following five parts.

i) Enclosure tank

ii) Under drainage system

iii) Filter material

iv) Filter media

v) Appurtenances

i) Enclosure tank: A rectangular tank is constructed either of concrete or masonry.

- The sides and floor are also coated with waterproof material.
- The depth of tank is about 2.5m to 3.0m
- The surface area of a unit of rapid sand filter varies from 10m² to 40m²

ii) Under drainage system : There are various forms of under drainage system of a rapid sand filter and most of them are patented by the manufacturers.

The following are two common types of under drainage system

a. perforated pipe system

b. pipe and lateral system

a) **Perforated pipe system :** In this system there is a central main or manifold and to this manifold the various lateral drains are attached as shown in Fig. 3.1.

- The drains are usually made of cast iron.
- The lateral drains are placed at a distance of about 20cm to 30cm.
- The lateral drains are provided with holes at the bottom side and such holes make an angle of 20° with the vertical as shown in Fig. 3.1
- The perforated pipe system is economical and simple in operation.

iv) **Pipe and washer system:** In this system also drain is covered drain or manhole with closed drains attached on either side as shown in the fig. drain in the system the shutters are placed on lateral drains instead of ordinary holes.

- A washer is a small pipe of 75mm dia which is placed in top and connects holes on its surface as shown in Fig.6.4
- The washers are either screwed or fixed on the top of lateral drains.
- When pipe and washer system is adopted the compressed air is used for the purpose of washing the drain. This results in saving of much water.

Following points also should be observed in designing the water drainage system:

i. The ratio of length of lateral drain to its diameter should not exceed 20.

ii. The cross sectional area of outlet drain should be about twice the cross sectional area of lateral drain.

iii. The total cross sectional area of perforations should be about 0.25% of the total filter area.

iv. The cross sectional area of lateral should be about two to four times the cross sectional area of perforations (v.c).

v. The perforations in the lateral drain should be of diameter 6mm to 12mm.

vi. The spacing of perforations in the lateral drain should vary from 75mm to 200mm centre to centre.

vii. **SAND MATERIAL:** The base material is gravel and it is found on the top of water drainage system.

- The gravel to be used for base material should be clean and free from clay, dust, silt and vegetable matter.

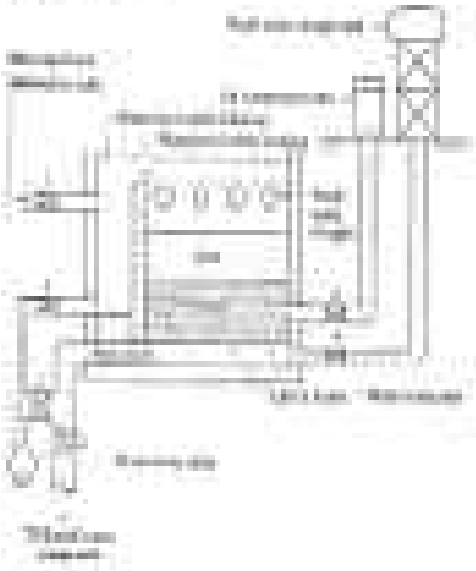


Fig.6.4

- The grain particle should be durable, hard, round and strong.
- The depth of base material varies from 100mm to 1500mm or so. It is usually graded and laid in layers of 150mm.
- The exposed layer should be of small size of gravel and the lower layer should be of big size gravel.

Following is a typical section of base material.

Top most layer: 150mm depth ← crushed rock to pass

Intermediate layer: 1) 90mm depth, crushed rock to pass 75mm

2) 90mm depth, coarse gravel to pass 50mm

Lowest layer: 150mm depth, coarse gravel to pass 90mm

Total effective depth

(iv) **FILLER MEDIA OF SAND**: A layer of sand is placed over a gravel.

- The depth of sand layer varies from 100mm to 300mm.
- It is commonly used as filter media.
- The effective size of sand varies from 0.2mm to 0.4mm and the uniformity coefficient of sand is between 1.25 to 1.55. Here the ratio of sieve which sand particle is recommended to result in the increase rate filtration.

(v) **APPURTENANCES:**

a) **AIR COMPRESSOR**: The agitation of sand grains during washing of filter is carried out either by compressed air or by water jet or by mechanical rakes. When air is used, the air compressor of required capacity should be installed.

b) **WASH- WATER TROUGHS**: The dirty water after washing of filter is collected in wash water troughs or gutter which is placed above sand bed level.

c) **RATE CONTROL**: There are various devices which are fitted to the valve and pipes to control the rate of flow.

3) Working and cleaning:

- The working of a rapid gravity filter can be understood by referring to Fig. 1.1. The raw water pipe and wash water outlet are provided with valves.

Valve 1 → Inlet valve

Valve 2 → Filtered water storage tank valve

Valve 3→ It is used to drain water from inlet chamber.

Valve 4→ It is used to recharge bulk tank.

Valve 5→ It is used to drain water from main drain.

Valve 6→ Compressed air valve.

- The valve 1 is opened and the water from completed sedimentation tank is allowed to enter the filter.
- The valve 2 is opened to carry filtered water to the filter water storage tank. All other valves are kept in closed position. Thus water flow is in such a way it enters only from inlet 2 and 2 are in open position.
- When the filter requires cleaning or washing it is carried out as follows.
  - i) The Valve 1 and 2 are closed.
  - ii) The Valve 4 and 6 are opened out. The wash water is then forced in the upward direction through the under drainage system, base material and filter media of sand. The compressed air assists the cleaning process of filters.
  - iii) The valve 6 is closed and the valve 5 is opened out to carry dirty water through the inlet chamber to the main waste drain.
  - iv) When washing of filter is over, the valve 4 and 5 closed and valve 1 and 3 are opened out. Now, when filter is put into normal working, the filtered water in the beginning is fed to the wash water drain through inlet drain. This is continued for few minutes to condition the filter.
  - v) The valve 3 is closed and the valve 2 is opened back to put the filter in the normal working condition.

ii) **Loss of head and negative head:** - When water passes through the filter it has to overcome the frictional resistance. It therefore loses some of its head. The loss of head can easily be computed by knowing the water level in the filter and pressure of water in the outlet pipe. The difference between the two heads represents the loss of head in filter. In the beginning when the filter is cleaned the loss of head is very small almost 10cms. In addition, the loss of head then gradually goes on increasing. The loss of head can be measured by inserting pressure gauges as shown in fig. The difference of water level in two tubes indicates the loss of head.

- As clogging occurs when the loss of resistance offered by filter media exceeds the available head, there would be a negative head. This is developed due to the deposit of suspended matter.

[illegible]

- [illegible]
- [illegible]

5. **Trouble in operation:** – Following two troubles are generally encountered in operating rapid sand filter:
   i. Mud **ball:** – The mud ball are generally formed near the top of filter media. They may even be formed and distributed throughout the filter. The mud balls are formed or caused due to insufficient washing of sand grains. The optimum filter formed during filtration is not removed on from sand grains during backwashing. The mud balls interfere with the normal working of the filter and therefore rate is down. Hence to filtrate.
   ii. **Cracking of filter:** – the fine mud is contained in the top layer of filter media and this air leakage leads to form cracks in the filter. These cracks are prominent near wall provision.

   To remove these troubles, the following precautions are adopted:
      i. The mud balls are broken with the help of rakes or water such equipment.
      ii. The washing of filters is carried out with high velocity of water.
      iii. The damaged portion of filter media is replaced.
6. **Size of filtration:** – The chief advantage of rapid sand filter is due to size of filtration is very high. It is about 3000 to 4000 than those other the high rate of filtration results in considerable saving of space for the installation of filter.
7. **Efficiency of rapid sand filter:** – The efficiency of rapid sand filter is as follows:

i. Bacterial load : The rapid sand filters are less effective in the removal of b
bacterial load. It is reported that they remove about 90 to 98 percent of bacterial
organisms present in water.

ii. The rapid sand filters are highly efficient in colour removal and the intensity of
colour can be brought down to below 10 on cobalt scale.

iii. Turbidity : The rapid sand filters are extremely suitable in the removal of fine pa
particles. As water entering rapid sand filter is invariably given the treatment of
coagulation and sedimentation tank, it possesses low turbidity. The turbidity is
brought down to nearly to the permissible limits by rapid sand filters.

PRESSURE FILTERS :–These filters are more or less similar to the rapid sand filters generally
main concept with the following differences.

i) **Housing of the unit – pressure filter** :- The pressure filter does not indicate that the
water is pumped through the filter under a high pressure. Also, that is indicates that
filter is enclosed in steel and the water passes under pressure greater than atmospheric
pressure. The pressure can be developed by pumping and it may vary from 0.5 to 0.7
kg/cm².

ii) **Construction** : The pressure filters are closed cylindrical steel tanks and hence
wind, dust etc. can not enter or exhaust to the. The diameters of pressure filters vary from 1 meter
to 3.65m, and their heights or length can vary from 3.65m to 10.65m. But maximum size
permitted as per the regulations.

Fig 6.8

5. **Working:** The water to be filtered is pumped to the pressure filter by the pump. Then the flocculation takes place inside the pressure filter itself. In normal working condition, all valves are closed except those for raw water and filtered water. The water is admitted through inlet and after it is filtered, it is collected in the central drain and is sent to the filtered water storage tank.
6. **Cleaning:** The arrangement is made to wash the sand by upward flow.
   - The valves for raw water and filtered water are to be closed position and those for wash water and wash water drain are to open position during the operation of washing of filter.
   - The cleaning of pressure filters may be required once in 24 months.
   - The automatic pressure filters are available to conduct washing of filter in more automatically at predetermined interval of time or loss of head.
7. **Rate of filtration:** The rate of filtration of pressure filters is high as compare to that of rapid sand filters. It is about 5000 to 12000 liters/hour/m^2. Of this area is compared to that of 3000 to 4000 liters/hour/m^2 of rapid sand filters.
8. **Efficiency:** The pressure filters are found to be less efficient than the rapid sand filters in terms of bacterial loads, colour and turbidity.
9. **Suitability:** The pressure filters are more suitable for public water supply projects. Another use is intended for small water supply projects such as schools of the factory, industrial plants, private estates, swimming pools etc.

CHAPTER-4

DISTRIBUTION SYSTEM

GENERAL

After complete treatment of water, it becomes necessary to distribute it to consumers. Pipeline system, industries and public places by means of a network of distribution system. The distribution system consists of pipes of various sizes, valves, meters, pumps, pipe fittings reservoirs, hydrants, stand posts etc. The pipe lines carry the water to each and every street, valves control the flow of water through the pipes. Meters are provided to measure the quantity of water consumed by individuals as well as by the users. Hydrants are provided to connect fire engines for fire fighting requirements during fire. Service connections are done to connect the individual building with the water line passing through the streets. Pumps are provided to pump the water to the elevated service reservoirs or directly to the water mains to obtain the required pressure in the pipe lines.

The following are the requirements of a good distribution system:

(1) It should convey the treated water up to the consumers with the same degree of purity.

(2) The water should reach in every consumer with the required pressure head.

(3) Sufficient quantity of treated water should reach the domestic and industrial area.

(4) The distribution system should be economical and easy to maintain as per system.

(5) It should be able to transport sufficient quantity of water during emergency such as fire fighting.

(6) It should be suitable for the use during breakdown in repair (It may be water should reach that locality from other line).

(7) During repair work, it should not cause obstruction to the traffic.

(8) It should be safe against any future extension. No extension may be done which should not be interfere the water lines.

(9) The quantity of the water lost should be given and it should be less.

(10) It should be water tight and the water before that is leakage should be minimum as far as possible.

METHODS OF DISTRIBUTION

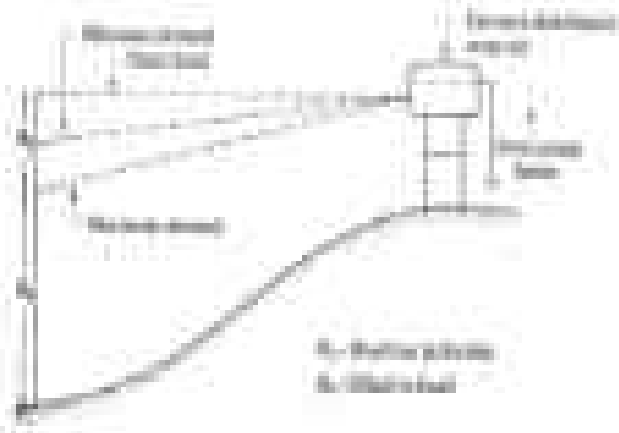
Depending upon the topography of the area/city, any one of the following three methods may be adopted for the distribution of water.

1. **Gravity system**—In this system the water is conveyed through pipes by gravity only. The gravity system is the most reliable methods of distribution. But it is useful only where the source of water supply is situated at a higher level than that of distribution area. Fig.7.1 shows the gravity system with hydraulic gradients during maximum and minimum demands. In case of a fire, the water pumps may be used to develop high pressure for fire fighting purpose.

Gravity system

Fig.7.1

2. **Gravity and pumping system combined**—In this system, the treated water is pumped and stored in an elevated distribution reservoir. The excess water during low consumption periods is also stored in reservoir and is supplied during the peak period. The pumps are generally worked at constant rate and the rate of pumping is so adjusted that the excess quantity of water stored in reservoir during low consumptions is nearly equal to the extra demands of water during peak period. Fig.7.2 shows the combined gravity and pumping system with hydraulic gradients during maximum and minimum demand.



Combined gravity and pumping systems

Fig 2

The method of distribution is usually applicable in most of the areas and it has the following advantages:

1. In case of fire, the water pumps can be used to develop high pressure at a fire demand and thereby the combined direct pump-house effort develop the total rate for the fire demand requirements.
2. In this method the pumps are generally worked in uniform rate. Hence, they suffer less wear and tear.

3. **Pumping system:** - In this system the water is directly pumped into the mains leading to the consumers. The number of pumps required in this system will depend on the demand of water. Fig. Shows the pumping system with hydraulic gradient during maximum and minimum demands.

SYSTEMS OF SUPPLY OF WATER: - Following are the two systems of supply of water which are based on the purposes of supply.

1. **Continuous system:** - In this system of supply, the water is supplied to the consumers for 24 hours of day. This is the most ideal system of supply and it should be adopted as far as possible.

The only disadvantage of this system is that considerable wastage of water occurs. If consumers do not prevent it by some how, the pressure of water in the mains is reduced. It is recommended way to avoid this defect of this system is to supply water through meters. Whether it is desirable to install meters or not it is

[illegible] quantity and hence, the diameter of small mains should be taken after careful consideration and calculations.

c) **Intermittent system :** In this system of supply, the water is supplied to the consumers for a few hours only. The total period is divided into few hours in the morning and few hours more period in the afternoon. For instance, the water may be supplied from 6 A.M. to 10 A.M. and then 4 P.M. to 6 P.M. The timing of supply of water may be changed to suit the convenience of consumers. This system of supply of water proves to be useful for the following two conditions :

1. The rainfall is [illegible].
2. The quantity of water available is not sufficient to meet with [illegible] demand for 24 hours.

Methods of laying of distribution of pipes : The following are the four main methods of laying distribution pipes.

1. Dead end method
2. Grid iron method
3. Circular method
4. Radial method

1) Dead end method : This method is also known as the Tree system of layout and a system of one supply main from which sub mains are taken. The sub mains again divided into several branch lines from which service connections are given to the consumers.

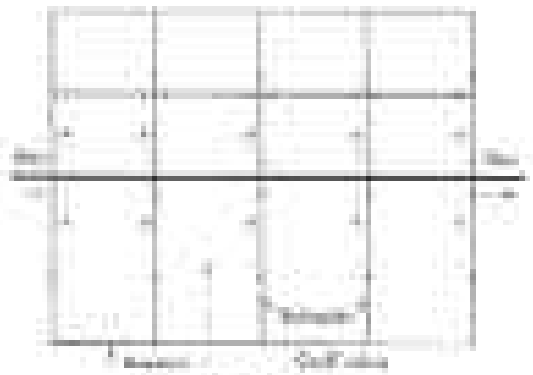
Advantages : The following are the advantages of the dead end method.

1. It is possible to control accurately the discharges and pressures at any point in the distribution system. The design calculations are simple and easy.
2. The overall length required for the system of layout are comparatively less in number.

Disadvantages : The following is the disadvantages of dead end method.

1. The dead ends in the [illegible] distribution area is difficult. It results into great inconvenience to the consumers of that area.

2) Grid iron method : This method is also known as the interlaced system or circulating system. The mains, sub mains and branches are interconnected with each other as shown in fig. (1).



Grid iron method of layout

Fig 7.3

Advantages: - The following are the advantages of grid iron method

i. In case of repairs a very small portion of the distribution area will be affected.

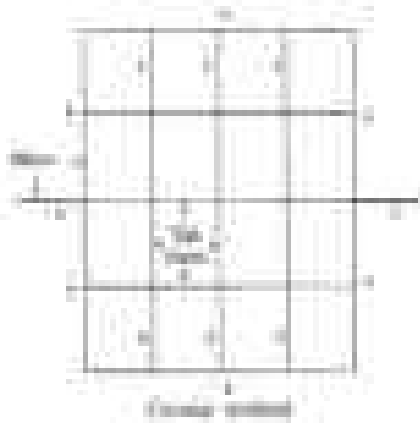
ii. There is the convenience of water and hence, it is very helpful for protection due to engineers.

Disadvantages: - The following are the disadvantages of grid iron method

i. The cost of laying water pipe is more.

ii. The grid iron system of layout requires longer lengths of pipes.

3) **Circular method** - This is also known as the ring system and a ring of mains is formed around the distribution area as shown in fig 7.4. The system possesses advantages and disadvantages as those of grid iron system.



Circular method

Fig 7.4

4) **Radial method** - This method of layout is just the reverse of the ring method. In this system, the water is taken from the source and pumped into the distribution reservoirs which are situated at centre of different zones as shown in fig 7.5. The water is then

supplied through radially laid pipes. The radial method of layout of water supply services and the calculations for design of various of types are simple. The radial method is most suitable for towns in a big scale laid out radially.

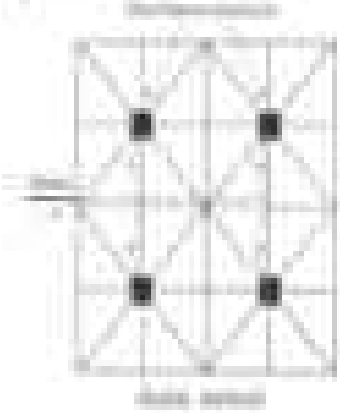


Fig 2.5

PRESSURE IN THE DISTRIBUTION SYSTEM

When the water comes in the distribution mains, the water should continuously at a low rate to maintain a supply, in emergency of outbreak, like as will be fire, breaks, water etc. All it becomes the consumer's tap. The water should be at the consumer's tap in the head at the elevation of the water main minus all the losses in the way. The effective head available at the various connections in a building is very important. It means the height up to which the water can rise in the building in the pipe on the available head only. This governs the height to which the water can rise in the building. The water will not reach the upper storeys (i.e. 2nd, 3rd etc.). To overcome this difficulty the required efficient head is maintained in the water pipe lines. The water should reach every and every consumer therefore it should reach at the uppermost storey. The pressure should be maintained in the distribution system depends upon the following factors.

(i) The height of highest building up to which water should reach without booster.
(ii) The distance of the building from the distribution reservoir.
(iii) The velocity of the consumed water. Higher pressure will be required to overcome the friction in the high loss of head in pipes.
(iv) The weight of water consumed per unit. Higher pressure will be required to overcome the friction in the high loss of head in pipes.
(v) The friction in the pipes.

APPURTENANCE IN DISTRIBUTION SYSTEM

Introduction :-

Water distribution system is essential for the safe and reliable supply of adequate quantity of water to meet the local requirements. Water is most of water is completely treated then also its needs to be distributed among the members of human. It means without such public places water may be used, therefore, may means this are needs is known as distribution system. This system is usually influenced by many different conditions such as, density, pressure, distribution, reservoir, various requirements etc.

This system must provide the treated water with some degree of purity, any chemical, economic, required pressure, head loss it should be economical and reliable also. It is efficient, distribution it is required that water should reach to every, in every consumer with required amount of flow. In every pressure in the pipes is required which should keep the water in every, at every demand. In considering the case of flow pressure head in order to maintain a normal distribution system this system is classified as follows :-

- Gravity System
- Pumping System
- Combined Gravity System & Pumping System

Some Important Fitting Items :-

In a network of distribution system a number of items are required, but mainly various valves, fire hydrants, and some meter pipes, a man hole in the distribution system and their are described as follows.

Various valves are provided to control the flow of water in pipeline at points to enhance or reduce or to prevent flow of water in opposite direction. Various are fitted according to the purpose of their function. Some different types of valves are given below :-

a. Sluice valves

b. Check Valves

c. Air valves.

a. Sluice valves:-

These are also known as gate valves and are mostly used in water work. This is cheap and offer less resistance to flow of water. Gate valves control the flow of water through pipes and fixed in the water lines bringing water from the source to a reservoir or a distribution main. As shown in fig 8.1

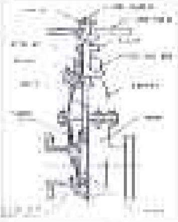


Fig 8.1

b. Check Valves:-

This is also known as reflux or non return valves. It automatically allows water to flow only in one direction and prevents it flowing in reverse direction. This type of valves are installed that in unidirectional flow of water. As shown in fig 8.2

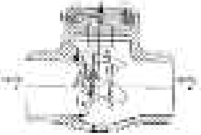


Fig 8.2

c. Air Valves:-

When water moves in pipe line some of the air carried along with it is collected at high points of the pipe. When the quantity of air increases it causes serious blockage to the flow of water therefore it is most essential to remove the accumulated air from the pipe line. Air valves are used for this purpose. As shown in fig 8.3

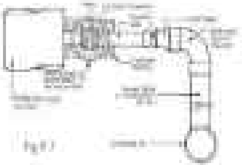


Fig 8.3

Fire Hydrant:-

Fire devices are used for tapping water from mains for fire extinguisher, house washing, flushing sewer lines etc. They are generally provided at all junction of road and at one or more spots along road.

Fig 5.1

Fire hydrants are of two types

Flush hydrants:- This type of hydrant are installed in an underground chamber to stop direction flush with the footpath. It is covered from top by a C.I cover. Waste drainage type is provided at it to enable to locate the position of hydrant even at night. As shown in fig 5.2

Stand hydrant:- This type of hydrant having a projected screw arrangement above the ground surface. Water hydrant have a long nozzle with screw and tail at the top to connect the fire delivery pipe. The pipe hydrant is connected to the main pipe through a branch pipe and it is controlled by means of a gate valve, as shown in fig 5.3

Fig 5.2

Water meters:-

Two types of devices are used to determine the quantity of water flowing through pipes. They are usually installed on account, the water consumer required to pay the water consumption given building etc. as shown in fig 5.4 Water meters are of two types:-

The positive displacement type

The velocity or inferential type.

