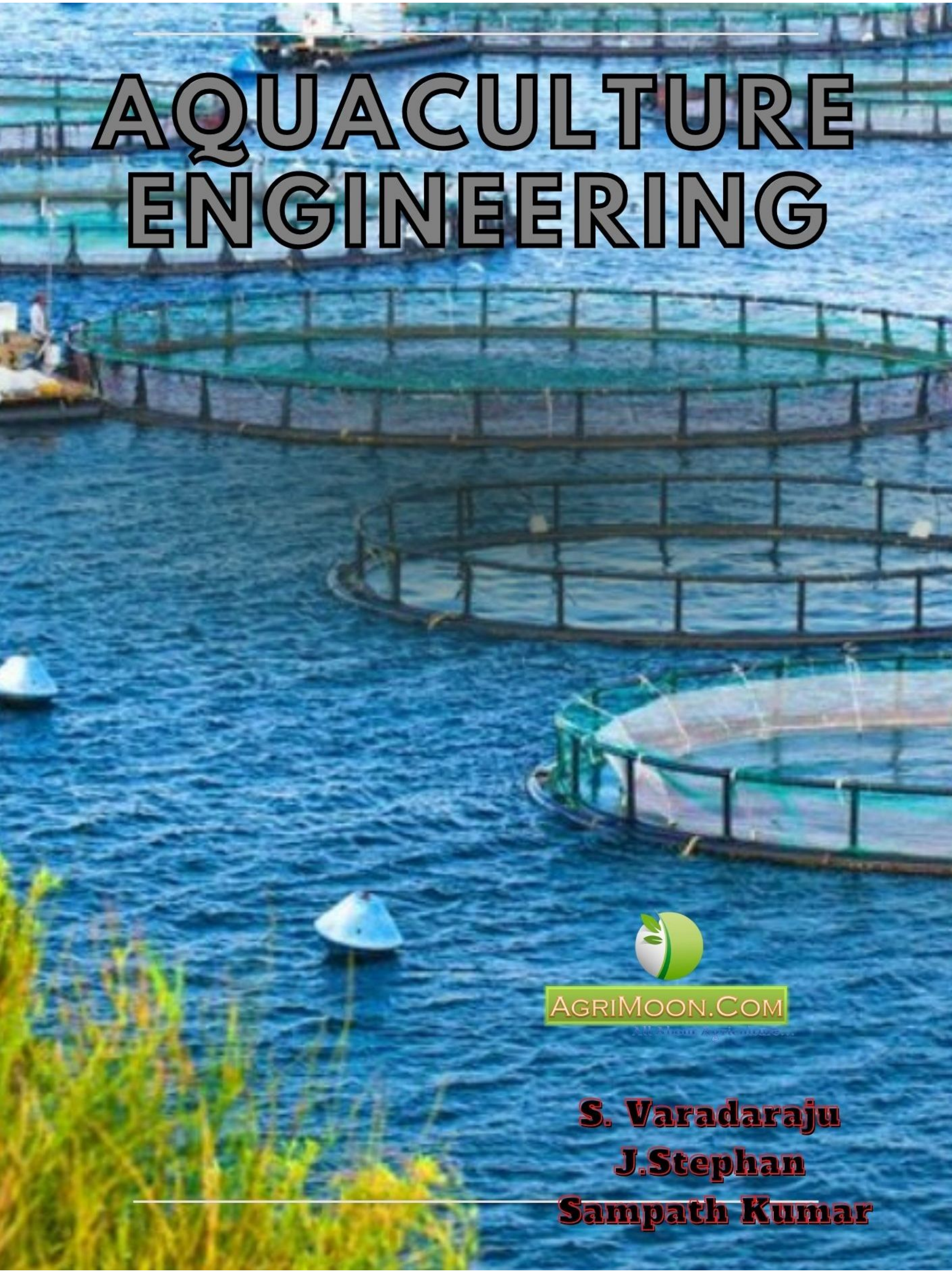

AQUACULTURE ENGINEERING

AgriMoon.Com

S. Varadaraju

J.Stephan

Sampath Kumar

Aquaculture Engineering

Author

S. Varadaraju
J.Stephan
Sampath Kumar

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Unit-1 Surveying

Unit 1 - Expected Learning Outcome

- Basic principles of surveying, classification of surveying, instruments used for chaining.
- Compass surveying, understanding concept of leveling and elevations and plane table surveying.
- Contour surveying and preparation of topographic map.

Definition

Surveying is the art of determining the relative positions of points on above or beneath the surface of the earth by means of direct or indirect measurement of distance, direction and elevation. It is also includes the art of establishing points by predetermined angular and linear measurements. The purpose of survey is to prepare plan or map so that it may represent the area on a horizontal plane.

Principles of surveying

The fundamental principles of survey are based on two aspects.
1)Location of a point by measurement, from two points of references.
2) Working from whole to part.

Location of a point by measurement from two points of references

The relative positions of the points to be surveyed should be located by measurement from at least two points of reference, the positions of which have been already fixed.

Let P and Q be the reference points on the ground. The distance PQ can be measured accurately and the relative positions of P and Q can be plotted on the sheet to some scale, using these reference points other points can be located.

- The distance PQ is known, measure the distance QR and PR. The point R can beplotted by swinging the two arcs to the same scale to which PQ has been plotted. This principle is very much used in chain surveying.
- A perpendicular line can be dropped on the reference line PQ and the length PS and SR is measured. This principle is used for defining details.
- Using the distance QR and the angle PQR, the point R can be plotted. This principle is used in traversing.
- Using the angle PQR and RPQ the position of R can be plotted. This principle is very much used in triangulation and this method is used for very extensive work.
- Angle PQR and the distance PR can be used for plotting of R. This principle used in traversing is of minor utility.

Working from whole to part

It is very essential to establish first a system of control points and to fix them with higher precision. Minor control points can be established by less precise methods. The idea of working in this way is to prevent the accumulation of errors and to control and localize minor errors, which otherwise would expand to greater magnitude if the reverse process is followed thus making the work uncontrolled at the end.

Classification of surveying

Primarily surveying can be divided into two classes

Plane surveying: Is the type of surveying in which the mean surface of the earth is considered as a plane surface and the spheroidal shape is neglected. All triangles formed by survey lines are considered as plane triangles. The level lines are considered as straight and all plumb lines are considered as parallel.

Geodetic surveying: Is the type of surveying in which the shape of the earth is taken into account. The lines lying on the surface are considered as curved lines. The triangles formed by survey lines are considered as spherical triangles. All Geodetic survey includes the work of large magnitude and high degree of precision.

Classification of surveying

Classification based upon the nature of the field of survey

- Land surveying
- Marine or Hydrographic surveying
- Astronomical surveying

Land surveying:

Land surveying is subdivided into three types.

- *Topographical surveying*: This consists of horizontal and vertical location of certain points by linear and angular measurement and is made to determine the natural features of a country such as rivers, streams, lakes, hills etc., and such artificial features as roads, railways, canals, towns and villages.
- *Cadastral surveys*: Cadastral surveys are made incident to the fixing of property lines, the calculation of land, area or the transfer of land property from one owner to another. They are also made to fix the boundaries of municipalities, state and federal jurisdictions.
- *City surveying*: This survey is useful in the construction of streets, water supply system, sewers and other works.

Marine or Hydrographic survey:

This survey deals with bodies of water for purpose of navigation, water supply, harbor works or for the determination of mean sea level. The work consists in measurement of discharge of streams, making topographic survey of shores and banks, taking and locating soundings to determine the depth of water and observing the fluctuations of the ocean tide.

Astronomical survey:

Astronomical survey is to determining the absolute locations of any point or the absolute location and direction of any line in the surface of the earth.This consists in observations to the heavenly bodies such as the sun or any fixed star.

Classification of surveying

Classification based on the Instruments

- Chain surveying
- Theodolite surveying
- Traverse surveying
- Triangulation surveying
- Tacheometric surveying
- Plane table surveying
- Photographic surveying
- Aerial surveying

Chaining:

Chaining is the term, which is used to denote the measuring distance either with the help of chain or a tape and is the most accurate method of making direct measurements.For a work of ordinary precision a chain can be used, but for higher precision a tape or special bar can be used.

Instruments for chaining:

- Chain or Tape
- Cross staff
- Ranging rod
- Arrows
- Pegs
- Plumb bob
- Field book, pencil etc.,

Chain:

Chains are formed at straight links of galvanized mild steel wire bent into rings at the ends and joined each other by three small circular or oval wire rings. These rings offer flexibility to the chain. The ends of the chain are provided with brass handle at each end with swivel joint, so that the chain can be turned without twisting. The length of a link is the distance between the centers of two consecutive middle rings, while the length of the chain is measured from the outside of one handle to the outside of the other handle.

Following are the various types of chain

- Metric chain
- Surveyor's or Gunter's chain
- Engineer's chain
- Revenue chain
- Steel band or Band chain

Chaining: Instruments used for chaining

Types of chain

Metric chain

Metric chains are commonly used in now a days. Metric chains are generally available in lengths of 5, 10, 20 and 30 m. To enable the reading of fractions of a chain without much difficulty, tallies are fixed at every meter length for chains of 5 and 10 m length. Tallies are provided at every 5 m length, for the chain of 20 and 30 m length. Small brass rings are provided at every meter length. To facilitate holding of arrows in position with the handle of the chain, a groove is cut on the outside surface of the handle. The tallies used for making distances in the metric chains are marked with the letters "m" in order to distinguish them from non metric chains.

Gunter's chain or Surveyors chain

A Gunter's chain or surveyor's chain consists of 100 links of 66ft long. Each link being 0.66 ft. or 7.92 inches long. It is used for land measurement.

Engineer's chain

Engineer's chain is 100 ft long and consists of 100 links. Each link is being 1 ft long.

Revenue chain

The Revenue chain is 33 ft long and consists of 16 links, each link being 2 1/16 ft long. This chain is mainly used for measuring fields in cadastral survey.

Steel band or Band chain

Steel band or Band chain consists of a long narrow strip of blue steel of uniform width of 12 to 16 mm and thickness of 0.3 to 0.6mm. Metric steel bands are available in length of 20 or 30 m.

During continuous use the length of a chain gets altered. Its length is shortened chiefly due to the bending of the links. Its length is elongated either due to stretching of the links and joints opening out of the small rings or due to the wear of wearing surface. For accurate work it is necessary to test the length of the chain from time to time and make adjustments in the length.

Tapes:

Tapes are used for more accurate measurements. They are classified according to the material of which they are made.

- Cloth tape or Linen tape.
- Metallic tape.

- Steel tape.
- Invar tape.

Cloth Tape or Linen tape

Cloth tapes are made up of closely woven linen, 12 to 15 mm wide, varnished to resist moisture. They are light and flexible, and may be used for taking comparatively rough and subsidiary measurement such as off sets. Cloth tapes are available in length 10, 20, 25 and 30 m (30, 50, 66, 100 ft). The end of the tape is provided with small brass ring whose length is also included in the total length of the tape.

It is not used for accurate measurements because

- It is easily affected by moisture or dampness
- The length gets altered by stretching
- It is not strong
- It is likely to be twist.

Metallic tape

A metallic tape is made up of varnished strip of water proof linen inter-woven with small brass, copper or bronze wires and does not stretch as easily as a cloth tape. Due to this reason it is used for some accuracy of work. Metallic tapes are made in length of 2, 5, 10, 20, 25, 30 and 50 m.\

Steel tape

Steel tapes vary in quality and accuracy of graduation, but even a poor steel tape is generally superior to a cloth or metallic tape for most of the linear measurements that are made in surveying. A steel tape consists of a light strip of width 6 to 10 mm and is more accurately graduated. Steel tapes are available in lengths of 1, 2, 10, 20, 30 and 50 m.

Invar tape

Invar tapes are used mainly for linear measurements of a very high degree of precision, such as measurement of base lines. The invar tape is made of alloy of nickel and steel, and has very low co-efficient of thermal expansion. Invar tapes and bands are more expensive. Invar tapes are normally 6 mm wide and are available in lengths of 20, 30 and 100 m.

Ranging rods

Ranging rods have a length of 2 or 3 m. It is made up of well seasoned wood or steel conduit. Ranging rods are having circular or octagonal shape with 3 cm cross section. They are shod at the bottom with a heavy iron point. The ranging rods are painted alternatively with two colours (Black and White or Red and White).

Ranging rods are used to range some intermediate points in the survey line. These rods are can also be used for rough measurement of short length.

Arrows:

An arrow is made up of steel wire. It is inserted into the ground after every chain length measured on the ground. It consists of 50 mm loop at top and 400 mm length.

Pegs:

Wooden pegs are used to mark the positions of the stations or terminal points of survey lines. They are made of stout timber. These are available about 2.5 to 3 cm square and 15 cm length. They are driven in the ground with the help of a wooden hammer and kept about 4 cm projection above the ground.

Plumb bob:

While chaining along a sloping ground, a plumb bob is required to transfer the points to the ground. It is used as centering aid in the theodolites, compass, plane table and a variety of other survey instruments.

Ranging, types of ranging

Ranging of survey line:

While measuring the length of a 'Survey line' or 'Chain line', the chain or tape must be stretched straight along the line joining its two terminal stations. If the length of the survey line is less than the length of the chain, there will be no difficulty in doing so. However, if the length of survey line exceeds the length of the chain, some intermediate points will have to be established in line with the two terminal points before chaining is started. The process of fixing or establishing such intermediate points is known as Ranging.

Methods of Ranging:

There are two methods of ranging

- Direct ranging
- Indirect ranging

Direct ranging:

Direct ranging is done when the two ends of the survey lines are intervisible. In such cases ranging can either be done by eye or through some optical instruments such as line ranger or a Theodolite.

Ranging by eye:

Let A and B be the two points at the ends of a survey line. One ranging rod is erected at the point 'B' while the surveyor stands with another ranging rod at point

'A' holding the rod at about half meter length. The assistant then goes with another ranging rod and establishes the rod at a point approximately in the line with AB, at a distance not greater than one chain length from 'A'. The surveyor at 'A' then signals the assistant to move transverse to the chain line, till he is in line with A and B. Similarly other intermediate points can be established.

Indirect ranging or Reciprocal ranging

Indirect ranging is resorted to when both the ends of the survey line are not intervisible either due to high intervening ground or due to long distance between them. In such a case, ranging is done indirectly by selecting two intermediate points M1 and N1 very near to the chain line in such a way that from M1 both N1 and B are visible, while from N1 both M1 and A are visible.

Two surveyors station themselves at M1 and N1 with ranging rods. The person at M1 then directs the person at N1 to move to a new position N2 in line with M1B. The person at N2 then directs the person at M1 to move to a new position M2 in line with N2 A. Thus the two persons are now at M2 and N2 which are near to the chain line than the positions M1 and N1. This process is repeated till the points M and N are located in such a way that the person at M finds the person at N in line with MB and the person at N finds the person at M in line with NA. After having established M and N other points can be fixed by direct ranging.

Chaining - Chaining on uneven or sloping ground

Two chain men are required for measuring the length of a line, which is greater than a chain length. The more experienced of the chainmen remains at the zero end or rear end of the chain and is called the follower. The other chainman holding the forward handle is known as the leader.

Unfolding the chain

To unfold a chain, the chainman keeps both the handles in the left hand and throws the rest of the portion of the chain in the forward direction with his right hand. The other chainman assists in removing the knots, etc., for making the chain straight.

Folding the Chain

Bring the two halves of the chain so as to lie along each other by pulling the chain in the middle. Commencing from the middle take two pairs of links at a time with the right hand and place them obliquely across with the left hand.

Lining and marking

The follower holds the zero end of the chain at the terminal point while the leader proceeds forward with the other handle in one hand and a set of 10 arrows and a ranging rod in the other hand. When he is approximately one chain length away, the follower directs him to fix his pole in line with the previous pole. When the point is ranged, the leader makes a mark on the ground, holds the handle with both the hands and pulls the chain so that it becomes straight between the terminal point and the point fixed. The leader then puts an arrow at the end of the chain, and then the leader swings the chain slightly out of the line and proceeds further with the handle in one hand and the rest of the arrows and the ranging rod in the other hand. The follower also takes the handle in one hand and ranging rod in the other hand and follows the leader till the leader has approximately travelled one chain length. The follower puts the zero end of the chain at the first arrow fixed by the leader and ranges the leader who in turn stretches the chain straight in the line and fixes the second arrow in the ground and proceeds further.

To get the horizontal distance in sloping ground, there are two methods

- Direct method
- Indirect method

Direct method or stepping method

In this method the distance measured in small horizontal stretches or steps. The follower holds the zero end of the tape at A, the leader select any suitable length l_1 of the tape and moves forward. The follower directs the leader for ranging. The leader pulls the tape tight, make it horizontal and the point 1(one) is transferred to the ground by plumb bob or by using drop arrow. The procedure is repeated. The total length "D" of the line is then equal to $l_1+l_2+l_3+$……………………It is more convenient to measure down-hill than to measure uphill. The lengths l_1, l_2 etc., to be selected depend on the steepness of the slope. Steeper the slope, lesser the length and vice versa.

Indirect method

(i) In the case of regular slope the sloping distance and sloping angle can be measured and using this horizontal distance can be calculated.

L_1 be the measured inclined distance between AB.
θ_1 = Slope of the line AB with horizontal
The horizontal distance $D_1 = L_1 \cos \theta_1$
Similarly for BC = $D_2 = L_2 \cos \theta_2$
Total length = D_1+D_2

(ii) Difference in level Measured

The Difference in the level between the points is measured with the help of a levelling instrument and the horizontal distance computed using the below formula

Chain surveying

Definition
Chain surveying is the type of surveying in which linear measurements are made in the field. This type of surveying is suitable for surveys of small extent in open ground to secure the data for exact description of the boundaries of piece of land.

Principles of Chain surveying
The principle of chain survey or chain triangulation is to provide a skeleton or frame work consisting of number of connected triangles, as a triangle is the only simple figure that can be plotted from the lengths of its side measured in the field.

- ***Survey stations:*** A survey station is the prominent point on the chain line. If it is at the beginning or at the end of the chain line is known as Main survey station.
- ***Survey lines:*** The lines joining the survey stations are called as survey lines. The lines joining the main survey stations are called as main survey lines. The biggest of the main survey lines is called as base line.
- ***Check lines:*** Check lines or proof lines are the lines which are run in the field to check the accuracy of the work. The length of the check line measured in the field must agree with its length on the plan. A check line may be laid by joining the apex of the triangle to any point on the opposite side or by joining two points on any two sides of a triangle.

Instruments used for setting out right angles
There are several types of instruments used to set out a right angle to a chain line, the most common being Cross staff, Optical square and Prism square.

There are three types of cross staff namely

- Open cross staff
- French cross staff
- Adjustable cross staff

Open cross staff
It is the simplest instrument used for setting out right angle. It consists of either a frame or box with two pairs of vertical slits and is mounted on a pole shod for fixing in the ground. The two pairs of vertical slits give two lines of sights at right angels to each other.

French cross staff
It consists of a hollow octagonal box. Vertical sight slits are cut in the middle of each face, such that the lines between the centres of opposite slit makes an angle

of 450 with each other. It is possible to set-out angles of either 450 or 900 with this instrument.

Setting out right angle by using cross staff

The cross staff is set up at a point on the line from which the right angle is to run, and then turned until one line of sight passes through the ranging rod at the end of the survey line. The line of sight through the other two vanes will be a line at right angles to survey line and a ranging rod may be established in that direction.

Conditions to be fulfilled by survey stations/survey lines

- Survey stations must be mutually visible.
- Survey lines must be as few as possible so that the frame work can be plotted conveniently.
- The frame work must have one or two base lines. If one base line is used, it must run along the length and through the middle of the area. If two base lines are used, they must intersect in the form of letter 'X'
- The lines must run through as level ground as possible
- The main lines should form well conditioned triangle
- Each triangle or portion of skeleton must be provided with sufficient check lines.
- As far as possible the main survey lines should not pass through obstacles.
- To avoid trespassing, the main survey lines should fall within the boundaries of the property to be surveyed.

Off-sets

An offset is the lateral distance of an object or ground feature measured from a survey line. By method of offsets, the point or object is located by measurement of a distance and angle from a point on the chain line when the angle of offset is 90°, it is called perpendicular offset or simply offset. When the angle is other than 90°, it is called oblique offset. Another method of locating a point is called the method of "ties" in which the distance of the point is measured from two separate points on the chain line such that the three points form, as nearly as possible an equilateral triangle.

Survey may be done in the following steps.

- Reconnaissance
- Marking and fixing survey station
- Running a survey lines

Reconnaissance

Before starting the actual survey measurements, the surveyor should walk around the area to fix best positions of survey lines and survey stations. During reconnaissance a reference sketch of the ground should be prepared.

Marking and fixing survey stations

After selected the survey stations, they should be marked to enable them to be easily discovered during the progress of the survey.

Running survey lines

After having completed the preliminary work, the chaining may be started from the base line. The work in running a survey line is two fold.

- to chain the line
- to locate the adjacent details

Basic Problems in chaining

To erect a perpendicular to a chain line from a point on it

I Method

AB is the chain line. It is required to erect a perpendicular to the chain line at point 'C' on it. Establish a point 'E' at a distance of 3m from 'C'. Take 10m tape and put the zero (0) end of the tape at 'E' and the 10m end at 'C'. The 5th and 6th meter marks of the tape are brought together to form a loop of 1m. The tape is now stretched tight by fastening the ends E and C. The point 'D' is thus established. Angle DCE will be 90°.

II Method

Select E and F equidistant from C (Fig (b)). Hold the zero end of the tape at E, and 10m end at F. Pick up 5m mark, stretch the tape tight and establish D. Join DC.

To drop a perpendicular to chain line from a point outside it

I Method

AB is the chain line. It is required to drop a perpendicular to a chain line AB from point 'D' out side it. Select any point 'E' on the chain line. With 'D' as center, and DE as radius, draw an arc to cut the chain line at F. Bisect EF at 'C' and then CD is perpendicular to chain line AB.

II Method

Select any point E on the line (Fig(b)). Join ED and bisect it at F. With F as centre and EF or FD as radius, draw an arc to cut the chain line in C, CD will be perpendicular to the chain line.

To run a parallel to chain line through a given point

I Method

AB is the chain line, C is the given point through which parallel line is to be drawn. Through 'C' drop a perpendicular CE to the chain line. Measure CE. Select any other point F on the line and erect a perpendicular FD. Make FD=EC. Join CD.

II Method

Select any point F on the chain line (Fig(b)). Join CF and bisect at G. Select any other point E on the chain line. Join EG and prolong it to D such that EG = GD. Join C and D.

In chain surveying, sometimes the chainman is unable to measure the distance between two points directly, due to obstacles. Hence it has to be found out by indirect measurements. Basically there are three types of obstacles

- Obstacle to ranging but not chaining
- Obstacle to chaining but not ranging
- Obstacle to both chaining and ranging

Obstacle to ranging but not chaining

In this type of obstacle, the ends are not intervisible and are quite common, except in a flat country.

AB is the line in which A and B are not visible from intermediate point on it. Through A, draw a random line AB1 in any convenient direction but as nearly towards B as possible. The point B1 should be chosen in such a way that B1 is visible from B and BB1 is perpendicular to the random line. Measure BB1. Select C1 and D1 on the random line and erect perpendicular C1C and D1D on it. Join CD and prolong.

Obstacle to chaining but not ranging

There are two types of obstacle in this case

- When it is possible to chain round the obstacle. E.g., pond.
- When it is not possible to chain round the obstacle. E.g., river

When it is possible to chain round the obstacle

Select two points A and B on either side (Fig(a)). Set out equal perpendiculars AC and BD. Measure CD; then CD=AB.

II Method

Set out AC perpendicular to the chain line (Fig(b)). Measure AC and BC. The length AB is calculated from the relation.

Obstacle to chaining but not ranging

When it is not possible to chain round the obstacle

I Method

Select point B on one side and A and C on the other side(Fig(a)). Erect AD and CE as perpendiculars to AB and range B, D and E in one line. Measure AC, AD and CE. If a line DF is drawn parallel to AB, cutting CE in F perpendicularly, then triangles ABD and FDE will be similar.

II Method

Erect a perpendicular AC and bisect it at D (Fig(b)). Erect perpendicular CE at C and range E in line with BD. Measure CE. Then AB = CE

Obstacle to both chaining and ranging

I Method

Building is the typical example for this type of obstacle.
Select two points A and B on one side of the obstacle. Erect perpendiculars AC and BD of equal length. Join CD and prolong it past the obstacle. Choose two points E and F on the line CD and erect perpendiculars EG and FH equal to that of AC or BD. Join GH and prolong it. Measure DE. BG = DE.

II Method

Select a point A and erect a perpendicular AC of any convenient length(Fig(b)). Select another point B on the chain line such that AB=AC. Join B and C and prolong it to any convenient point D. At D, set a right angle DE such that DE=DB. Choose another point F on DE such that DE=DC. With F as centre and AB as radius, draw an arc. With E as centre, draw another arc of the same radius to cut the previous are in G. Join GE which will be in range with the chain line. Measure CF. Then AG=CF.

Compass surveying

Introduction

Chain surveying can be used when the area to be surveyed is comparatively small and is fairly flat. However, when large areas are involved methods of chain surveying alone are not sufficient and convenient. In such cases it becomes essential to use some sort of instruments which enables angles or direction of survey lines to be observed. In engineering practice, following are the instruments used for the measurements.

Instruments for the direct measurement of direction

- Surveyor's compass
- Prismatic compass

Instruments for measurement of angles

- Sextant
- Theodolite

Introduction

- **Traverse survey**
- Traversing is that type of survey in which number of connected survey lines form the frame work, and the direction and lengths of the survey lines are measured with the help of an angle measuring instrument and a tape

respectively. When the line from a circuit which ends at the starting point it is known as a closed traverse, if the circuit ends from elsewhere, it is said to be open traverse.

Bearing and angles

The direction of a survey line can either be established

- with relation to each other
- with relation to any meridian

The first one gives the angle between two lines, while second will give bearing of the line.

Bearing

Bearing of a line is its direction relative to a given meridian.

Angle

An angle is the difference in direction of two intersecting lines.

Systems of angular measurement

There are three systems of angular measurements

Sexagesimal system

1 Circumference = 600 degree

1 degree = 60’ (minutes)

1 minute = 60” seconds

Centesimal system

1 Circumference = 400” grade

1 grade = 100 c centigrade

1 centigrade = 100cc centi centi grade

Hour system

1 Circumference = 24” (hour)

1 hour = 60 minute

1 minute = 60 seconds

Meridian

A meridian is any direction. There are three meridians

- True meridian
- Magnetic meridian
- Arbitrary meridian

True meridian

True meridian through a point is the line, in which a plane passing through that point and the north and south poles, intersects with the surface of the earth. It, thus passes through the true north and south.

True bearing

True bearing of a line is the horizontal angle, which it makes with the true meridian passing through one of the extremities of the line.

Magnetic meridian

Magnetic meridian through a point is the direction shown by a freely flatting and balanced magnetic needle free from all other attractive forces. The direction of magnetic meridian can be established with the help of a magnetic compass.

Magnetic bearing

The magnetic bearing of a line is the horizontal angle, which it makes with the magnetic meridian passing through one of the extremities of the line.

Arbitrary meridian

Arbitrary meridian is any convenient direction towards prominent mark or signal, such as church spire or top of a chimney.

Arbitrary bearing

Arbitrary bearing of a line is the horizontal angle which it makes with any arbitrary meridian passing through one of the extremities of the line.

Whole circle bearing system and Reduced bearing system

The common systems of notation of bearings are

- The Whole Circle Bearing system (W.C.B) or Azimuthal system.
- The Quadrantal bearing system or Reduced bearing system**.**

Fore bearing, back bearing, conversion one bearing to other bearing

Fore bearing and Back bearing

The bearing of a line, whether expressed in WCB system or in Q.B system, differs according as the observation is made from one end of the line or from the other. If the bearing of line AB is measured from A towards B, it is known as forward bearing or Fore bearing. If the bearing of the line AB is measured B towards A is known as Backward bearing or back bearing. Since it is measured from backward direction.

Considering W. C .B system, From fig 1 Fore bearing of the line AB is θ, back bearing of line AB = Φ, evidently of Φ= θ +180° and From fig 2 the back bearing of CD is Φ and fore bearing is θ . Hence Φ = θ – 180°. In general it can be stated that B.B = F.B +__ 180°.Using plus sign when F.B is less than 180°. and minus sign when F.B is greater than 180°.

Consider the Reduced Bearing system. From Fig 3 the fore bearing of the line AB is N θ E and the back bearing of the line is S θ W. Similarly from the fig 4, the fore bearing is of the line CD is S θ W and back bearing is called to N θ E .Thus it can be staled that to convert the fore bearing to back bearing it is only necessary to change the cardinal points by substituting N for S, and E for W and vice versa, the numerical value of the bearing remaining same.

Calculation of angle from bearings

From fig (a) the included angle α between the lines AB and AC is $\theta_2 - \theta_1$ = Fore bearing of one line- fore bearing of the other line

It is possible when the bearing being measured from common point A

Fig (b) The angle $\alpha = (180° + \theta_1) - \theta_2$

Back bearing of previous line – Fore bearing of next line

Let us consider Reduced Bearing system

From Fig (a) both the bearings have been measured to the same side of common meridian, the included angle $\alpha = \theta_2 - \theta_1$,

In Fig (b) both the bearing have been measured to the opposite sides of the common meridian = $\alpha = \theta_1 + \theta_2$,

From Fig (c)both the bearings have been measured to the same side of different meridians and the included angle $\alpha = 180° - (\theta_2 + \theta_1)$

In Fig (d) both the bearings have been measured to the opposite sides of the different meridians and angle $\alpha = 180° + \theta_2 - \theta_1$.

In the case of traverse in which the included angles between successive lines have been measured the bearing of the lines can be calculated provided the bearing of line is also measured. Let α, β, γ, δ be the included angles measured clockwise from back stations and θ_1 be the measured bearing of the line A.B.

The bearing of the next line BC = Bearing of the line AB + included angle at 'B' +- 180°= $\theta_1 + \alpha + 180°$

The bearing of the line CD = Bearing of the line BC + included angle at C + 180°= $\theta_2 + \beta$ +_ 180°

The bearing of the line DE = Bearing of the line CD + included angle at D +_ 180° = θ_3 γ +_180°

The bearing of the line EF= θ_5 = Bearing of the line DE + included angle at E +_ 180° = $\theta_4 + \delta$ +_ 180°

To get the bearing of the next line, add the measured clockwise angles to the bearing of the previous line. If the sum is more than 180°,deduct 180°, if the sum is less than 180° add 180°

Theory of magnetic compass

Magnetic compass gives directly the magnetic bearing of line. The bearing may either be measured in the W.C.B system or R.B system.

The general principles of all magnetic compass depends upon the fact that, if a long, narrow strip of steel or iron is magnetized and is suitably suspended or pivoted about a point near its centre. So that it can oscillate freely about the vertical axis, it will tend to establish if self in the magnetic meridian at the place of observation.

The most essential features of a magnetic compass are
Magnetic needle - to establish the magnetic meridian

- A line of sight -To sight the other end of the line
- A graduated circle - Either attached to the box or to needle to read the direction of the lines
- A compass box - To house above parts
- A tripod - used to support the box

Following are the different types of compass

- Surveyor's compass
- Prismatic compass
- Transit or level compass

The prismatic compass

Prismatic compass is the most convenient and portable form of magnetic compass which can either be used as a hand instrument or can be fitted on a tripod. Prismatic compass having a magnetic needle is attached to the circular ring or compass card made up of aluminium a non magnetic substance. When the needle is on the pivot it will orient it self in the magnetic meridian. The line of sight is defined by the object vane and the eye slit both attached to the compass box. The object vane consists of a vertical hair attached to a suitable frame while the eye slit consists of a vertical slit cut into the upper assembly of the prism unit, both being hinged to the box. When an object is sighted the sight vanes will rotate with respect to the NS end of ring through an angle which the line makes with magnetic meridian. A triangular prism is fitted below the eyes slit, having suitable arrangement for focusing to suit different eye slits. The prism has both horizontal and vertical faces convex, so that magnified image of the ring graduation is formed. The 00 or 3600 reading is therefore engraved on the south end of the ring, so that bearing of the magnetic meridian is read as '0' with help of prism which is vertically above south end in this particular position. The readings increase in clockwise direction from 00 at south end to 900 at the west end, 1800 at north and 2700 at east end. If the instrument is not uses, the object vane can be folded on the glass lid which covers the top of the box. To sight the objects which are too high or too low to be sighted directly a hinged mirror capable of sliding over the object vane is provided and the objects sighted by reflection when bright objects are sighted dark glasses may be interposed into the line of sight.

The main advantage of prismatic compass is that both sighting the object as well as reading circle can be done simultaneously without changing the position of the eye.

Adjustment of prismatic compass

There are two types of adjustments

- Temporary adjustment
- Permanent adjustment

Temporary adjustment

Temporary adjustment consists of

- Centring
- Levelling
- Focussing the prism

Centring: Centring is the process of keeping the instrument exactly over the station. The centring is invariably done by adjusting the tripod legs. A plumb-bob may be used to judge the centring and it is not available, it may be judged by dropping a pebble from centre of the bottom of the instrument.

Levelling: If the instrument is a hand instrument it must be held in hand in such a way that the graduated disc is swinging freely and appears to be level as judged from the top edge of the case. Generally a tripod is provided with ball and socket arrangement with the help of which the top of the box can be leveled.

Focussing the prism: The prism attachment is slided up or down for focusing till the readings are seen to be sharp and clear.

Permanent adjustment:

Permanent adjustment are those adjustment which are done only when fundamental relation between the parts are disturbed.

Problems

1. Determine the values of included angles in the closed compass traverse ABCD, conducted in clock wise direction, given the following fore bearings of their respective lines.

Line Fore bearing
AB 40°
BC 70°
CD 210°
DA 280°

Included angle = Back bearing of the previous line - Fore bearing of the next line

A = B.B line AD – F.B of line AB= (280° -180°) - 40° = 60°
B = B.B of line AB – F.B of line BC= (40° + 180°) – 70 ° = 150°
C = B.B of line BC – F.B of line CD (70° + 180°)-120° = 40°
D = B.B of the line CD – F.B of line DA = (210° – 180) -280 + 360° = 110°

Check : (2n -4) * 90° = (2 x 4 - 4) x 90° =360°
A+B+C+D+E = 60° + 150° + 40° + 110° = 360°

Problems 2. The following angles were observed in clockwise direction in an open traverse, ∟ABC = 124° 15”, ∟BCD = 156° 30’, ∟CDE = 102°, DEF = 95°, and ∟EFG = 215° 45’
Magnetic bearing of the line AB was 241° 30’ what would be the bearing of the line FG
Bearing of the line BC = Bearing of the line AB+ ∟B + 180°
= 241° 30’ +124° 15’ -180° =185° 45’
Bearing of the line CD = Bearing of the line BC + ∟C+180°
= 185° 45’ +156° 30’-180° =162° 15’
Bearing of the line DE = Bearing of the line CD + ∟D+ 180°
= 162° 15’ + 102° – 180° = 84° 15’
Bearing of the line EF = Bearing of the line D E + ∟E + 180°
= 84° 15’ + 95° 15’ -180° =359° 30’
Bearing of the line FG = Bearing of the line E F + ∟F + 180°
= 359° 30’+215° 45’- 360° - 180° = 35° 15’

Levelling

Definition

Levelling is the branch of surveying the object of which is

- To find the elevation of given points with respect to a given or assumed datum.
- To establish points at a given elevation or at different elevations with respect to given or assumed datum. Levelling deals with measurement in a vertical plane.

Level Surface

A level surface is defined as a curved surface at which each point is perpendicular to the direction of gravity at the point. The surface of still water is truly level surface.

Level Line

A level line is a line lying on a level surface. It is normal to the plumb line at all points.

Horizontal Plane

Horizontal plane through a point is a plane tangential to the level surface at that point. It is perpendicular to the plumb line through the point.

Horizontal Line

It is a straight line tangential to the level line at a point. It is perpendicular to the plumb line.

Vertical Line

It is a line normal to the level line at a point. It is commonly considered to be the line defined by a plumb line.

Datum

Datum is any surface to which elevations are referred. The mean sea level offords a convenient datum world over and elevations are commonly given as so much above or below sea level.

Elevation

The elevation of a point on or near the surface of the earth is its vertical distance above or below an arbitrarily assumed level surface or datum. The difference in the elevation between two points is the vertical distance between the two level surfaces in which the two points lie.

Vertical Angle

Vertical angle is an angle between two intersecting lines is a vertical plane.

Mean Sea Level

Mean sea level is the average height of the sea for all stages of the tides. At any particular place it is derived by averaging the hourly tide heights over a long period of 19 years.

Bench Mark

Bench mark is a relatively permanent point of reference whole elevation with respect to some assumed datum is known. It is used either as a starting point for leveling or as a point upon which to close as a check.

Methods of levelling

There are three methods of levelling.

Barometric levelling

Trignometric levelling

Spirit levelling

Barometric levelling

Barometric levelling makes use of the phenomenon that the difference in elevation between two points is proportional to the difference in atmospheric pressure at these points. At a given point, the atmospheric pressure does not remain constant in the course of the day, even in the course of an hour. This method is therefore relatively in accurate.

Trignometric levelling

(Indirect levelling): Trignometric levelling is the process of levelling in which the elevation of points are computed from the vertical angles and horizontal distances measured in the field.

Spirit levelling or Direct levelling

It is the branch of levelling in which vertical distances with respect to a horizontal line may be used to determine the relative difference in elevation between two adjacent points.

Levelling instruments:

The instruments commonly used in direct levelling are

- A level
- A levelling staff

A level: The purpose of a level is to provide a horizontal line of sight. A level consists of the following four parts.

- A telescope – To provide line of sight
- A level tube – To make the line of sight horizontal
- A levelling head – To bring the bubble in its centre of run
- A tripod – To support the instrument

There are four types of level

- Dumpy level
- Wye (Y) level
- Reversible level
- Tilting level

Terms and abbreviations

Station

In levelling, a station is a point where the level rod is held and not where level is set up. It is the point whose elevation is to be ascertained or the point that is to be established at a given elevation.

Height of Instrument (H.I)

For any set up of level, the height of instrument is the elevation of plane of sight (line of sight) with respect to assumed datum. It does not mean that height of telescope above the ground where the level stands.

Back Sight (B.S)

Back sight is the sight taken on a rod held at a point of known elevation, to ascertain the amount by which the line of sight is above that point and thus to obtain the height of instrument. It is also known as plus sight as the back sight reading is always added to the level of the datum to get the height of the instrument. The object of back sighting is therefore, to ascertain the height of the plane of sight.

Fore Sight (F.S)

Foresight is a sight taken on a rod held at a point of unknown elevation, to ascertain the amount by which the point is below the line of sight and thus to obtain the elevation of the station. It is known as minus sight as the foresight reading is always subtracted from the height of instrument to get the elevation of the point. The object of fore sighting is therefore to ascertain the elevation of the point.

Turning Point (T.P)

Change Point: Turning point is point on which both minus sight and plus sight are taken on a line of direct levels. The minus sight is taken on the point in one set of instrument to ascertain the elevation of the point, while the plus sight is taken on the same point in other set of the instrument to establish the new height of instrument.

Intermediate Station (I.S)

Intermediate station is a point, intermediate between two turning points on which only one sight is taken to determine the elevation of the station.

Types of spirit levelling

Differential levelling

It is the method of direct leveling, the object of which is solely to determine the difference in elevations of two points regardless of the horizontal positions of the points with respect to each other. When the points are apart, it may be necessary to set up the instrument several times. This type of levelling is also known as fly-levelling.

Profile levelling

It is the method of direct levelling, the object of which is to determine the elevations of points at measured intervals along a given line in order to obtain a profile of the surface along that line.

Cross–sectioning

Cross-sectioning or cross–levelling is the process of taking levels on each side of a main line at right angles to that line in order to determine a vertical cross – section of the surface of the ground.

Reciprocal levelling

It is the method of levelling in which the difference in elevation between two points is accurately determined by two sets of reciprocal observation when it is not possible to set up the level between two points.

Precise levelling

It is the levelling in which the degree of precision required is too great, is attained by ordinary methods and in which, therefore special equipment or precautions or both are necessary to eliminate as far as possible all sources of error.

Find out the elevation of points using different methods

Steps in levelling

There are two steps in levelling

To find by how much amount the line of sight is above the bench mark.

To ascertain by how much amount the next point is below or above the line of sight.

A level is set up approximately mid way between the benchmark and the point of elevation of which is to be ascertained by direct levelling. A back sight is taken on a rod held at the bench mark.

H.I. = Elevation of the Benchmark + Back sight

Turning the telescope to bring into view the rod held on the point "B" a foresight is taken.

ELEVATION = H.I – Fore sight

Eg: Bench mark = 210.852 m.

Back sight = 2.324 m

Fore sight = 1.836 m

H.I = Elevation of B.M + B.S

= 210.852+2.324=213.176m.