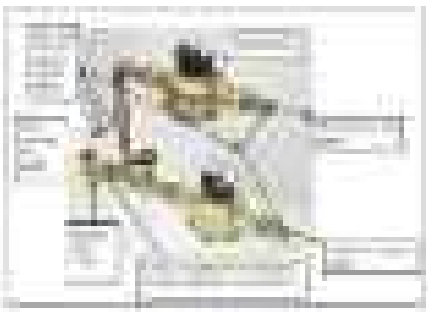


Fig 5.4

Uses:- For the normal use of water such as washing of vehicles, cooking, drinking purposes, bathrooms and other public conveniences is obtained by the hydrants.

CHAPTER-5

WATER PLUMBING IN BUILDINGS

Methods of water connection from water mains to building supply

[illegible]

General layout of plumbing arrangement for water supply in multi-storied building

[illegible]

Water supply fittings/fixtures, their purpose, fixing and pressure

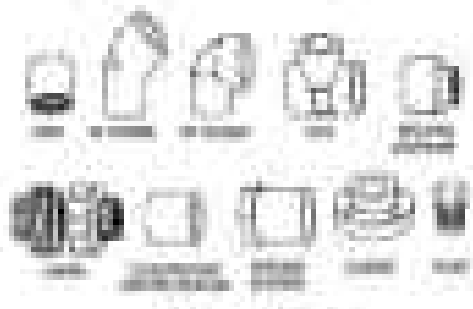
PIPES AND PIPE FITTINGS

[illegible]

For jointing, laying and fixing all soil waste, rain water and soil pipes of various types of fittings are required as shown in Fig 9.1

FIXING AND JOINTING PIPES AND ACCESSORIES

Water mains, soil waste and rain pipes can be embedded in the earth and floors or fixed to them. When they are embedded in floors different fixing devices are required that for wall to support and accommodate usually there are found in the number of walls. For fixing these special types of brackets are required. Fig shows one most common type of fixing bracket having aluminium plastic clips. These brackets do usually require the help of masonry drilling machine the wall and have the fixing to the face of the face of the concrete. When fixed, the pipe is now ready.



The jointing of pipes and accessories is done as follows. First a gasket or hemp rope is inserted in the socketed end of the pipe. The spigot end of the pipe is then inserted in the socket and pushed home. The joint is then caulked with a caulking iron and hammer. The caulking iron is a tool which is used to caulk the joint. The joint is then filled with molten lead and is caulked with a caulking iron and hammer. The joint is then filled with molten lead and is caulked with a caulking iron and hammer.

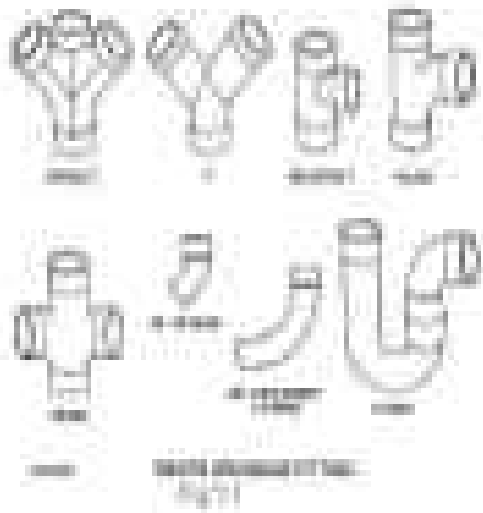
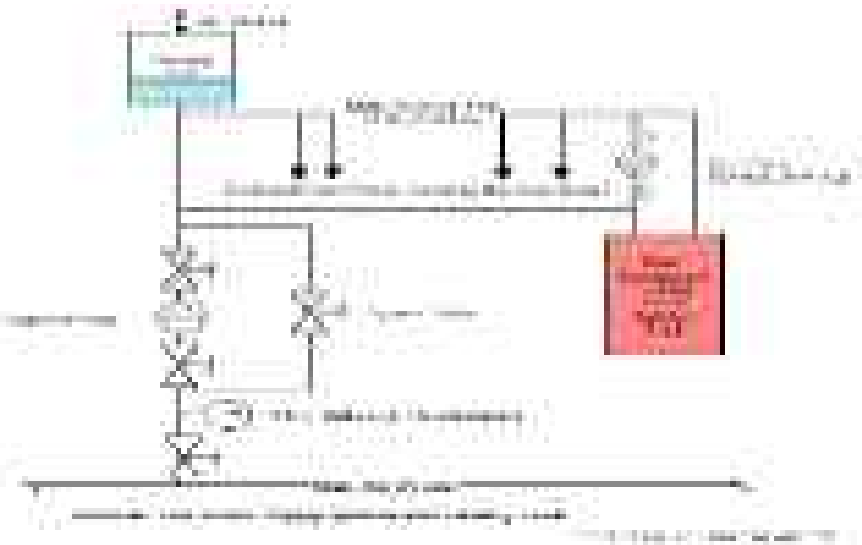


Fig 9.1



other fixing and passing all pipes and accessories have to be sealed for water tightness. This is done by providing lip where bolts/ accessories and bringing such accessories by nut.

HOT WATER SUPPLY –

The water services for the water supplies in residential and public buildings and in industrial enterprises are for their operational and daily maintenance to provide and must satisfy the requirements of the so-

Drinking Water Requisite. The quality of water intended for human use (wholesomeness) by the form of a colourless odorless and tasty. Hot water supplies may be either centralized or local (decentralized). In centralized systems, the heat is generated by heat and electric power plants and the so-

called outside heat or industrial enterprises, underground boilers and other sources is also used. The heat is transmitted to consumers through heating system pipelines. The treatment of hot water is carried out at the heat source that is delivered to the consuming points or right in the home. In case of distant heat source for warming the water is produced in the case when the water is used, or we should hot water supply may be a closed system in which the water is permanently a heat-

transfer medium (water or steam) from heating networks in water heaters that have been installed and further moving pipes to points within the home, or hot water supplies built on open systems, the consumer water is hot water directly from a heating network. This open water with the heat in public water heaters in homes is an unpressed heating points and receives the possibility of corrosion in local pipelines. However, the numerous hot

water is used in such systems requires large volumes of water and heat consumption.

[illegible] is required to prevent scaling and corrosion in the pipelines and the heat transfer equipment. The maximum water temperature in hot water systems is [illegible] °C, and the [illegible] [illegible] °C.

To prevent cooling of the water in hot water supply delivery pipelines, a constant circulation is maintained during low demand periods with the [illegible] help of the [illegible] circulation pipelines. [illegible]

[illegible]

[illegible] hot water accumulator tanks are used [illegible] to meet the hot water [illegible] during low demand periods [illegible] during high demand periods. [illegible]

[illegible]

[illegible] hot water supply systems [illegible]

[illegible] supply:

The use of of electricity for public and private supply of water and the wastewater treatment is an important factor in economic growth and sustainability in the United States. As the economy grows, all sectors increase their demand for fresh water and generate additional quantities of waste water that must be treated before discharge. [illegible] electricity requirements for the supply of fresh water and the treatment of wastewater across the U.S. economy. These [illegible] requirements are then used to project total electricity requirements [illegible] sectors of the economy. Sectors included in this analysis include:

• Public water supply systems

• Publicly owned wastewater treatment facilities and privately operated wastewater treatment facilities

• Self-supply of water to the domestic, commercial, industrial, mining, irrigation, livestock and thermal power generation sectors.

CHAPTER-4

SANITARY ENGINEERING

Introduction

Sanitation is a term which mainly concerns with proper management for the collection, treatment and disposal of all the waste water produced from different sources like bathroom, kitchen, lavatory, sewer work etc and for a basic environment that makes human life convenient is known as sanitary engineering. Proper sanitation is the most essential in every town or city even in every individual for a sound and safe community.

1. **Aims and Objectives:**
   - The following are the basic aims and object of sanitary engineering.
   - For the proper collection and disposal of waste water from individual houses, public, industries etc.
   - To prevent the accumulation of dispersed water.
   - It also aims at the safe disposal of used or sanitary water source after some primary treatment.

2. **Definition and terms related to sanitary engineering:**

Anti-siphon age pipe:

A pipe which is installed in the house drainage to prevent the water seal from breaking is known as anti-siphon age pipe. It maintains the ventilation and does not allow the siphonic action.

Siphon age:

Water seal of trap may break due to siphonic action and it is known as siphon age. It takes place when water is suddenly discharged from a fixture or pipe flows.

Vent Pipe:

The pipe which is meant for the purpose of ventilation is known as vent pipe.

Refuse:

It is meant to indicate what is left as worthless and for the study of sanitary engineering and it is divided in 3 categories.

- **Garbage:**

  It is dry refuse, mixture of paper, glass, bottle, plastic product etc.

- **Sewage:**

  It is the waste liquid mainly generated from latrines, urinals, bathroom etc.

  It is the combination of human sewage and storm water.

- **Fresh Sewage:**

  The sewage which has more quantity of animal or putrescible.

- **Septic Sewage:**

  The sewage which is undergoing the decomposition process.

Storm water:- It is used to indicate the total water of the locality.

Sullage:- It indicates the waste water from bathrooms, kitchens etc.

Trade:- The undesired products of the trade brought which the sewage is contaminated.

Sewerage:- The service system of collection, conveyance, treatment and disposal of sewage by means of sewerage system through sewers.

System of collection of sanitation:-

For the disposal of waste water collection is the primary step and basically the combination of a sewer or any a drain by following two methods. They are-

a. Conservancy system

b. Water carriage system

Conservancy System:-

It is a method, a use of pits or buckets for collecting night soil, i.e., refuse or material dropped into the system is still present. These systems are also called dry systems. In this system various types of refuses and excreta is taken into a chemical and disposed by different method or it is called **conservancy system**.

Drainage or duct which are called as the sanitary pipes to drain out the waste and sewers from where it is subsequently conducted to the point of disposal. All the non-combustible portions of the garbage are removed for filling of lower level areas or to cover the trench for future use. The combustible portions of the garbage are burnt and the charring from burnt and vegetables are then dried and then disposed of by burning in or the manufacture of biomass.

[illegible] human excreta is night soil is collected separately by human agency and also all the liquid and water liquid waste. Most common night soil they are brought into machine which are outside of the town and get burned, ashes is it [illegible] very good [illegible]

In [illegible] the slops and waste water can be [illegible] in small open drains up to the point of disposal where they are allowed to mix up with sewage in sewers which are [illegible]

Water Carriage System:-

With the development and attainment of civic regime [illegible] has felt to replace the conservancy system with the more improved type of system in which human agency should not be used for collection and conveyance of sewage. Water carry organization need is found as the simplest substitute for the collection and conveyance of sewage. So to the system more prior as important role. So it is called water carriage system. In this system all the refuse liquid and water liquid waste are mix up with large amount of water and then they are taken out of the city with planned sewage system, where they can be disposed after necessary treatment to [illegible] wastes.

Comparison between Conservancy System & Water Carriage System.

Sno.	Conservancy System	Water Carriage System
1.	Initial cost is low	Initial cost is very high
2.	Foul smell may found	There is no foul smell is occur.
3.	Sanitary is not maintained considerably	Sanitary is maintained considerably with [illegible]
4.	Storm water is carried to nearby surface drains because problem of pumping for storm water.	Sewage is treated before disposing off. It may or may not require pumping. It depends upon the topography of the town.
5.	This system is fully dependent upon human agency	No human agency is required in this system
6.	In this system the sewage is disposed without any treatment. So it may pollute the water courses or disposal area.	In this system sewage is treated upon required degree of treatment.

CHAPTER-7
QUANTITY OF SEWAGE

Introduction:

- The sewage collected from the municipal area consist of wastewater generated from the residences, commercial centers, recreational activities, institutions and industrial wastewater discharge into sewer network. Over the particular industries involved within the city limits.
- Before designing the sewer it is necessary to know the discharge i.e. quantity of sewage, which will flow in it after completion of the project.
- Accurate estimation of sewage discharge is necessary for hydraulic design of the sewers.
- Too much overestimation than reality will cause load to inadequate sewer size also commissioning of the scheme or the sewers may not remain adequate for the entire design period.
- Similarly, very high discharge assessment will lead to larger sewer size affecting economy of the sewerage scheme and the lower discharge actually flowing in the sewer may not meet the criteria of the self cleaning velocity and hence leading to deposition in the sewers.
- Actual measurement of the discharge is not possible if the sewers do not exist, and where the capacity of the existing sewers is inadequate and need to be increased, still actual present discharge measurement may not be accurate due to measurement overflow and leakages that might occurring in the existing sewers.
- Hence correct use designers some for some more future years engineering skills have to be used to accurately estimate the sewage discharge.

Sources of sanitary sewage

- Water supplied by some authority for domestic usages, after its use it is discharged as it is known as sewage.

- Water supplied to the various industries for various industrial processes by local authority. Some quantity of this water after use in different industrial applications is discharged as wastewater.
- The water supplied to various public places such as schools, cinema theatres, hotels, hospitals, and commercial complexes. Part of this water after domestic use joins the sewers as wastewater.
- Water drawn from wells by individuals or MCD domestic demands. Part of this water is discharged into sewers.
- The water drawn for various purposes by industries from individual water sources such as wells, lakes, rivers, etc. A portion of the water is consumed for industrial purposes in different industrial processes or used for public services within the industry premises/compounds. The wastewater is let into sewers.
- Infiltration of groundwater into sewers through faulty joints.
- Provision of rainwater in sewers during rainy season through faulty joints or cracks in sewers.

Dry weather flow:

- Dry weather flow is the flow that occurs in sewers or separate sewerage system in the time that occurs during dry seasons or continued rains.
- This flow indicates the flow of sanitary sewage. This depends upon the rate of water supply, type of area served, economic conditions of the people, weather conditions and infiltration of groundwater in the sewers. Normally dry weather flow is considered safe.

Evaluation of sewage discharge:

- Correct estimation of sewage discharge is necessary; otherwise, sewer may prove inadequate resulting in overflow of raw sewage into local drainage which may cause the system uneconomical and hydraulically ineffective.
- Various factors designing the sewerage system it is important to know the discharge quantity of the sewage which will flow in it after completion of the project and at the end of design period.

- Apart from assumed water supplied by water authority, few will be connected to wastewater. Following questions are considered while estimating the sewage quantity:

(1) Addition due to unaccounted private water supplies:

People using water supply from private wells, tube wells, etc., contribute to the wastewater generation more than the water supplied by municipal authority. Similarly, various industries utilize their own source of water. Part of this water, after desired use, is converted into wastewater and ultimately discharged into sewers. This quantity can be estimated by actual field observations.

(2) Addition due to infiltration:

This is additional quantity due to groundwater seepage in to sewers through faulty joints or cracks formed in the pipes. The quantity of the water depends upon the height of the water table above the sewer invert level. If water table is well below the sewer invert level, the infiltration can occur only after rain when water is moving down through soil. Quantity of the water entering in sewers depends upon the permeability of the ground soil and it is very difficult to estimate.

(3) Subtraction due to water losses:

The water loss, through leakage in water distribution system and house connections, does not reach sewerage and hence are taken as sewage.

(4) Subtraction due to water not entering the sewerage system:

Various amount of water is used for many purposes, which does not generate sewages, e.g. lawn, food items, water sprinkled over the roads, streets, lawns, and gardens, water consumed in industrial products, steam used in air coolers, etc.

The quantity of sewage

The net quantity of sewage production can be estimated by considering the additions and subtraction as discussed above over the accounted quantity of water supplied by water authority as follows:

Net quantity of sewage = (Accounted quantity of water supplied from the water works) +

(Addition due to unaccounted private water supplies) +

(Addition due to infiltration) +

(Subtraction due to water losses) +

(Subtraction due to water not entering the sewerage system)

(normally 12 to 36%) of accounted water supplied is considered as quantity of storage provided.

Variations in average flow:

- Variation occurs in the flow of average (not actual average daily) flow. Fluctuation in flow occurs from time to time and from season to season.
- The physical hourly variation of the average flow is shown in the figure. (1.1). If the flow is gauged over an hour, the peak flow will be quite pronounced. The peak will occur if the average flow at most long distance.
- The storage of the time required to collecting sufficient quantity of storage required to fill the stream and time required to the filling.
- The average flow in every hour, every day/week average is stored in it due to continuous increase in the water being carried by the stream flow.
- The daily to variations in the fluctuations in the storage flow and the lag period gives an increasing.
- The magnitude of variation in the storage quantity varies from place to place that it is very difficult to predict.
- For smaller assembly this variation will be more pronounced due to lower length and hence long before storage could in the main stream and the large distribution reservoir will be less.

Typical hourly variations in storage flow

Figure 11.1

For estimating design discharge following relation can be considered:

maximum daily flow = (Five times the annual average daily flow
(Representing seasonal variations)

maximum hourly flow = (1.5 times the maximum daily flow
(Accounting hourly variations)
= (Seven times the annual average daily flow

In the tributary area maximum peak hourly flow will decrease. For smaller population served (less than 10000) the peak factor can be 2.5 and as the population served increases its value reduces. For large cities it can be considered about 1.5 to 2.0. Therefore for useful assessment the peak flow can be considered as 1.5 times the annual average daily flow. In case the design of the treatment facility, the peak factor is considered as 1.5 times the annual average daily flow.

The minimum flow passing through sewers is also important to develop self cleansing velocity to avoid silting in sewers. This flow will generated in the sewers during late night hours. The effect of this flow is more pronounced in small sewers than the main sewers. Normally minimum flow is considered the minimum capacity as follows:

minimum daily flow = 2/3 Annual average daily flow

minimum hourly flow = (2/3 minimum daily flow
= (2/3 Annual average daily flow

The overall variation between the maximum and minimum flow is more in the domestic sewage than in the main sewers. This variation is due to the mixing of storm water in the sewers. It is 3 to 4 in case of main sewers.

Design Period:

The future period for which the provision is made in designing the capacities of the various components of the sewerage scheme is known as the design period. The design period depends upon the following:

- Life and difficulty in expansion
- Amount and availability of investment
- Anticipated rate of population growth, including shifts in commercial, industrial and commercial importance.
- Probable economic life of the scheme developed, and
- Life of the material and equipments

In this city design period can be considered for different components of sewerage scheme.

1. Trunk or main sewers	40 to 50 years
2. Treatment Units	15 to 20 years
3. Pumping plants	5 to 10 years

Design Discharge of sewage

The total quantity of sewage generated per day is commonly a product of three components namely the end of design period considering per capita sewage generation and appropriate peak factors. The per capita sewage generations can be considered as 70 to 80% of the per capita water supply but per day. The increase in population and result in increase in per capita water demand and hence, per capita production of sewage. This increase in water demand occurs due to increase in living standards, betterment in socio-cultural conditions, changes in habit of people, and commercial demand by public utilities.

Problem:

A city has a projected population of 140000 spread over area of 30 hectares. Find the design discharge for the separate sewer line by assuming rate of water supply of 270 LPCD. 80 percent of this total supply only 75 % reaches to sewer as transmission losses. Make reasonably assumptions wherever necessary.

Solution:

Given data:

M = 250 lit/capita/day

Sewage flow = 75% of water supply

$$= 0.75 \times 250$$

$$= 187.5 \text{ LPCD}$$

Total sewage generated $= \frac{\text{Population} \times \text{Sewage flow}}{\text{seconds}}$

$$= 0.41 \text{ lit/s}$$

$$= 0.41 \text{ m}^3/\text{s}$$

Assume peak factor = 2

Total design discharge = 0.8 m^3/s

Factors affecting the quantity of storm water:

The surface run-off resulting after precipitation contributes to the storm water. The quantity of storm water resulting in the sewers or drains at any large as compared with sanitary sewage. The factors affecting the quantity of storm water flow are as below:

- Area of the catchment
- Slope and shape of the catchment area
- Porosity of the soil
- Obstruction to the flow of water as trees, bushes, gardens, etc.,
- Initial state of catchment area with respect to moisture
- Intensity and duration of rainfall
- Atmospheric temperature and humidity
- Position and area of ponds present in the area.

Measurement of rainfall:

The rainfall intensity could be measured by using rain gauges and recording the amount of rain falling in unit time. The rainfall intensity is usually expressed in mm/hr or cm/hour. The rain gauges used can be manual recording type or automatic recording rain gauges.

Methods for estimation of quantity of storm water:

1. Rational Method
2. Empirical formulae method

In both the above methods, the quantity of storm water is considered as function of intensity of rainfall, coefficient of runoff and area of catchment.

Time of concentration:

- The period after which the entire catchment area will start contributing to the runoff is called as the time of concentration.
- The rainfall with duration lesser than the time of concentration will not produce maximum discharge.

- The runoff may not be maximum even when the duration of the rain is more than the time of concentration. This is because in such cases the intensity of rain reduces with the increase in its duration.
- The runoff will be maximum when the duration of rainfall is equal to the time of concentration and is called as critical rainfall duration. The time of concentration is equal to sum of inlet time and time of flow.
- Time of concentration = inlet time + time of flow in

Runoff from a given catchment:

Figure 11.2

Inlet Time

The time required for the rain to falling on the most remote point of the catchment area to flow across the ground surface along the natural drains or gutters up to point of entry is called inlet time. **Figure. The inlet time T_i can be estimated using relationships similar to Kirpich.** These coefficients will have different values for different catchments.

$T_i = 0.0883 L^{0.77} S^{-0.385}$

Where

T_i = Time of inlet, minutes

L = Length of overland flow to Kilometre from critical point to mouth of drain.

H = Land fall of level from the critical point to mouth of drain, metre

Time of travel:

The time required by the water to flow in the storm channel from its mouth to the point under consideration or the point of concentration is called as time of travel.

Time of Travel (t) = Length of drain / velocity in drain

Runoff Coefficient

The total precipitation falling on any area is disposed as percolation, evaporation, storage in pools or moves out with surface runoff. The runoff coefficient can be defined as a fraction, which is multiplied to the quantity of water rainfall to determine the quantity of rain water which will reach the sewers. The runoff coefficient depends upon the quantity of soil cover, vegetation and ground cover.

The overall runoff coefficient for the catchment area can be worked out as follows.

Overall runoff coefficient, $C = (A_1C_1 + A_2C_2 + \dots + A_nC_n) / (A_1 + A_2 + \dots + A_n)$

Where, $A_1, A_2 \dots$ [illegible] $C_1, C_2 \dots C_n$ are the coefficients of runoff respectively.

The typical runoff coefficients for the different ground cover is provided in the following table.

Type of Cover	Coefficient of runoff
Business areas	0.70 – 0.95
Apartment areas	0.50 – 0.70
Single family areas	0.30 – 0.50
Parks, Playgrounds, Lawns	0.20 – 0.35
Paved streets	0.85 – 0.90
Wooded or park areas	0.10 – 0.25

Rational Method:

Storm water quantity can be calculated by rational method as follow.

Storm water quantity, $Q = CIA / 360$

Where,

Q = Quantity of storm water in m^3/sec

C = Coefficient of runoff

I = Intensity of rainfall (mm/hour) for the duration equal to time of concentration, and

A = Drainage area in hectares

OR

$Q = 0.278CIA$

Where, Q is in m^3/sec, I is in mm/hour, and A is area in square kilometer.

Empirical Formula:

Empirical formulae are used for determination of runoff from very large area. Various empirical relationships are developed based on the past observations on specific site conditions existing a particular region. These empirical formulae can be used for prediction of run-off from that particular catchment.