Elevation of the point "B" = H.I – Fore sight

= 213.176-1.836=211.340 m.

It is to be noted that if a back sight is taken on a bench mark located on the roof of a tunnel or on the ceiling of a room with the instrument at a lower elevation the back sight must be subtracted from the elevation to get the height of the instrument. Similarly if the foresight is taken on a point higher than the instrument, the fore sight must be added to the height of the instrument to get the elevation of the point.

Differential levelling

Levelling is to determine the elevation of points at some distance apart is called "differential levelling". When two points are at such a distance from each other that they cannot both be within range of level at the same time the difference in elevation is not found by single setting but the distance between the points is divided in two stages by turning points on which the staff is held and the difference of elevation of each of succeeding pair of such turning points is found by separate setting up of the level.

A and B are the two points. The distance AB has been divided into three parts by choosing two additional points on staff readings has been taken. Points 1 and 2 are turning points.

Reduced level of point A = 240.000m. The height of the first setting of the instrument is therefore 240.000+2.024 = 242.024m. If the following Fore sight is 1.420. The R.L of TP1=242.024-1.420=240.604 m. The back sight for the second set up of instrument is 1.986. The H.I for second set up is = 240.604+1.986=242.590 m. By similar process of calculations R.L. of TP2 = 240.490 and R.L of B = 241.202.

Booking and Reducing Levels

Height of Instrument method

In this method, the height of the instrument (H.I) is calculated for each setting of the instrument by adding back sight (plus sight) to the elevation of the B.M. The elevation of (Reduced Level) the turning point is then calculated by subtracting fore sight from H.I the. For the next setting of the instrument the H.I. is obtained by adding the B.S taken on TP1 to its R.L.

The process continues till the R.L of the last point (fore sight) is obtained by subtracting the staff reading from height of the last setting of the instrument. If there are some intermediate points the R.L of those points is calculated by subtracting the intermediate sight (Minus sight) from the height of the instrument for that setting.

Check

The difference between the sum of back sight and sum of the fore sights should be equal to the difference between the last and first R.L.

$\sum B.S - \sum F.S$ = Last RL – First RL

1. The following staff readings were observed successively with a level, the instrument having been moved after, second, fifth and seventh readings.

0.865, 2.105, 1.025, 1.580, 1.865, 2.230, 2.835, 2.355, 1.760

Enter the above readings in a page of a level book and calculate the R.L of points, if the reading was taken with a staff held on a B.M. of 560.500

∑ B.S = 6.475 ∑ F.S = 8.565
Check = ∑ BS - ∑ FS = First R.L - Last R.L
= 6.475-8.565 = 560.500-558.41
2.09= 2.09

Rise and Fall method

In this method the height of instrument is not at all calculated but the difference of level between consecutive points is found out by comparing the staff reading on the two points for the same setting of the instrument. The difference between their staff readings a rise or fall according as the staff reading at the point is smaller or greater than that at the proceeding point. The figures for rise and fall worked out thus for all the points give the vertical distance of each point above or below the preceding one, and if the level of any one point is known the level of the next will be obtained by adding its rise or subtracting its fall as the case may be.

Check

The difference between the sum of back sight and sum of the fore sights should be equal to the difference between the sum of rise and sum of fall and should also be equal to the difference between the first R.L. and Last R.L.
∑ BS - ∑FS = ∑Rise - ∑Fall = First R.L.- Last R.L.

2. The following staff readings were observed successively with a level, the instrument having been moved after second, fifth and seventh readings.
0.865, 2.105, 1.025, 1.580, 1.865, 2.230, 2.835, 2.355, 1.760
Enter the above readings in a page of a level book and calculate the R.L. of points if the first reading was taken with a staff held on a B.M. of 560.500 (Use rise and fall method)

Check = ∑BS - ∑FS = ∑rise - ∑Fall = Frits RL – Last RL
= 6.475 – 8.565= 0.595-2.685 = 558.41-560.500
= 2.09 = 2.09 = 2.09

Last modified: Tuesday, 17 May 2011, 8:31 AM

Rise and Fall method

Problems 3. The following staff readings were observed successively with a level, the instrument having been moved after third, sixth and eighth readings.

2.228, 1.606, 0.988, 2.090, 2.864, 1.262, 0.602, 1.982, 1.044, 2.684 m.

Enter the above readings in a page of a level book and calculate the R.L. of points, if the first reading was taken with a staff held on a bench mark of 432.384 m.

Check = ∑BS-∑FS = ∑rise = ∑fall = first RL – last RL
=5.964=6.916=2.842=3.794=432.384-431.432
=0.952 0.952 0.952

4. The following consecutive readings were taken with a level and 5 m. levelling staff on continuously sloping ground at common intervals of 20 m.
0.385, 1.030, 1.925, 2.825, 3.730, 4.685, 0.625, 2.005, 3.110, 4.485

The reduced level of the first point was 208.125. Rule out a page of level field book and enter the above readings. Calculate the reduced levels of the points by rise and fall method.

Check = ∑B.S. = ∑F.S. = First R.L = Last R.L
1.01 = 9.17 = 208.125 = 199.965
= 8.16 = 8.16

Levelling Staff

Levelling staff in a straight rectangular rod having graduations the foot of the staff representing zero reading. The purpose of a level is to establish a horizontal line of sight. The purpose of levelling staff is to determine the amount by which the station (foot of the staff) is above or below the line of sight.

Levelling staffs may be classified into two classes.

- Self reading staff
- Target staff

Self reading staff

is the one which can be read directly by the instrument man through the telescope.
Target staff: on the other hand, contains a moving target against which the reading is taken by a staff man.

There are usually three forms of self reading staff

- Solid staff
- Folding staff
- Telescopic

Solid staff

The staff is generally made up of well seasoned wood having a length of 10 feet or 3m. In most common forms the smallest division is of 0.01feet or 5 mm. However some staves may have fine graduation up to 2 mm. These staves gives the reading is English and metric units.

Folding staff

Folding staff usually 10ft long having a hinge at the middle of its length. When the staff is not in use the rod can be folded about the hinge so that it becomes convenient to carry it from one place to the other. Since the self-reading staff is always seen through the telescope all readings appear to be inverted. The readings are therefore taken from above downwards.

Telescopic staff

It is arranged in three telescopic lengths. When fully extended it is usually of 14ft length. The 14 ft staff has solid top length 4'6" sliding in to the central box of 4' 6" length. The central box in turn slides into the lower box of 5' length. In the 5 m staff the three corresponding length are usually 1.5, 1.5 and 2 m.

The levelling staves graduated in English unit generally have whole number of feet marked in red to the left side of the staff. The odd lengths of the feet are marked in black to the right hand side. The top of these black graduations indicates the odd length, while the bottom shows the even length. The hundredth feet are indicated by alternate white and black spaces, the top of a black space indicating odd hundredth feet and top of a white space indicating even hundredth. Some times when the staff is near the instrument the red mark of whole foot may not appear in the filed of view. In that case the staff is raised slowly until the red figure appears in the field of view, the red figure thus indicating the whole feet.

Folding level staff in metric units

Folding level staff is in 4 m length. The staff comprises 2 m thoroughly seasoned wooden pieces with the joint assembly. Each piece of the staff is made of one longitudinal strip without any joint. The width and thickness of staff is kept 75 mm and 18mm respectively. The folding joint of the staff is made of the detachable type with a locking device at the back. The staff is joined together is such a way that

- The staff may be folded to 2 m length.
- The two pieces maybe detached from on another when required facilitating easy handling and manipulating on with one piece.
- When the two portions are locked together the two pieces become rigid and straight. Each meter is subdivided into 200 divisions the thickness of graduations being 5mm.

Plane table surveying

Definition

Plane table surveying is the graphical method of survey in which the field observations and plotting proceed simultaneously. It is a making of manuscript map in the field, while the ground can be seen by the topographer and without intermediate steps of recording and transcribing field notes.

Instruments used for plane table surveying

- Plane table with levelling head having arrangements for i) Levelling ii) Rotation about vertical axis iii) Clamping in any required position
- Alidade for sighting
- Plumbing fork and plumb bob
- Spirit level
- Compass
- Drawing paper with a rainproof cover

The plane table

The plane table consists of a small drawing board mounted on a light tripod in such a way that the boards can be rotated about the vertical axis and can be clamped in any position.There are three types of plane table,

- Traverse table
- Johnson table
- Coast survey table

Alidade

A plane table alidade is a straight edge with some form of sighting devices. It generally consists of a metal or wooden rule with two vanes at the ends. The two vanes or sights are hinged to fold down on the rule when the alidade is not in use. One of the vane is provided with a narrow slit, while the other is open and carries a hair or thin wire. Both the slits thus provide a definite line of sight which can be made to pass through the object to be sighted. The alidade can be rotated about the point representing the instrument station on the sheet so that the line of sight passes through the object to be sighted. A line is then drawn against the working edge of the alidade. The alidade is not very much suitable on hill area since the inclination of the line of sight is limited.
There are two types of alidade.

- Plane alidade
- Telescopic alidade.

Plumbing Fork

The plumbing fork used in large scale work, is meant for centring the table over the point or station occupied by the plane table when the plotted position of that point is already known on the sheet. Also in the beginning of the work, it is meant for transferring the ground point on to the sheet so that plotted point and the ground station are in the same vertical line. The fork consists of a hair pin-shaped light metal frame having arms of equal length in which a plumb bob is suspended from the end of lower arm. The fitting can be placed with the upper arm lying on the top of the table and the lower arm below it, the table being centered when the plumb bob hangs freely over the ground mark and the pointed end of the upper arm coincides with the equivalent point on the plan.

Spirit level

A small spirit level may be used for ascertaining if the table is properly level. The level may be either of the tabular variety or of the circular type essentially with a flat base so that it can be laid on the table and is truly level when the bubble is central. The table is levelled by placing the level on the board in two positions at right angle and getting the bubble central in both positions.

Compass

The compass is used for orienting the plane table to magnetic north. The compass used with a plane table is a trough compass in which the longer sides of the trough are parallel and flat so that either side can be used as a ruler or laid down to coincide with a straight line drawn on the paper.

Drawing paper

The drawing paper used for plane tabling must be of superior quality so that it may have minimum effect of changes in the humidity of the atmosphere. The changes in the humidity of the atmosphere produce expansion and contraction in different directions and thus alter the scale and distort the map. To overcome this difficulty, sometimes two sheets are mounted with their grains at right angles and with a sheet of muslin between them. Single sheet must be seasoned previous of the use by exposing it alternatively to a damp and a dry atmosphere.

Working operations

Three operations in plane table surveying

- Fixing : Fixing the table to the tripod
- Setting : i) Levelling the table ii) Centring iii) Orientation
- Sighting the points

Fixing

Fix the plane table to the tripod properly

Setting

Levelling

for small scale work, levelling is done by estimation. For work of accuracy an ordinary spirit level may be used. The table is levelled by placing the level on the board in two positions at right angles and getting the bubble central in both directions.

Centring

The table should be so placed over the station on the ground that the point plotted on the sheet corresponding to the station occupied should be exactly over the station on the ground. The operation is known as centring the plane table.

Orientation

Orientation is the process of putting the plane-table into some fixed direction so that a line representing a certain direction on the plane is parallel to the direction on the ground. This is the essential condition to be fulfilled when more than one instrument station is to be used. If orientation is not done, the table will not be parallel to itself at different positions resulting in an overall distortion of the map. The process of centring and orientation dependent on each other. For exact work the centirng and orientation is repeat until the work is accurate.

There are two main methods of orientation of the plane table

- Orientation by means of trough compass.
- Orientation by means of back sighting.

Working operations

Orientation by means of trough compass

The plane table can be oriented by compass under the following conditions.

- When speed is more important than accuracy.
- When there is no second point available for orientation
- For approximate orientation prior to final adjustment.

For orientation, the compass is so placed on the plane table that the needle floats centrally and a fine pencil line in ruled against the long side of the box. At any other station where the table is to be oriented, the compass is placed against thin line and the table is oriented by turning it until the needle floats centrally. The table is then clamped is position.

Orientation by back sighting

To orient the table at the next station say B represented on the paper by a point "b" plotted by means of a line "ab" drawn from a previous station A, the alidade is kept on the line "ba" and the table is turned about its vertical axis in such a way that the line of sight passes through the ground station "A". When this is achieved the plotted line "ab" will be co-insiding with the ground line AB and the table will be oriented. The table is then clamped line position.

Sighting the points

When once the table has been set, i.e., when levelling centring and orientation has been done, the points to be located are sighted through the alidade. The alidade is kept pivoted about the plotted location of the instrument station and is turned so that the line of sight passes or bisects the signal at the point to be plotted. A ray is then drawn from the instrument station along the edge of the alidade. Similarly the rays to other points to be sighted are drawn.

Methods of plane tabling

Methods of plane tabling can be divided into four distinct heads.

- Radiation
- Intersection
- Traversing
- Resection

The first two methods are generally employed for locating the details, while the other two methods are used for locating the plane table station.

Radiation

In this method, a ray is drawn from the instrument station towards the point, the distance is measured between the instrument station and that point, and the point is located by plotting to some scale the distance so measured. This method is more suitable when the distances are small and one single instrument station can control the points to be detailed.

The following steps are necessary to locate the points from an instrument station T.

- Set the table at T, level it and transfer the point on to the sheet by means of plumbing fork, thus getting "t" representing T. Clamp the table.
- Keep the alidade touching "t" and sight to A, draw the ray along the fiducial edge of the alidade. Similarly sight different points B, C and D, E etc., and draw the corresponding rays (A pin may be inserted at "t" and the alidade may be kept touching the pin while sighting the points)
- Measure TA, TB, TC, TD, TE etc., in the field and plot their distance to some scale along the corresponding rays, thus getting a, b, c, d, e etc., Join these if needed.

Intersection

Intersection is resorted to when the distance between the point and the instrument station is either too large or cannot be measured accurately due to some field conditions. The location of an object is determined by sighting the object from two plane table stations and drawing the rays. The intersection of these rays will give the position of the object. It is therefore very essential to have at least two instrument stations to locate any point. The distance between the two instrument stations is measured and plotted on the sheet to some scale. The line joining the two instrument stations is known as the "base line".

The following is the procedure to locate the points by the method of intersection.

- Set the table at "A" level it and transfer the point "A" on to the sheet by way of plumbing fork. Clamp the table.
- With the help of the trough compass mark the north direction on the sheet.
- Pivoting the alidade about "a" sight it to "B". Measure AB and plot it along ray to get "b". The base line "ab" is thus drawn.
- Pivoting the alidade at "a" sight the details C,D,E etc., and draw corresponding rays.
- Shift the table at "B" and set it there. Orient the table roughly by compass and finally by back sighting "A".
- Pivoting the alidade about "b" sight the details C, D, E etc., and draw the corresponding rays along the edge of the alidade to interest with the previously drawn rays in C, D, E etc., The position of the points are thus mapped by way of intersection.

Contour surveying

Definition

Contour is an imaginary line on the ground joining the points of equal elevation. It is a line in which the surface of ground is intersected by a level surface. "A contour line is a line on a map representing a contour".

a pond with water at an elevation of 100 m. If the water is lowered by one meter another water mark representing 99.00 m elevation will be obtained. These water marks may be surveyed and represented on the map in the form of contours. A topographic map represents a clear picture of the surface of the ground. If a map is to a big scale it shows where the ground is nearly level where it is sloping, where the slopes are steep and where they are gradual. If a map is to a small scale, it shows the flat country.

Contour interval

The vertical distance between any two consecutive contours is called the contour interval. The contour interval is kept constant for a contour plan; otherwise the general appearance of the map will be misleading. The horizontal distance between two points on two consecutive contours is known as the horizontal equivalent and depends upon the steepness of the ground.

The contour intervals depend upon the following considerations.

- Nature of ground
- Scale of the map
- The purpose and extent of the survey
- Time and expense of field and office work

Nature of ground

The contour interval depends upon whether the country in flat or highly undulated. For very flat ground, a small interval is necessary. If the ground is more broken, greater interval should be adopted, otherwise the contours will become too close to each other.

Scale of the map

The contour interval should be inversely proportional to the scale. If the scale is small, the contour interval should be large. If the scale is large the contour intervals should be small.

The purpose and extent of the survey

The contour interval largely depends upon the purpose and the extent of the survey. For example, if the survey is intended for detailed design work or for accurate earth work calculations small contour interval is to be used. In this case extent of survey will be generally small. In the case of location survey, for lines of communication for reservoir and drainage areas, where the extent of survey is large, a large contour interval is to be used.

Time and expense of field and office work

If the time available is less, greater contour interval should be used. If the contour interval is small greater time will be taken in the field survey in reductions and in plotting the map.

Methods of locating contours

There are two methods for locating contours

- The direct method
- The indirect method

In direct method, the contour to be plotted is actually traced on the ground. Only those points are surveyed which happed to be plotted. This method is slow and tedious. It is used for small areas and where great accuracy is required.

In the indirect method some suitable guide points are selected and surveyed, the guide point need not necessarily be on the contours. These guide points having been plotted serve as a basis for the interpolation of contour.

Direct method

The direct method is divided into two forms.

- Vertical control : Location points
- Horizontal control: Survey of those points.

Vertical control

The points on the contours are traced with the help of a level and staff. The level is set at a point to command the area as much as possible and is levelled. The staff is kept on the B.M and the height of the instrument is determined. If the B.M is not nearby fly levelling may be performed to establish a temporary bench mark (T.B.M.) in that area. Having known the H.I the staff reading is calculated so that the bottom of the staff is at an elevation equal to the valve of the contour.

E.g.: H.I =101.80 meter, the reading to get a point on the contour of 100.00 m elevation will be 1.80 m. Taking one contour at a time, the staff man is directed to keep the staff on the points on contour so that reading of 1.80 m is obtained every time.

Indirect method

In this method, some guide points are selected along a system of straight lines and their elevations are found. The points are then plotted and contours are then drawn by interpolation. There are three indirect methods in locating contours.

- By squares
- By cross-sections
- By Tachometric methods

By squares

This method is used when the area to be surveyed is small and the ground is not very much undulating. The area to be surveyed is divided into number of squares. The size of the squares may vary from 5 to 20 m depending upon the nature of the contour and contour interval. The elevations of the corners of the square are then determined by means of a level and a staff. The contour lines may be drawn by interpolation.

Interpolation of contour

Interpolation of the contours is the process of spacing the contours proportionately between the plotted ground points established by indirect methods. The methods of interpolation are based on the assumption that the slope of ground between the two points is uniform.

Following are the three methods of interpolation.

- By estimation
- By arithmetic calculation
- By graphical method

By estimation

This method is extremely rough and is used for small scale work only. The position of contour points between the guide points are located by estimation.

By arithmetic calculation

This method so accurate and is time consuming. The positions of contour points between the guide points are located by arithmetic calculation e.g. A, B, C and D be the guide points plotted on the map. Elevations at each point are 607.4, 617.3, 612.5 and 604.3 respectively. Let AB=BD, CD=CA= one inch on plan. The vertical difference in elevation between A and B is (617.3-607.4) = 9.9 feet. Hence the distance of the contour points from A will be calculated as follows

i.e., 1/x * y*z
where,
x= Difference in contour elevation between two points
y= The distance between two points
z= The distance between the starting point to contour line

Distance of 610 feet contour point says A1 is calculated by interpolation using the formula,
The difference in contour elevation between two points is (617.3-607.4) = 9.9 feet.
The distance between the two points = 2.0m
The distance between the starting point to contour line is 610- 607.4 = 2.6 feet
Distance from point 'A' is = (1/9.9) x 2.6 x 2 = 0.52 m

These contour points may be located on AB the contour points for any lines can be calculated.

Contour surveying

Uses of contour

Following are the some of the uses of contour map,

- Drawing of section
- Determination of inter-visibility between two points
- Tracing of contour gradients and location of route
- Measurement of drainage area
- Calculation of reservoir capacity

Unit-2-Fish farm (Expected Learning Outcome)

It emphasise the importance of site selection for aqua farm. It gives an idea about important points to be remember before prepare aqua farm project. It describe about the important points to be considered to select a suitable site for aqua farm. Different stages of site selection, how these factors influences in reducing cost of construction, trouble free culture, easy maintenance for ponds and other related structures. How the accessibility of the site condition, physical feature of the land and water source influences in reducing the cost of construction. Site condition, topography and other factors influences in preparing layout of fish farm, planning and designing of the ponds. It also briefly describe about classification of ponds based on various factors like construction and source of water and their merits and demerits.

Definition

Fish farm is a set of scientifically planned, designed and constructed ponds for various fish cultural activities like breeding, hatching, rearing, nursing and stocking of fishes.