(a) Dicken's Empirical formula

$$Q = C A^{3/4}$$

(b) Ryve's formula

$$Q = C A^{2/3}$$

(c) Inglis's formula

$$Q = \frac{C A^{3/2}}{\sqrt{A + 10.4}}$$

Where, Q = Peak run-off in cumecs per thousand hectare, A = Area in sq. km.

C = Empirical constant varying from 6 to 30.

Empirical formula for rainfall intensities:

The intensity of rainfall can be evaluated from the rainfall records of the area under consideration. The rainfall intensity may be taken from rainfall records of that area for which run-off values are to be designed.

In case where rainfall records are not available the intensity of rainfall is obtained by applying suitable empirical formula.

(a) Talbot's formula,

$$i = \frac{a}{t + b}$$

Where, i = intensity of rainfall in cm/hr.

t = duration of storm in minutes

a & b are constants.

According to Meteorological Department of India, the values of constants a and b are as follows:

- a = 10 and b = 15 for duration of storm 5 to 30 minutes.
- a = 40 and b = 20 for duration of storm 30 to 100 minutes.

(b) For localities where rainfall is frequent

$$i = \frac{25}{t + 10}$$

[illegible]

[illegible] formula is adopted for area having heavy and frequent rainfall. A given intensity of rainfall would cause more in [illegible] area.

(c) For storm sewer[illegible] area in [illegible] ha.

$$Q = \frac{CIA}{3.6}$$

(d) For storm sewering area in a town

(i) [illegible]

[illegible]

(e) Hawksley's formula

(i) [illegible] for storm sewering area in [illegible] ha

(ii) [illegible] for storm sewering area in [illegible]

Design of sewers:

[illegible] sewers are laid in deeper gradients falling towards the outfall point with circular pipe cross sections. Storm water drains are separately constructed as rainfall drains in suitable gradients, either rectangular or trapezoidal sections. Sewers are designed to carry the maximum quantity of sanitary sewage (Qsdf) to be produced from the area contributing to the particular sewer. Storm water drains are designed to carry the maximum storm runoff that is likely to be produced by the contributing catchment area from a rain of design frequency and of duration equal to the time of concentration.

Requirements of Design and Planning of Sewerage System:

The sewerage scheme is designed to provide safe, economical sewage disposal and efficiently from its houses to the point of treatment and disposal. Following aspects should be considered while designing the system.

- The service provided should be adequate in order to avoid overflow and possible health hazards.
- The constructional proper diameter of the sewer, correct combination of sewage discharge is considered.

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

Difference between Water Supply Pipes and Sewer Pipes:

Water Supply Pipe.	Sewer Pipe.
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Hydraulic Formulae for Determining Flow Velocities:

Various flow equations have been developed to open channels, except in the case of circular conduits and discharge free of pumping stations. Following formulae can be used for design of sewers.

(1) Manning's Formula

This is most commonly used for design of sewers. The velocity of flow through sewers can be determined using Manning's formula as below:

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

Where V = velocity of flow in the sewer, in m/s

R = Hydraulic mean depth of flow, in

$= \frac{A}{P}$

A = Cross sectional area of flow, m^2

P = Wetted perimeter, m

n = Rugosity coefficient, depends upon the type of the channel or face i.e. material and has between 0.011 and 0.015. For brick sewer it could be 0.017 and 0.01 for sewer having smooth.

S = Hydraulic gradient, equal to invert slope for uniform flows.

(2) Chezy's Formula:

$$V = C\sqrt{RS}$$

Where, C is **Chezy's constant and remaining terms are same as above equation.**

(3) Crimp and Burge's Formula:

$$V = K(R)^{x}(S)^{y}$$

(4) Hazen- Williams Formula:

$$V = 0.849\, C_H R^{0.63} S^{0.54}$$

The Hazen-**Williams coefficient C_H** varies with life of the pipe and it has high value when pipe is new and lower value for older pipes. For example for ACC new pipes it is 140 and the value recommended for design is 120, as the pipe interior may become rough with time. **The design values of C_H** for ACC pipes, Plastic pipes, CI pipes, and steel lined with cement are 120, 120, 100 and 120, respectively. Modified Hazen-**Williams's** equation is also used in practice.

3 Minimum Velocity: Self Cleaning Velocity

- The velocity that would just prevent the solids in sanitary sewer and storm water drains from deposited particles of a given size is called as self cleaning velocity.
- The minimum velocity should at least be any one size in a combination of deposition in the sewers.
- Otherwise, if such deposition takes place it will obstruct the flow causing further deposition and finally leading to the complete blocking of the sewers.

The minimum velocity or self cleansing velocity can be worked out as below:

$$V_s = \sqrt{\frac{8k}{f}(G_s - 1)d}$$

Where, V_s = minimum velocity where inorganic particle >0.06 mm and the organic particle >0.06 mm

f = Darcy Weisbach friction factor (for sewers = 0.03)

k = Specific gravity of sediments

g = gravity acceleration

d = diameter of grain, m

- Hence, for scouring the deposited grains in sewage (i.e., sand up to 1 mm diameter with specific gravity 2.65 and organic particles up to 1 mm diameter with specific gravity of 1.2), it is necessary that a minimum velocity of about 0.45 m/sec and an average velocity of about 0.9 m/sec should be developed in sewers.
- Hence, while designing the sewer and gradients of the sewers, they must be checked for the minimum velocity that is likely to generate at minimum discharge, i.e. about 1/10 of the average discharge.
- While designing the sewers the flow velocity at full depth is generally kept at about 0.9 m/sec or so. Storm sewers are generally designed for ½ to ¾ full, the velocity at **designed discharge** (i.e., ½ to ¾ full) would come to more than 1.5 m/sec. Thus, the minimum velocity generated in sewers will help in the following ways:

1) Adequate transportation of suspended solids.

(2) Keeping the water constantly stirred, and

(3) Preventing the sewage from decomposition by mixing a basic material (generally an alkaline soil) that gives

Maximum Velocity or Non-scouring Velocity:

- It is the velocity of the sewage, just sufficient due to the continuous presence of suspended solids present to scrape
- The velocity is proportional to higher velocity, the more will be tolerated by the pipe materials. The more velocity of the sewage will reduce the life span of the pipe and then carrying capacity
- A factor of safety is necessary to limit the maximum velocity that will be produced in sewer pipe at any time. This limiting or non-scouring velocity mainly depends upon the material of sewer.

Limiting or non-scouring velocity for different sewer material

Sewer Material	Limiting velocity, m/sec
Vitrified clay	0.75 to 1.5
Cast iron sewer	0.75 to 3.0
Concrete pipe	0.75 to 3.0
Metal work sewer	1.0 to 1.5
Brick masonry	0.75 to 1.5

- The problem of maintain of non-scouring velocity is serious in hilly areas where ground slope is very steep and this is overcome by constructing drop manholes at suitable places along the length of the sewer.

Size of sewers:

- The minimum size of a sewer depends upon the practical difficulties in the locality.
- Usually the sewers of 100 mm diameter are provided up to a maximum length of 9 meter or so
- Use check the length of sewer line provided about it meets a sense of minimum diameter (150 mm is allowed)

- [illegible]

[illegible]:

[illegible]

(a) [illegible]

(b) [illegible]

(c) [illegible]

(d) [illegible]

(e) [illegible]

$$[illegible] = [illegible]$$

(f) [illegible]

[illegible]:

[illegible]

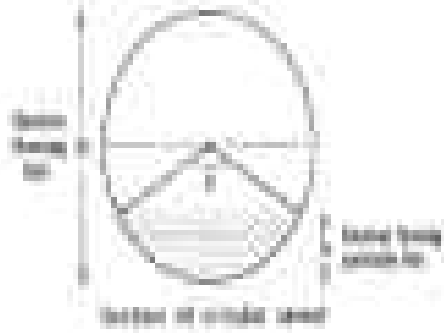


Figure 11.2

Symbol in Figure 11.2, D = diameter of circular sewer

d = depth of flow when sewer is flowing partially full

θ = angle subtended at the centre when flowing partially full

(1) When the sewer is flowing full, the hydraulic parameters will be as follows:

Cross sectional area: $A = \frac{\pi D^2}{4}$

Wetted perimeter: $P = \pi D$

Velocity of flow = v

Discharge $Q = Av = v$

(2) When the sewer is flowing partially full the hydraulic parameters will be as follows:

Depth expressed as ratio $= \frac{d}{D} = \frac{\text{depth}}{\text{diameter}}$

Trigonometrical depth $= \frac{1}{2}D = \frac{1}{2}D\cos\left(\frac{\theta}{2}\right)$

Cross sectional area when flowing partially full $= a$

$$a = \frac{\pi D^2}{4} - \frac{\theta}{360} - \frac{\pi D^2}{4} \times \frac{1}{2} \times \frac{D}{2} \sin\frac{\theta}{2}$$

$$= \frac{\pi D^2}{4} \times \frac{\theta}{360} - \frac{\sin\theta}{4}$$

Proportional area $= \frac{a}{A} = \frac{\text{partial area}}{\text{area}}$

p = partial wetted perimeter

$$= \frac{\pi D \theta}{360}$$

Proportionate wetted perimeter : $p/P = \frac{n}{360}$

n = hydraulic mean depth

θ = wetted perimeter

Proportionate hydraulic mean depth = proportionate area/ proportionate perimeter

$$\frac{\frac{1}{360}\pi d^2 \theta}{\frac{\pi d}{360}\theta}$$

$$= \frac{1}{360}\pi d^2 \frac{360}{\pi d}\frac{\theta}{\theta}$$

$$= \frac{d}{4}$$

According to Manning's formula

$$V = \frac{1}{n} R^{2/3} S^{1/2}$$

Where R = hydraulic mean depth

Proportionate velocity = (Proportionate hydraulic mean depth)$^{2/3}$

$$= \frac{1}{n}\left(\frac{d}{4}\right)^{2/3} S^{1/2}$$

Proportionate discharge = $q/Q = a_1v_1/Av$

(proportionate area) (proportionate velocity)

$$= \frac{\frac{\pi d^2}{4}\theta}{\frac{\pi d^2}{4}} \times \frac{\frac{1}{n}\left(\frac{d}{4}\right)^{2/3} S^{1/2}}{\frac{1}{n}\left(\frac{d}{4}\right)^{2/3} S^{1/2}}$$

Effect of Flow Variation on Velocities in a Sewer:

- The discharge flowing through sewers can be considered to have been in three flow zones with variations in depth of flow and flow variations of Hydraulic Mean Depth (d/4 & d/2).
- After (d/2) change in d/4 & d/2, there occurs changes in flow velocity, however it is proportional to d/4 & d/2 ($d^{2/3}$).
- Therefore, it is necessary to check the action for minimum velocity of about 0.61 m/sec in the dry weather minimum flow (1/3 of average flow) and flow velocity of about 0.9 to 1.2 m/sec should be developed in a sewer at its ranges flow.

- The velocity should give no chocked for limiting velocity i.e. non-silting velocity at the minimum discharge.
- For the ground contour, the velocity should be self-cleaning velocity at maximum discharge. The soil particle gradual for scours.
- For solid weighing ground, the condition of the shaping self-cleaning velocity at average flow may be considered. Whereas, in fully scour, sewers can be designed for self cleaning velocity at minimum discharge, but the design must be checked for non-scouring velocity at maximum discharge.

Problem 1: Calculate the velocity of flow in a sewer of diameter 1.2 m. The sewer is laid at a gradient of 1 in 400. Value of C in the discharge through this sewer when running full is assumed as 50 **in Manning's formula.**

Solution:

According to Manning's formula,

$$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where, n = 0.012

$$R = \frac{A}{P}$$

$$= \frac{\pi}{4}$$

Where d = diameter of pipe

$$= 1.2 \text{ m}$$

$$= 1200 \text{ mm}$$

$$n = 0.012$$

Discharge, $Q = [\frac{1}{n} R^{\frac{2}{3}}] \times [AS^{\frac{1}{2}}] \times 1000$

$$= 1.867 \text{ m}^3 \text{ per second}$$

$$Q = \frac{\pi \times 1200^2}{4 \times 1000} \times 1.867$$

$$= 2.11 \text{ m}^3 \text{ per second}$$

Problem 2: Calculate the velocity, discharge and Chezy's coefficient for a symmetrical sewer running full. The diameter of sewer is 100 mm and it is laid at a gradient of 1 in 100. Assume **n=0.013 in Manning's formula.**

Solution: According to Manning's formula

$$v = \frac{1}{n} R^{2/3} S^{1/2}$$

Where v = velocity of flow in m per second

n = [illegible]

m = hydraulic mean depth or mean [illegible]

= [illegible]

= 0.125 m

= 2.50 m

v = 1.66

Substituting $v = \frac{1}{0.025} \times \left(\frac{0.5}{2.50}\right)^{2/3} \times \left(\frac{1}{50}\right)^{1/2}$

= 1.111 m per second

Since $\frac{dQ}{dt}$ = dv

Where Q = discharge in m^3 per second

A = cross-sectional area of channel

$= \frac{\pi \times 0.5^2}{4}$

v = 1.111 m per second

Substituting $Q = \frac{\pi \times 0.5^2}{4} \times 1.111$

= 0.218 m^3 per second

According to Chezy's formula

$v = C\sqrt{m \times i}$

Where i = 1 in 50 m per second

m = 0.25 m

v = 1.66

Substituting $1.111 = C\sqrt{0.25 \times \left(\frac{1}{50}\right)}$

$C = 1.111 \times 14.14$

= 15.71

Problem 3 Determine the size of a circular sewer for a discharge of [illegible] litres per second running half full. Assume slope = 1 in [illegible] and n = [illegible] in **Manning's formula**.

Solution: As sewer is running half full.

Proportionate depth $= \frac{1}{2}\left(1 - \cos\frac{\alpha}{2}\right)$

[illegible]

[illegible]

[illegible]

[illegible]

Partial area [illegible]

[illegible]

Partial wetted perimeter

[illegible]

Hydraulic mean depth

[illegible]

Using Manning's formula

[illegible]

where v = velocity of flow in metres per second

[illegible]

Q = discharge in m³ per second

[illegible]

[illegible] per second

[illegible]

From the above value of Δ we see that

CHAPTER-8

Quality and Quantity of SEWERAGE SYSTEM

System of sewerage:

In India we use the three system of sewerage.

- Separate system
- Combined system
- Partially separate system

Separate system:-

In this system, the two sets of sewers are built, one for carrying sewage and the other for carrying storm water. The sewage is carried to the treatment plant and the storm water is directly discharged into the nearest water in the form of river or stream.

Advantages:-

1. The load on treatment unit becomes less.
2. The sewers are small in size.
3. The storm water can be discharged into natural streams without any treatment.
4. The natural water is not contaminated, polluted as the storm water is not fresh in nature.

Disadvantages:-

1. The cleaning of sewer is difficult as they are of small size.
2. The system requires two sets of sewer and hence it may prove to be costly.
3. The area for laying the storm water sewers calls for any period, for it may be clogged by garbage in that period.

Combined system:-

In this system, only one set of sewer is laid and it carries both, sewage and storm water. The sewage and storm water are carried to the sewage treatment plant.

Advantages:-

1. It is easy to clean a combined sewer as it is of large size.
2. The sewer is more suitable for the strength of sewage by dilution.
3. The system requires only one set of sewer and it is true, thus prove to be economical.

Disadvantages:-

1. During unprecedentedly heavy storms, the combined sewer may overflow and it may thus

[illegible]

2. The combined sewer, if not properly designed, gets easily silted.
3. The sewers are large in diameter.
4. The treatment plant is unnecessarily located with the combined volume of sewage and storm water, so very exceed the normal capacity of the plant.

Partially separate system:

The system consists of two sewer lines, one is of large diameter for carrying sewage and the other is of smaller diameter for carrying storm water only. When it rains, the storm water of the beginning is allowed to flow into the sewage through the large sewer line. When the rain continues for a long time then the storm water is diverted to the smaller sewer line to discharge in the river directly. Thus the load on the treatment plant is controlled and kept within the permissible capacity of the plant.

Advantages:

1. The entry of storm water avoiding silting in sewers.
2. The sewers are of reasonable size.
3. It reduces the load on the treatment plant and the excess storm water can be safely discharged in the river.
4. The storm water from individual houses may be safely disposed of in the large sewer.

Disadvantages:

1. The smaller sewer remains silted by dry season.
2. If the division of storm water is not done at proper time, then it may create unnecessary hydraulic load in the treatment plant and in the sewer.

Shapes of sewer:

Generally, the circular shaped sewers are adopted. The advantages of circular sewers are:

1. The perimeter of circular sewer is the least with respect to the sewer of other shape.
2. The inner surface is smooth hence the flow of sewage is uniform and there is no chance of deposition of suspended particle.
3. The circular sewer is easy to construct.

The following are the four circular sewers that are commonly adopted:

(1) Egg-Shaped sewer:

In this sewer, the lower surface is circular. The inner surface is divided into two portions:

As shown in figure 12.1, the upper portion resembles a basket handle and the lower portion is like a channel. the lug pin secures the carriage bolt through the lower portion and the lug receives the additional carriage bolt through the full section.

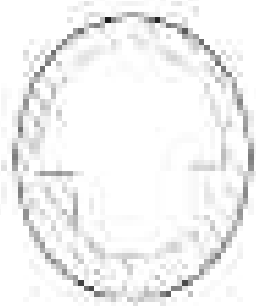


Figure 12.1

(1) Egg shaped section:

The egg shaped section construction for of two types such as normal egg shaped and inverted egg shaped. Both the sections are suitable for carrying both A and combined carriage

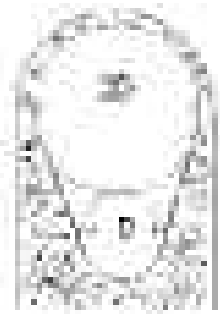


Figure 12.2

(2) Horse shoe section:

This type of tunnel is constructed for carrying heavy discharges. It is of horse tunnel and resembles a horse shoe, as shown in figure 12.3. The ratio of its height and maximum width is 0.84, the sewers are very easy.

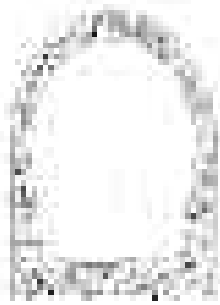


Figure 12.3

(4) Parabolic section:

As shown in Figure 12.4 the upper surface of the section is in the shape of a parabola and the invert is in the shape of an ellipse. This type of section is suitable for carrying small discharges.

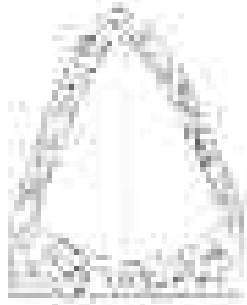


Figure 12.4

(5) Rectangular section:

This type of section can be easily constructed. These are suitable for large carriage to carry heavy discharges of sewage. The maintenance works are easy in this section.

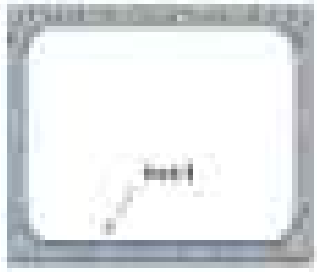


Figure 12.5

(f) U-shaped section:

As shown in figure 4.8, this type of pipes resembles the letter "U". These type of pipes is suitable for carrying high heavy discharges. The maintenance involves are easy in this section.

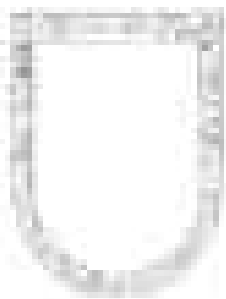


Figure 4.8

Important Factors Considered for Selecting Material for Pipes

Following factors should be considered before selecting material for manufacturing water pipes:

a. **Resistance to corrosion**

Ferrous carbon manufacturer like cast iron pipes such as SCH. This pipe in contact with moisture's can be corroded into sulphuric acid. The formation of rust can lead to the corrosion of water pipe. Hence, selection of corrosion resistance material is cause for long life of pipe.

b. **Resistance to abrasion**

Sewage contain considerable amount of suspended solids, part of which are inorganic solids such as sand or grit. These particles moving at high velocity can cause wear and tear of water pipe internally. This phenomena can reduce thickness of pipe and hydraulic efficiency of the sewer by making the material rougher.

c. **Strength and flexibility**

The water pipe should have sufficient strength to withstand the forces that are likely to come on them. Sewers are subjected to unavoidable external loads of backfill material and traffic load, if any. They are also subjected to internal pressure of sewage. So underground material must safely withstand bending, traffic and shrinkage of

pipe or reinforcement is essential. In addition, the material selected should be durable and should have sufficient resistance against external weathering agents to provide longer life to the pipe.

4. **Weight of the material**

The material selected for sewer should have less specific weight, should be light weight pipe light in weight. Use light weight pipes are easy for handling and transport.

5. **Impervious:**

To eliminate chances of sewage seepage from sewer to surrounding, the material selected for pipe should be impervious.

6. **Economy and cost**

Sewer should be less costly so make the sewerage scheme economical.

7. **Hydraulically efficient**

The sewer shall have smooth interior surface to have less frictional coefficient.

Materials for Sewers:

Following are the various materials which are used for sewers:

(1) **Asbestos Cement Sewers**

- These are manufactured from a mixture of asbestos fibres, silica and cement. Asbestos fibres are thoroughly mixed with cement to act as reinforcement.
- These pipes are available in sizes 15 to 100 cm internal diameter and length up to 4.0 m.
- The pipe and joints are in corrosion resistant.
- These pipes are used for external sewerage of 5 lakes. For example, sewerage of colonies, town units, multi storeyed buildings, for sewerage is provided and for sewerage of low cost settlements i.e., economical in construction and maintenance.

Advantages

- These pipes are light in weight and hence easy to carry and transport.
- Easy to cut and assembly without skilled labour.

Disadvantages

- These pipes are structurally not very strong.
- These are susceptible to corrosion by sulphuric acid. When calcium sulphate ($CaSO_4$) in presence of water, H_2SO_4 acid is formed leading to corrosion of pipe material.

(2) Plain Concrete Concrete or Reinforced Concrete Concrete pipes

- Plain concrete pipes (C.C.C. I pipes) are available up to 0.45 m diameter and reinforced concrete pipes are available up to 1.8 m diameter. Hand pipes can be used in place of precast pipes.
- Precast pipes are better in quality than the cast in situ pipes.
- The reinforcement in these pipes can be different such as single cage reinforced pipes used for internal pressure less than 0.5 m/ double cage reinforced pipes used for both internal and external pressure greater than 0.5 m
- Elliptical cage reinforced pipes used for as per diameter current subjected to internal pressure.
- The reinforced concrete pipes can be prepared either in the site or factory. In any case, the concrete pipe pipes should be of uniform shape, free from cracks, fractures or any other defects and they should give a clear ringing sound when struck with a hammer.
- The factory made products are known as the precast concrete pipes. The plain concrete pipes are generally available and only R.C.C. pipes concrete pipes are used.
- The reinforced R.C.C. pipes are constructed where it is more economical or where non-standard sections are required.

Advantages of concrete pipes

- Strong in tension as well as compression.
- Resistant to erosion and abrasion.
- They can be made of any desired strength.
- Easily available and can be in situ or precast pipes.
- Economical for medium and large sizes.