Objectives of fish farms

- For breeding of fishes
- To maintain brooders
- To conduct the research to improve fish variety and their culture
- To make facilities to store required quantity of fish seeds
- To demonstrate the fish cultural activities to fish culturists

The success of fish culture is mainly depending upon proper planning and construction of pond. The design of the fish ponds are very much influenced by the type of pond and system of culture to be practised in the pond.

Types of farms

Classification of fish farm

Fish farms can be classified into various types based on various factors.

a) Based on the characteristics of the farm environment

- Warm water
- Cold water

b) Water salinity

- Fresh water
- Brackishwater
- Marine water

Fresh water is defined when the salt content in it is less than 0.5 ppt, brackish water is defined when the salt content in it is in the range of 0.50 – 30 ppt, marine water is defined when the salt content in it is more than 30-35 ppt.

c)Water replacement

- Running
- Stagnant

Physiographical zone

- Inland fish farm
- Coastal fish farm
- Marine fish farm

Types of farms

Classification of fish farm

e) Kind of materials used for enclosure

- Plastic tanks
- Cement concrete
- Earthen ponds
- FRP ponds

f) Based on water source

- Rain fed farm
- Tide fed farm
- Sewage water
- Seepage water
- Ground water
- Spring water
- Municipal/corporation water
- River/canal /dam

g) Based on culture

- Extensive
- Semi – intensive
- Intensive
- iSuper intensive
- Traditional culture

Selection of site for Aquafarm

Site selection criteria

Selection of a suitable site is the first and fore most step in the design, planning, construction, operation and maintenance of fish farms. A mistake is made during the phase of site selection may result in higher cost of construction, culture operation and maintenance and may creates environmental problems also. Selection of a suitable site strongly influences the ultimate success of the aquaculture enterprise. The process of site selection is not only to determine the suitability of site, it is also valuable in determining the modifications required with regard to make farming possible at a given site. For high production and efficient management knowledge of local area and experience coupled with scientific and engineering expertise are also required. Although no site will poses all desired characteristics. Yet one has to select a site so as to obtain maximum production at minimum cost of construction and management. "A suitable site is one that provides optimum conditions for the growth of species cultured at the targeted production level given an effective pond design and support facilities".

Site selection criteria mainly depending upon the following points

- The species to be cultured
- The targeted production level
- Culture technology
- Investment

Stages of site selection

Selection of suitable site for an aqua farm can be done in two stages.

- Reconnaissance survey (Pre-investment survey)
- Detailed survey

Reconnaissance survey/ Pre-investment survey

While conducting reconnaissance or pre-investment survey,the following important points to be considered.

- Accessibility
- Physical features of the land
- Soil characteristics
- Water source

Accessibility

The proposed site should be as far as possible near to the good, approachable road and market. During construction of farm it is easy to transport the construction materials to the site. It reduces the cost of construction and time. During culture it is easy to transport feed and fertilizer to the farm and also fish and its products to the market conveniently. It reduces the cost of production, which helps to increase the profit.

Physical features of the land

Physical features of the land are classified into two types.
i) Natural feature
ii) Artificial features.

Natural features such as river, mountain, spring, forest, lakes, streams, rocks etc,.

The artificial features are ponds, buildings, electrical pole, roads, rails etc., It is necessary to note down all these things and prepare a rough sketch.

Soil characteristics

Soil is the basic material for fish farms. Because in general the bottom of the ponds is soil, dykes are constructed by using soil to retain the water, reservoir may also built by soil to store the water and water is supply to the ponds through canals, and drainage canals to discharge unwanted, polluted water is also make up of soil. So it is very important to study some of the important properties such as fertility, texture, permeability and water holding capacity of soil.

Water Source

The proposed site should be as far as possible very near to the source of water. The source should be perennial. There should not be any shortage of water, particularly during summer to replenish the ponds. The water should be clean and well oxygenated.

Detailed survey

Important points to be considered during detailed survey.

Main factors

- Site condition
- Topography
- Soil characteristics
- Water properties and supply

Other factors

- Environmental condition
- Socio-economic condition
- Pollution
- Availability of materials
- Technical assistance

Main factors - Site condition

The proposed site for pond construction should be essentially having sufficient area to accommodate all the desired number of ponds. The site is considered to be ideal for pond construction if the land surface is flat or has uniform gentle slope in one direction. It gives facilities for quicker filling and emptying of the pond water. From the economic point of view a pond should be located where the largest storage volume can be obtained with the least amount of earth fill. This condition generally will occur at a site where the valley is narrow, side slopes are relatively steep and slope of the valley floor will permit a large deep basin.

Avoid a site in a valley, relatively open and wide at down stream end. If so it is necessary to build long dam. It increases the cost of construction. Site should be good soil, which will hold the water well. The site should have the facility to adequate drainage arrangement. It is necessary to avoid forest area or the site with full of large number of trees. Other wise which may difficulty to remove and it leads to increase the cost of construction and also create problems during operation and maintenance. Dampy areas are also not suitable for pond construction because pond drainage is always difficult and much expensive. The optimum slope is between 0.5 to 1%. The ground slope should not be more than 2% as it needs construction of high and costly embankments. Shape of the site should be regular, irregular and oblong shape results in difficulty for planning, designing, construction, operation and maintenance of ponds. Sites with excessive undulating topography should be avoided as a lot of excavation and embankment would be needed during the construction, which will increase the cost of construction. The area should be sufficiently extensive to allow future expansion.

Main factors - Topography

Topography is the science of measuring the earth and its features and making of maps, charts and plans to show them. A topographical map not only shows the location of the features but also shows the slope of the ground. Weather the ground is flat, having uniform gentle slope, steep slope or undulated aground etc., and how much steep in between these locations. Topographic map helpful to find out

- Size and shape of the land
- Slope of the land
- Its elevation in relation to the water source
- Distance between source of water and location of site
- The best way of water supply to the ponds
- The easiest way of draining the ponds

Main factors - Soil characteristics

Soil characteristics play a vital role for selection of suitable site. The site should contain soft bottom soil or mixed soil comprising of clay, silt and sand in proper proportion to ensure good water holding capacity as well as production of natural food organisms on which aquatic organisms could feed and grow. One of the most important characteristics is the water holding capacity.

Gravel and sand are non-cohesive soils. Their cohesiveness almost nil under dry condition and have no plasticity. In sand and gravel bed water percolates easily. Hence sand and gravel bed are not suitable for pond construction. Clay, silt and fine grained soils are cohesive soils. Cohesive property imparts structural stability in pond dykes, bottom etc., clay is very absorbent under wet condition, it swells to double its volume. So only clay, silt are also not that much suitable for pond construction. A combination of cohesive and non-cohesive soils such as sand, silt and clay in proper proportion are suitable for pond construction. According to textural classification of soil, clay loam, sandy clay loam, silty clay loam and sandy clay soils are suitable for pond construction. Too much organic matter in the soil is harmful. Land with a layer of organic matter greater than 0.6 m deep is unsuitable for ponds. Because organic stratum will cause excessive seepage losses, when it decays. Highly organic soils are not suitable for dyke construction. Organic soils also cause rapid oxygen depletion in the pond water.

Main factors - Water properties and supply

Once the source of water has been selected the next necessary step is to supply the water from the source to the fish ponds. Open channels, conduits and pipe lines are the three common means of conveyance of water. As far as possible the water supply should be made by gravity flow. As far as possible every pond should have its own inlet and outlet structure. So that it is easy to supply the water to the ponds when it required and discharges the unwanted or polluted water easily and conveniently. It is better to avoid direct entry of water from surface rivers, streams and springs to the fish ponds during rainy seasons. It may consist of clay and silt etc,. It may deposit on the pond bed which may increase the load on pond bed and sides of the dyke and also reduce the volume of the pond. Similarly it is better to avoid water from the agriculture lands. It may consist of chemicals, antibiotics and pesticides. It may affect aquatic animal's life. Water quality management is ongoing and never ending process. It is very essential to study some of the important properties such as pH, temperature, dissolved oxygen, salinity, turbidity, alkalinity; acidity etc,. The management of water quality is the most important factor in the productive fish farming. An analysis of physical, chemical and biological properties of the proposed source of water must be conducted. A good quality is nothing but a web of physical, chemical and biological factors, which constitute the water environment and influence the production of fishes and shrimps.

Other factors - Environmental condition (Meteorological) factors

Meteorological parameters such as rain fall, its quantity, duration, intensity and type, evaporation, temperature, humidity, atmospheric pressure, winds, its speed, direction have a great role in the growth of fish food organisms as well as in the design of the aqua farms. A thorough hydrological survey should be conducted for the water source and area surrounded around the site.

Other factors - Socio-economic condition

Information regarding socio-economic conditions of the locality is important for managing farm efficiently. Details regarding seasonal availability of laboures, professionals like competent biologists, skilled labours, local customs traditions should be gathered. Man power planning mainly depends upon local wages and the availability of skilled labours.

Other factors - Pollution

It is better to select the site away from the pollutant area. Industrial effluents, sewage out falls, insecticide affected agriculture land affect the air and water, and results in reduce the growth rate of aquatic animals.

Other factors - Available materials
It is better to plan and design the farms for construction of the ponds and other facilities using locally available materials. It reduces the cost of construction and project time.

Other factors - Technical guidance
Technical guidance from the fisheries department or private consultants help the farmers to solve common problems like excessive seepage, soil erosion, aquatic animal's diseases etc,. A good technical guidance can even motivate the other farmers to take up fish culture. Farmers will come to know the latest researches, findings, development etc., if proper technical guidance is given.

Ponds

Definition
Ponds are the water bodies created by constructing a dam across a source of water or excavating a pit.

Classification of ponds based on construction

- *Excavated ponds*: These are the ponds created by excavating a pit across the source of water.
- *Embankment ponds*: These are the ponds created by constructing a dyke or embankment across the water source

Unit 3-Soil and its properties

Unit 3 - Expected Learning Outcome

This chapter helps to know about definition of soil, various classification of soil. It is helpful to decide the suitability of soil for aqua farming. It emphasise the importance of soil sampling and types of sampling used in aqua farming. It also gives an idea to understand the occurrence of soil in nature. Soil properties can be understood by learning some of the definition. Permeability of soil and its application in aqua farm also learnt from this topic.

Classification of Soil

The purpose of soil classification is to arrange various types of soils into groups according to their engineering or agricultural properties and various other characteristics. For general engineering purposes, soil may be classified by the following system.

- Particle size classification.
- Textural classification
- Highway research board classification
- Unified soil classification and I.S.classification system

Classification of Soil - Particle size classification

In this system, soils are arranged according to the grain size.
Usually four types

- Clay
- Silt
- Sand
- Gravel

These terms are used only as designation of particle size and do not signify the naturally occurring soil types.

- Clay < 0.002 mm
- Silt – 0.002 to 0.02m
- Sand 0.02 to 2 mm
- Gravel > 2 mm

Classification of Soil - Textural classification

Soils occurring in nature are composed of different percentage of sand, silt and clay size particles. Classification of composite soil exclusively based on the particle size distribution is known as textural classification. This classification is based on the percentages of silt, clay and sand sizes making up the soil.

Classification of Soil - Highway research board classification

This system is based on both the particle size composition as well as the plasticity characteristics. This system is mostly used for pavement construction.

Classification of Soil - Unified soil classification and IS classification system

According to this classification soil may be classified into three groups.

a) Coarse grained soils

In these soils more than half of the total material by mass is larger than 75 micron I.S. sieve size.

b) Fine grained soils

In these soils more than half of the material by mass is smaller than 75 micron I.S. sieve size.

c) Highly organic and other miscellaneous soil material

These soils contain large percentage of fibrous organic matter such as peat and particles of decomposed vegetation. In addition certain soils containing shells, concretions, cinders and other non soil materials in sufficient quantities are also grouped in this system (Division) Coarse grained soils are sub-divided into two sub groups.

Soil Sampling

Definition

Soil sampling means collection of soil from the ground for testing purpose.

Types of soil sampling

The soil samples are classified into two groups

- Disturbed sample
- Undisturbed soil samples

Types - Disturbed sample

A disturbed soil sample is that in which the natural structure of soils get partly or fully modified and destroyed although with suitable precautions the natural water content may be preserved. Which do not represent exactly how the soil was in its natural state before sampling. Disturbed sample are used for the more simple tests that will be performed and particularly for those test will conduct in the field.

Types - Undisturbed soil samples

An undisturbed sample is that in which the natural structures and properties remain preserved. This represents exactly how the soil was in its natural slate before sampling. Undisturbed samples are necessary for the more sophisticated tests which must be performed in the laboratory for more detailed, physical and chemical analysis. Undisturbed samples must be collected with the greater care for they should represent exactly the nature of the soil. For complete study of the soils in the site it is necessary to conduct both disturbed and undisturbed samples test. Soil samples for aquaculture are normally taken to a depth of 2 m so each soil horizon up to that depth can be examined. If the water table is found at a depth of less than 2 m soil samples should always be taken as deep as possible.

Three phase system of soil

In general, the soil sample will be consisting of soil solids, water and air, which is designated as three phase system of soil. The sum of the air content and water content of a sample is called as voids. If the voids are completely filled with water such a sample is called as a purely saturated sample or 100% saturated sample. If the voids of soil is completely filled with air such a sample is called as purely dried sample, on the other hand if the part of the voids are filled with water and remaining with air it is called as a moist sample. The figure shows the diagrammatic representation of the three phase system of soil element in terms of volumes and weights respectively.

In figure,

V_a = Volume of air in the sample
V_w = Volume of water in the sample
V_s = volume of soil solids in the sample
V_v = Volume of voids in the sample
V = Total volume of the soil sample
W_a = Weight of air in the soil sample can be considered as zero.
W_w = Weight of water in the soil sample
W_s = Weight of soil solids in the sample
W = Total weight of soil sample.
Further $V_v = V_a + V_w$
$V = V_s + V_v$
$W = W_w + W_s$

Unit 4-Layout planning of fish pond

Unit 4 - Expected Learning Outcome

This chapter gives an idea about layout planning which includes material and manual planning and its influence on successful completion of project. It also helps to utilization maximum area for cultivation and less area for other infrastructures. It also emphasises the important points to be considered while selecting the size of the ponds for aqua farming. It compares the merits demerits of large and small ponds. It highlights the comparison of square and rectangular shape ponds for aqua farming. It describe about type of ponds used for fish farming and their differences. It briefs about design of ponds, includes ponds geometry, shape size and bottom slope of the pond. It also gives an idea about dykes, important points to be considered for designing the dyke, important points required for determining the height of the dyke and also designing the dyke.

Lay out planning of aquafarm - Classification

Depending upon the nature of the work involved the process of farm design has been classified into following groups

- Layout planning
- Man power planning
- Material planning

Classification - Lay out planning

Lay out planning is the most important aspect of any aquafarm project, because the shape of the farm ponds and the arrangement of water channels and ponds dictate the efficacy and cost of construction of the farm. Layout planning deals with the distribution of total farm area for various farm elements depending upon the requirement based on the scientific consideration. Layout planning gives the information like location of main channel, required productive area, dimensions of sluice gates etc. The best layout would be one that gives maximum cultivable area and minimizes the area occupied by bunds and channels, which in turn reduce the cost of construction per hectare of water area of the farm.

Layout planning also deals with design of all the farm elements like embankments, ponds, inlets, outlets, water channel, drainage unit, hatcheries, other sheds etc. Layout planning varies considerably from site to site, depending upon topography, level of the site, location of water recourses and purpose of the farm. Layout should also be planned to have a good water exchange system.

Classification - Man power planning

Man power planning deals with economical aspects ie estimation of cost of the project and time required to complete the project. Total number of skilled labours, unskilled labours, masons, supervisors, technical and scientific personal required in total construction of the farm is calculated in addition to calculation of total number of man days required to complete the project. Sound knowledge of locality, socio- economic condition of the locality, daily wages paid, time period required for various farm elements is very much desired for proper man power planning. Since it deals with financial aspects of the farm construction, proper care should be taken during planning.

Classification - Materials planning

Material planning deals with the procurements of construction materials and equipments. All the materials required for construction must be brought and kept in a safe dry store room as non availability of construction materials during the time of construction greatly hampers the progress of the work. Construction of a temporary shed to store the materials is also important.

Classification of ponds based on culture

In general, for fish culture ponds can be grouped into following types,

- Nursery ponds
- Rearing ponds
- Stocking ponds

Nursing ponds

Nursery ponds are small and shallow depth. These ponds are used for raising spawn to fry stage (4-5 mm to 20-30mm). Generally 5 % of total area will be allotted for these ponds. Usually 0.02 to 0.06 hectare area is to be provided. The depth of pond ranges between 0.75 to 1 m.

Rearing ponds

Rearing ponds are used for growing of fry to finger lings, size (20 -30 mm to 50 -60 mm). Generally 20 % of total area will be allotted for these ponds. Usually 0.06 hectare to 0.12 hectare area is to be used. Depth of rearing ponds ranged between 1.0 to 2 m.

Stocking ponds

The stocking ponds are larger in size and deeper in depth and serve for the purpose of growing finger lings to the marketable size. Generally 75 % of total area will be allotted for these ponds. Usually 0.2 to 2 hectare area is using and the depth varies from 2 to 3.0 m.

Important points to be considered to select the size of the pond

There is no set of standards for ponds size. The sizes are determined based on situation. The following are the some of the important factors to be considered for determining the size of the pond.

- Shape and size of the land.
- Slope of the land.
- Type of fish.
- Type of culture.
- Quantity of fish to be stocked.
- Size of fish.
- Duration of culture.

Total available area is allocated to the different types of pond according to the particular requirements.

Important points to be considered to select the size of the pond

Approximate allocation for different types of ponds

- Breeding ponds - 0.5%
- Brooders stocking ponds - 1.5%
- Nursery ponds - 2.5% - 5%
- Finger lings - 10%
- Rearing ponds - 23%
- Stocking ponds - 60%

Square and rectangular ponds

A square shape ponds construction cost is less than cost of construction of rectangular shape ponds.

Total length of dyke required for construction of one hectare water spread area pond is 400 m. Where as in rectangular shape pond of same area require 500 m length of dyke. Hence the cost of construction of square shape pond is less. But from operation, maintenance and harvesting point of view, rectangular shape pond is preferable than square shape pond. As far as possible the ponds should be regular in shape. Irregular and oblong shape ponds are difficulty in construction, management and maintenance point of view.

Large and small ponds

In designing pond layout emphasis should be always given to economies of construction, operation and subsequent maintenance of ponds. The cost of construction of large ponds per acre in less compared to cost of construction of small ponds.

Advantages of large ponds

- Cost of construction in less per hectare of water spread area.
- Area required is less per hectare water spread area.
- Availability of oxygen is more in the water.

Disadvantages

- Filling or emptying of ponds takes long time
- High maintenance cost
- Difficulty in controlling diseases.
- Harvesting is difficult.

Advantages of small ponds

- Harvesting can be done easily and quickly.
- Drain and refill can be done easily.
- Treatment for disease is easy.
- Erosion due to wind velocity is less.

Design of ponds

Pond geometry

Pond geometry, example shape and size mainly depend upon the species to be cultured, purpose of the pond. Example whether for nursery, rearing, grow out or any other purposes, culture system to be employed, soil characteristics and topography of the area. Ponds design varies considerably from one level of management to another. The usual practice is to have the pond size between 1 to 5 ha for extensive farming, 0.25 to 1 ha for semi-intensive farming and 0.025 to 0.25 ha for intensive farming. For intensive farming smaller size ponds are constructed in different shapes such as circular, square, rectangular, triangular. Circular and square shapes are more commonly used. They are economical from the point of view of construction, enhance the water circulation in the pond and facilitate central drainage. The larger ponds, on the other hand are usually constructed in rectangular shape as it facilitates the pond management and culture operation.

Depth of pond

The depth of pond should be just being enough to retain optimum quantity of water required for fish culture. Excessive depth hinders the penetration of light, consequently effect the photosynthesis activity and primary productivity of the fish food organisms and fishes.

Top Width

The top width or crown of the dyke depends on the height of the dyke and its purpose. Engineering standard require a minimum top width of 2.4 m for all dykes between 3 to 4.5 m high. Dykes between 4.5 to 6m require a top width of 3.7 m. However in actual practice most of the main dykes of a coastal aquaculture farms are built with a top width between 1.5 to 2.5 m. If the dykes are to be used as a roadway a minimum of 3.7 m top width should be provided.

Side slope

For stability of a dyke side slope is required. The side slope mainly depends on soil texture and prevailing site condition. The flatter the slope, the more stable will be the dyke. The ideal slope is 1.5:1 to 2:1

Type of soil - *Side slope*
Clayey soil - 1:1
Loamy soil - 1.5:1
Sandy soil - 2:1
Loose soil - 2.5:1

Bottom slope of pond

For intensive and semi-intensive culture system, regular flat bottom pond bed with uniform slope is preferred. In case of extensive farming, pond bed maybe designed with trenches which cover usually 20 to 25 percent of the total pond area. Trenches are designed to have a total water depth of normally 1m while, the rest of the pond area may have approximately 0.6 to 0.75 m of water depth. Trenches provide protection against birds and shelter from high temperature during the day. During pond construction, soils from these trenches are utilized in dike construction. This reduces the cost of dike construction because of reduced lead in soil movement, as well as avoids the loss of more fertile top soil which otherwise is used in construction of pond dike. The depth of excavation for those trenches and their width are decided taking into consideration the requirement of volume of soil in dyke construction. The bed level of those trenches should be designed so as to drain off the water completely from them during the pond drying. The pond bottom is provided a slope between 1000:1 to 1000:5 towards the drain to facilitate the water flow during harvest and pond drainage. The pond bottom should be designed so as to remain above the ground water table which is necessary for effective drying of pond bottom during pond preparation. A coastal aquaculture pond is normally designed for a water depth of 1 to 1.5m depending upon the species of fish to be cultured, location and various other factors.

Dykes

Definition

The dyke is usually constructed by the soil which is usually available from pond excavation. The dyke protects the pond from all sides.

Height of the dyke

The height of the dyke is determined on the basis of the following consideration.

- Depth of water.
- Free board.
- Wave height
- Settlement allowance
- Frost action / allowances

Depth of water

Depending upon the quantity of water required for culture and area of the pond, the depth of water can be calculated. It is the vertical height of water from bottom of the pond to full water level of the pond.

Free board

Free board is the added height of the dam provided as a safety factor to prevent over topping of the dam. Free board may be defined as the vertical distance from the top of the dyke to pond water surface after settlement.
The free board may be taken approximately equal to

Wave allowance / height

Dam height must be sufficient to prevent over topping due to wave action. Wave height is a function of fetch. Which is un obstructed straight inedistance from the furthest point of the pond to the dyke. It is straight line distance from the dyke to the closest point on the obstruction. Wave may cause erosion of the dam face if precautions are not incorporated into the design.

Wave height can be calculated with relation to the fetch by the following equation.

Settlement allowance

A newly constructed dyke keeps on settling for some time due to its huge height and compactness. The amount of settlement will depend on soil material used for construction, soil moisture content during construction, amount of compaction done during construction and speed of construction. The usual allowance for settlement allowance is approximately 10% of the height of the dyke. The rate of settlement of various soils is given below

- Ordinary earth - 1½ – 2” per foot of height
- Compact earth - 1” to 1½ “ per foot of height
- Black cotton soil - 2” to 3” per foot of height

Frost action

The last allowance must be providing for dam height is frost action. Due to freezing and thawing, loosen soil making it unstable as a dam. So dam height is increased in sufficient amount depending on location.

$$\text{Height of the dyke} = H = h + h_f + h_w + h_s + h_{fa}$$

h = Depth of water
h_f = Height of free board
h_w = Dam height needed for wave action.
h_s = Height for settlement
h_{fa} = Height for frost action.

Problem
What is the required dam height for a pond with a 2 m water depth at the dam if the frost action penetrates to 0.3 m, the fetch is 100 m and compaction during dam construction is not done at optimum moisture content.

Unit 5 - Construction of fish ponds

It describe about the important steps to be followed in sequence during the construction of ponds. It details about land clearing, and their types and also its influence in reducing the cost and duration of the project. It helps to understand how to make the land marking before excavation of site. It describe about excavation of soil, construction of drainage system, dyke and also sealing of ponds and sides of the dyke to prevent the seepage of water. It emphasis about the drainage system of aqua farm. It also details about the types of seepage control methods used in aqua farm. It defines evaporation, factors which influence the evaporation, erosion of dykes and its control. It helps to calculate the time required for emptying the pond.

Introduction

Construction is very important step in an aquaculture project. Type of construction mainly depending upon the availability of raw materials like bricks, stones, cement etc,. Type of construction also depends on the function of farm element and culture system, e.g. cement concrete ponds are constructed for nursery ponds. Ordinary earthen embankments are constructed for extensive ponds and pre-stressed rein forced cement concrete ponds are constructed for intensive and super intensive culture practices. The best time period to construct the ponds is in between late winter and early summer season. Construction process requires careful supervision and skilled workmanship as the success of entire project depending upon the efficient construction.

Following are the sequences of operations to be carried out in the process of construction.

- Survey of the site
- Land clearing
- Land making
- Excavation
- Construction of drainage system
- Construction of dykes and sluices
- Lining of the embankments/ dykes
- Hatcheries and other units
- Office lab, store room etc.
- Construction of residential quarters, watchmen shed etc.

Survey of site

It is essential to conduct the detail survey of the area to plan the form systematically.

Land clearing

The site is to be cleared off from big boulders stones, trees, bushes etc,. The land is to be made levelled, if there is steep slope or broken surface. There are three types of land clearing methods based on the density of vegetation, and mode of removal of materials from the site where an aqua form is to be constructed.

Manual clearing

If there are only small boulders and thin vegetation like small bushes or trees, then by engaging labours the site can be cleared off. Clearing the site by engaging labour is called as manual clearing. It is require more time. The cost of work is generally less.

Mechanical clearing

Clearing of the site by engaging machines is called as mechanical clearing. It is help full if the site consists of large boulders and thick vegetation like large bushes and trees. It require less time, generally cost will be more.

Chemical clearing

If the soil at the site, contains harmful bacteria or any other micro-organisms which are harmful to aquatic animals, then some sort of chemicals are mixed in the soil to kill these harmful bacteria and this method of using the chemicals to kill these bacteria is called as chemical method of land clearing. Chemicals are used to eradicate unnecessary aquatic weeds also.

Land marking

After the land is cleared off then the land is to be marked for the construction of various farm elements as per the layout planning. This operation involves laying out the features of ponds on the ground in order to mark out the area from where the earth will have to be cut or removed, and also where earth will have to be embanked. Initially lines are drawn according to the layout followed by pegging and fixing stakes or posts. Strings are stretched between the top of pegs and posts to mark the complete profile of the dyke with its correct height, width and slope. Dry white lime powder is used to show the positions of various farm elements like dykes, channels and ponds which are to be constructed. It is called as staking.

Excavation of soil

The excavation of ponds may be done either engaging manual labour, when speed of construction is under consideration bulldozer or scoop may be utilized. The excavation of the pond should be as far as possible preceded in layers. The top ground soil should be stocked in one place and it should not be used for any construction. Few dead men should be left on the pond bed for measuring volume of earth work. Which should be removed and pond bed made even immediately after the measurements have been recorded in the measurement book.

Construction of drainage systems

During construction of drainage channel the elevation of drainage channels bottom and pond bottom elevation place a vital role. The elevation of pond bottom should be above the elevation of channel bottom, so that the water can be drained completely from the pond.

Construction of dykes and sluices

Construction of dykes

The construction of pond dykes becomes essential if earthen dykes are made around the pond using the excavated earth from the pond bed. All dykes should be raised dumping the earth layer by layer stretching right across the whole section and in such cases each layer should not exceed 30 cm thickness. All large clods should be broken and each layer should be thoroughly consolidated by watering and ramming. The sides and top of the dykes should be property dressed and finished with wooden thappies. When the dyke is to be constructed on a sandy, gravelly or marshy soil base the construction of key trench is essential and in such cases digging should be done until water tight foundations are reached. The key trench is a small ditch or furrow dug along the line of the centre of the walls about 0.5 to 1m wide and 0.5 m deep. This trench is filled in with a good clayey soil and is well rammed. If good clayey soil is not available in the area, ordinary soil should be well compacted into the trench. The purpose of the trench is to stop seepage of water under heath the walls.

Water inlet structures

An inlet structures should provided through which water can be let into the pond. A proper inlet enables the quantity of water flowing into the pond, to be regulated, preventing the entry of undesirable fish and other aquatic animals and the escape of stoked fish. For small ponds the best inlet structure is p.v.c pipes of about 10-15 cm diameter with a control top and a screen basket.

Lining of ponds and dyke

The protection of slopes of the dyke against soil erosion is called as lining of the dykes. The following are the some of the important methods of lining

- Stone pitching
- Brick pitching
- Cement concrete lining
- Soil-cement lining
- Stone slab lining
- Polyethylene paper lining
- Grassing

Pond drainage system

All ponds need to change some water during fish culture. For this purpose ponds must have suitable independent water outlet with controlled device. The outlet may be open channels, conduits or pipes. The pipes or conduit outlets are suitable for all types of ponds. Asbestos pipes, cement concrete, galvanized Iron pipe, PVC pipes, cast iron pipe are some of different types of pipes used for pond drainage system. The size of the drainage pipe depends on the area of the pond and volume of water in the pond to be drained out. For a pond of 0.1 to 0.2 ha area, an outlet pipe of about 15 cm diameters will be ideal. The pipes of less than 10 cm diameter may be lead to clogging. The outlets or drainage pipes installed at the lowest elevation of bottom of the pond. For larger fish ponds the construction of concrete outlet are highly useful. The outlet pipes should be properly covered with screens to prevent the escape of fish form ponds. For larger ponds pipes are bigger diameter as 20-25 cm are preferable. Drainage pipe should be laid at a slope of 1 in 400. The pipe should be rest on layer of sand hard bed to prevent the pipe against unequal settlement at the base. The percolation of water along sides of drainage pipe can be checked by providing a few concrete collars with pipe which will acts as impervious barriers against the path of flow of seeping water.

Maintenance of ponds

Seepage and its control

The ponds constructed on porous soils are required to be protected with impervious material to prevent loss of water owing to seepage from the pond. There are many types of pond lining but the type selected should be cheapest combine with its stability, use fullness and efficiency. Pond lining has some other advantages also. Lining prevents growth of weeds and vegetation on the pond surface. It prevents raise of water table and add safety to the pond structure. Clay puddling, brick work with cement mortar, cement concrete and plastic membrane are few methods of pond lining.

Clay puddling

Clay puddle lining is quite satisfactory under wet condition. A layer of good clay of at least 15 cm thick, uniformly spread on the bed and the sides of the pond and compact it. The surface is then cover with 30 cm of silt.

Brick lining

It reduces the seepage at about 80% provided bricks are manufactured of best material and observed less water. Bricks may be laid flat or on edge and are embedded on 1.2 cm layer of 1:6 cement mortar on consolidated pond surface. The bricks should be plastered or pointed with cement mortar of 1:3 proportions.

Plastic lining

The plastic membrane or poly vinyl chloride (PVC) lining offers a compact water barrier. This system is considerable economy. This method of lining the pond is very simple. The pond surface should be cleared first of all roots, vegetation etc., and the surface is made smooth over which the PVC membrane is laid. Anchorages are made in the ground for holding the membrane in proper position. The membrane is then covered with 30 cm of thick earth layer and well compact it.

Evaporation

Evaporation is the process by which water is converted into gaseous stage and is returned to the atmosphere as vapour. The water is continuously evaporating from the water surface of natural and artificial sources like river, streams, ponds, reservoir etc.,water evaporates from the surface of the soil also. As such a part of the precipitation reaching the earth's surface is lost through evaporation.

Evaporation depends upon several factors such as temperature, humidity, wind velocity, atmospheric pressure, salinity of water and surface area. The rate of evaporation increases with the increase of temperature as well as wind velocity and vice versa. The rate of evaporation decreases with increase of humidity and increases of dissolved salts in water. Evaporation increases when the surface area increases. Rate of evaporation is increases with decreasing of atmospheric pressure.
To find out the rate of evaporation commonly used methods are

- Empherical formula.
- Direct measurement with the help of evaporation pan.

Erosion of soil in dykes and its control

The water wave developed on the top water surface due to the winds try to notch out the soil from the upstream face and may even some times cause the slip of the upstream slope. Upstream stone pitching be provided to avoid such failures. Heavy rains falling directly over the down stream face and the erosive action of the moving water may lead to the formation of gullies on the down stream face, ultimately leading to the dam failure. This can be avoided by proper maintenance, filling the cuts from time to time especially during rainy season. Grassing the slopes and by providing proper berms at suitable height,so that the water has not to flow for considerable distance. The proper drainage arrangements are made for the removal of the rain water collected on the horizontal berms. Since the provision of berms ensures the collection and removal of water before it acquires high down ward velocities, the consequent erosion caused by the moving water is considerably reduced.

Calculation of time required for emptying the pond

The area of pond is 5000 m2, depth of water in the pond is 3 m and radius of the pipe is 10 cm. The co-efficient of discharge is 0.6. There is no seepage in the pond. Find the time required for emptying the pond in hours

Unit 6 - Calculation of area and volume

It highlights the methods used to calculate the area of regular and irregular shapes using trapezoidal and Simpson's formulae. It describes the calculation of volume of regular and irregular shape using the above formulae as applied to stacks and heaps etc., quantity of soil required for construction of dykes also calculated. Differentiate between excavation, embankment, longitudinal and side slopes. It helps to calculate quantity of soil required to be removed from elevated place, quantity of soil need to be filled to pits or lower places for easy supply of water to the ponds in the form of canals or roads using mid-sectional area method mean sectional area method trapezoidal rule and Simpson's rule.

Calculation of area

Calculation of area of regular plane surfaces

The area of the trapezium

A = 1/2* h *(a+b)

Calculation of area

Problem 1. The difference between the two parallel (line) sides of a trapezium is 8 ft. and the perpendicular distance between them is 24 ft. and the area of the trapezium is 312 square feet. Find the length of the two parallel sides.

Problem 2. A railway platform has two of its opposite sides parallel and its other two sides are equal. The two parallel sides are 1001 and 120 ft. is length they are 15^1 each other. Find its area.

ABCD is the trapezium in which AB and CD are the parallel sides of a railway plat form and $AB^1 = 120^1$ and $OC = 100^1$

Since the other two sides are equal and perpendicular to the platform,

A = ½ h (a+b)
= ½ x15(100+120)
= 1650 sq.ft

Problem 3. The parallel sides of a trapezoid are 55 and 77 ft and the other two sides are 25 and 31. Find the area.

ABCD is a given trapezium

Problem 4. One of the parallel sides of a trapezoid is one foot longer than the other. The breadth is one foot and the area is 216 sq. inches. Find the length of the parallel sides.

ABCD is a given trapezium. Length of the side is x”
Length of the other side = x+12”

Irregular Rectilinear Figures

Problem 1. Find the area in square yard, square feet and square inches of a rectilinear figure ABCDEF. Given AC = 160”, CE = 142”, EA = 139”, Bb = 24”, Dd=14”, Ff=20” and Ee = 114”.

Given
AC = 160”
CE = 142”
EA = 139”
Bb=24”
Dd = 14”
Ff = 20”
Ee = 114”

Problem 2. ABCDE is a five sided figure and the angles at B,C and D are right angles. If AB=15’, BC=30’, CD=22” and DE=6’ find the area of the figure and length AE

Given =
AB = 15’
BC =30’
CD=22’
DE=6’

Problem 3) From the given notes draw a plan of the field and find the area in sq.ft.
600 D
400 – 120 C
E 100 – 360
250 – 140 B
F 160 – 200A

Problem 4. From the given notes draw a plan of the field and find the area in ft2

50-300 B
240-50
160
60-100
80-50
A-40

Problem 5) From the given notes draw a plan of the field and find the area in sq.ft.
L 94 - K 198 – J 204
H 122 – I 10
G 64 – F 117
E 14 – D 88
B 63 – C 70A

Calculation of area of irregular plane surfaces

Calculation of area of irregular surfaces can be calculated using the following formulae.

The trapezoidal rule

A trapezoid is a plane four sided figure, having two sides parallel to each other. If the lengths of these sides are Y_1 and Y_2, and they are "h" apart, the area of the trapezoid is given by,

$A = h/2\ (Y_1+Y_2)$

Let us consider a curvilinear figure. It can be divided into number of approximate trapezoids by covering it with "n" equally spaced ordinates, which are at a distance "h" apart. The breadth of the ordinates are in order being Y_1, Y_2, Y_3, Y_4…………………Y_n .

Commencing from the left hand side the area of each trapezoid are given by
$a_1 = ½\ h\ (Y_1+Y_2)$
$a_2 = ½\ h\ (Y_2+Y_3)$
$a_3 = ½\ h\ (Y_3+Y_4)$
$a_4 = ½\ h\ (Y_4+Y_5)$
$a_5 = ½\ h\ (Y_5+Y_6)$
$a_6 = ½\ h\ (Y_6+Y_7)$ and so on
By addition the total area A of the figure is given by
$A = a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + \ldots\ldots$
$A = ½\ h\ (Y_1+Y_2) + ½\ h\ (Y_2+Y_3) + ½\ h\ (Y_3+Y_4) + ½\ h\ (Y_4+Y_5) + ½\ h\ (Y_5+Y_6) + ½\ h\ (Y_6+Y_7)$
$A = ½\ h\ (Y_1+2Y_2+2Y_3+2Y_4+2Y_5+2Y_6+\ldots\ldots+Y_n)$
$A = ½\ h\ [Y_1+Y_n +2\ (Y_2+Y_3+Y_4+Y_5+\ldots\ldots+Y_{n-1})]$

This is termed as TRAPEZOIDAL RULE, the more numerous the ordinates; the more accurate will be the answer.

Calculation of area of irregular surfaces can be calculated using the following formulae.

Simpson's I st rule

Let us consider a curvilinear figure; it can be divided into number of small strips by covering it with "n" equally spaced ordinates, which are at a distance "h" apart. The breadth of the ordinates are in the order of Y_1, Y_2, Y_3, Y_4…………………Y_n .
The area within ordinates number 1 and 3 is
$a_1 = 1/3\ h\ (Y_1+4Y_2+Y_3)$
The area within 3 rd and 5th ordinates
$a_2 = 1/3\ h\ (Y_3+ 4Y_4+Y_5)$
The area within 5 th and 7th ordinates
$a_3 = 1/3\ h\ (Y_5+4Y_6+Y_7)$
The total area is given by
$A = a_1 + a_2 + a_3 + a_4 + a_5 +\ldots\ldots$
$A = 1/3\ h\ (Y_1+4Y_2+Y_3) +1/3\ h\ (Y_3+ 4Y_4+Y_5) + 1/3\ h\ (Y_5+4Y_6+Y_7) + - - -$
$A= h/3\ (Y_1+4Y_2+2Y_3+4Y_4+2Y_5+4Y_6+2Y_7) + - - -$
$A= h/3\ [\ (Y_1+Y_n+4(Y_2+Y_4+Y_6+\ldots\ldots.+Y_{n-1}) + 2\ (Y_3+Y_5+Y_7+\ldots\ldots\ldots+Y_{n-2})\ ]$
This is the generalized form of the Simpson's first rule applied to areas. The common multiplier is 1/3 x the common interval "h" and the individual multipliers are 1,4,2,4,2,4,2,4,2,4,1. It is suitable for 3, 5, 7, 9, 11, 13 etc., ordinates.

Calculation of area of irregular surfaces can be calculated using the following formulae.

Simpson's second rule

Let us consider a curvilinear figure. It can be divided into number of strips by covering it with "n" equally spaced ordinates, which are at a distance "h" apart. The breadth of the ordinates in the order of Y_1, Y_2, Y_3, Y_4…………………Y_n .
Simpson's second rule for four evenly spaced ordinates becomes
$a_1= 3/8\ h\ (Y_1+3Y_2+3Y_3+Y_4)$
$a_2= 3/8\ h\ (Y_4+3Y_5+3Y_6+Y_7)$
$a_3= 3/8\ h\ (Y_7+3Y_8+3Y_9+Y_{10})$
$a_4= 3/8\ h\ (Y_{10}+3Y_{11}+3Y_{12}+Y_{13})$
In general
$A = a_1 + a_2 + a_3 + a_4 + a_5 + \ldots\ldots..$
$A = 3/8\ h\ (Y_1+3Y_2+3Y_3+Y_4) +3/8\ h\ (Y_4+3Y_5+3Y_6+Y_7) +3/8\ h\ (Y_7+3Y_8+3Y_9+Y_{10}) + 3/8\ h\ (Y_{10}+3Y_{11}+3Y_{12}+Y_{13}) + \ldots..$
$A=3/8h\ (Y_1+3Y_2+3Y_3+2Y_4+3Y_5+3Y_6+2Y_7+3Y_8+3Y_9+2Y_{10}+\ldots\ldots\ldots\ldots\ldots\ldots\ldots.+Y_n)$
Thus the common multiplier in this case is 3/8 times the common internal "h" and the individual multipliers 1,3,3,2,3,3,2,3,3,1. It is suitable for 4, 7, 10, 13, 16, 19, 22 etc., ordinates.