Disadvantages of concrete pipes

- The carrying capacity of the pipe reduces with time because of corrosion.
- The pipes are susceptible to corrosion by sewage containing salt and acid.

The concrete mixes can be protected internally by vitrified clay linings. With protection lining they are used for sewers of the branch and main sewers. Only high alumina cement concrete should be used when pipes are exposed to corrosive liquid like sewage.

(3) Vitrified Clay or Stoneware Pipes

These pipes are used for house connections as well as lateral sewers. The size of the pipe available is 3 cm to 40 cm internal diameter with length 0.9 m to 1.2 m. These pipes are rarely manufactured for diameter greater than 40 cm. These are joined by tarl and spigot flexible compression joints.

Advantages

- Resistant to corrosive action of the carrying polluted waste such as sewage.
- Interior surface is smooth and is hydraulically efficient.
- The pipes are highly impervious.
- Having low maintenance.
- These pipes are durable and economical for small diameters.

Disadvantages

- Heavy, brittle and bulky and hence difficult to transport.
- These pipes cannot be used as pressure pipes because they are weak in tension.
- These require large number of joints as the individual pipe length is small.

(4) Cast Iron Sewer:

- These pipes are stronger and capable to withstand greater tensile compressive as well as bending stresses. However, these are costly.
- Cast iron pipes are used for outfall sewers, rising mains of pumping stations and inverted siphons, where pipes are running under pressure.
- These are also suitable for sewers under heavy traffic load, such as sewers below railways and highways.
- They have 100% leak proof joints due to avoid groundwater contamination.
- They are also resistant to corrosion, usually lined from inside with cement concrete, and are protected by a...

(2) Steel Pipes

- [illegible] are used under the situations such as pressure mains and rising mains, water mains crossing, bridge crossing, temporary connections for pumping stations, laying pipes over hill supporting spans, hallway crossings, etc.
- They are withstand internal pressure, impact, backward thrusts etc much better than CI pipes.
- They are more ductile and can withstand more internal pressure rather.
- They are susceptible to corrosion and are not generally used for partially flowing sewers.

(3) Plastic sewers (PVC pipes)

- Plastic is another material used for sewer pipes. These are used for internal drainage works in houses.
- These are available in sizes 75 to 315 mm external diameters and used in drainage works.
- They offer smooth internal surface.
- The additional advantages they offer are resistant to corrosion, light weight of pipes, economical in laying, jointing and transportation, the pipe is weight and rigid, and have no [illegible] and transport of these pipes.

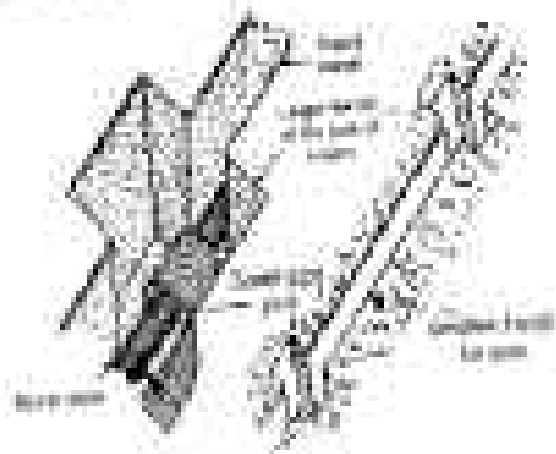
Laying of sewer

(1) Making sewer line of sewers:-

- The center lines of sewers are marked on the ground and roads from the plan showing from the known point or the central of the water processing operation.
- The setting out of work is done by means of sheet and theodolite and compass.
- After checking the center line during construction generally wooden pegs are driven at 30 meters interval and a line parallel to the center line at such a distance which remain undisturbed during excavation work.
- After checking the levels of the sewer pipe and their alignment temporary bench marks are established at 200–400 meters interval.
- On the center line of sewer the positions of the sewer appurtenances are also marked as per the plan which have been finalized.

(2) Excavation of trenches:-

- [illegible] the trench for laying the water mains after the completion of the trench cut, when the roads, streets are encountered, laying the service line is usually done along the sides of the streets or in the middle.
- Excavation after marking the layout of the water lines on the ground, the first step is the removal of pavement.
- The material of the pavement is carried from the trench and at the earliest convenient opportunity.
- After removing pavement the excavation of trench is carried. The excavation of trenches is done manually in India where as in some countries it is done by means of machinery.
- The width of trench depends on the diameter of the pipes and the depth of pipes line below the ground level.
- For large size pipes the trench width should be 1½ size more than the nominal diameter of the pipes for easiness in lowering and adjusting the pipes joint.
- The minimum trench width of 60 to 100 cm is necessary for convenient laying and jointing of pipes in very small size pipes.
- Sometimes in case of small diameter pipes the trench width is kept equal to or larger than the pipes' dia but at both the end trigger trench is excavated for jointing the pipes as shown in figure 12.7.



Excavation of trenches

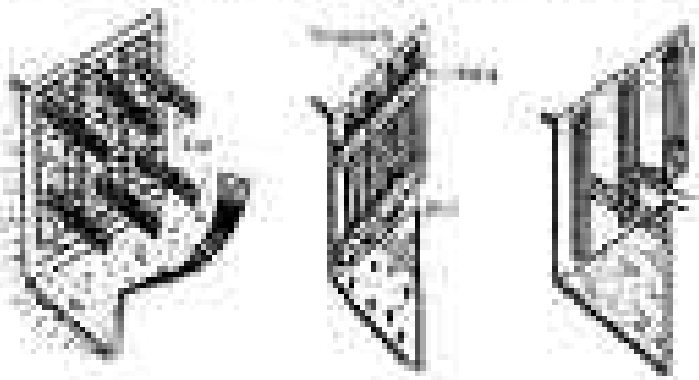
Figure 12.7

- [illegible] should be [illegible] to [illegible] the [illegible] of the [illegible] pipe from the bottom and in case the soil material is firm the trimming [illegible] should be [illegible] to semi-circular shape, to conform to the shape of the lower half of the outer side of the pipe.

(3) Shoring and timbering of trenches:-

- In case of hard soils and rocks, the sides of the excavated trench will not collapse and will remain in a [illegible] But in case of soft soil the trench sides require shoring and timbering to prevent their collapse till the sewer are laid and tested.
- The following are the [illegible] of the timbering or shoring.
  - (i) To prevent the collapse of the sides of the trenches.
  - (ii) To reduce the width of the trench at the top to the minimum possible.
  - (iii) To prevent the seepage of the ground water into the trench.
  - (iv) [illegible]

The various methods of shoring and timbering of trenches have shown in figure 12.7.



(a) Method of supporting trench wall in soft soil

(b) Method of supporting trench wall in moderate [illegible] firm soil

(c) Method of supporting trench wall in firm soil

Figure 12.8

When vertical faces are to be kept below the ground water table, the ground water enters the trenches during excavation and causes many difficulties. Therefore the dewatering

of capacities is completely under such circumstances. There are various methods for the removal of this water, but some common are

- **Draining method:**

  In this method the occurrence is noticed from the limited level and a drain opened so that whenever water enters the trench is automatically flows towards outlet due to gravity

- **Pumping method:**

  In this method during occurrence the amount of water entering the trench is pumped outside the trenches. In some cases the level of water which is depressed by drawing down wells using trenches and pumping the ground water.

  In some places provide pipe a bed below the water source has to collect the ground water entering in the trench. This provide pipe carries the seepage water to the water reservoir. At the lower construction water is stored from the lower level, the water entering the trench must be carried by the sewer constructed. But even if it is not possible to convey the seepage water through the sewer under construction, a sump is provided out.

(4) Laying of sewers:-

Trenches are excavated in the proper grade so that the sewage may flow in sewers due to gravitational flow only.

Sewer pipes may have to be laid under the following conditions

(a) **Extreme conditions**: When the pipe is constructed underground and it passes where the pipe is laid in a relatively narrow and shallow trench in such a manner that the top of the pipe is at an elevation below the natural ground surface.

(b) **Trench Conditions**: When the pipe is laid in a trench excavated for the purpose.

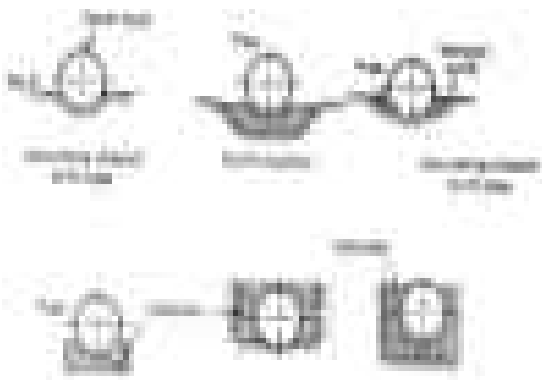
(c) **Negative projecting conditions**: when the pipe is laid in a relatively narrow and shallow trench in such a manner that the top of the pipe is at an elevation below the natural ground surface.

(d) **Open Conditions**: In this conditions the pipe is laid such that it projects entirely or partly above the ground surface.

When a sewer has to be laid in soft soil/ground where the trench shall be excavated deeper than what is ordinarily required. The extra trench shall be refilled by the

addition of cement grout or mud. In case of rocky land soil the trench bottom shall be filled in with cement concrete of appropriate grade.

The water pipes are not usually laid directly on the soil in the trenches. Bedding as mud lying the bottom of the trench is prepared to receive the pipe and then the load is distributed uniformly. It is also very preferred to provide concrete bedding to the trench before the cement pipes. Figure 12.9 shows various types of pipe beddings usually provided under various conditions.



Various types of pipe beddings

Figure 12.9

The correct line of servant and their grades are transferred from the ground to required right tool and bowing rod as shown in figure 12. It is by following method:

(i) From one station one driven into the ground is fixed over the pillars.

(ii) The second trench called right rod are fixed on the station opposing the servant.

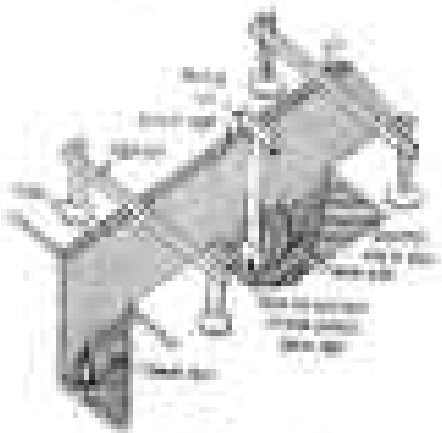
(iii) The correct line of servant is marked on the right rod and both are fixed on the right ends as the provision of centre line.

(iv) The top of the rod or right rod is fixed at same fixed distance from the centre from of the servant or line upon. This line passing the top of each fixed on the right ends also confirms to the grade of the servant.

(v) Right rods are usually fixed at 1 km centre to centre spacing and also at all junctions and change of gradient or alignment.

(vi) Next a strong twine is stretched between the nails fixed on sight rails. This line is parallel to the crown of the sewer and also lies in the vertical plane passing through the central line of the sewer.

(vii) Now with the help of boning rod using plumb bob the line and pegs in the sewer line is given as shown in figure 12.10.



Laying of sewer pipe

Figure 12.10

Jointing of sewer pipes:

Jointing of pipes can be done by the pipe-layers themselves by hand only, but in case of large size pipes, the operation is done by passing ropes around them and supporting through a sling.

Jointing of sewers :

i. **Stoneware pipes** – All the pipe joints shall be socketed with the spigot pushed to and caught the next joint and sufficiently deep to maintain the correct alignment of the pipe. The gasket shall be caulked tightly into such as so as to occupy more than a quarter of the socket depth. The gasket shall then be filled with a mixture of one part of cement and one part of clean fine sand mixed with just sufficient quantity of water to form a consistency of reasonably workable stiff paste. This shall be pressed round the pipe with a trowel forming an angle of 45° with the barrel of the pipe.

ii. **Concrete pipes** – The collars shall be placed symmetrically over the ends of the pipes and the annular space between the inside of the collar and the outside of the pipe shall be filled with cement mortar composed of one part cement and quantity of water to form a consistency of semi-dry workable stiff gasket and.

thoroughly cleaned with washing soda and then filled with cement mortar 1:2. The joints shall be finished off with a fillet sloping at 45° to the surface of the pipe. The finished joints shall be protected and cured for at least 24 hours. Any plastic, asbestos or cement mortar that may be squeezed in the pipe shall be removed to leave the inside of the pipe perfectly clean.

iii **Cast Iron pipes:** - The C.I. pipes shall be examined for true and level and the space left in the socket shall be filled in by pouring molten pig lead. This shall be done by using proper leading ring. One or two or more shall be provided around the lower end of the joint. The lead used shall be soft and of best quality.

(f) Hydraulic testing of sewer pipes:

Following two tests are generally done for testing the sewer pipes:

i **Water test:** - Each section of the sewer is tested for water tightness preferably between manholes. The sewer are tested after giving sufficient time for the joints to set for leakage. For this sewer pipe sections are tested between the manholes to ascertain under a test pressure of about 1.5 m water head. In carry this, the downstream end of the sewer is plugged and water is filled in the manhole at upper end. The depth of water in manhole is maintained at about 1.5 m. The sewer line is inspected and the joints which leak are repaired.

ii **Test for straightness of alignment:** - This can be tested by placing a mirror at one end of the sewer line and a lamp at the other end. If the pipe line is straight, full circle of light will be observed.

(g) Backfilling of trenches:

i After laying and removing defects in pipe line, the trenches are back filled with earth. Generally the excavated earth is used for back filling but before using it, the pebbles, stone pieces and lumps must be removed from it.

ii The back filling is not done at once, but the back filling is done by ramming the soil in layers, using mallet for proper consolidation. When the height of the back filled material will reach 30 cm above the crown of the pipe, the back filling is stopped for a week for making it.

iii) ...after a week, again the back filling is carried in layers and the trench is filled to ex... stores the gravel to it. During the course of time bank filled soil gets compacted and this filled soil comes to the ground level.

iii) The back filling is not done immediately after construction of the sewer lines. It is done after 7 days for pucca pipes and after 15 days in case of cast in situ after casting the sewer. Jumping should be done carefully when doing it near the crown of the sewer.

(7) Treatment of sewers :-

The sewers are to be properly and satisfactorily maintained for the following reasons:

i) **Continuous flow:** The outflow of sewage should remain in contact with fresh air; otherwise the foul will be formed.

ii) **Disposal of sewer gases:** The decomposition of sewage inside the sewer develops gases which are known as the sewer gases. These gases are harmful in many ways and hence they should be carefully disposed off to the atmosphere. The sewer gases include ammonia, carbon monoxide, carbon dioxide, methane, nitrogen etc. The gases like methane are highly explosive and if sewer is not properly ventilated, the methane which may be thrown off (evolved) the gases being lighter in weight have a tendency to move upwards. They also exert pressure on the internal face of sewage and cause an explosion when they accumulate into atmosphere.

Methods of ventilation, following are methods are adopted for the ventilation of sewers:

i) **Ventilation with chemicals:** – In this method, the chemicals are placed in the manholes/sewers. These chemicals react with the sewer gases and make them harmless. As this method is costly, it is rarely adopted.

ii) **Ventilation with gratings:** – In this method manholes/sewers are provided with gratings or openings through which sewer gases escapes. This is a simple method, but it causes air pollution and hence it is adopted for residual places where air pollution does not cause public nuisance. The other disadvantage of this method is that a person would also inhale foul air, in case of the sewer.

(c) **Proper construction of sewers:** - The sewer should be laid in such a position that self cleansing velocity is developed and the sewage will have no chance of resting in the pipe for a longer period.

(d) **Proper design of sewer:** - The sewers are designed in such a way that it never runs full full and the remaining top space is kept vail for the accumulation of sewer gases. The proper design of sewer requires enough ventilation of sewers.

(e) **Proper house drainage system:** - The house sewers are ventilated independently by suitable provision of ventilating shafts or columns. The sewer gases are carried to these columns and they are allowed to escape from above the height of the building.

(f) **Ventilating columns or shafts:** - The ventilating columns or shafts are formed by joining cast iron or steel pipes. They are placed at a distance of about 50 m or 100 m along the sewer line. A frictionless bend is provided at the bottom end of shaft to keep it in vertical position. A cowl is provided at the top end of shaft to allow the escape of sewer gases.

Figure 12.11 shows a typical vertical ventilating shaft for the ventilation of sewer.

Ventilating Column

Figure 12.11

[illegible] should be kept in mind when the method of ventilation of sewers is adopted:

(a) The internal diameter of the ventilating column should be preferably not less than [illegible] the diameter of the sewer it is [illegible] and not [illegible]

(iv) The joints of pipes forming the ventilating column should be made airtight. If the joints are not airtight, there will be leakage of sewer gases and it will result in unpleasant odours causing nuisance in the surrounding area.

(vi) The diameter of ventilating columns should be such that they should contribute for the proper purpose of the city. The lack of ventilation causes improper circulation of air.

(vii) The top of ventilating column should be covered with wire mesh or cowl so as to prevent the birds from building their nests at the top of ventilating columns.

(viii) The ventilating columns should be carried higher than the height of nearby structures.

(f) Cleaning and maintenance of sewers:

The sewers should be properly cleaned and maintained in good working condition. The sewers which are laid and buried into the ground should not be forgotten as they are also liable to corrosion, deterioration and so on etc.

Causes: There are three important causes which make it necessary to clean the sewers

i) Blockage of sewers: - The sewers are sometimes blocked after being laid under the ground. Several factors may contribute to the blockage of sewers. Bad improper constructing work, foundations, accumulation of unwanted loads, impact due to vibrations etc.

ii) Clogging: - The clogging mainly occurs in sewer of small size as it is not possible for a man or sewer rats such sewer and clean them. The clogging may be due to waste building materials, deposition of sand and grit etc. Clogging is predominant in common but as the slopes at which soft cleaning velocity are not adequate.

iii) Others: - The organic matter present in sewers decomposes and gives rise unpleasant odour.

Methods:

In following are the most commonly adopted the methods which are employed for the cleaning and maintenance of sewers.

(1) Cleaning and flushing

(2) Cleaning of catch pits

(3) Inspection

(4) Provision of repairs.

(5) Proper construction

(3) Cleaning and Packing: -

- The cleaning of large corners is done manually. The root canal is first enlarged with [illegible] and scraps the sides of dentin by hand. The cleaned material is removed through [illegible].
- The cleaning of small corners is effected by flushing. For this purpose, the [illegible] flushing tube are sometimes modified as the canal size.

When flushing is inadequate to remove obstructions in the canal, the following methods are employed to make the canal clean and unobstructed:

(a) **Flexible rod** :- A flexible rod (steel, brass or bought) is taken and inserted into the canal. It is then pushed back and forth. The movement of rod dislocates the obstructions and it becomes easy to remove them by flushing.

(b) **Mechanical tools** :- In this method, special cleaning tools are attached to the brass portion of the rod and the cleaning of canal is done mechanically by moving the rod backward and forward. The tools may be double-ended cotton, donut brush, nylon brush etc.

(c) **Tie of pills** :- This is an interesting method of cleaning the canal. In this method, the small pills of both shape of wood or [illegible] tissue or cotton covered with cotton are used. A small pill is put in the cavity above the obstruction. The pill floats in the syringe and enters a canal near the obstruction, it is caught there and the syringe starts collecting method is. When sufficient head is developed the accumulated syringe removes the obstruction and the pill is caught in the next moment. Now a pill is taken larger diameter than the previous one is taken and the process is repeated until a pill having diameter about [illegible] mm less than that of apical portion reached. Extra care needed in this method.

(3) Cleaning of catch pin:

- The catch pin used to collect stone water are cleaned after every stone. The catch pin contain debris, old, and etc. and every the water is removed and pin is likely to give rise to the growth of microorganisms.
- The old and grease traps are also periodically cleaned to avoid the nuisance due to unpleasant odours.

(3) Inspection:

- [illegible]
- [illegible]
- [illegible]

(4) Periodical repairs:

- [illegible]
- [illegible]
- [illegible]
- [illegible]

(5) Proper connection:

- [illegible]

CHAPTER-9
SEWER APPURTENANCES

Definition:-

The structures, which are constructed at suitable intervals along the sewerage system to help in efficient operation and maintenance, are called as sewer appurtenances. These include

1. Manholes
2. Drop manholes
3. Lamp holes
4. Chambers
5. Street inlets called Gullies.
6. Grit chambers
7. Flushing tanks
8. Inverted Siphons & Outfall
9. Inverted Siphons.
10. Storm Regulators

1) Manholes:-

- The manholes are necessary as IS:C.C. chamber constructed at suitable intervals along the sewer lines, for providing access into them. Thus, the manholes helps in inspection, cleaning and maintenance of sewers.
- These are provided at every bend, junction, change of gradient or change of diameter of the sewers.
- The access line between the two manholes is laid straight in the most gradient.
- For straight sewer lines manholes are provided at regular intervals depending upon diameter of the sewer. The spacing of manholes is recommended as IS:1742-1960
- For sewer up to 0.3 m diameter or sewers which cannot be entered for cleaning or inspection the maximum spacing between the manholes are recommended as 30 m, and 60m spacing for sewer greater than 2.0 m diameter (IS:0.5.1).
- A spacing allowance of 300 m per 1 m diameter of sewer as a general rule in case of very large sewers (CPHEEO, 1993). The maximum dimensions required for the manholes are given in table 8.2 in IS:0.5.0. 1976).

- The minimum width of the manhole should not be less than internal diameter of the cover plus 150 mm resulting in such the sides.

Spacing of Manholes

Pipe Diameter	Spacing
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

The minimum internal dimensions for manhole chambers:

Depth of sewer	Internal dimensions
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

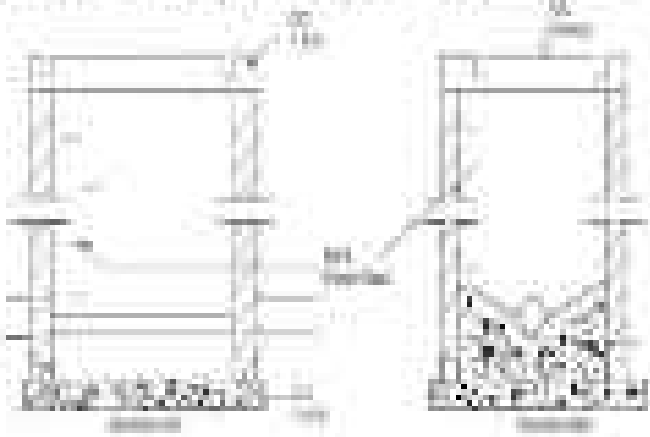
Classification of manhole:

Depending upon the depth the manholes can be classified as

(a) Shallow Manholes, (b) Normal Manholes, and (c) Deep Manholes

a) **Shallow Manholes**

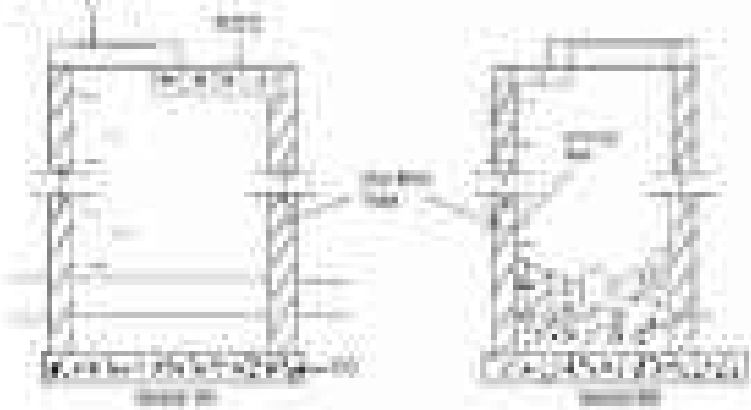
- These are 0.7 to 0.9 m depth, commonly at the start of the branch sewers or at a place not subjected to heavy traffic conditions.
- These are provided with light cover or iron and cement concrete pavement.



Shallow Manhole

Figure 13.1

b) Normal Manhole



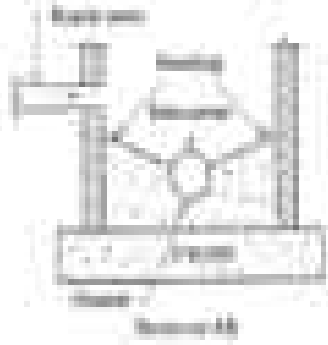
Rectangular Manhole for depth 0.9 m to 2.5 m

Figure 13.2

c) Deep Manhole

Deep manhole

Figure 13.3



[illegible]

[illegible]

Figure 13.1

Component parts

A typical manhole consists of the following components

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

Access shaft – The upper portion of a deep manhole is known as an access shaft and for rectangular manholes its minimum size should be about 750 mm x 600 mm. For circular manholes the minimum diameter should be about 600 mm to 750 mm. Its depth depends on the depth of manhole and the required for working chamber.

Base or Invert – The bottom of manhole is constructed of concrete concrete or brick paving. A semi-concrete or U-shaped [illegible] channel is constructed and the sides are made in slope towards it. It is known as the benching and it facilitates the entry of sewage into the main channel. If sewers enter at the same level in the bottom of manhole, the channels connected with each other will form a continuation.

Cover with Frame – The manhole is provided with cover and frame at its top. The cover and frame both are of cast iron. The depth of frame is about 200 mm to 300 mm and its base is about 100 mm wide. It is firmly embedded in the pavement and the cover rests in the groove which is kept inside the frame.

The weight of cover and frame varies from 40 kg to 270 kg. The light type is adopted to carry light traffic and the heavy type is adopted to carry heavy traffic.

The shape of manhole cover may be rectangular or circular, the latter being very common. The size of the cover is about 600 mm x 450 mm, and of the latter, it is about 600 mm to 900 mm diameter. The circular covers are stronger than rectangular ones and have the advantage that the cover cannot drop into the manhole.

The top surface of manhole covers is made rough by suitable designs. The smooth surface is objectionable as it is slippery.

The top of manhole covers should be properly adjusted so as not to be the road surface. They should not form a source of inconvenience to the traffic using road.

Steps or ladder:

In order to make the entry and exit of man easy, the steps are provided in the manhole. The steps are made of cast-iron and they are placed staggered at a horizontal centre to centre distance of about 250 mm and at a vertical centre to centre distance of about 300 mm.

If depth of manhole is large, it is desirable to provide a ladder instead of steps. The ladder or steps should start from about 450 mm from ground or road level and should be continued up to about 300 mm (height from bottom level of manhole).

Walls: The walls of a manhole may be made of brick work in cement or cement concrete. The brick walls are very common and the minimum thickness of wall should be 230 mm.

Working chamber: The lower portion of a deep manhole is known as working chamber and it provides a working space to carry out cleaning and inspection of sewer line. The minimum size of rectangular working chamber should be about 900 mm x 1200 mm and that of circular working chamber should be about 1200 mm diameter. The height of the working chamber should preferably be not less than 1800 mm or so.

Other types of Manholes:

Straight-Through Manhole:

- This is the simplest type of manhole, which is built on a straight run of sewer with no side junctions.
- Where there is change in the size of sewer, the soffit or crown level of the two sewers should be the same, except where special conditions make it undesirable.

Junction Modules:

- The type-II modules are connected at every junction of two or more servers and at the central portion of the servers, with curved portion situated in this modules.
- The type-II modules can be communicated with the ships other than navigation to load the cargo representation and action in economy.
- The width of the smaller servers at junction should not be more than that of the larger servers.
- The gradient of the smaller servers may be made steeper than the previous modules to reduce the difference of levels at the point of junction to a convenient amount.

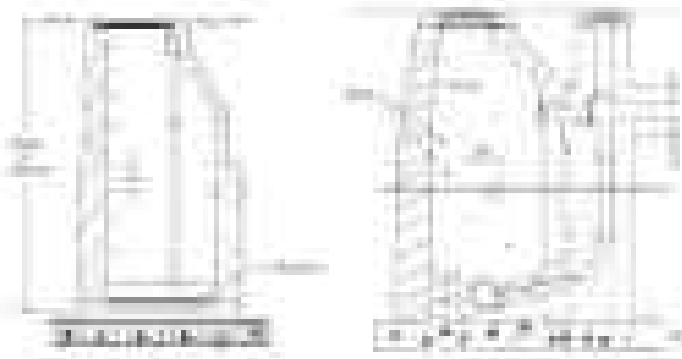
Side servers Modules:

- In large servers where it is difficult to obtain direct communication to the servers from the ground level due to obstructions such as other pipe lines like water, gas, etc., the access shaft should be constructed in the vicinity of the servers to provide access to the manholes chambers by a lateral passage.
- The floor of the side entrance passage which should fall at about 1 in 10 towards the servers should be above the chamber wall from that the soffit level of the servers.
- In large servers necessary steps or a ladder (with safety chain or manhole handrail) should be provided to reach the benching from the side entrance above the soffit.

Drop Modules:

- When a sewer connects with another sewer whose the difference in level between the invert of the both sewers and water line in the main sewer at maximum discharge is greater than 1 m, a manhole must be built either in the vertical or nearly vertical drop pipe from higher sewer to the lower one (Figure 11.2).
- The drop manhole is also required in the large sewer line in flowing ground, when drop more than 1m is required to control the gradient and to catch the maximum excavation i.e., from existing ground.
- The drop pipe is connected to the shaft and the sewer is connected to the bottom of the shaft, inside the shaft.
- If the drop pipe is outside the shaft, a continuation of the sewer should be built through the shaft wall so that a working and inspection way provided with half round flange (Figure 11.3).

- [illegible]



[illegible]

[illegible]

Flushing Manholes:

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

(2) Lamp hole –

Definition: - [illegible]

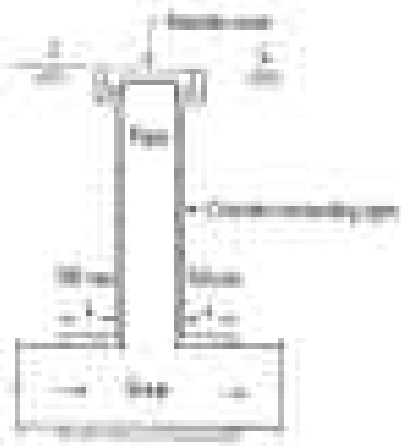
Description: – The lamp hole consists of vertical cylindrical pipe of bricks or concrete rings of the sewer line through a manhole as shown in figure 11.6. The pipes are connected by channel to make them visible at the ground level. The manhole cover with frame is provided to make up the load of traffic.

Types: – A lamp hole is installed in a sewer length to achieve the following three types:

- Inspection: The lamp hole useful for ascertaining the sewer length between adjacent manholes. An electric lamp is inserted in the lamp hole and the light of lamp is observed from the manholes.
- Flushing: Under some circumstances the lamp hole may be also used as the flushing chamber.
- Ventilation: If the cover at the top of lamp hole is perforated, the ventilation of sewer is achieved.

Location: – Following are the places where the lamp holes are to be located:

- If construction of a manhole is difficult, a lamp hole may be constructed in its place.
- A lamp hole proves to be economical when change in direction or gradient is to be made between two adjacent and closely spaced manholes.
- When the sewer length is straight for a considerable distance beyond the maximum horizontal visibility, the provision of a lamp hole is advisable.



Lamp Hole

Figure 11.6

(3) Clean-out:

- It is a pipe which is connected to the underground sewer. The other end of the clean-out pipe is brought up to ground level and a cover is placed at ground level (Figure 11.1).
- A clean-out is generally provided at the upper end of lateral sewer in place of manhole.
- During blockage of pipe, the cover is taken out and water is forced through the clean-out pipe to lateral sewer to remove obstacles in the sewer line.
- For large obstacles, flexible rod may be inserted through the clean-out pipe and normal forward and backward is done to remove such obstacle.

[illegible]

Figure [illegible]

(4) Inspection called Gullie:

Definition: An inlet is an opening through which storm water and surface runoff flowing along the streets are admitted conveyed to the storm water drain or conveyed using by means of pipes.

Location: The inlets are located or placed by the side of road at a distance of [illegible] m or so. The inlets are so located that every water is collected in a short period and there is no flooding or accumulation of huge quantity of water water on the road.

Types: These are classified in three major groups viz. curb inlets, gutter inlets, and combined inlets

Curb Inlet :-

- These are vertical opening in the road side through which storm water flow enters the storm water drains. These are preferred where heavy traffic is anticipated.

Grate Inlet :-

- These are transverse openings in the gutter which is covered by one or more grating through which storm water is admitted

Combined Inlet:- -

- In this, the curb and gutter inlet both are provided as a single unit. The gutter inlet is normally placed right in front of the curb inlet.

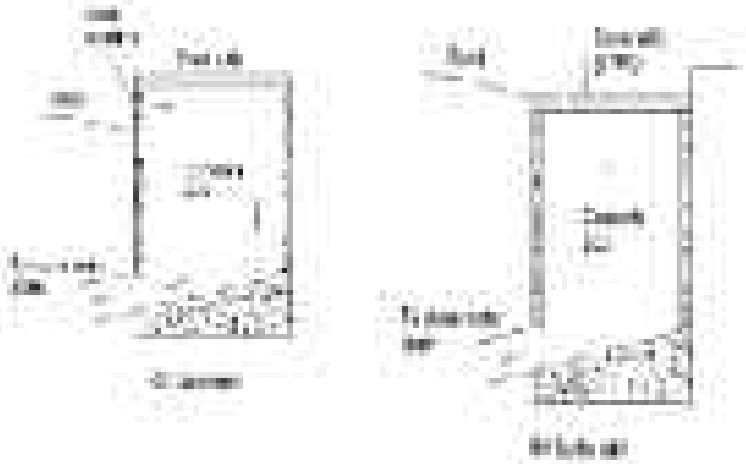


Figure 13.3

(7) Catch basins or catch pit:-

- Catch basins are provided to trap the sand, debris present in the storm water into the sewers.
- However, they are a discontinued because of the nuisance due to mosquito breeding.

- In the bottom of the basin space is provided for the accumulation of separation.
- The heated cover is provided at the top of the basin to adsorb raw water into the basin.

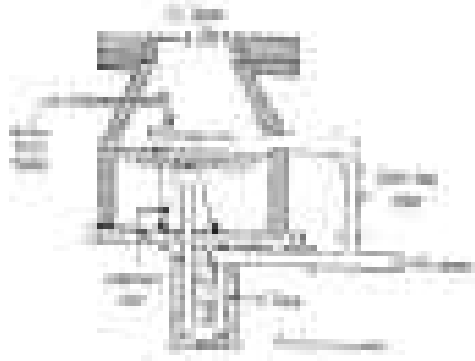
A faucet is provided to prevent escape of serum gas.

Figure (3)

- [illegible] the sewer, hence provides a temporary storage of wastewater contained in [illegible] Various [illegible] periodical cleaning. Otherwise the organics material decomposes and gives out foul smell.

(f) Flushing Tanks:

- When the gradients of the sewers are flat and the velocity of wastage is very low, the suspended matter of wastage start settling in the bed of sewer and causes clogging of sewer lines.
- To such places where low self cleansing velocity is met or unsuitable, flushing tanks are provided to flush the sewers.
- These tanks are usually provided at the beginning points of the sewers and may be either automatic or manual in their functioning. Automatic flushing tanks are more commonly used.
- An automatic operated flushing arrangement makes use of wastage or build up in the sewer by plugging the outlet and control works of the sewers. When the flushing tank is filled up to its [illegible] by [illegible] the counter plug is drawn out, all the water rushes towards the sewer and flushes the sewer.
- In automatic flushing tank the water is automatically released from the tank at regulated intervals which can be adjusted by the supply pipe tap and flushes the sewer.
- An automatic flushing tank is shown in figure (3). It consists of a masonry or concrete chamber fitted with a trap for filling the tank with water. A U-cycle with a relief cap at its one end connects the chamber with sewer. When the water level increases in the chamber, it also increases in the bell cup. As soon as it reaches a certain level, siphonic action takes place and the whole water of the chamber rushes in the sewer pipe and flushes it.
- The capacity of flush tanks is usually 900 - 400 litres and it is adjusted to reach a flush as it would occur in three to five days depending on the quantity of dry sewage in the sewer and size of sewer.



Automatic Flushing Tank

Figure 12.10

(7) Grease and oil trap:

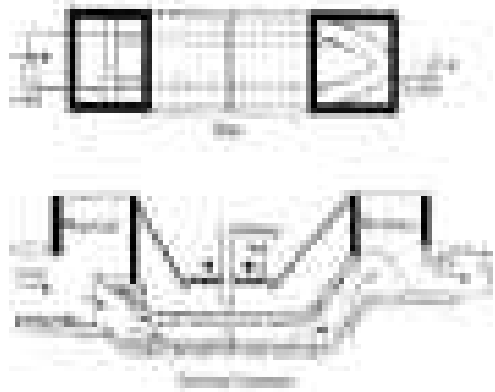
- The sewage from hotels, restaurants, kitchen and bathrooms contains grease, oils and fats, which if not removed before it enters the sewers, will stick to the interior surface of the sewer, choked and will become hard and cause obstruction to the movement of the sewage.
- To retain these grease traps are required which are placed in the pipe connecting the kitchen with sewer line.
- Sewage from garages and service stations contains sand, mud, silt and grease which should also be removed before the sewage enters the sewer line.

Combined silt and oil trap

Figure 12.11

(f) Inverted siphons:

- [illegible] is [illegible] at some places the hydraulic gradient [illegible]
- If there is some depression in the ground and the sewer is [illegible] sewer has [illegible] by supporting on piers. The sewer comes to [illegible] at such places.
- To overcome such an obstruction in sewer line, inverted siphons are provided.
- In an inverted siphon the hydraulic gradient line for hydraulic gradient [illegible] the flow line, whereas in the siphon the hydraulic line is below the flow line.
- Inverted siphons are also known as depressed sewers, because the sewer portion at each position is below the general sewer line.
- Figure 13.12 shows the plan and sectional elevation of an inverted siphon.
- The pipe of inverted siphon must be able to withstand the internal pressure.
- The pipe diameter should be such that the sewage may flow with a great velocity to avoid silting.
- The inverted siphons are generally constructed of cast iron or R.C.C.
- At the ends of the inverted siphon manholes are provided for inspection and cleaning purposes. Both inlet and outlet should be given such a slope that the sewage can easily flow.
- The outlet chamber should be so designed as to prevent the back flow of sewage into pipes which are not being used at the time of minimum flow.



Inverted Siphon

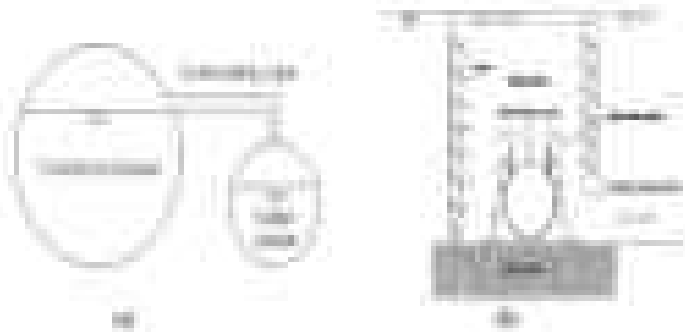
Figure 13.12.

(f) Storage regulation:

These are used for preventing overloading of reservoirs, pumping stations, treatment plants or disposal arrangements, by diverting the excess flow to relief systems. The overflow devices may be side flow or looping weirs according to the position of the weir, siphon spillways or flow actuated gates and valves.

(i) Side flow weir:

- It is constructed along one or both sides of the combined sewer and delivers the excess flow during storm periods to relief sewers or natural drainage courses (Figure 13.11)
- The crest of the weir is set at an elevation corresponding to the limited depth of flow in the sewer
- The weir length must be sufficient long for effective regulation of the flow



(a) (b)

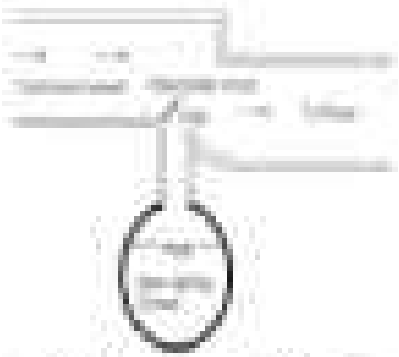
(a) Side flow weir (b) Overflow weir arrangement

Figure 13.11

(ii) Looping weir:

- The weir looping weir is used to maintain the gap or opening in the crown of a combined sewer.
- The looping weir is formed by a gap in the crown of a sewer through which the dry weather flow falls and over which a portion of the storm water escapes
- This has an advantage of operating as regulator without the risk of fog entering gaps.

- [illegible] the disadvantage of this weir is that the grit material gets accumulated in the front [illegible] channel.
- Under practical consideration, it is desirable to have moving weirs to make the opening adjustable.
- When discharge is small, the entire flow directly over the [illegible] comes through this opening, but when the discharge exceeds a certain limit, the excess passage begins to pass across the weir and it is controlled without causing an [illegible]



[illegible] weir with adjustable gate

Figure 12.14

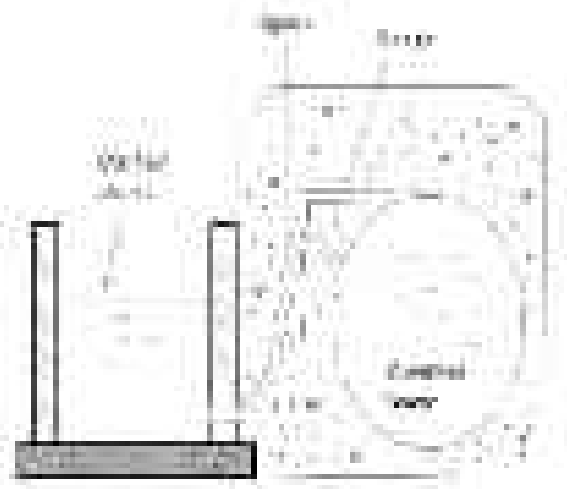
(c) Three screened gate and valve:

- The excess flow in the weir can also be regulated by means of automatic mechanical regulators.
- These are actuated by the flow according to the water level in the sump and connected to the system.
- When, moving part is [illegible] in this regular maintenance of this regulator is required.

(d) Siphon spillway:

- This arrangement of draining excess [illegible] from the combined sewer is most effective because it works on the principle of siphon action and it operates automatically.
- The overflow channel is connected to the combined sewer through the siphon

- [illegible]



Siphon spillway

Figure 12.17

Sewage Pumping :-

[illegible]

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

Capacity of pumping system:

- The capacity of pumping station is determined by the present and future sewage flows based on a design period of 15 years.
- Care should be taken regarding future expansion, such as provision of additional space for replacing the installed pumping unit by larger ones, thus increasing the capacity of the unit and not necessitating new pumping stations to cope with the increased sewage flows.

Type of pumping stations:

- Pumping stations are provided with two separate units one is wet well for receiving the incoming sewage and dry well for installing the pumps.
- The wet well and dry well may be any of the following:

(1) Circular with centrally dry well and peripheral wet well.

(2) Rectangular with dry and wet wells adjacent to each other.

(3) Circular with cutting wall to separate the dry and wet well.

Location of pumping stations:

- The following points should be considered while choosing the site of pumping stations:

(1) The topographical conditions of the city should be thoroughly studied to locate the site of pumping station.

(2) If the quantity of sewage is very large, the site should be near the point of disposal.

(3) The site should be such that during flood it should not be flooded with storm water.

(4) Provision should be made to pump all the sewage which is to be received during storm condition of rain.

Requirements of sewage pumps:

- It can pump the sewage upto maximum distance.
- It should be reliable.
- It should be cheap in initial cost and maintenance.
- It should not be corroded by the organic and inorganic acids of sewage.
- It should not be damaged by the presence of sand, grit or other matter in the sewage.
- It should require less space for installation.
- It should not make much noise during working.

Classification of pump:

Various pumps can be classified as

(a) Centrifugal pump

(b) Reciprocating pump

(c) Rotary pump

(d) Jet, Gil Pumps.

(a) Centrifugal Pump:-

- These pumps work on the principle of centrifugal force.
- They essentially consists of two main parts (i) the casing and (ii) the impeller.
- The impeller of the pump rotates at high speed inside the casing.
- Suction is drawn through the suction pipe into the pump where centrifugal force [illegible] up through the outlet pipe.
- The discharge increases the head of the impeller is sufficient to allow any solid matter entering the pump to pass out in the outlet.
- These pumps are very simple in working and construction can be installed to result pro and pumps.
- Centrifugal pumps are not economical for the generation of small quantities head to the pumps.
- The open impeller type centrifugal pumps are more suited because solids and other [illegible] materials can be easily pumped by open types.
- The centrifugal pumps are classified on the basis of their speeds they as the point of maximum efficiency.
- The specific speed of an impeller is defined as the speed in revolutions per minute at which a geometrically similar impeller would run if of such size to deliver one [illegible] against 1 m head.
- The specific speed is given by the equation

  $N_s = 3.65 N Q^{1/2} / H^{3/4}$

  Where, Q = [illegible] in m^3/sec

  H = [illegible] in metre

  N = [illegible] in rpm

  The centrifugal pumps can be classified as follows:

(i) **Axial flow pumps:** These pumps develop most of their head by the propelling action of the impeller vanes on the liquid. They are characterized by a single inlet impeller with the flow entering axially and are usually used for capacity more than 200 litres/ sec and head less than 8 metres. These pumps are of vertical type. The axial flow pumps have relatively high specific speed from 8000 to 15000. The vertical pumps have problem of entrainment of the impeller for their proper operation.

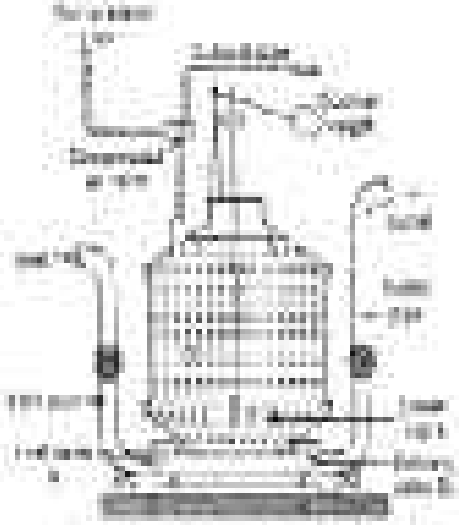
(ii) **Mixed flow pumps:** These pumps develop head due to part of lift of the impeller vanes on the liquid. These pumps have single inlet impeller with the flow entering axially and leaving at an axial and radial direction, usually into a volute casing. These pumps are used for medium heads of 10 to 25 m and for medium to large capacities. The specific speeds of these pumps are from 4200 to 9000. These pumps require priming arrangement, but can also be used for limited suction lift.