Problems 1) Find out the area of the land show in fig, using Simpson's rule (All measurements are in m.)

$A = h/3 \{Y_1+Y_n+ 4 (Y_2+Y_4+Y_6+Y_8+Y_{10})+ 2 (Y_3+Y_5+Y_7+Y_9+Y_{n-1}) \}$
$= 4/3 [7.2+ 0 + 4 (9.4+11.9+11.6+8.6+3.2) + 2 (11+12.1+10.5+6.2)]$
$= 354.13m^2$

Problems 2) Find out the area of the land given below by Simpson's rule (All measurements are in m.)

$A=h/3 [Y_1+Y_n+ 4(Y_2+Y_4+Y_6+Y_8)+2(Y_3+Y_5+Y_7)]$
$= 1/3 [10+3.5 + 4(10.5+11.5+9.5+5.5)+2(11+11+6.9)]$
$=73.1m^2$

Problems 3) Find out the cross sectional area of the heap as show in Fig. The distance between each interval is 2 m apart. Use Simpson's rule.

Problems 4) Find out the cross sectional area of the stack as shown in Fig. The distance between each station is 1.5 m. apart.

Cross sectional area of the stack
$A = h/2 [(y_0+y_n+2(y_1+y_2+y_3+y_4+y_5+.....y_{n-1})]$
$= 1.5/2 [(1+0+ 2(3.6+5.1+6.7+7.9+10.3+14.2+15.6+14.1+13.8+12.6+10.3)]$
$= 172.05 m^2$

Volume of a trapezium
Volume = Area * Length
$V= L * h / 2 (b_2 + b_1)$

Volume of a triangular prism
Volume = Area * Length
V= 1/2 * H *B * L

Volume of a cube
Volume of a cube = Area * Height
V= L * W * H

Volume of a cylinder

Volume of a cylinder = Area * Height
$V= \pi r^2 h$

Problems

Calculation of quantity of soil required for construction of dyke.

1) An embankment is to be built for a length of 150 m with top width 1 m and height of 3 m. If the side slope recommended is 1:1. Calculate the quantity of soil required for it.

$A = BY + KY^2$
$= 1 \times 3 + 1 \times 3^2$
$= 12\ m^2$
$V = A \times D$
$= 12 \times 150 = 1800 m^3$

or

$A = h/2\ (b + a)$
$= 3/2\ (1+7.0)$
$= 12\ m^2$
$V = A \times D = 12 \times 150 = 1800 m^3$

2). An Embankment is to be built with 4 m wide at top with side slopes 1 to 1 and 3 m height. Assuming the ground is level. Calculate the volume of earth required to construct the embankment, if the length is 200 m.

$V = A \times D$
$A = By + KY^2$
$= 4 \times 3 + 1 \times 3^2$
$= 21 m^2$

$V = A \times D = 21 \times 200 = 4200 m^3$

3) An embankment is 6 m wide at the bottom with side slope 1:1. Assuming the ground is level in the direction of transverse. Calculate the volume of earth work required to construct an embankment, if the length and breadth of the embankment are 125 m and 3 m.

b =3m Slope = 1:1
Bottom width = 6 m.
So the height of the embankment is 1.5 m
Area of the embankment $A = h/2\ (a + b)$
$= 1.5/2\ (3+6) = 6.75 m^2$

Or

$A = BY+KY^2=3 \times 1.5+1.5 \times 1.5^2=6.75 m^2$
Volume of earth required = V = A x L
$=6.75 \times 125= 843.75 m^3$

Trapezoidal Rule

Let us consider a curvilinear figure. It can be divided into number of small areas by covering it with "n" equally spaced parts, which are at a distance "h" apart. The areas are in the order of $a_1, a_2, a_3, a_4 \ldots\ldots\ldots\ldots\ldots\ldots a_n$.

Commencing from the left hand, the volume of each part is given by
$v_1= ½ h (a_1+a_2)$ $v_2 = ½ h (a_2+a_3)$ $v_3 = ½ h (a_3+a_4)$ $v_4 = ½ h (a_4+a_5)$
$v_5 = ½ h (a_5+a_6)$ $v_6 = ½ h (a_6+a_7)$ and so on
By addition the total volume V of the figure is given by
$V= v_1 +v_2 + v_3 + v_4 + v_5 + v_6 + \ldots\ldots\ldots$
$V= ½ h (a_1+a_2) + ½ h (a_2+a_3) + ½ h (a_3+a_4) + ½ h (a_4+a_5) + ½ h (a_5+a_6) +½ h (a_6+a_7)$
$V = ½ h (a_1+_2 a_2+2a_3+2a_4+2a_5+2a_6 +\ldots\ldots\ldots\ldots\ldots\ldots+a_n)$
$V = ½ h [a_1+ a_n +2 (a_2+a_3+a_4+a_5+\ldots\ldots\ldots\ldots\ldots\ldots+a_{n-1})]$
This is termed as TRAPEZOIDAL RULE, the more numerous the areas; the more accurate will be the result.

Simpson's I st rule

Let us consider a curvilinear figure. It can be divided into number of small areas by covering it with "n" equally spaced parts, which are at a distance "h" apart. The areas are in order being $a_1, a_2, a_3, a_4 \ldots\ldots\ldots\ldots\ldots\ldots a_n$.
The volume within ordinates number 1 and 3 is
$v_1 = 1/3 h (a_1+4a_2+a_3)$
The volume within 3 rd and 5th ordinates
$v_2 = 1/3 h (a_3+ 4a_4+a_5)$
The volume within 5 th and 7th ordinates
$v_3 = 1/3 h (a_5+4a_6+aY_7)$
The total volume is given by
$V = v_1 + v_2 + v_3 + v_4 + v_5 +\ldots\ldots$
$V = 1/3 h (a_1+4a_2+a_3) +1/3 h (a_3+ 4a_4+a_5) + 1/3 h (a_5+4a_6 +a_7) +\ldots\ldots$
$V= h/3 (a_1+4a_2+2a_3+4a_4+2a_5+4a_6+a_7) +\ldots\ldots$
$V= h/3 [(a_1+ a_n+ 4(a_2+a_4+a_6+\ldots\ldots\ldots+ a_{n-1}) + 2 (a_3+a_5+a_7+\ldots\ldots\ldots+a_{n-2})]$
This is the generalized form of the Simpson's first rule applied to volume. The common multiplier is 1/3 x the common interval "h" and the individual multipliers are 1,4,2,4,2,4,2,4,2,4,1. It is suitable for 3, 5, 7, 9, 11, 13 etc., areas.

Simpson's second rule

Let us consider a curvilinear figure. It can be divided into number of small areas by covering it with "n" equally spaced parts, which are at a distance "h" apart. The areas are in order being $a_1, a_2, a_3, a_4 \ldots\ldots\ldots\ldots\ldots\ldots a_n$.

Simpson's rule for four evenly spaced ordinates becomes
v_1= 3/8 h (a_1+3a_2+3a_3+a_4)
v_2= 3/8 h (a4+3a_5+3a_6+a_7)
v_3= 3/8 h (a_7+3a_8+3a_9+a_{10})
v_4= 3/8 h (a_{10}+3a_{11}+3a_{12}+ a_{13})
In general
A = v_1 + v_2 + v_3 + v_4 + v_5 +.....
A = 3/8 h (a_1+3a_2+3a_3+v_4) +3/8 h (a_4+3a_5+3a_6+a_7) +3/8 h (a_7+3a_8+3a_9+a_{10}) + 3/8 h (a_{10}+3a_{11}+3a_{12}+a_{13}) +.......
A=3/8h (a_1+3a_2+3a_3+2a_4+3a_5+3a_6+2a_7+3a_8+3a_9+2a_{10}+.............+a_n)
Thus the common multiplier in this case is 3/8 times the common internal " h" and the individual multipliers 1,3,3,2,3,3,2,3,3,1. It is suitable for 4, 7, 10, 13, 16, 19, 22 etc., ordinates.

Calculation of volume of earth work as applied to stacks and heaps

Problem 1) Calculate the volume of soil in a heap. The cross sectional areas of the heap are given below. The cross sections are equally done at a distance of 1 m.

Calculation of volume of regular shape as applied to volume of pond

Problem 1) An excavation is to be done for a pond of 80m long and 50 m wide at the bottom and 3 m deep. The side slopes of excavation is 1.5 H : 1 V. Assuming the surface of the ground to be level before excavation. Calculate the volume of earthwork.

Problem 2) A pond is to be dug with 15 m wide and 20 m long at the bottom to a depth of 2.5 m. If the side slope recommended is 1 in 1. Find the volume of earth work

Problem 3) An excavation is to be made for a pond 20 m long and 12m wide at the bottom; having the side slope of the excavation at 2H:1V. Calculate the volume of excavation, if the depth is 4 m. The ground surface is level before excavation.

Unit 7-Earth Work Calculations

It gives an idea about excavation, embankment, longitudinal and cross-slope. It describe the mid – sectional area method, mean sectional area method, trapezoidal rule and Simpson's rules used to calculate the quantity of soil need to be removed from the elevated place, quantity of soil need to be filled to the lower elevated places for easy supply of water to the ponds, in the form of canals. It also describes to calculate the quantity of soil required for constructs in roads.

Methods used to calculate volume of earthwork

Excavation and Embankment

A given section is said to be in cutting or excavation, when the formation line at that section is lower than the existing ground.On the other hand a given section is said to be filling or embankment when the formation line at that section is higher than the existing ground level.

Longitudinal slope and cross slope

The slope of the ground along a given line is known as the longitudinal slope. On the other hand slope of the ground perpendicular to the given line is known as the cross slope or transverse slope. A ground having a cross slope is also known as side long ground. In flat country the cross slope is usually negligible. In a hilly terrain the cross slope is usually significant.

Note: Unless otherwise specified we should always assume that cross slope is zero.

Formation in cutting and filling

Usually slope of the section is considered only horizontal to vertical. When ever the side slope is not clearly specified we shall assume the given side slope has horizontal to vertical.
For instance a side slope is 2:1 i.e., H = 2 V=1 . . . K=2
Side Slope is 3:2 means H=3 V=2 K = 1.5. . . . 1.5 H =1V

Methods of computing the volume of earth work

The following are the few methods normally used to calculate the volume of earth work.

Mid sectional area method

Y1 and Y2 are the depth of cut or height of bank at any two sections, which are at a distance "D" apart. Let "Y" be the depth of cut or height of bank at the section lays mid way between the sections, then

Let "A" be the cross sectional area of the earth work at the mid section. Then the volume of earth work between two given sections is computed from the relating V = A x D.

Mean sectional area method
Let A1 and A2 be the cross sectional areas of earth work at two given sections, which are at a distance "D" apart. Then the mean sectional area is given by,

Trapezoidal formula method
This formula provides an extension of mean sectional area method. In other words the trapezoidal formula method and mean sectional area methods are one and the same. Let A1, A2, A3 ....An be the cross sectional area of earth work at the section along the given line.

Let "D" be the distance between any two adjacent sections. Then the total volume of earth work along the given section can be computed from the relation.

$V = D/2\ (A_0+A_n+2(A_1+A_2+A_3+ \ldots\ldots\ldots\ldots\ldots\ldots +A_{n-1})$

Prismoidal formula method
According to this formula volume of earth work along a given line can be computed from the relation.

V= D/3 [(Ao+An+4(A1+A3+A5+.....................+An-1)+2(A2+A4 + A6 +A8+.................+An-2)]

This formula is applicable provided "n" is even. The smallest value of "n" for which Prismoidal formula can be applied is "2"b.

Calculation of volume of earth work as applied to roads and channels
Problem
1. Compute the depth of cut and height of bank at the various section along the given line from the following data.

Solution
Distance between any two adjustment sections is 30 m
Falling gradient is 1 in 50
For every 30 m = 1/50 x 30=0.6
The depth of cut or height of bank is tabulated below.

Problem 2.Compute the volume of earthwork between the two sections from the following data by using a) Mid-sectional area method b) Mean-sectional area method. Assume the following data, formation width = 10 m, Side slope = 1.5:1

Problem 3.Compute the volume of earth work from the following data.

Formation width = 10 m, Side slope -Embankment = 2:1, Cutting = 1.5 :1

Solution
Rising gradient -1 in 200
Depth of cut or height of bank between two stations = 1/200 x 40 = 0.2

Unit 8 - Brackish and marine water fish farms

It describe about types of brackish water farms such as tide fed, pump fed and tide cum pump fed farms and their merits and demerits. It helpful to understand important factors to be considered to select a suitable site for brackish water fish farm and how these factors influences in reducing cost of construction, easy culture, trouble free maintenance and ultimately increases the profit.

It describes about marine water fish farm, important points to be considered to select a site for marine water fish farm, such as water source, soil characteristics etc., It also helps for proper planning and construction of marine water aqua farm. It deals with types of dykes used in marine water farm such as peripheral dyke and secondary dyke.

Definition

Brackish water ponds is defined when the salt content in these ponds water is in the range of 0.50 – 30 ppt.

Classification of ponds

Ponds are classified into various types based on number of parameters. Based on source and construction, these ponds are classified into following types.

- Tide fed farms
- Pump fed farms
- Tide-cum pump fed farms

Tide fed farms

Tide fed aquafarms are best suited for traditional extensive system. Tide fed farms are suitable at the places where mean spring tide range is in between 1.3 to 2 m with maximum and minimum spring tide ranges around 1-2.5 m respectively; provided the ground levels are around the mean sea level. Invariably tide fed aqua farms require only one water channel which is generally called as “Feeder cum drainage channel”. These farms require a main sluice gate which controls the flow of water into the feeder channel as well as all the ponds. The main sluice gate which controls the flow of water into the feeder channel as well as to all the ponds. The main sluice gate also prevents the farm from flooding during heavy floods.

Tide fed farms are not suitable for semi-intensive and intensive culture system as it is very difficult to maintain the quality of water due to inadequate water exchange sudden de-watering of the pond is not possible as there is no separate drainage system.

Following are the some of the major disadvantages of the tide fed aqua farms.

- Water quality management poses a problem since entire water intake process is mainly based on tidal influence. It may also be difficult to maintain the designated water level in the ponds.
- Cost of construction of dykes, ponds and channels etc. will be higher as design of these elements mainly depends upon the tidal levels.
- Since individual pond dewatering is very difficult, efficient harvesting is not possible in tide–fed farms.
- Control of predators in tide fed farm is difficult.
- Pond preparation is difficult as tidal water seeps through the dykes and sluices due to tidal thrust.

Pump fed farms

Pump fed aqua farms is best suited for semi-intensive and intensive culture system. Pump fed farms will generally have a separate water channel and drainage channel. Pump fed farms also require storage cum sedimentation tank and an efficient pumping unit. At the places where mean spring tide range is too small (<0.8m) or too big >2m) pump fed farms prove economical and advantageous. Areas around a meter below the highest water level may be selected for pump fed aqua farming so that with a minimum excavation of 20 cm to 50 cm economical ponds may be constructed. Water storage cum sedimentation tank is to be constructed to store the water. The capacity of this storage tank should be such that it should supply the water to all the ponds at least for 2-3 days at the desired rate of water exchange in case of failure of electricity.

Pump fed farms do not require a big main sluice gate to supply the water. In these farms big embankments and ponds can be avoided. At the places where ground levels are much higher than the tidal levels, the tide fed farms construction is more expensive because of huge excavation and higher pond sluices. In such cases the site can be easily developed as pump fed farms.

Pump fed farms got the following advantages.

- Bundhs can be formed to a minimum height.
- Earth to be excavated from the ponds is just sufficient to meet the requirements of farming the bundhs to the required height.
- Daily and continuous exchange of water is possible which need not to be depending upon the rise or fall of tides.
- Emergency exchange of water is possible when the quality of water deteriorates and immediate replacement of water can be done.

Tide-cum pump fed farms

The places where free tidal water is available only during some months period tide cum pump fed farms are suitable. In such farms for some months one has to depend upon the pumps to lift the water from the creeks. A site having mean spring tide range between 0.8 m to 1.3 m with ground levels at about low spring tide levels is suitable for such farms. These farms would require to be supplemented by pumping of water during certain months when spring tide range is smaller and exchange of water is not possible for several weeks at a stretch. This would also require main sluice gate and individual pond sluice like in the case of tide fed farms. But in addition pumping unit is required for supplying the water during the shortage of water.

Tide fed farms proves expensive on investment but economical in operation. Pump fed farms prove economical on investment but expensive in operation. The tide cum pump fed farms proves expensive on whole because of heavy investment and operation.

Site selection for Brackish water fish farms

The following are the important points to be considered for selecting a site for brackish water fish farming

- Topography and Tidal amplitude
- Availability of active tidal creek resources
- Existence and density of mangrove vegetation
- High flood levels
- Range of tidal variations
- Type of soil and its quality
- Water sources

Topography and Tidal amplitude

Topography is one of the most important criteria in the process of site selection. When selecting a site for aquaculture, preference should be given to locations where the gravitational flow may be used to fill the ponds, as gravity flow is economical. It is also advantageous to drain the ponds by gravity flow. To take the advantage of gravity flow, the pond bottom should be at a higher elevation than the water table when the pond is drained (for pond drainage).Topography refers to the changes in the surface elevation of natural ground i.e. whether the ground is flat, sloping, undulating, or hilly. The best area for fish ponds/shrimp ponds is where the ground is levelled (flat) or where there is a slight slope. The optimum slope is between 0.5 to 1.0%. The ground slope shouldn't be more than 2%, as it needs construction of high and costly embankments. Rectangular or square shaped flat areas located near the active creek and other natural water resources like rivers/canals/reservoirs/streams, etc; with an average natural ground elevation of 1 to 3 meter above the mean sea level, having minimum vegetation on it and slight sloping in one or two directions are ideal for coastal aquaculture development.

Sites with excessive undulating topography should be avoided as a lot of cut and fill would be needed during the construction, which will increase the cost of construction. Sites with average elevation lower than the mean low water should be avoided as ponds cannot be drained properly. Areas covered with large number of big trees and thick vegetation should be avoided as cleaning of the site will be difficult and will increase the cost. Proper elevation of the site in relation to tidal datum is another question, which needs to be considered especially in brackish water projects. At the places where tidal fluctuations (daily fluctuations) are too high (say 4 m and above) would be problematic because very big and costly dikes would be required to prevent flooding during the high tide. Areas where tidal fluctuations are too small (say 1 m or less) would pose serious problems because filling and draining of the pond cannot be fully executed. In general, the sites where tidal fluctuations are moderate (say between 2 m and 3 m) are most suitable for proper management. Ideal tidal amplitude for extensive and semi-intensive culture is 1.5 meter.

Availability of active tidal creek resources

The site should be selected at the place where the site is rectangular or square in shape and located near the active creek and other natural water resources like rivers/canals/reservoirs/streams, etc;

Existence and density of mangrove vegetation

Mangroves are the group of flowering halophytic shrubs and trees growing up to 30 m of height, belonging to several unrelated families occurring around sheltered tropical shores. Mangroves occur along protected sedimentary shores, particularly in the tidal lagoons, embayment's and estuaries. Capable of tolerating full saline conditions, mangroves are never totally isolated from sea, though they may grow far inland. However the dense ever green growth of mangroves shelters a large number of terrestrial animals, while their complex root system, together with the thick silty sediments in which they grow, harbour a variety of marine invertebrates. Filamentous algae are abundant on the sub stratum as well, and utilize the fine sediments while the leafy algae directly attach to the mangrove roots. In addition, numerous fish and crustaceans move in and out of the mangrove vegetation with the tidal flow.

High flood levels

For extensive and semi-intensive culture practices where the water supply and draining are mostly done by gravity, the sites with an elevation above MHWL (Mean Higher High Water Level) are not suitable as they would require much excavation; similarly sites with elevation below LLWL (Mean lower low water) are also not suitable as the draining and drawing of the water in ponds become a big problem. For extensive and semi-intensive ponds, elevation of the land should be slightly above MLLW and slightly below MHWL; while intensive ponds should be slightly above MHWL, but should not exceed 2 meter above MHWL.

Range of tidal variations

Speed of tidal currents and its characteristics, pattern of water circulation are to be given due importance in the process of site selection. High currents of tidal water lead to soil erosion of the embankments. Therefore there must be a minimum distance of 50.00 meter between the creek and outer dike of the farm. The HFL (High flood level) and storm surge levels should also be studied to fix up the top levels of dikes.