(iii) **Radial flow centrifugal pumps:** These pumps consist of two parts (1) the casing and (2) the impeller. The impeller of the pump rotates at high speed inside the casing. Water is drawn from the suction pipe into the pump and various rotating vanes throw it up through outlet pipe because of centrifugal force. Radial flow pumps do not the liquid entering the centre of the impeller can not escape unless it is moving. The impeller of all centrifugal pumps can be closed, semi open, or open depending on the application. Open impeller type pumps are more suitable because incorporated solids and fibrous matter present in the sewage can be easily pumped without clogging. These pumps can have a horizontal or vertical design. These pumps are commonly used for any capacity and head. These pumps have specific speed up to 4200.

(iv) **Reciprocating Pumps:** These pumps are not suitable for sewage pumping because solids and fibrous materials clog them, even after passing the sewage through screens. They are high initial cost, difficult in maintenance, have low efficiency and cause much noise and loss of suction. Therefore not used in sewage pumping.

(5) Pneumatic Ejector:

- Centrifugal pumps are suitable for pumping large quantity of sewage. They are not suitable for pumping small quantity of sewage, because the pumps required in such cases are of very small size, which will often remain clogged. In such places the pneumatic ejectors are most suitable.



Pneumatic Ejector

Figure 12.10

- Figure 12.10 shows the vertical through flow type pneumatic ejector which is mostly used in sewage [illegible] system. It works on compressed air which can be supplied from the central station. Its working is as follows:
- Sewage enters through the inlet pipe by gravity and after opening the inlet valve i.e. it rises in the ejector chamber 'A'.
- During this operation the delivery valve for pressure shaft and the air from chamber 'A' escapes out through the exhaust pipe by opening exhaust valve.
- The rising sewage also lift ball in the lower cage 'c', which is connected to the compressed air valve by means of a set of levers.
- When the cage 'C' is lifted up to a certain level, it operates the lever opening the compressed air valve.
- As the compressed air valve is opened the compressed air enters the chamber 'A' and pushes the sewage up through the delivery pipe after opening the delivery valve [illegible].
- When the level of sewage drops in 'A', the cage 'C' also drops and closes the compressed air valve. The cycle is continued until the sewage is lifted.
- Following are the main advantages of Pneumatic Ejector:

(a) As the sewage is completely enclosed, no sewer gases can escape except through the vent shaft.

(b) The operation of this system is fully automatic.

(c) Very little attention and lubrication of part is required, because only a few parts are in direct contact of the sewage.

(d) There is less chances of clogging.

(f) Air lift Pump.

- These pumps work on compressed air and have no moving parts, therefore are most suitable for sewage pumping.
- These are simple in operation and give least trouble because they have no valves or submerged moving parts.
- It consists of a vertical pipe known as rising main pipe placed inside the water well.
- An inlet pipe is connected to the rising main pipe with the direction of its outlet upwards as shown in figure 13.17.

Air lift pump

Figure 13.17

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

[illegible]:

[illegible]

(1) [illegible]

(2) [illegible]

(3) [illegible]

(4) [illegible]

(5) [illegible]

(1) [illegible]:

- [illegible]
- [illegible]
- [illegible]
- [illegible]

(2) [illegible]:

- [illegible]
- [illegible]

- The sump well is an underground masonry or R.C.C. chamber, placed at such a level that sewage from the trunk sewer can flow into it by gravity only.
- The sump may be rectangular or circular in shape in the plan. Normally circular manholes are used, the inside of which is given a 1:1 slope to enable a cleaner to reach the end of suction pipe of the pump is placed.
- The depth of well depends upon the depth of incoming sewage main.
- Cooling pipes filled with fine screens of mosaic, netlon of plastic mesh, sewage level indicator etc. should be installed in the wet well at suitable places.
- Gate valve should be fitted on the incoming sewer line to stop the sewage flow during inspection, repair and cleaning of the wet well.
- In the top of the wet well manhole with ladder are provided for its cleaning, maintenance and inspection.
- Electric flood lights and by pass arrangements are also provided in the wet well for diverting the sewage during emergency floods.

(2) Pump room or dry well

- It is placed in convenient place and pumps are installed inside it. Its location should be such so that pumps can easily function.
- It is an underground masonry or R.C.C. structure having circular or rectangular shape in the plan.
- The sewage pump, their driving motor, control valves and necessary pipes and dry fittings are installed in it.
- The size of the dry well should be sufficient for the movement of the operators during operation, maintenance and repair as well as installation of pumps etc.
- The size of the dry well should be sufficient to accommodate installation of more pumps for the future expansion with the design period.
- Provision of small sewage pumping room or separate dry well is provided.
- It is better to take sump floors as flat, so that pumps may not require any priming during starting.
- The pumps may be submerged in the wet well or may be provided at the roof of the wet well.

(i) Pipe, valve, fittings etc:

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

(ii) Pump with driving engine or motor

- **Location of driving unit:** [illegible]
- [illegible]
- [illegible]

- **Power of the driving unit:**
- The power of the driving motor to be installed on the tube/ pumping motor depends on the following
- The maximum total head under which pumping is to be done including loss of heads.
- The maximum pumping rate or discharge of pumping
- The efficiency of the pumps
- The efficiency of the driving unit
- The loss of head due to friction is determined by the following formula

  $h_f = \frac{4fLv^2}{2gd}$

  The B.H.P of the driving unit is directly calculated by the following formula

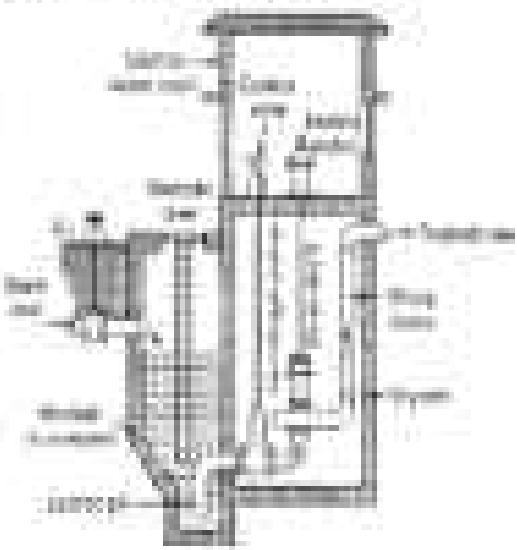
  $B.H.P = \frac{wQH}{75\eta_p\eta_m}$

  Where Q = the discharge

  H = water head

  η_p = efficiency of the pump

  η_m = efficiency of the driving engine of motor



Section through a pumping station

CHAPTER-9

SEWAGE DISPOSAL

The sewage begins to cause nuisance as it becomes stale. So the sewage need to be disposed off without nuisance to other outside nuisances. Finally the sewage is disposed off either in natural water course or on land.

9.1 DISPOSAL ON LAND

SEWAGE FARMING

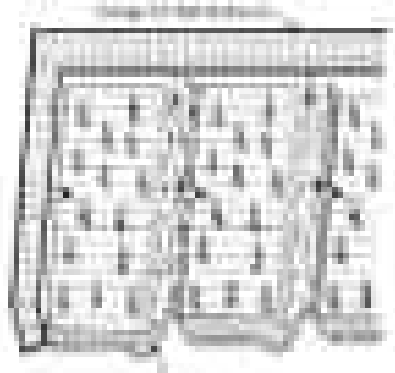
When the sewage is used for growing crops it is called sewage farming. The nutrients of sewage like nitrogen, phosphorous and potassium along with microbes as well as organic matter are directly utilized by the plant. The sewage increases the fertility of the soil along with irrigation potential. The good sewage farm should not be necessarily have as the primary objective of disposal of sewage utilization to the possible extent as a good sanitary measure without polluting the soil, open water courses or underground water or contamination of the crops or causing the production by of the farm and hygienic safety to the staff against the infection by pathogenic organisms. Under no circumstances raw sewage should be applied to the farms directly.

SEWAGE APPLICATION AND DOSING

The sewage can be applied to the land by the following methods

1. **Surface Irrigation**

   The parallel drains are constructed in the fields. All drains are connected to a distributory drain by means of regulating devices such that the sewage can flow in the required drain. This method is suitable to sloppy areas. The sewage is allowed to overflow through holes from one drain towards another.



Surface Irrigation

Fig 9.1

2. Subsoil irrigation

In this method a network of porous steel pipes is laid down from below the ground level. The sewage is allowed to flow through these pipes which is diverted by the soil. The remaining quantity of sewage, if any, can be used for irrigation in another place or discharged in natural water courses.

Sub soil irrigation

Fig 10.2

3. Flooding

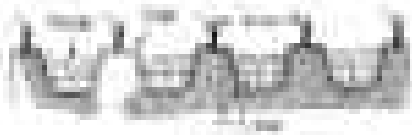
The irrigation area is divided into various parts surrounded by dykes. The sewage is filled into small people in between the dykes as shown in fig. The depth of sewage flooded over the fields varies from four centimetres to 30cm depending on the requirement of the vegetation.

Flooding

Fig 10.3

4. Ridge and furrow.

In this method the land is first ploughed deep up to 45cm furrows and ridges are given and cultivate. Then seed sowing is employed by small dykes. Water, fertilizer and fertilizers are formed in each sulphur. The sewage is allowed to flow in furrows, where as crops are grown on ridges as shown in fig. After an interval of 8-10 days the sewage can be again applied depending on the crops requirement and the nature of the soil.



Bridge Soil Sections

Fig 11.4

2. **Spray irrigation**

This method is not used in India. In this method, river the sewage is filtered or made to flow upstream outside sugar wells. Then the sewage is sprayed over the fields by pumping it through pipes fitted with sprinklers at the other end.

SEWAGE SICKNESS

When the sewage is continuously applied on the land, the pores of soil continuously get on decreasing and a stage comes when the soil gets clogged by the deposition of solids of sewage. After reaching this stage, the air cannot circulate through the soil pores, therefore anaerobic conditions always continue resulting in the starting of anaerobic conditions. When anaerobic decomposition starts, the hydrogen sulphide gas is produced causing nuisance in the area. In this condition the sewage purifying capacity of the land is exhausted and it is said to be sick. This type is known as sewage sickness. When such stage is reached the land is said to be sick.

REMEDIES

- By giving primary treatment to the sewage the suspended solids are removed, due to which the pores of the soil will not be clogged easily.
- By giving rest to the land i.e. intermittent application of sewage on land. The land should be ploughed thoroughly during the non-supply period so that the soil gets aerated.
- By planting different crops in the land to consume, which will aerate the soil and utilize the following elements of sewage.
- By providing under drainage system to collect the excessive quantity of sewage.
- By frequent ploughing and aeration of soil.

11.2. DISPOSAL BY DILUTION

The disposal of sewage by discharging it into water courses such as streams, rivers or large body of water such as lake, sea is called **dilution**. This method is only possible when the natural water is required quantity to dilute and purify the sewage.

If the sewage is to be discharged to sea or lake or on land, the required standards for the polluted water are given in table **12.1**.

Class of	Standards of polluted sea or lake water	Use of polluted water
A	i) Total coliform of flowing water should not exceed 50 MPN of 100 ml. ii) pH should be between 6.5 and 8.5. iii) Dissolved oxygen should not be less than 6 mg/l. iv) BOD 5 days at 20°C should not be more than 2 mg/l.	It is fit for drinking purpose after disinfection.
B	i) Total coliform of flowing water should not exceed 500 MPN per 100 ml. ii) pH should be between 6.5 and 8.5. iii) Dissolved oxygen should not be less than 5 mg/l. iv) BOD 5 days at 20°C should not be more than 3 mg/l.	It is fit for outdoor bathing.
C	i) Total coliform of flowing water should not exceed 5000 MPN per 100 ml. ii) pH should be between 6.5 and 8.5. iii) Dissolved oxygen should not be less than 4 mg/l. iv) BOD 5 days at 20°C should not be more than 3 mg/l.	It is fit for irrigation and industrial cooling.
D	pH should be between 6.5 and 8.5. Free ammonia should not be more than 1.2 mg/l. Boron should not be more than 2 mg/l.	It is fit for wild life and fisheries.
E	Boron should not be more than 1 mg/l. Sodium absorption ratio should not be more than 26. Electrical conductivity should not be more than 2250 micro mhos/cm.	It is fit for irrigation purpose.

SELF PURIFICATION OF STREAM

When sewage is discharged into normal waters, its organic matter gets oxidised by the dissolved oxygen present in water. The oxidation of organic matter converts such matter into simple inoffensive substances. The deficiency of dissolved oxygen thus created in water is soon made up by the absorption of atmospheric oxygen. Thus the oxygen which is consumed by the sewage and at the same time, is replenished by the atmosphere. This phenomena which occurs in all natural waters is known as the **self purification** of natural waters.

The rate of self purification will depend on various factors such as lack of oxygenation, type of organic matter present in sewage, temperature, velocity of flow, presence of available oxygen in receiving waters, sedimentation etc. The self purification process of stream polluted by sewage can be grouped in following four zones

1. **Degradation Zone**

This zone is situated just near the point of entering sewage into the stream. The water is turbid with dark colour. The decomposition of soil matters take place in this zone and the anaerobic microorganisms prevail.

2. **Active decomposition Zone**

In this zone the water is greyish and darker than the previous zone. The insoluble solids or the organic materials and other simpler compounds present and bacteria also increase in the number in this zone.

3. **Recovery zone**

In this zone the mineralization of organic matter takes place and the BOD of water is reduced . The contents of dissolved oxygen start raising up above 40% of the saturation value. The bacterial load decreases as the food supply of bacteria diminishes.

4. **Clear water Zone**

In the zone the stream attains normal conditions as were prevailing before sewage is discharged into it.

CHAPTER-10

SEWAGE TREATMENT

PRINCIPLES OF TREATMENT

Sewage contains various types of impurities and disease bacteria. Now sewage is disposed of by dilution in sea land and in surface and underground. If the sewage is already disposed of, it will be mixed with the natural forces, which will convert it into harmless substances. The natural forces of purification cannot purify any amount sewage within specified time. If the quantity of sewage is more, then receiving water will become as the land will become sewage sick. Under such circumstances it becomes essential to do some treatment of sewage so that it can be accepted by the land or receiving water without any objections.

Thus the main object of all the treatment units is to reduce the sewage contents from the sewage and convert the entire treatment in such a way that it can be safely discharged to the natural water course, approved on the land.

FLOW DIAGRAM OF CONVENTIONAL TREATMENT

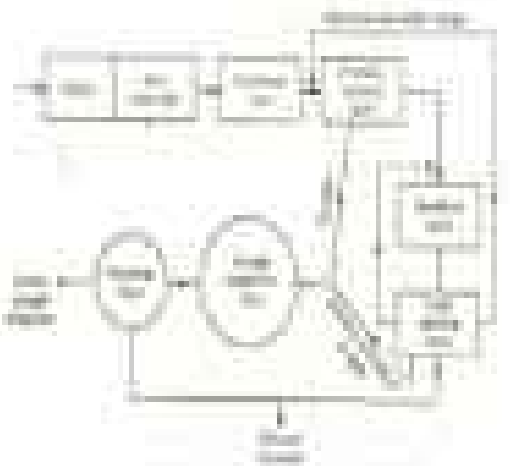


FIG.10.1

SECONDARY TREATMENT

The sewage contains various impurities, floating, and oily substances. By primary treatment these substances are removed from the sewage so that the following secondary treatment units may function well. Here we discuss the operation of these units.

[illegible]

[illegible] is the first unit of primary treatment plant. Flat [illegible] of solids & to remove silt, fine floating debris like wood pieces, cloth and paper pieces, discarded fruits and vegetables etc. If heavy floating matters are not eliminated, it may choke the pipe lines or it may cause damage to the pumping unit.

Construction: The screens may be constructed of M.S flat bars, gratings, wire meshes or perforated plates. The M.S. bar screen is made by placing parallel bars with spacings according to the following types.

Coarse screen: The spacing of bars is more than 40mm used to screen...

Medium screen: The spacing of bars is from 20mm to 40mm.

Fine screen: The spacing of bars vary from 2.5mm to 10mm.

The screens may be fixed or movable. The inclination of the screen varies from 30° to 60°... The screens are placed in the [illegible] inclination in an inlet channel of the [illegible]. The width of the chamber are expanded, so as to compensate for the [illegible] cross-section. The screen surfaces are cleaned and [illegible] at least once in a day. A perforated rectangular channel is provided at the top of the screen for collecting floating debris.

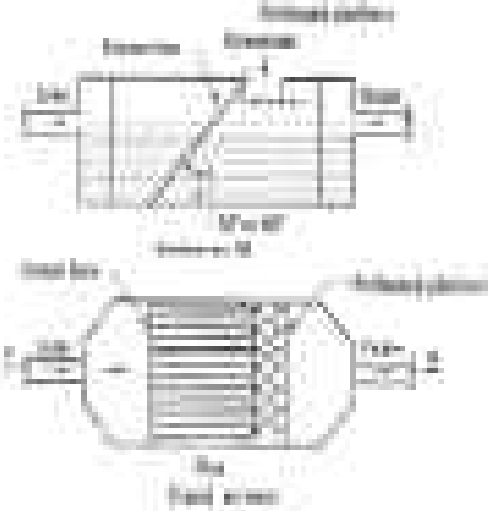


FIG 3.1

Operation: The user accepts a attempt to enter the chamber through the main door. The floating debris are minimized to the system and collected back in. The storage containing the other recuperated materials passes through the system and is stored in the main unit.

Cleaning: The debris may be cleaned by manual labours or mechanical devices. In manual system, the debris are taken by workers and collected to the predetermined disposal from where these are disposed off. In mechanical devices system, a sliding arm like mechanism is provided which collect the debris as impulse material and throws on a collecting trash from where these are disposed off.

Disposal

Dumping: The debris are dumped in low lying areas far away from the locality.

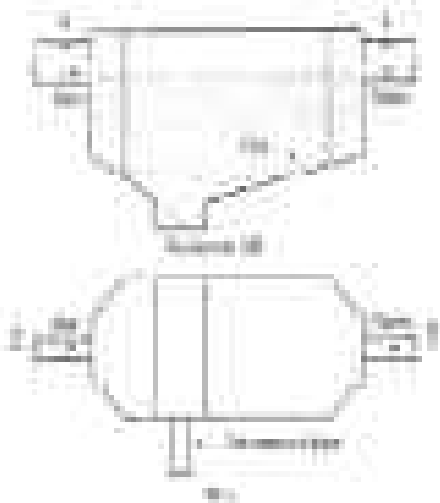
Burning: After burning the debris are found to ashes.

Composting: Good quality manure may be obtained by composting the debris in compost pits.

DUST CHAMBER.

The function of grit chamber is to remove the inorganic substances like grit, sand and other suspended materials. The velocity of flow in the grit chamber is kept low so that a detention period is provided for the settlement of the above substances.

Construction: The grit chamber is an offering rectangular chamber and constructed with brick masonry. As shown in fig the floor of the chamber is kept sloping for the collection of grit in a particular zone. The inner surfaces are plastered and finished with neat cement punch. It consists of an agitator for agitating the dispersed grit at the time of cleaning. A pipe line with valve is provided at the bottom of the chamber for periodic removal of the grits. The length, width and depth are designed according to the volume of sewage.



Grit chamber with detail flow

FIG.10.3

Operation: The sewage from the screen chamber is allowed to enter the grit chamber and flow at a low velocity of 20 cm to 30 cm per sec. Due to the low velocity the grits, sands etc are carried down at the bottom of the grit chamber.

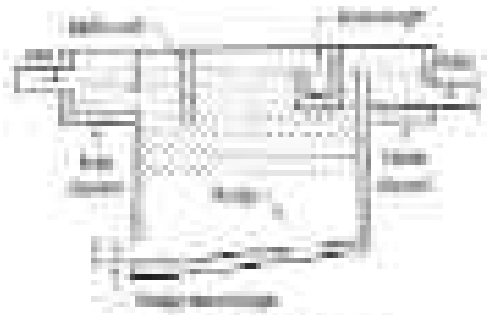
Cleaning: At the time of cleaning, the deposited grits are agitated by agitators and the muddy water comes out through the outlet pipe. The grits may also be cleaned manually by manual labours with the help of buckets.

Disposal The grits are generally dumped in low-lying areas for the reclamation of land.

PRIMARY SEDIMENTATION TANK

The function of primary sedimentation tank is to remove settleable particles like silt and clay and some organic substances. Moreover it reduces the load on the secondary treatment. Coagulants may be used if necessary.

Construction: It is a rectangular tank constructed with brick masonry. Baffle walls are provided in zig-zag way so as to lengthen the path of the flow of the sewage. Inlet and outlet pipes are provided on opposite corners and flows are provided with valves. A sludge removal pipe is provided at the bottom of the tank.



Rectangular settling tank

FIG 15.1

Operation: The sewage enters the tank through the inlet pipe and flows along the sloping path and hence the velocity of flow is reduced. Thus the sewage is detained for a considerable period in the tank. The collected particles and organic substances are settled down at the bottom of the tank. The completely clear water passes out through the outlet pipe.

Cleaning: The sludge is cleaned periodically through the removal pipe by opening the valve.

Disposal: The sludge may be disposed of by pumping in ditches or low lying areas or may be dried in sludge drying beds and can be used as manure.

10.3 SECONDARY TREATMENT

In the primary treatment, the larger solids in sewage are removed. But the effluent still contains organic matters, bacteria, colloidal matters etc. Such effluent cannot be discharged into the natural water course. So secondary treatments are given to the effluent of primary treatment to make it safe in all respects and suitable for discharging it into the river. The units of the secondary treatments are as follows:

Contact Bed

A contact bed is a method of filtration of sewage. In case of filtration it is to be passed first, the sewage is brought in contact with the filtering media for some specified period. During this period, a biological film is formed around the particles of the filter media and the bacterial colonies are formed in the film. These bacteria are responsible for the oxidation of organic matters. Again, when the bed is kept empty for some period, the filter gets oxygen from atmosphere and so aids the organic matters of film remain decomposed.

Construction: It is a rectangular tank which is divided into several units. The depth of tank varies from 1m to 2m. Each bed is filled up with filtering media of gravel, ballast or broken stones as shown in fig. The effluent is made of ballast varies from 2 mm to 50mm in diameter.

dosing tank is provided for the supply of sewage to all the beds simultaneously. Generally the rate of filtration is 100 litres per sq.m. of filter media.

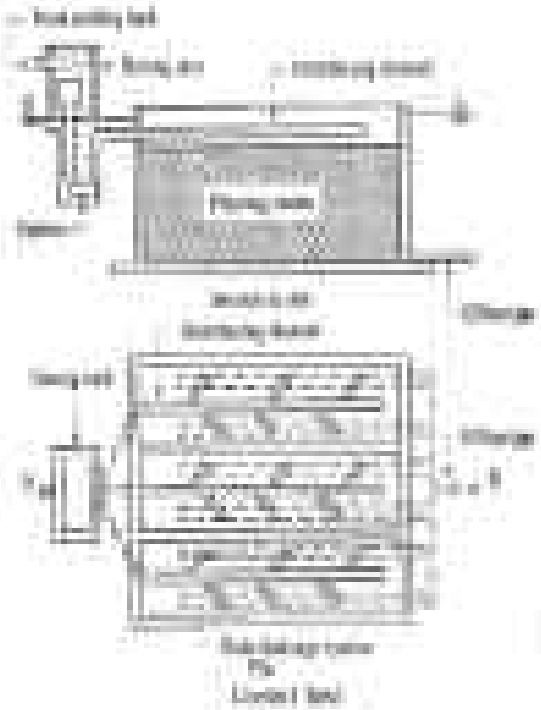


FIG 16.1

Operation: The bed is filled with sewage through the upstream dosing tank and it may take about two hours. The sewage is allowed to rest in the filter media for about 2 hours. The effluent is allowed to flow through the effluent pipe for the disposal to natural water course. The rest may take about 2 hours. The bed is allowed to rest empty for about 4 hours. Thus, the cycle of operation continues during the working period.

TRICKLING FILTER

A trickling filter is a method of filtration of sewage. The term filtration is kept as compared to contact bed. The principle of trickling filter is that the biological film which is formed around the filtering media in the presence of atmosphere all the biological processes. These bacteria decomposes the organic matters for their survival. So the trickling filter serves the purpose of breaking the complex organic matter by feeding the bacteria.

Elements of trickling filter

Construction of filter: Generally the trickling filter is circular in shape. It consists of a bed of coarse stone having some voids for the purification in the bacteria. The stone are fitted with a

[illegible] is treated by a scientific device. The floor of the filter is made of concrete and its slope is made towards the periphery.

Dosing of filter: A rotating dosing tank is provided with the revolving filter for uniformly supply of effluent over the filtering media.

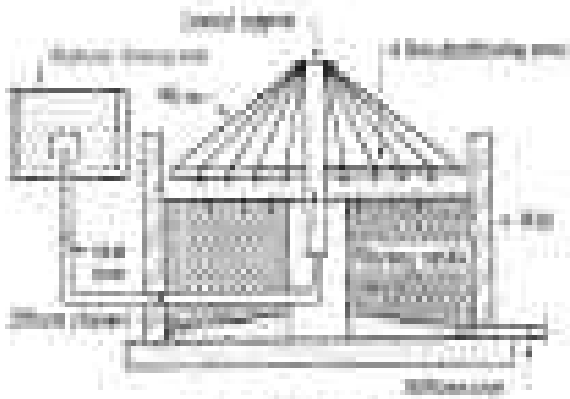
Filtering media: It consists of broken stones. Stones are laid in such a way that the bigger size stones are placed at the bottom layer and the smaller size stones are arranged towards the top. The stones or clinkers should of good quality.

Under drainage system: It consists of a channel along the periphery of the filter. The channel is open to sky and connected to the outlet pipe.

Ventilation: The ventilation of the filter is necessary for the smooth working of the filter. The ventilation are achieved by providing vent pipes at the periphery.

Working: The effluent is spread over the filtering media at broken stones by rotary arms. The effluent trickles down the media and gets collected in the channel. The channel carries the effluent to the outlet pipe through which the effluent is taken for disposal.

Cleaning: After working for long period, the upper surface of the media may be clogged by sediments. The rate of filtration may be decreased or stopped due to this. To clean them, the upper layer of stones are scrapped off and fresh layer of stones of same size are replaced properly.



Circular trickling filter

Fig 15.5

ACTIVATED SLUDGE PROCESS

Definition

The sludge which is made powerful by the process of aeration is known as activated sludge. It contains high content of oxygen and high no. of aerobic bacteria. It possesses maximum jet power to oxidise the organic matters.

Notes:

The following are the names of activated sludge:

(i) The activated sludge when mixed with sewage, the microorganisms multiply rapidly.

(ii) The activated sludge oxidises the organic substances rapidly.

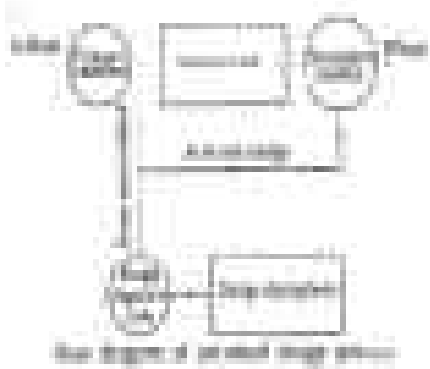
(iii) It converts the unwanted matters in colourless odourless rapidly.

Operational Sequence

1. **Mixing of screened sludge**: In this system of the activated sludge method at the outlet of secondary settling tank is recirculated and mixed with the effluent of primary settling tank just before its entry to the aeration tank.
2. **Aeration**: In aeration tank, at the first stage of the activated sludge process, there the effluent of the primary settling tank and air are brought in intimate contact by agitating with some mechanical devices. This devices are as follows:
   a) Air diffusion system
   b) Mechanical aeration system
   c) Combination of the diffusion and mechanical aeration system

Air diffusion system may be achieved by (i) Air diffusers (ii) Plate diffuser (iii) Tube diffuser.

Sludge settlement: The secondary sedimentation tank is the second unit. After aeration in aeration tank, the effluent is taken to the secondary settling tank and detained for a specified period, generally of 1 hr. During this detention period, the sludge is formed as activated sludge. Some portion of this sludge is recirculated to aeration tank and the remaining portion is sent to digestion tank. Thus, the cycle of activated sludge process goes on working.



[illegible]

FIG 1C7

AERATED LAGOON

An aerated lagoon is an earthen basin about 2.5m to 4.0m deep in which the sewage is filled and aerated by means of diffused air or mechanical aerators. Commonly mechanical aerators are used. These are fixed on the pontoons floating or rest on the lagoon after passing through the grit chamber, without giving any primary treatment. The aerated lagoon acts as a settling cum aeration tank, where settled solids are retained in the lagoon for a longer detention period. The detention period of 1 to 3 days is provided. The efficiency of aerated lagoon is 70to 90% to 0 to 14 removal. These are most suitable for small size towns for which conventional treatments costs from Rs. 1 to 2 per capita. For waste water of industries such as paper, straw board and food industries can also be easily treated by aerated lagoons.

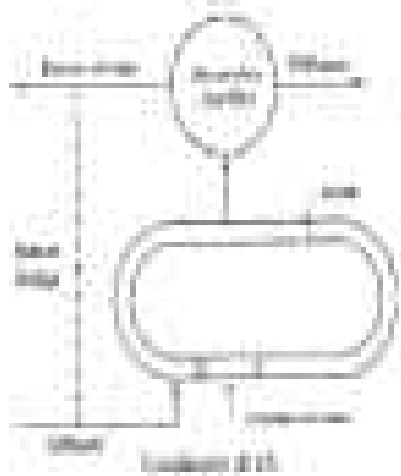
FIG 1E1

OXIDATION DITCH

[illegible] is a modification of the activated sludge process that is designed to treat large volumes of wastewater from small communities. It consists of a ditch or channel that is usually oval or racetrack in shape and is equipped with one or more aerators. The aerators provide oxygen to the wastewater and mix the contents of the ditch. The wastewater flows through the ditch in a circular pattern, and the aerators create a current that keeps the solids in suspension. The solids are then removed from the wastewater by settling in a clarifier or other separation device.

One of the main advantages of the oxidation ditch process is its simplicity. It requires relatively little mechanical equipment and is easy to operate and maintain. It is also relatively energy efficient, as the aerators only need to operate intermittently to maintain the desired level of dissolved oxygen in the ditch. The process can also be designed to remove nutrients, such as nitrogen and phosphorus, from the wastewater.

However, the oxidation ditch process also has some disadvantages. It requires a large amount of land area, and it can be difficult to control the odors that are produced by the process. The process can also be sensitive to changes in the temperature and pH of the wastewater.



[illegible] of O.D.

FIG 14.9

SLUDGE DISPOSAL

Before disposing the sludge, the sludge digesters are to be drained.

SLUDGE DIGESTION

The decomposition of complex organic material in sludge by bacteria. Chemical reactions involved in converting the material to a form suitable for disposal. A portion of solids is converted into liquid and gases, due to which the volume is reduced by 40-70%.

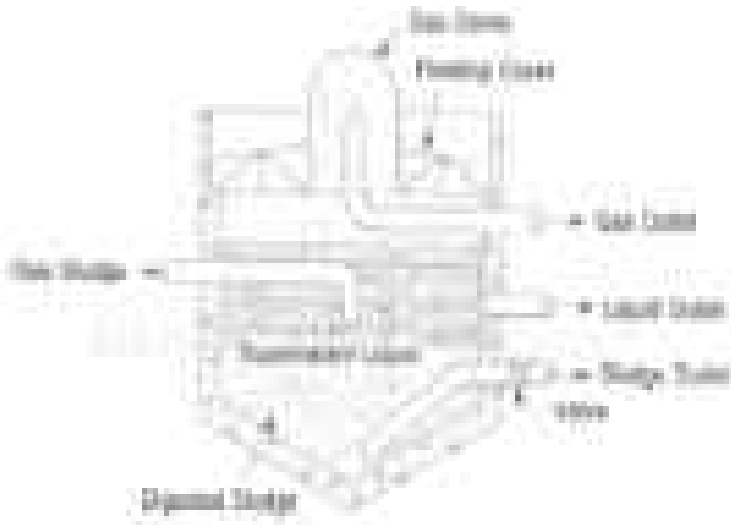


FIG 19.12

Necessity of Sludge Digestion: The following are the necessity of sludge digestion

- To destroy pathogenic bacteria.
- To reduce the volume of sludge so that it can be disposed of easily.
- To obtain combustible gases.
- To obtain good fertilizer.
- To reduce the necessary content for the facility of handling and transporting.

The sludge digestion is taken in sludge digestion. There are 2 types of sludge digestion.

HAIGHT DIGESTION TANK

Constructional features:

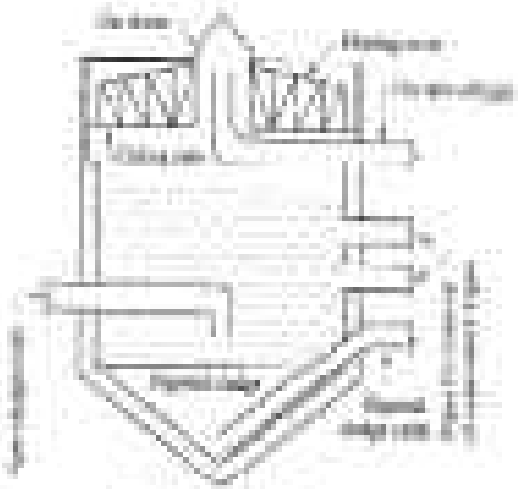
1.Enclosure tank : The enclosure tank is generally circular in shape and is constructed with R.C.C. The diameter of the tank is varies from 4-20 m and depth varies from 1-4m, however the actual it is depends upon the volume of the sludge. The floor of the tank includes sloping like hopper and the slope is generally 1:12 or 1:6.

2. Gas Dome: A gas dome is provided with the floating roof for the collection of gas formed during the process of digestion.

3.Inlet and Outlet: An inlet pipe is provided for the entry of raw sludge. A sludge outlet pipe is provided at the bottom. Supernatant liquid outlets are provided at different levels. A gas outlet pipe is provided at the top for drawing the gases from dome.

4. Mixing Device: A suitable mixing device should be provided for mixing the incoming raw sludge with the digested sludge.

c.Cross breaking device: Some device should be provided to break up the scum which may form on the top surface.



Sludge digestion tank

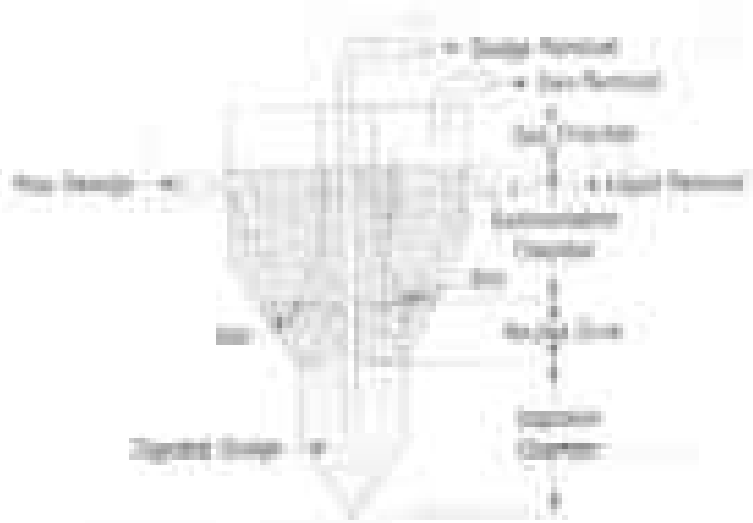
Fig.(6.1)

Working principle

1. The raw sludge is allowed to enter the tank through the inlet pipe and it throws at the centre of the tank.
2. The sludge is digested by the decomposition of complex organic matter by anaerobic bacteria.
3. The digested sludge is settled at the bottom of the tank which is withdrawn through the outlet valve and left for drying. The gases are collected at the dome. The gases are withdrawn through the outlet pipe and are used as fuel.
4. The supernatant liquid is collected, in the space between the digested sludge zone and the gas dome. The digest is withdrawn from different levels and disposed of to the natural water course.

[illegible] TANK

In which soon, the sedimentation and digestion are carried out simultaneously. The following are the parts and working of Imhoff tank.



DIGESTER

FIGURE

(a) **Sludge**: It is a concrete or steel, or silt hopper tank, fixed on the ground and constructed in R.C.C.

(b) **Sedimentation Chamber**: It is the central area of the silt hopper tank, this sewage containing heavy sludge from the secondary clarifier is allowed to enter the chamber and is distributed for quantified period.

(c) **Settle plate and Slots**: The tank consists of baffle plates with hopper shaped bottom. There are provided between the baffle plates and the body of the tank. The sludge is gravitally emitted down through the slots and deposited in the digestion chamber.

(d) **Digestion Chamber**: This is the lower part of the hopper tank, in this chamber the sludge is digested under anaerobic conditions.

(e) **Neutral Layer**: The space between the slot and the top digestion chamber is known as neutral zone. The depth of this zone is generally 30cm. This zone prevents the entry of digested sludge into the sedimentation chamber.

(f) **Gas Chamber**: It is the upper zone of the inverted tank. In this chamber, the gases (mainly methane) are collected which are withdrawn and used as fuel.

(g) **Sludge Removal**: The digested sludge from the digestion tank is withdrawn through the sludge removal pipe and taken to the drying bed.

[illegible] OF DIGESTED SLUDGE:

The sludge removed from all the sources has an objectionable odour and it possesses the property of putrescence if not properly disposed off. The following are the methods of sludge disposal.

1. The sludge is disposed by spreading on drying bed to a thickness of 15cm. After 7 days, the sludge is ready to concrete and acted suitable for the use as manure. It should not come in contact with vegetables and flows directly as well.
2. The sludge is disposed by spreading over barren land as an treatment of stone / laterite and ploughed frequently which enhances the fertility of the land.
3. The sludge is disposed by pouring in trenches on barren land. The trenches are excavated at some perpendicular to each other at an interval of disposal period (about 1 months).
4. Where there is no safety of sludge, very easy and cheap method of sludge disposal is throwing the sludge into the drain and very far away from the above meaning that the sludge may not return to the town.
5. The sludge is disposed by composting. The sludge is from a mixture of fresh type (common of a town) or mature fourth type (common of a mixture). What from composted sludge is used as a benefit.
6. Lagooning is one of the process of sludge disposal. A lagoon is an artificial pond of depth of about 1m with the embankments on 3 sides. The lagoon is filled up with raw sludge and left for few months. The sludge is dried and cracks are formed on the surface. Then the dried sludge is removed and used as manure. This is a very cheap method if sufficient land is available.

[illegible] TREATMENT UNITS

SEPTIC TANK:

a) **Theory** - Septic tank is based on the principle of sedimentation of sewage and digestion of sludge. In this tank the sewage is detained for some period, during this detention period, the sewage is decomposed by anaerobic bacteria and the sludge is deposited at the bottom (as sedimentation tank). The digestion of sludge is carried out by the anaerobic bacteria as

disposition units. The effluent is clear and it is discharged into the nala (it is considered as a natural water).

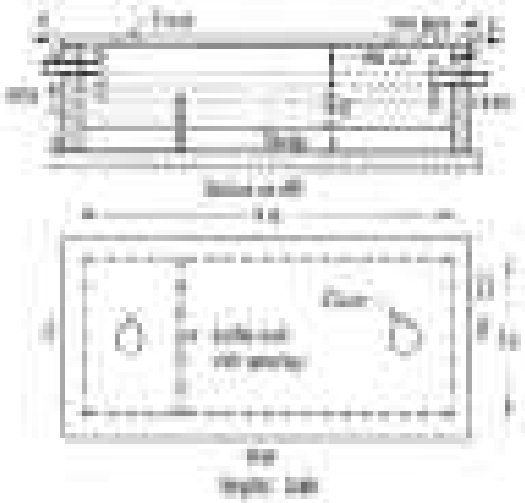


FIG 11.11

Application: the septic tank is suitable for the areas where it is not possible to construct the water carriage system. It is provided in institutional buildings, hostels, hotels, hospitals, schools, colleges, etc.

Constructional features: Fig. shows a septic tank. The following are the constructional features of septic tank.

(i) It is a rectangular tank constructed with brick masonry over concrete foundation. Its length is usually 3 times the breadth.

(ii) The liquid depth varies from 100 to 150 cm.

(iii) A dry board of 30 cm is provided above the liquid level.

(iv) The inlet pipe and outlet pipe consist of 'T' or 'elbow' which are arranged as a hydraulic almost 25 cm below the liquid level.

(v) The outlet level is always 3 cm lower than the inlet level.

(vi) The inside surface of tank should be plastered and finished with neat cement paint to make it completely watertight.

(vii) A or circular scum pipe baffle wall should be provided. Also the septic tank two baffle should be provided near both the ends.

(viii) The top of the baffle should be at least 30 cm above the liquid level.

(b) Openings should be provided near the bottom of the baffle for the flow of effluent from first chamber to second chamber. Submerged hanging baffles may be provided.

(c) R.C.C. slab with manhole is provided at the top of the tank.

(d) Ventilation pipe is provided for the removal of foul gas.

c. Working Of Septic Tank: The first two steps from the list have been taken the first chamber already called the scum. Just floating as the beginning. Within few days, the anaerobic bacteria decomposes the solid and sludge a formed which is settled down at the bottom of the tank, and is digested further by these bacteria. The effluent from the first chamber flows in the second chamber through the opening in the baffle wall and finally disposed of in the soak pit. During this decomposition, the gases like carbon dioxide, methane and hydrogen sulphide are formed which are released through the vent pipe.

Due to the digestion of sludge, the capacity of the tank goes on reducing gradually. So, the tank should be cleaned every year, or as extra reasonable period.

3. Design Aspects: Following are the design aspects of the septic tanks:

(a) **Capacity:** The volume of septic tank is calculated by taking into consideration the quantity of flow and detention period. It can also be designed as per capita basis which varies from 45 to 180 litres per day as per the septic tank. The para for sludge is kept normally at the rate of 25 to 40 litres per capita per year.

(b) **Detention Period:** The detention period varies from 12 hr. to 72 hours, the minimum being 24 hours.

(c) **Freeboard:** This should be about 300 mm to 450 mm.

(d) **Shape:** The septic tanks are generally rectangular in shape. The ratio of length to width is about 2 to 4.

SOAK PIT/ SOAK TRENCH

Function: The function of soak pit is to receive effluent from the septic tank and disperse the liquid to the surrounding soil through the openings provided in the wall and through the bottom. The soak pit should not be constructed very near to an open well or tube well.

Constructional Features: The following are the constructional features of the soak pit:—

(i) The soak pit is constructed in the form masonry in the shape of a square or circle. The depth varies from 3 to 30m. But the depth depends upon the water table of the locality. It should be remembered that the depth should not be taken below the water table.

(ii) The diameter of the pit depends on the volume of effluent and number of users. However,

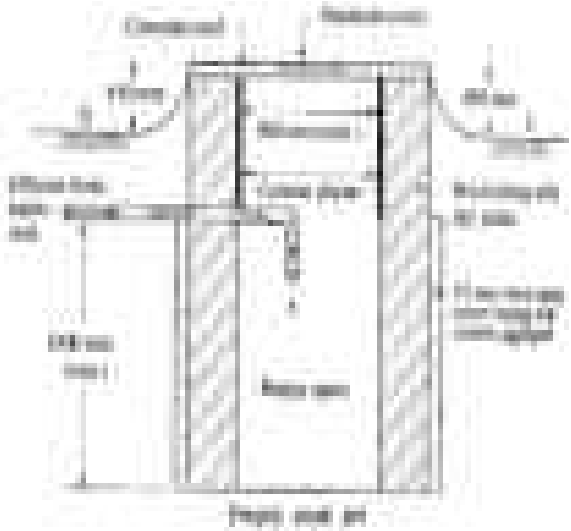
[illegible] the diameter can be fixed. [illegible]

(v) Openings are provided in the wall of the pit, as shown in Fig. The bottom is kept open so that the waste can be absorbed by the surrounding soil.

(vi) The pit [illegible] is filled up with brick bats and broken stone.

(vii) Sometimes, a parking of coarse sand (15 cm thick) is provided around the pit to increase the percolating capacity of the soil.

(viii) If the working capacity of the pit is determined, it should be cleaned and filling materials may be replaced.



Deep soak pit

FIG 10.14

DESIGN OF SEPTIC TANK AND SOAK PIT

PROBLEM

Design a septic tank having the following data.

(i) Number of users 200.

(ii) Rate of water supply 120 lit/head/day

(iii) Detention period 24 hours

(iv) Percolating capacity of filter media 120 lit/m²

Also find the diameter of the soak pit. Assume [illegible] data if required.

Solution

Assuming that the whole quantity of water comes as sewage,

Rate of sewage per day = 200 × 120

= 4000 lbs.

Adequate Practical is 10 times

lbs. Tank capacity = 4000 X 10 = 40,000 lbs.

Assuming sludge storage capacity at the rate of 25 lbs per person per

Volume of sludge = 200 X 25

= 4000 lbs.

Tank capacity = 40,000+4000

= 44,000 lbs.

Considering 20% provision for future extension.

Extra volume = 44,000 X 0.2 = 8,800 lbs.

Total volume of tank = 44,000+8,800

= 52,800 lbs.

= 52,800 lbs/cu.ft

= 705.34 cubic ft (1 ft³ = 1000 lbs)

Considering the effective depth of liquid as 7 ft.

Area required = 705.34 / 7 = 100.76 sq.ft

Let, width = 4

and length = 3B

B X 3B = 100.76

or B² = 33.6

B = 5.796 = 6 ft

Length = 3 X 6 = 18 ft

Considering free board as 0.5 ft.

Overall depth = 7.5 ft = 7 ft.

Therefore, the size of septic tank is 18ft x 6ft x 7ft.