Type of soil and its quality

The type of soil and its composition at a site is of crucial importance. It has direct bearing on the productivity of pond. The site should contain soft bottom soil or mixed soil comprising of clay, sand and silt to ensure good water bearing capacity as well as production of natural food organisms on which fish and prawn could feed and grow. One of the most important characteristics is the ability of soil to hold the water. Good soil should contain a layer of impervious material thick enough to prevent excessive seepage. Clays and silty clays are excellent impervious materials. A soil permeability of K (Coefficient of permeability) less than 5 x 10-6 m/sec is desirable.

A sandy clayey soil to clayey loam soil is the best soil type for fish/shrimp pond construction. Clayey loam is an ideal soil as it has low permeability and also rich in organic matter. In case of mixed soils, clay content up to 30% is desirable. Loamy soils have great fertility. Clayey loam has both properties i.e. low permeability and high fertility. Organic matter of clayey loam helps in the production of benthic blue algae, which in turn along with some associated micro-organisms form natural food for fishes and prawns. Clayey loam soil also has high load bearing capacity, therefore it is the best material for constructing the embankments.

Soil texture requirements vary with the level of culture technology to be applied. In extensive culture system, which relies mainly on benthic organisms as natural food for the shrimp, loamy to sandy bottom is preferred. On other hand sandy clay loam to sandy loam is preferred for semi-intensive and intensive cultures where artificial food is given as main source of food. Pond bottom soil reacts with water and influences water quality. It plays a very important role in the storage and release of nutrients to water and mineralization of organic waste matter. Hence soil characteristics (Like texture, composition and fertility) govern water quality and pond productivity.

Water sources

A reliable water supply is perhaps the single most important factor to be considered when selecting a site for an aquaculture. Water of proper quantity and quality should be available in accordance with the cycles of aqua cultural operation. Therefore when selecting an aquaculture sites the water supply must be thoroughly investigated. Although well water is usually the preferred source of water but it is uneconomical especially when water is pumped from deep in the ground. Depending upon the nature of occurrence water sources can be classified in to following two groups,

- Freshwater Resources
- Brackishwater Resources

Freshwater Resources

The following are the fresh water sources such as wells, springs, streams, rivers, reservoirs, rain water, cycled water etc.

Brackishwater Resources

The following are the brackish water sources such as sea, creeks, estuaries, lagoons, artificial sea water etc. Like other surface waters, brackish and seawater sources are subject to contamination usually increasing in severity the closer one is to the shoreline. Coastal pollution is an ever worsen without strict governmental regulation. Water intakes should be located as far offshore as economically practical and should not be located near industrial or municipal discharges or near area subject to agricultural runoff. Salt water is very corrosive; therefore, pipes, fixtures, pumps, and other components that come into contact with the water should be fabricated from corrosion-resistant materials. Fouling is also a considerable problem wherever salt water is used. Measures that can be taken to mitigate fouling problems are discussed at length by Wheaton (1977).

The saltwater source should be of constant salinity. This is generally not a problem where the water intake is located far offshore. Intakes located near freshwater inflows from rivers and streams or in shallow water areas that may be affected by evaporation and rainfall are subject to rapid fluctuations in salinity and should be used with caution. Saltwater intrusion in some coastal regions makes it possible to extract brackish water from the ground. The quality of such wells depends on site conditions and the geology of the water bearing strata.

Marine water fish farms

Site selection

The following are the important points to be considered for selecting a site for marine water fish farming.

Main factors

- Topography and tidal amplitude
- Type of soil and its quality
- Water source and the quality of water
- Drainage facilities

Other factors

- Environmental factors (Meteorological factors)
- Accessibility
- Socio-economic conditions
- Pollution problems
- Availability of seed and feed
- Availability of freshwater & electricity (public amenities)
- Transportation and Marketing facilities (communications)
- Social and political factors
- Availability of technical guidance
- Security, etc.

Pond dyke

Pond dykes are usually constructed using soil or concrete. Earthen dikes with or without lining are the most economical although they occupy more level space than concrete. Use of concrete dikes is normally limited to smaller size ponds for intensive culture practice. An aquaculture pond generally has the following to kinds of dike.

- Wide and strongly built main dike constructed around the pond. This is known as peripheral dike.
- Partition dike or secondary dike constructed inside the pond, limiting the size of each pond. It is smaller than main dike.

Pond dyke

Main or peripheral dike

Main or peripheral dike form the boundary of the entire pond system. The purpose of this dike is to retain water for culture operation as well as to provide overall protection to the farm from floods, spring and storm tides etc,. Main dike encloses the entire farm. Its design and strength depend upon the prevailing conditions at the site. The vertical distance from the ground surface to the top of dike is the designed height for construction. This height must consider allowances for waves and floods; shrinkage and settlement and free board. The total height of the main dike above the ground level of a brackish water pond can be computed by the following formula.

Where,
H_m = Height of main or peripheral dike (m)

H_t = Highest astronomical tide above the zero datum or mean lower low water.
H_g = Elevation of ground surface with respect to zero datum or MLLW (m)
F_a = Flood allowances
H_f = Free board
%S = Percentage of soil settlement allowance

The amount of soil settlement depends on the type of soil material used for construction, soil water content during construction, amount of compaction done, speed of construction and characteristics of foundation material. When mechanized earth moving equipments are used, 5 to 10 percent of allowances may be provided for settlement. In many coastal aquaculture ponds, however the settlement allowances used is between 20 to 25 percent. Depending upon the organic matter content in the soil, following values of soil settlement may be used.

For soil with exceptionally high organic matter content, settlement allowance requirement may be 40 percent or even more.

Free board is provided as a safety factor to prevent over topping of dyke. It is the vertical distance from the surface of water level in the pond at its design depth to the top of the dyke after settlement. A free board of 0.6 meter to 1 meter is provided in the main dyke. A minimum of 0.6 meter free board is necessary in the case of well compacted peripheral dyke.

Side slope is necessary for stability of dyke, the flatter the slope, the more stable it is. The outer slope and the inner slope of the dyke depend upon soil texture and prevailing site conditions. The minimum required slope for different soil textures is given.

The minimum slope of dyke at outer edge should be 1:5:1 and preferably 3:1 if it is exposed to strong floods and storm surges. Unstable soils may require 4:1 or flatter slopes. The top width or the crown of dyke depends upon the height of dyke and its purpose. Engineering Standard requires a minimum top width of 2.4 m for all dykes between 3 to 4.5 m high. Dykes between 4.5 to 6 m require a minimum top width of 3.7 m. However in actual practice most of the main dykes of a coastal aquaculture farms are built with a top width between 1.2 to 2.5 m. If the dyke is to be used as a road way a minimum of 3.7 m top width should be provided. The base width or bottom width of dyke depends upon the depth of water; top width of the dyke and type of soil. The base should be sufficiently wide so that the seepage line should not appear above the toe on the downstream side of dyke. Berms are constructed at dyke base to provide additional stability to dyke or when there is excess soil.

Partition dyke or secondary dyke

Partition dyke or secondary dyke divides the pond system in compartments. Its height is computed by following equation.

$H_p = H + H_w + H_f + H_s$

Where,
H_p = Height of partition dyke (m)
H = Maximum desired depth of water in the pond (m)
H_w = Dyke height required for wave action (m)
H_f = Dyke height required for optimum free board
H_s = Dyke height required for settlement

Maximum desired depth of water in coastal aquaculture ponds is usually less than 1.5 m. Dyke height must be sufficient to prevent overtopping due to wave action. Wave height is a function of fetch, which is the unobstructed straight line distance from the furthest point in the pond to dyke. It can be calculated by the following equation.

H_w = Wave height (m)
F = Fetch
The free board requirement in the pond will vary according to site conditions and local requirements. For ponds with secondary dykes up to 200 m long, a minimum free board 0.3 m should be provided. Where as for ponds between 200 m and 400 m long minimum free board should be 0.5 m. Allowance for settlement is usually calculated as a percentage of partition dyke height H. Average settlement allowance used is between 10 and 25 percent of dyke height, minimum allowance being 5%. Top width of secondary dyke is usually between 1 to 2 m.

Problem 1. Compute the optimum height of a main dyke for a coastal pond site located in a flood free zone. The site is 1 m above zero datum, height of highest astronomical tide above the zero datum being 3 m. Assume medium soil for the give site.

Elevation of ground surface with respect to zero datum
H_g = 1m
Highest astronomical tide above the zero datum H_t = 3 m
Allowance to be given for flood = f_a = o
For given soil condition %S = 15
Assume minimum free board of 60 cm , f_b= 0.6m

Problem 2.Compute the required height of a secondary dyke of a coastal pond site with a maximum desired depth of water 1 m, if the fetch is 100 m. Assume soil settlement allowance to be 10%.

Maximum desired depth of water in the pond = 1 m
F = 100 m Dyke height required for wave action

Creeks and estuarine

Estuaries can be defined as semi-enclosed bodies of coastal water that retain a free connection with the open sea, and within which sea-water is measurably mixed with fresh water of terrestrial origin. Though estuaries are the interface between open marine and a fully fresh water environment, the estuarine water is not a simple dilution of sea water.

Types of estuaries

Based upon the geomorphological characters and their models of formation, estuaries can be classified into the following types

- Drowned river valleys
- Tectonic estuaries
- Fjords or drowned glacial valleys
- Bar-built estuaries

Marine water source utilization

Salt-water wells often must be drilled very deep to reach below freshwater aquifers. Typically the deeper the well, the more expensive will be the construction and pumping costs. Also, the deeper one drills, the warmer the water. Cooling may be required before use if the well water has too high a temperature. If the system appears to be economical, salt-water wells have all of the same advantages as fresh groundwater. Where salt water is required, salt-water wells reduce system complexity and costs by reducing the need for treatment. A disadvantage of salt water wells is that site conditions and geology often produce unfavourable groundwater quality.

Unit 9 - Hatcheries

It deals about important points to be considered to select a site for hatcheries. It highlights about the infrastructure facilities required for hatchery, such as brood stock ponds, water supply system, main hatchery complex, brood stock unit etc., It helps to design different facilities such as brood stock ponds, Larval rearing unit, Artemia hatching tanks etc., ultimately it helps how these factors influences in reducing coast of construction, trouble free operation, maintenance and also increases the production.

Fresh water prawn hatchery

Layout plan and location of fresh water prawn hatchery

For the establishment of a giant fresh water prawn hatchery the following things to be essentially considered for its successful operation.

Site selection

Selection of a suitable site is one of the most important factors for the establishment of a prawn hatchery. Large scale commercial prawn hatcheries require coastal sites having adequate supply of sea water and fresh water free from pollutants. The site should be amenable for provision of infrastructural facilities such as availability of electricity, accessibility etc. Backyard hatchery can be established at any place where good quality of freshwater is available along with either concentrated brine solution or artificial sea water.

Infrastructural facilities

The infrastructural facilities include earthen brood stock ponds to maintain adequate supply of brooders, water supply system, aeration system, main hatchery shed for housing brood stock holding tanks, hatching tanks, larval rearing tank, post-larvae holding tanks, power house, pump house etc.,

Brood stock ponds

Continuous supply of good quality brooders is one of the pre-requisite for the successful operation of a commercial hatchery. Therefore it is essential to have brood stock ponds located in the proximity of the hatchery complex so as to avoid rough handling and long distance transportation of brooders. The texture of the soil suitable for brood–stock ponds is sandy–loam or sandy clay loam, which should have pH between 6.5 to 8.0. The site should have perennial source of freshwater free from pollutants.

Water supply system

The water supply system consists of seawater intake, filtration units, storage tanks for sea water, freshwater and brackish water (mixed water) and their distribution to various sections of the hatchery.

Sea Water: If the seawater is to be drawn from inter tidal zone sea water should be drawn through a sub-soil filter arranged 5-6 feet below the sand, in order to make the water free from suspended particles and turbidity. If sea water is to be drawn from surface, the water should be passed through a shore sand filter before storing into the reservoir.

Fresh water: The source of fresh water may be from a tube well or from a perennial canal. If water contains any suspended particles or turbidity, it should be passed through a sand filter before storing into the reservoir. The hardness of the fresh water should be below 50 ppm.

Brackish water (mixed water): Supernatant water from the fresh water and seawater storage tanks are pumped into the mixing tanks so as to get the desired salinity (14 ± 2 ppt) with thorough aeration or with an agitator. The mixed water is treated with bleaching power to get 10 to 15 ppm chlorine to kill the micro flora and fauna. After 10 to 12 hours of chlorination (contact period) the water should be de-chlorinated with sodium thiosulphate (1 ppm residual chlorine needs 7 ppm of sodium thiosulphate).The de-chlorinated water is treated with 10 ppm of EDTA to eliminate the dissolved heavy metals if any.

Main hatchery complex

The main hatchery complex is a shed covered with asbestos cement sheets. The main hatchery complex consists of brood stock unit, larval rearing unit, artemia hatching unit, post – larval rearing unit.

Brood stock unit

This unit has provision to hold berried females and hatching the eggs of berried females. The unit is provided with freshwater, brackish water and air supply grids of P.V.C. all along the walls inside the shed.

Berried female holding tanks

The brood stock unit consists of various size (2 to 10 ton capacity) cement tanks/plastic pools/F.R.P tanks to hold the berried females collected from the brood stock ponds. These tanks are housed under an asbestos roofed shed. The berried females having different stages of egg development are stocked in separate tanks. Depending on the colour of eggs, the berried females are grouped into three categories.

- The prawns with orange colour eggs.

- The prawns with brown colour eggs.
- The prawns with grey colour eggs.

Hatching tanks

The size of hatching tanks varies from 0.5 to 1 ton capacity in commercial hatcheries. Normally F.R.P tanks are used for hatching.

Larval rearing unit

The larval rearing unit plays a major role in the successful operation of prawn hatchery. The larval rearing shed should be situated with a North-South orientation having large windows on eastern and western sides for proper ventilation. The roof of the shed is covered with asbestos cement sheets interspersed with one translucent fibre glass sheet after every three sheets. The hatchery should have concrete flooring with proper shape and drainage facility. The unit is provided with fresh water, brackish water and air supply grids of P.V.C. all along the walls inside the shed.

Larval rearing tanks

Prawn larvae are reared in different types and sizes of tanks made up of cement, FRP Ferro-cement etc., Smaller hatcheries use 0.25 to 1.0 ton and commercial hatcheries use 1 to 5 ton capacity parabolic shaped or circular tanks with disc shaped bottom. The tanks are provided with aeration.

Atermia hatching unit

Artemia hatching unit consists of 50 lt. to 500 lt capacity FRP cylindro – conical jars. The conical part of the jar is translucent and the innersurface of the jar is white in colour. The jar has a lid. Aeration is provided at the centre of the cone. An outlet valve is provided at the centre of the cone to harvest the artemia naupdil after hatching. Above the each jar two florescent tube lights are fixed to get 1000 Lux light.

Post-larval rearing unit

In the hatcheries the post-larvae are generally reared in 10 to 20 ton capacity cement tanks/plastic pools/FRP tanks. These tanks are roofed under asbestos side open sheds. Aeration is provided in the tanks. In the field post-larvae are reared in hapas fixed in the earthen ponds.

Equipment

The essential equipments are pumps, oil free air blowers, generator, salinity, refracto meter, chloroscope, pH meter, thermo meter, oxygen meter, analytical balance, mixer, cooker, refrigerator, oven, hotplate, sieves etc.,

Other facilities

In addition to the above facilties the hatchery complex consists of pump houses, power house, filter units, over head tanks, small lab, store office, staff quarters etc.,

Assumptions

Production target = 10 million PLI annum
No. of cycles = 4
Production per cycle = 2.5 million
Survival from stage-1 to PL = 25%
Stage - 1
larvae required per cycle = 10 million
No. of berries females required (Assuming a 50g female gives 20,000 stage – I larvae) = 500 Nos.
Additional stock of 25% = 125 Nos.
Total berried female required = 625 Nos./cycle
No. of berried females required for 4 cycles = 625x4 = 2500 Nos.
No. of males required at 1:4 male and female ratio = 625 Nos.
Total number of prawns required
Male and female = 3125 Nos.

Design of brood stock ponds

Continuous supply of good quality brooders is one of the pre-requisite for the successful operation of a commercial hatchery. Therefore it is essential to have brood stock ponds located in the proximity of the hatchery complex so as to avoid rough handling and long distance transportation of brooders. The texture of the soil suitable for brood – stock ponds is sandy – loam or sandy clay loam which should have pH between 6.5 to 8.0. The site should have perennial source of freshwater free from pollutants.

Brood stock raising units

Ist phase – for raising juveniles to sub-adults water spread area required for raising
10,000 Nos. of juveniles at 4 Nos/m^2 = 2500 m^2
II nd Phase – For raising sub-adults to brood stock water spread area required for raising 3125 Nos. of sub-adults at 2 No./m^2 = 1562.5 m^2

Brood Stock unit

Berried females holding cum hatching tanks
cement tanks of 5 x2 x1 = 10 Nos.

Larval rearing unit

Proposed system = 2 phase

I st phase
Stocking density of stage I – larvae = 400 Nos/l
Volume of water required = 25,000 lt.
Volume of each tank = 1000 lt
Dimensions of tank = 1.2 m x 1 x 1 m = 1.2x 1x 1
Total no. of tanks required = 25 Nos.
Survival in the Ist phase = 80%
No. of larvae recovered after completion of Ist phase of rearing is 10 to 12 days = 80 lakhs

IInd Phase
Stocking density = 80-100 larvae/lt
Total volume of water required = 1,00,000 lt
Volume of each tank = 4000 – 5000 lt
Dimensions of tank = 2.5 m x 2.0 m x 1 m
No. of tanks = 25 Nos.

Atermia hatching tanks
FRP cylindro-conical jars of 1 x 0.6m = 6 Nos.

Post larvae rearing tanks
Cement tanks of 5 x 2 x1 m = 10 Nos.

Sheds
No. of sheds required = 2 Nos.
One for brood stock tanks, PL tanks, laboratory, feed preparation etc., and the other shed for larval rearing tanks, Artemia hatching tank.
Size of shed -1 = 49 x13.5 m = 661.5m^2
(for brood stock tanks, PL tanks, lab and packing)
Size of shed II = 60x11.5 = 690 m^2
(for larval rearing tanks, artemia hatching tanks etc)

Water requirements and storage tanks
Brackish water
Initial requirement
Small tanks = 25 x1000 l = 25,000 lt
Big tanks = 25 x 4000 l = 1,00,000 lt
Total = 1,25,000 l (125 m^3)
Daily requirement at 50% exchange = 62,500 l (62.5m^3)
Size of tank = 10 x5 x 2 = 100 m^3
No. of tanks = 2 No.

Sea Water
Requirement = 20,000 lt (20 m^3)

Size of tanks = 10 x 2 x 2 m
No. of tanks = 1 No.

Fresh water
Requirement = 100 m^3
Size of tank = 10 x 5 x 2 = 100 m^3
No. of tanks = 2 Nos.

Other facilities
Pump house (4 x 4 m) = 2 No. = 32 m^2
Generator room (10 x 5) = 1 No. = 50 m^2
Air-blower room (10 x 5 m) = 1 No. =500 m^2
Store (10x10) = 1 No. = 100m^2
Office (10x5m)=1No. = 50 m^2
Staff quarters (10x5) = 10 No. = 500 m^2
Total = 782m^2

Note :
The above calculations have been made on the basis of the existing technology with an average survival of 25% from stage I Larvae to post Larvae (PL 5-10). With the same infrastructural facilities the production may increase by 50% (i.e., 15 million per annum)

Unit 10 - Race way culture

It describe about merits and demerits of raceway culture verses pond system. What are the important points to be considered to select a suitable site for raceway culture ponds. It gives an idea about layout plan, Water supply system and types of raceway culture system, such as with treatment, without treatment, parallel and series system.

Race way system

Definition

Raceways are culture units, in which water flows continuously, making a single pass through the unit before being discharged. These systems are also referred to as flow through systems. The residence time of water in a raceway is very short usually on the order of a few minutes instead of hours or days in ponds.

Advantages and disadvantages of this system

Raceway culture has been traditionally practised for hatchery production of fish, because for decades and there are several good reasons for this. Environmental parameters (i.e., water quality, temperature etc., and water quantity are easier to manage in raceways than in pond systems. Flowing water flushes wastes from the culture units. Flowing water also forces the fishes to exercise. Studies have shown that exercised fish have better survival rates when stocked into the Wild (Wheaton 1977). The shallow water in raceways allows visual observation of the fish so that diet and /or disease problems can be promptly corrected. Finally feeding and harvesting are generally easier in raceway systems. Feeding and disease treatment are more easily managed in raceway systems than in open systems or ponds. On the negative side fish are normally cultured in very high densities in raceway, leading to increased risk of diseases due to the stress caused by confinement and crowding. Better management skills are required for raceway culture. Feed may be more due to waste/passes through the water.