Size of Soak well:

Volume of soak well = 40,000 / 100 = 400 cu.ft

[∵ Percolation Capacity = 1000 lbs/cu.ft]

Oxidation Pond

History The oxidation pond is an improvement of the complete stock oil oxidation ditch. The sewage is stored in the pond for a considerable time. During this period, the sewage is

decomposed by the action of aerobic bacteria, algae and protozoa. (Soil system, it is a natural method of sewage treatment. The aerobic bacteria decomposes the organic matter present in the sewage and break up the organic matters in sewage to simple stable compounds.

Construction and Operation The oxidation pond is constructed by excavating a rectangular ditch of shallow depth. The length varies from 0.5 miles, the width from 100 feet and the depth varies from 3 to 4 feet. The pond is divided into several compartments. The sewage is allowed to enter the pond through the inlet channel at one corner. The sewage flows in a zig-zag manner across the whole pond to flow out. The detention period varies from 7-14 days. The decomposition of sewage is achieved by the aerobic bacteria. After complete decomposition black bottom is obtained which may be used as manure.

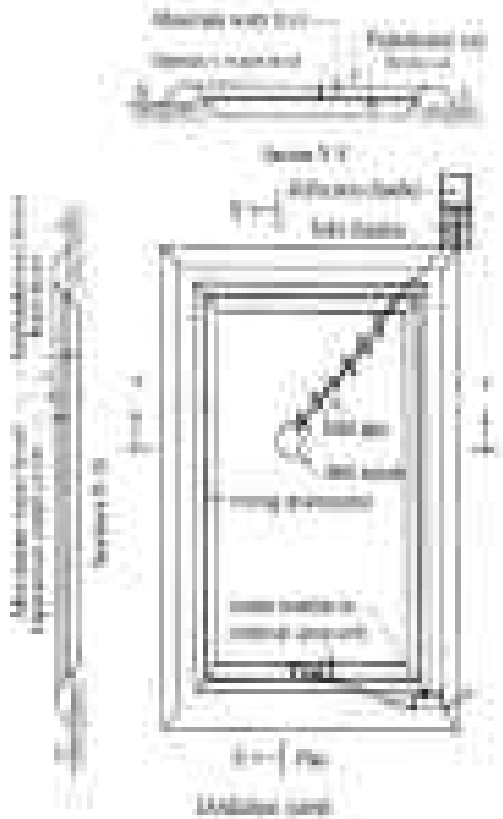


Fig. 11.17

Advantage:

(a) It is a natural method of decomposition, so it is cheap.

(b) Its operation and maintenance is simple.

(c) It is highly efficient in removing [illegible].

Disadvantage:

(a) Large area is required for treatment.

(b) It creates bad smell and mosquito nuisance.

(c) In rainy season or [illegible] weather the sewage becomes septic and the septic conditions

CHAPTER-11

SANITARY PLUMBING FOR BUILDING

Requirements of building drainage

(1) It is advisable to fix cisterns by the side of building rather than below the building.

(2) Cisterns should be kept away from inspection Chambers or manholes. All drainage fittings and pipelines should be so laid as to keep them away from cisterns.

(3) The house drain should be connected to the public sewer only if the level permits i.e., only when public sewer is deeper than the house drain. Otherwise there will be reverse flow from the public sewer to the house drain.

(4) The water system should be properly ventilated from the nearest point of disposal.

(5) The house drainage should contain enough number of traps at suitable points for efficient functioning of it.

(6) The house drain should be disconnected from the public by the provision of an intercepting trap to prevent solid matter from the public sewer to enter the house drain.

(7) The joints of pipes should be scientific and properly tested before starting the drainage work in use.

(8) The trench cavities should be laid at proper gradients so that they will develop self cleansing velocity.

(9) The layout of house drainage system should permit easy cleaning and removal of obstructions.

(10) The materials of pipes should comply with the standard requirements. They should be non-absorbent and no such substance should be given off to pollute water from chemical leach.

(11) The provisions of ventilation of soil pipes, rainwater pipes, waste pipes etc. should be properly studied and provision should be made in the design to provide them.

(12) The rainwater from terrace is collected from roofs and it is allowed to flow freely on the road and thus leads to water logging. To avoid this water should be

(13) The sewage from each house should be connected as possible after its formation.

(14) The size of barrel screen should be such that not overflow at the time of maximum discharge.

DRAWING PLAN OF RECEIVING

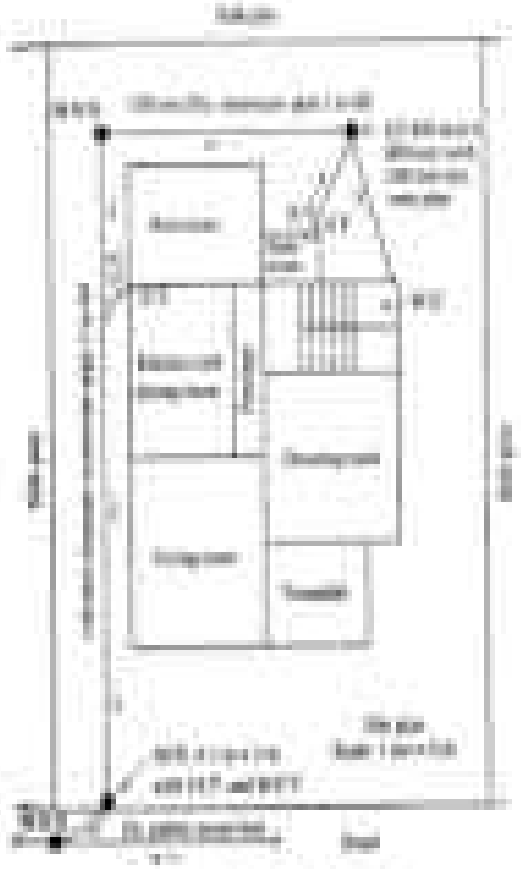
It is necessary to prepare the detailed plans showing the proposed house drainage system and to get it approved or sanctioned from the competent authority. Following points should be noted.

(1) The site plan of the building should be drawn to the convenient scale and it should show all public sewers as well as the house drain (Fig. 17.1).

(2) The longitudinal section of proposed sewer line should show diameter, slopes in a convenient scale (Generally the longitudinal sections of drains greater than 150 mm in diameter drawn).

(3) The longitudinal sections should show diameters, gradients, invert levels, ground levels, depths of cutting, types of inspection and manholes, cover and gradients (Typical one, as shown Fig. 17.2).

(4) The position of gullies and it should be clearly shown in the plan and longitudinal sections of drains. It is advised to join the house drain to manhole on gully cover.



Drainage plan of a building

Fig 1.2

LAYOUT OF SANITARY BLOCKS IN RESIDENTIAL BUILDING

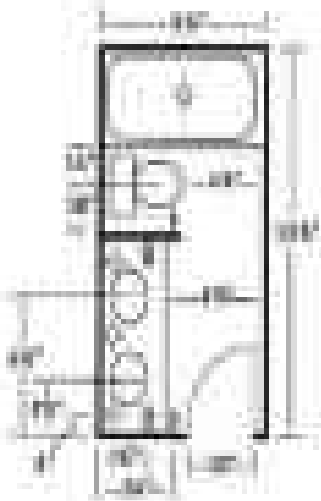
The scale of provision of sanitary facilities in a building will be dictated by the nature and size of the building, the overall building occupancy, gender ratio and particular patterns of use. These factors should be considered alongside the discovery of building every month to contribute the range, frequency and type of facilities that will provide access for all

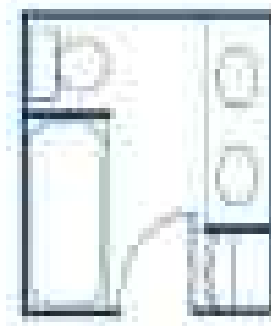
The number and range of sanitary appliances should be established at an early stage in the design process and should involve consultation with users as well as with the local planning, building control and environmental health, and relevant licensing authorities, where applicable.

The quality rules should take account of the likely proportion of males and females but also acknowledge the fact that the physiological and social reasons the Multi-

[illegible] Association recommends the following ratio of provision: Number of male urinals: one number of male water c.c. : maximum number of female cubicles

The purpose of use of a building will affect the demand on sanitary facilities and may influence the number, type and location of facilities provided. In an office, for example, the toilets are likely to be used almost intermittently throughout the day. By contrast, the toilets in an assembly building, such as a theatre, cinema, or entertainment arena will be assessed by a large number of people in a very short time frame such as immediately before or after the performance or during the interval. In this case, the number of toilets should be based on the maximum number of people likely to require the facilities at any particular time.





Layout Of Sanitary Blocks
Fig 1.2

PLUMBING ARRANGEMENT IN A MULTI STOREY BUILDING
DISTRIBUTION SYSTEM

There are four basic method of distribution of water in a multi-storeyed buildings

(i) Direct supply from mains or distributary type and the flow is the

Water is used as fully supplied by overhead tanks.

(ii) Direct Pumping System.

(iii) Hydro-pneumatic System.

(iv) Overhead / gravity Distribution.

Direct Supply System:-

[illegible] a set point when adequate pressure is available round the clock at the topmost floors. With limited pressure available in most city mains, water from direct supply is normally not available above three floors. Water is pumped directly into the distribution system without the aid of any overhead tanks, except for flushing purposes. The pumps are controlled by a pressure switch installed on the line, normally a jockey pump of smaller capacity installed which meets the demand of water in night & switches over to the operating cycle during hrs consumption and the main pump starts when the demand is greater. The start and stop operations are accomplished by a set of pressure switches installed directly on the line, in some installations, a timer of the pump

Direct Supply System
Fig [ ]

ADVANTAGES OF DIRECT PUMPING SYSTEM

[illegible] pumping system are suitable for buildings where constant amount of pressure and water is always necessary. These buildings are all normally tall buildings like [illegible] commercial complexes, large supply for air conditioning, cooling towers, industries.

(v) The system depends on a constant and reliable supply of power. Any failure in the power supply would result in a breakdown in the water supply system.

(vi) The system effectively the requirements of overhead tanks for domestic purposes except for building and massive architectural types.

Hydro pneumatic System:

(i) Hydro pneumatic system is a variation of direct pumping system. In an open pneumatic vessel is installed on the line to regulate the operation of the pumps. The vessel is arranged to consist of approximately half the capacity of water. The pumps operate, the incoming water in the vessel compresses the air on top. When a predetermined pressure is reached in the vessel, a pressure switch installed on the vessel switches off the pumps. As water is drawn out the system, pressure falls and the vessel starting the pump at preset pressure. The air in the pneumatic tank slowly reduced as it dissolves in distribution in water and leakages from pipe lines. An air compressor is also necessary to feed air into the vessel so as to maintain the required air water ratio.

(ii) There are various types of motors available in the market and the designer has to select the system according to the needs of each application.

(iii) Hydro pneumatic system generally eliminates the need for an over head tank and may supply water at a much higher pressure than available from overhead tanks particularly on the upper floors, resulting in more distribution of water at all floors.

Overhead Tank Distribution

(i) This is the most common of the distribution system adopted in various type of buildings.

(ii) The system comprises pumping mains in sump or wells of overhead tanks placed at the top most location of the buildings.

SANITARY FIXTURES

Various of buildings various types of sanitary fittings are required to collect the wasting water from the building.

The fittings can be classified as below

(A) Kitchen Fittings

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

(B)Bath Fittings

- [illegible]
- [illegible]
- [illegible]

All type of sanitary fittings should be fixed against the structural wall, so that the buildings can be ventilated with light and air. The floor and wall around should be non-absorbent with a proper angle to the pipelines.

FLUSHING CISTERN

There are many kinds flushing system (cisterns) and valves, all the time.

Here are six basic variations of flushing cisterns. High level cisterns are intended to operate with a minimum height of 120 cm between the top of the pan and the underside of the cistern. Low level cisterns are intended to operate at a height not more than 30 cm between the top of the pan and the underside of the cistern.

Cisterns may be of cast iron, glazed earthenware, glazed fireclay, stone or pressed steel or any other impervious material.

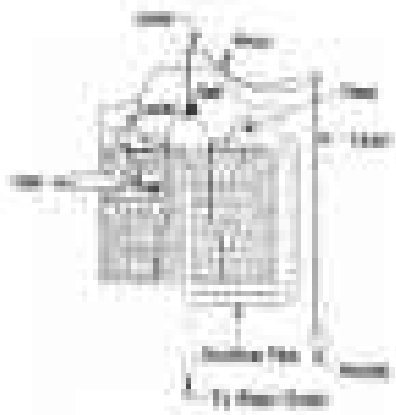


Fig 17.4

Two common types of cisterns are

(c) [illegible]

(d) [illegible]

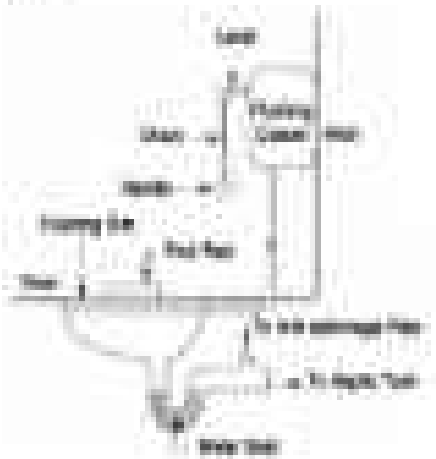
[illegible]

The inlet is kept near the water pipe, the outlet end of which is slightly above the water level. When the chain is pulled the ball is lifted causing the water to spill over the water pipe and starting the siphonic action due to which the whole water flushes through the water seal. Refer the water closet.

Due to shortage in the water supply, there has arisen demand to reduce the quantity of water consumption. All flushing cisterns manufactured and working in the Building Offices, discharge their full quantity of water even for small purposes or for which small quantity of water will suffice for the purpose.

WATER-CLOSET

This is a sanitary appliance to connect the human excreta directly with the underground sewer pipe by means of a trap.



Water Closet
Fig 17.3

The water closets are classified as follows:

(A) SQUATTING TYPE OR INDIAN TYPE

(i) [illegible]

(ii) [illegible]

(iii) [illegible]

(iv) [illegible]

[illegible] shows the section through an [illegible] type water closet. The w [illegible] is manufactured in two different patterns, a [illegible] type [illegible]

The [illegible] is provided with an integral flushing rim of [illegible] type. The inside of the bottom of the pan is [illegible] sufficient slope towards the outlet for the quick disposal during flushing.

There are inside of [illegible] basin also. The basin portion is glazed to make it easy to cleaning. The pan is connected to the flushing cistern by means of flushing pipe. The top of the trap is connected to the anti-siphon or vent pipe.

Figure shows the general view of an [illegible] type water closet.

Figure shows the section through a [illegible] which is most commonly used in high class buildings. It is provided with a wide flushing rim and P [illegible] trap. It is very good construction in which the pan and trap are not separate. It is provided with an inlet hole or supply hose for connecting to the flushing pipe. It may be provided with P and S trap as desired. These types of water closets requires less space than squatting pattern of pan water closet. Flushed by one hand pattern, have a slight objection water closets are very popular.

Hand flush cisterns are one piece construction, each is provided with non-flushing bottom and this side for fixing it on the wall. At the bottom an outlet hole is provided for connecting it to the trap. The inside surface is regular and smooth for ensuring efficient flushing. The bottom of the cistern is provided a bit outflowed slope from the front towards the outlet for efficient drainage of the cistern. Flush type cistern are also provided with flushing rim which is connected by flushing pipe to the flushing cistern. Figure shows a hand type cistern.

Various sizes and shapes of urinals are manufactured either as a urinal or as a range of two or more and are used in public places such as cinema halls, restaurants, railway stations, offices etc.

The [illegible] type urinals are mostly used in [illegible] latrines.

REQUIREMENTS OF SANITARY FITTINGS

The requirements of sanitary fittings should be kept in by [illegible] and the requirements type of fittings is

TRAPS

Trap [illegible] provided in the sanitary fittings [illegible] pipes from various [illegible] by retaining in the bottom through [illegible] remaining pipes. If there passage is not checked by some suitable device. This device which are used to stop the escape of foul gases inside in [illegible] the [illegible] are known as traps. The traps generally consists of a bend tube which provides a water

seal between the atmosphere and the sewer gases. The efficiency of this trap depends on the depth of water seal, deeper the seal more efficient will be the trap.

The following are the requirements of a good trap

(i) It should be made of non-absorbent material.
(ii) It should provide sufficient depth of water seal (about 50 mm) having large surface area.
(iii) It should be self-cleaning and should not obstruct the flow of sewage.
(iv) It should be provided with access door for cleaning.

The water seal of the traps can be broken due to the following conditions—

(i) If there is any crack in the bottom of the seal or the pipe is broken.
(ii) If the siphonage or back pressure in the sewer will evaporate the water seal.
(iii) If due to blockage or any other reason there is an increase in the pressure of the sewer gases it will pass through the water seal.
(iv) If partial vacuums are created in the sewer flushes it will suck up the seal water. To avoid the breakage due to this reason the pipe connecting the trap and the soil pipe should be connected to the vent pipe.

TYPES OF TRAPS

The following are the types of traps most commonly used.

(i) 'P', 'Q', and 'S' TRAPS –

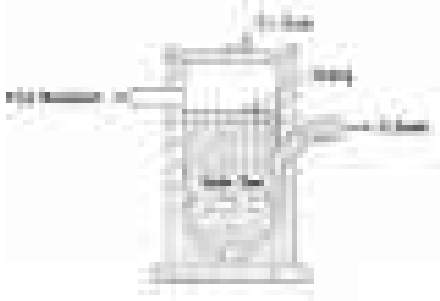
These traps are classified according to their shape, as shown in Fig. Fig. They essentially consist of a U- tube which allows water acting as a seal between the soil pipe atmosphere.

(a) 'P' trap (b) 'Q' trap (c) 'S' trap

Fig.17.1

(b) Gully trap:-

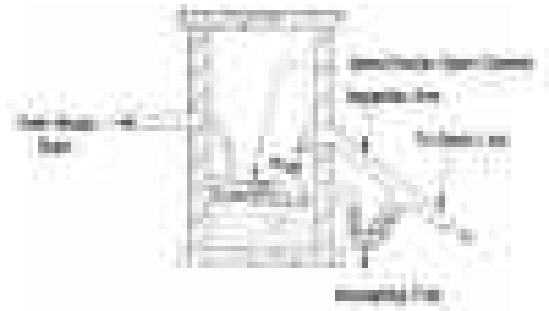
This trap is provided at different places in the drain pipes. Waste water from



Gully Trap
Fig. [7.7]

(c) An intercepting trap

The sewage flow in any house gets in sewer system which carry sewage from



An intercepting trap
Fig.[7.8]

(d) Anti-D trap:-

[illegible] and [illegible] are largely used for baths, sinks and showers. In such cases they are made with enlarged ends so that the next pipe may be snugly fitted into this. A deep seal trap is also sometimes used in the drainage. These traps are made of various circular sections. [illegible] pipes are improvements over the above traps which are made for Mr. Mulliyar of

England. By a series of experiments Mr. Mullyar found that the diameter of water movements of the sludge from the trap can be prevented by re-shaping the trap that the water [illegible] continued and the water is kept sweet. This trap also prevents siphonic action. The water [illegible] in the trap is reduced to a level to the removal of all refuse, whilst the water being larger prevents the pipe from filling full and causing siphonic action.

(3) Anti-siphonic trap –

There are several types of anti-siphonic traps in the market which are also called re-walled trap. These traps avoid the connection to the vent pipe and reduce the expensive work. Lincoln trap which is more common. The construction of this trap is such that when water seal is subjected to the pull due to the siphonic action, the heavier atmospheric pressure on the side will [illegible] the water down and the air can pass from it. **[illegible]**

FIXING AND JOINING OF NEW ACCESSORIES.

Most water and waste pipes can be embedded in the walls or floors or can be fixed to them. When they are embedded no fixing devices are required. But for ease in repair and maintenance usually they are fixed to the outside of the walls. For fixing these special type of brass are required. It is the most common type of fixing practiced for fixing galvanised pipes to walls. I have to advise the [illegible] fixed the pipe in a workmanlike manner. Initially beneath the socket and hold pipe for securing to the face of the face of the structure. When they are fixed, they present a neat appearance.

The jointing of new accessories are done as follows. First gasket of hemp rope saturated with [illegible] jointing compound is caulked about 2.5 cm depth. Then the space between the collar and plain end is packed with stiff mixture of cement. Figure shows the method of jointing.

When fixing and jointing of pipes and accessories care to be taken for some [illegible]. This is done by checking the whole work in sections and proving each section also by test.

TESTS FOR PIPE FITTINGS

Several types of materials which are used in the construction of sewer pipes

[illegible] are essential components. Land [illegible] which [illegible] etc. All these essentials are discussed in the construction of pipes required in the house drainage. In the house drainage works many works, different essential kind and new pipes are used.

SYSTEMS OF PLUMBING:

Following are the main systems of plumbing for the building drainage.

(a) TWO PIPE system:

This the most common type of system used in India. Here pipelines are fitted whatever where it is not possible to do the house directly. In this system two pipes are provided. One pipe collects the foul and sullage waters, whereas the second pipe collects the rainfall water from kitchen, bathrooms, house washings and rain water. Etc. The soil pipes pipes carrying the soil wastes are directly connected to the drain, whereas the waste pipes pipes carry rainfall waters are connected through the trapped gully. All the traps used in this system are fully ventilated.

(b) ONE - PIPE system:

In this system only one main pipe is provided which collects both soil waste as well as rainfall and waste from the building. The main pipe is directly connected to the drainage system. If the system is provided in multi storeyed building the accessory fittings of various floors are placed one over the other, so that the waste water discharged from the different floors can be carried through short branch drains. Figure shows the line diagram of this system.

All the W.C. basin, urinal, etc., are fully ventilated and connected to the ventilation pipe. But all gully traps and waste pipes are completely dispensed with.

(c) Single stack system:

This is similar to single pipe system. The only difference being that no ventilation is provided even in the single one.

(d) SINGLE STACK PARTIALLY VENTILATED SYSTEM:

This system is an advanced one over pipe and single stack system. In this system only one pipe is provided to collect all type of waste water load as well as ventilation. A ventilated pipe is provided for ventilating only the water closet traps.

Now a days in modern multi storeyed building one pipe system is more economical. Ideal one in low cost. All features of this system discussed that the

[illegible] from the appliance to the mask through branch is connected to [illegible] at the [illegible] changes of flow front of direction, transmitted a plug of water is formed immediately at the junction, which depends upon the rate of change of direction and size of branch. This gives rise to marginal pressures at the walls. So the inner flows of the building and connections it breaks the water mask of the various appliances.

The function of the sensors is to prevent the formation of the plugs of water in the critical mask and to apply a correction of water and so of low specific gravity. The sensors are provided at every flow:

(i) [illegible] of water to various sanitary fittings

(ii) [illegible] of water water from various sensor fittings

(iii) [illegible] of rain water from roofs, lawns and paved parts of buildings.

The fittings of sanitary appliances in the mask, flows and other places and their [illegible] play in [illegible] by [illegible] for their proper functioning. Arrangements are provided at the foot of the mask to separate air and water to avoid [illegible] pressure. Each of these fittings can be safely used up to 12 storeys. Where as a single mask system without these fittings can be used up to 3 storeys.