Site selection and Layout plan of raceway culture

Site selection for earthen raceways must be done with care. Raceway culture is water intensive. Therefore, the most important consideration is the water supply. Most raceway culture is in mountain regions where gravity flow conditions can be taken advantage of to supply the needed water to the raceway system. In the trout culture industries in the Northeast and Northwest united sates. Freshwater springs are the main water source due to their relatively low and constant water temperature. The water quality and temperature required depends upon the species cultured and the size of the operation.

In actuality incoming water usually requires some degree of pretreatment before it can be used. Pretreatment may consist of nothing more than sedimentation or it may consist of a combination of a number of processes including aeration, heating, cooling, degassing or filtration. Depending on the effluent water quality, discharge water may also require post treatment before it can be released into the environment.

Multiple raceway facilities are arranged either in series or in parallel. Series raceway system can be used in regions where there is sufficient land slope so that the outlet for one raceway serves as the inlet for the next in the series. A 1-2% slope is considered adequate for good water flow (Pillay 1990). Waste build up can be a serious problem in the series systems since the wastes from the upstream unit enter the next unit downstream etc., Wastes tend to increase as the water traverses through the system.

For this reason there is a practical limit to the length of raceways and the number of unit in serious (These limitations will be demonstrated in example problems). The waste problem is some what alleviated by arranging the raceway units in parallel. There are no culture units down stream receiving wastes from upstream units. Therefore, waste build up and aeration problems are minimized. However, the quantity of water required increases in direct proportion to the number of raceways. Thus if pumping is required, operating costs are higher in the parallel arrangement.

Many large raceway farms use a combination of the serious and parallel configuration. The figure illustrates a re-circulation technique using a large pond for waste deposition and water recycling.

Construction materials

Although earthen raceways are some times used, the majorities are constructed from concrete or cement blocks. Earthen race ways are some times lines with water proof liners to reduce water loss through leakage. Many small experimental race ways are fabricated from wood, metal, fibre glass, plastics or other materials.

Water supply system

Raceways are designed to provide flow, through for culturing very dense populations of fish. An abundant flow of good quality water is essential to provide for the health of the animals and to flush wastes from the system. Water quality in a raceway is maintained by manipulation of the water flow rate and by adjusting other water treatment processes. Water quality tends to vary along the long axis of a raceway and a distinct degradation of conditions is evident between the inlet and outlet. The specific flow rate required meeting the oxygen demand of the fish and flushing of metabolites is determined by the influent water temperature and dissolved oxygen concentration and by the oxygen consumption and ammonia excretion of the fish in the raceway.

Unit 11 - Water distribution and control structures

It defines about canal and types of canals used for aqua farm such as feeder canal, diversion, drainage and protection canal. It also deals with formula used to calculate cross sectional area of the canal. It describe about the pipe line and types of pipes used for supply of water in aqua farm. It briefs about water budget equation. It describe about terminology required for design of canal, most economical section of the channel erodible and non-erodible canals.

It also details about water controlling structures or gates and their types, such as main gate, secondary gate, pond inlet gates etc., It describe about computation of discharge through sluices.

Water supply systems

Canals

Open channels are suitable means of conveyance of water from adjoining source like river, steam etc., to fish ponds.

Water control structures or Gates

Definition

Gates are part of water distribution system in an aquacultural farm and are installed to control the water flow. Following are the basic requirements of a gate.

- It should be of sufficient capacity to handle the required flow of water during pond draining and filling.
- It should be properly located and carefully constructed taking into the account the pond bottom level and channel bed level for an efficient flow of the water and complete drainage as and when required.
- It should be made of a material which can withstand the saline action and where fouling action is minimum.
- Self weight of the gate as far as possible should be lighter but not sacrificing the structural requirements. It should require minimum additional foundation depending upon the soil characteristics and should be economical and easy to construct.
- It should be firmly situated at the bottom of pond or channel and linked with the dikes to prevent seepage and possible collapse.
- It should be easy to operate and maintain, and should have proper provision for filtering predatory fishes, their eggs and other organism.

Main gate

The main gate connects the main channel of the pond system to the source of water. In a tide fed farm, it regulates the exchange of water. It is the biggest gate in the pond system and is usually made of reinforced cement concrete (R.C.C.). Depending upon the local site conditions and on the size of farm number of main gate may be more than one. Main gates may have one or more openings, size of each opening being usually 1 to 1.2 m in width for easy handling. A gate with wider opening will require a lifting mechanism for operation of the gate. The height of the main gate depends on the combine height of highest tide and the river flood. Generally the height of main gate is taken as that of the main or peripheral dike. It is located at a place where fresh sea water can be obtained most of the time. A typical design of main supply gate is shown in fig. The various components of the main gate are floor, apron, cut off walls, side walls, wing walls, walking plat form, flash boards and screens.

The gate rests on a floor which serves as its foundation. The elevation of the floor should be lower than the lowest pond bottom elevation inside the pond system of the farm. Preferably it should be lower than lowest tide to ensure complete drainage of the pond system. The gate foundation must be rigid and stable. Often bamboo poles or coconut timbers are used as piles for providing foundation for the structures. Sometimes layers of boulders and gravel are also used along with the piles. The extended and clear part of the floor upstream and downstream of the gate is known as apron. It provides protection against scouring action of flow.

Cut off walls are necessary at both ends of the gate floor if it lies over alluvial soils, for its safety against seepage and consequent piping action. Side or breast walls are used as a retaining wall for the dike fill. In the side walls, grooves are made for fixing screens and flash boards. Most of the main supply gates are provided with 4 grooves two at each sides. Usually the top of the walls are made the same height as that of the dike. Sometimes buttress supports are also built for strengthening the side walls and to reduce seepage flow along the side walls.

Wing walls in the main gate provides transition of the flow from water source such as tidal creek to the gate and then from gate to the channel. They also help in retaining the earth on both sides of the gate. Cat walks or walking plat forms are provided between the two side walls. Usually they are made of RCC slabs or wooden planks. Screen made of high density polyethylene or nylon meshes are attached to a wooden rectangular frame which fits into the two outer grooves of the gate–one at channel side and the other towards the water source. They prevent entry of predators along with incoming water and exist of cultured fish. Amount of water flowing through the gate is controlled by the flash boards. They are generally made of wooden planks of size 5 cm thick and 30 cm wide inserted into the remaining two grooves of the main gate. A one meter wide opening of the main supply gate needs a channel bed of at least 3 m wide.

Secondary gates

Secondary gates regulate the flow of water from the main feeder channel to the secondary feeder channels. In many farms, they are also used to convey water from the secondary feeder channel into the ponds. Generally they are made of concrete, R.C.C., brick masonry or wood. A typical design of secondary gate is show in fig. The secondary feeder channel bed should be wider than its supply gate by at least 0.5 m on both sides to minimize scouring.

Pond inlet gates

Pond inlet gates regulate the flow of water from feeder channel into the various ponds. The two most commonly used pond gates are P.V.C. pipe made and open type. They are usually designed for allowing free fall of water from feeder canal into the ponds. A typical design of P.V.C. pipe made pond inlet gate is shown in Fig. It consists of P.V.C. elbow or bend and two pieces of P.V.C. pipes. The top edge of the elbow or bend is usually flushed with the bed of the feeder channel and at the bottom; a P.V.C. pipe is horizontally fixed into it. The vertical P.V.C. pipe piece fits into the top edge of the elbow or bend fitting and is detachable. The length of this vertical stand pipe should be higher than the maximum designed depth of water above the particular inlet gate in the feeder channel. The flow of water into the pond is accomplished by taking out the vertical pipe and is checked by pressing it to its original position. The outer diameter of both P.V.C. pipe pieces and the inner diameter of the bend or elbow should be same. The discharge capacity of this type of pond inlet gate can be computed by using the equation.

D = Internal diameter of the pipe (m)
g= Acceleration due to gravity 9.81 m/sec^2
H = The vertical height of the water at its free surface in the feeder canal above the central axis of the horizontal pipe (m)
C_d = Co-efficient of discharge, value of which may be taken equal to 0.81 for length of pipe equal to 3 times the diameter i.e., for L = 3 D
C_d= 0.71 for L = 25 D, C_d= 0.64 for L = 50 D

A typical design of open type pond inlet gate is shown in Fig. It is generally made of R.C.C. or wood. Usually two rows of grooves are made vertically in the side walls, one for mounting wooden planks or cast iron plate shutter and the other facing towards feeder canal for mounting screen shutter. Flow of water into the pond is regulated by sliding the wooden planks or cast iron plate shutter vertically up or down. The free fall discharge through open type of pond inlet gate can be computed by using the following equation.

Where,
Q = Discharge through the open type inlet gate m^3/sec
b= breadth of the inlet gate or width of flow (m)
H_2=Height of pond water above the bottom or floor of the gate (m)
H_1 =Height of pond water above the top of the shutter or vent opening (m)
C_d = Discharge co-efficient value of which may be taken equal to 0.62

A typical design of open type pond inlet structure

Unless the head over the upper sill is less than the depth of the shutter opening value of Q can be obtained by using the expression $Q = C_d A (2gh)^{1/2}$. The head is being measured to the centre of the opening. Sometimes pipes are used instead of rectangular vents in the pond inlet gate. The size for one ha pond inlet gate should not be less than 300mm of the pipe diameter.

Computation of discharge through sluices

While water flows though a sluice or gate following three conditions are possible

- Free flow condition
- Submerged flow condition
- Partially submerged flow condition

When discharge from the gate at its outlet (downstream side) falls free into atmosphere it is called free flow condition. It is said to be submerged if out let of the gate discharges under the water.

Computation of discharge under free flow condition

Free discharge taking place through a monk sluice as shown in fig. can be computed by using the equation.
g = Acceleration due to gravity 9.81m/sec^2
H = Height of water (on u/s) above the central axis of the pipe (m)
D = Internal diameter of the pipe (m)
C_d = Co-efficient of discharge.
The value of Cd for the corresponding length of the pipe in terms of its diameter (D) has been given below.

Where,
K_e = Entrance friction co-efficient value of which may be taken equal to 0.5
f = Friction factor value of which for a concrete pipe may be taken equal to 0.03
L = Length of the pipe

Free discharge through an open sluice as shown in Fig. can be computed by using the equation.

Where,
b= Bottom width of the sluice
H_1= Height of the water (on u/s side), above the top of the sluice opening or vent.
H_2 = Height of water (on the u/s side) above the bottom of the sluice.

Values of C_d under free flow condition for various conditions of sluice are given below.

Submerged flow condition

Discharge through a monk sluice whose outlet pipe is under water can be computed by using the equation.

Discharge under submerged condition taking place through an open sluice can be computed by using the equation.

Value of co-efficient of discharge C_d for a submerged flow condition may be taken one percent less than its value for the same sluice under the same effective head when discharging freely into the air (i.e., free flow condition). For sluice opening provided with cut waters and wing walls value of C_d is taken between 0.9 and 0.95. For head sluice this value is usually taken as 0.80.

Computation of discharge under partially submerged flow condition

Discharge through an open sluice, outlet side of which is partially under water can be computed by using the equation.

The value of C_d may be taken equal to 0.62. The value of C_{d1} may be taken as given below.

Types of canals

Different types of open channels are used to transport water to fish farms. They are divided into four types in fish farms depending upon their purpose or use.

Feeder canals

These are the canals used to supply water from the main water intake to the fish ponds. In a large farm with several diversion pond units there is usually a main feeder canal branching into secondary and even tertiary feeder canals.

Diversion canals

These canals are used to divert the required amount of water to fish ponds or to divert excess amount of water from (ponds) source.

Drainage canals

These canals are used to remove the unwanted or polluted water from fish ponds.

Protection canals

To divert run off water away from fish ponds or channels which carrying the water to ponds.

Formula used to calculate the cross- sectional area of the canal

For earthen channels trapezoidal cross sections are more suitable. The area of the channel should be kept sufficient to carry the required volume of water for filling the pond to the optimum level. The cross-sectional area may be determined by using the following formula.

$A = Q/V$

Where,

A = Cross sectional area of the channel (m^2)

Q = Discharge or rate of flow in the channel m^3/sec
V = Velocity of flow in the channel (m/sec)

The velocity of flow in the channel should be non-covering and non-silting. The average velocity of water in the channel of loose earth or silt is 30 cm to 45 cm/sec. For channel in ordinary earth or alluvial soil is 75 cm to 90 cm/sec. The bed slope of the channel should be gentle, so that flow in all the cases is uniform. For channels in alluvial soil, a bed slope of one in thousand (1 in 1000) may be found safe.

Area of trapezoidal section
$A = BY+KY^2$
Where,
A = Cross sectional area of the section (m^2)
Y = Depth of water (m)
K = Side slope of the channel, is the ratio of change in horizontal distance to 1 meter vertical distance
f = Free board of the channel

Pipeline
The layout of the pipe lines should be as for as possible straight line. There should not be many bends in the pipe lines, which greatly reduces the discharge due to internal turbulence in the pipes. The metal pipes need to be protected with a coating of anti corrosive paint. Pipe lines passing through dams and marshy lands to be protected by canvas soaked in bituminous materials. The pipe line should be rest on at least 10 cm thick cement concrete bed with proper side packing on soft soil to safe guard against settlement. The diameter of the pipe should be large enough to discharge the required volume of water in specific time. The mouth of the supply inlet should be covered to prevent the entry of trash fish or predatory.

Water budget for pond
Water budget for pond may be expressed as follows.
Inflows = Out flows +storage.

Inflows include

- Precipitation falling directly in the pond.
- Run off from water shed.
- Seepage from the bottom and sides of the pond
- Regulated in-flow of water through water control device from source like, steams, rivers etc.

Out flow

- Evaporation and transpiration
- Seepage from bottom and sides of the ponds.
- Over flow from the ponds

- Intentional discharge through water control device
- Consumptive use for live stock.

Feeder channel

Main feeder channel starts form the main gate or pumping station and usually traverses the central portion of the farm. Depending upon the area of the farm, the main feeder channel could feed a number of secondary feeder channels before water is conveyed to the ponds. Flow of water into the pond is regulated by using gate or water inlet structure. Depending upon the shape, a channel is prismatic or non-prismatic. A channel is said to be prismatic when the cross-section is uniform and bed slope is constant. In a non-prismatic channel either the cross-section or the bed slope or both change.

Aquacultural farms usually have prismatic channels which can be of any regular shape such as rectangular, parabolic, trapezoidal or circular. However, most of the unlined channels are designed in trapezoid shapes, for it provides side slope for stability. Rectangular shape is commonly used for channels built of stable materials. The channels used for supplying water into the ponds are usually in the farm of the canal or flume. The canals is usually a long and mild–sloped channel built in the ground which may be unlined or lined with stone masonry, concrete, cement, wood or bituminous materials. The flume is a channel of wood, metal, concrete or masonry usually supported on or above the surface of the ground to carry water. Elevated flumes are most efficient water conveyors than earth canals but they require high initial investments. They are usually installed on top of earthen dikes. The cross–section of a flume is normally that of a rectangular channel.

The flow in a channel can be either uniform or non-uniform. The flow is uniform when the rate of flow, velocity of flow, depth of flow, area of flow and slope of bed remains constant over the given length of the channel. Change in any one of the above conditions causes the flow to be non-uniform. An obstruction constructed across a channel of uniform width will also cause the flow to be non-uniform. Aquaculture farms are usually designed for a uniform flow in the channel.

The discharge of uniform flow in the channel may be expressed as the products of the velocity and water area.

$Q = A \times V$

Where,

Q = Discharge m^3/sec

A = Water area/Area of flow m^2

V = Mean velocity m/sec

C = Chezzy's co-efficient

Terminology

The term channel section refers to the cross–section of a channel taken normal to the direction of flow.

The depth of flow is the vertical distance of the lowest point of a channel section from the free surface.

The top width T is the width of channel section at the free surface.

The water area A is the cross–sectional area of flow normal to the direction of flow.

Design of side slope and bottom slope of the channel

The bottom slope of a channel mainly depends upon the topography and energy head required for the flow of water. The natural slope of the land is usually the deciding factor in determining the channel bed slope. The steeper the channel the more will be the discharge. However, excess gradients produce very high velocities which cause erosion. Normally a channel slope about 0.1%, silting may take place in the channel if the slope is less than 0.5%. For determining the bed slope of the channels, the velocities should be checked and the maximum grade designed so that the velocities do not exceed the maximum permissible limit.

The side slope of the channel depends mainly on kind of material the channel section is made of. A general idea of the slopes suitable for use with various kinds of materials is given below.

The free board of a channel is the vertical distance from the top of the channel to the water surface at the design condition. The free board should be sufficient to prevent waves or fluctuation in the water surface from overflowing the sides. Under ordinary condition, the free board requirement can be approximately computed by using the equation.

$f = (CD)^{1/2}$

Where,

f= freeboard in feet

D = Depth of water in the channel (feet)

C = co-efficient

Co-efficient varying from 1.5 for a channel capacity of 20 cubic feet per second to 2.5 for a channel capacity of 3,000 cubic feet per second or more.

Channel of most economical cross section

A channel which gives maximum discharge for a given cross–sectional area and bed slope is called a channel of most economical cross–section. In other words, it is a channel, which involves lesser excavation for a designed amount of discharge. It is some time, also defined as a channel which has minimum wetted perimeter so that there is a minimum resistance to flow and thus resulting in a maximum discharge. The conveyance of a channel section increases with increase in the hydraulic radius or with decrease in wetted perimeter.

Therefore, the channel section having the least wetted perimeter or maximum hydraulic radius for a given area has the maximum conveyance and is known as the best section. The most efficient section is usually also the most economical section but not necessarily. The semicircle has the least perimeter among all sections with the same area. Hence it is the most hydraulically efficient of all sections. For a most efficient trapezoidal section or best hydraulic section of trapezoidal shape, the most economical side slopes are

Design of feeder channel

The feeder channels used in an aqua-cultural farm are either lined channels and build up channels (i.e, flume) or unlined channels. While lined channels and built up channels are non-erodible and can with stand the erosion satisfactorily, unlined channels are generally erodible.

However for design purpose, the most economical section is always designed. For maximum discharge through a rectangular section for a most economical rectangular channel section b = 2d and

For maximum discharge though a circular channel i.e., for a most economical circular channel section.
d = 0.95 D
Where,
d = Depth of flow
B = Base width
k = Side slope (i.e., 1 vertical to k horizontal)
D = Diameter of circular pipe

Dimensions of the most economical channel section can be easily computed in the following steps.

Determination of non- erodible and erodible channel section dimensions

Determination of non-erodible channel section dimensions

The dimension of the section for non-erodible channel such as concrete channel, flumes etc., include the following steps.

- Estimate the value of Manning's rugosity co-efficient , N ; select the channel bed slope S and side slope Z or K (in case of trapezoidal section)
- For the required discharge Q in the channel,

- In the above expression, substitute the value of A and R in terms of bottom width b and depth of flow d. Assuming a suitable value of b solve the expression thus obtained for the depth of flow "d". Compute the values of A and R. Estimate the mean velocity or $V = 1/N\ R^{2/3}\ S^{1/2}$ and then find out the discharge Q = AV. Check if velocity thus obtained is above the minimum permissible limit and the discharge, nearly equal to the required value. If no, assume another value of b and solve for depth of flow d till desired value of Q is obtained at a value of V above the minimum permissible limit.

- If the best hydraulic section is required directly substitute in expression obtained in step (2) for A and R for best hydraulic section and solve for depth of flow d. This best hydraulic section may be modified for practicability. Check the minimum permissible velocity if water carries silt.
- Add a proper free board to the depth of channel section and compute the values of the total depth; bottom width, top width, water area and velocity of flow in the channel section.

Unlined channel section is normally constructed in the trapezoidal shape using the maximum permissible velocity as criteria the designing procedure for a trapezoidal channel section consists of the following steps.

Determination of erodible channel section dimensions

Dimensions of the section for erodible channel or unlined channel such as earth canal, can be easily computed by the method of permissible velocity. The maximum permissible velocity or the non-erodible velocity is the greatest mean velocity that will not cause erosion of the channel body. An old and well seasoned channel will stand much higher velocities than new ones. When other conditions are same, a deeper channel will convey water at a higher mean velocity without erosion than a shallower one.

Water control structures or Gates

Definition

Gates are part of water distribution system in an aqua cultural farm and are installed to control the water flow. Following are the basic requirements of a gate.

- It should be of sufficient capacity to handle the required flow of water during pond draining and filling.
- It should be properly located and carefully constructed taking into the account the pond bottom level and channel bed level for an efficient flow of the water and complete drainage as and when required.
- It should be made of a material which can withstand the saline action and where fouling action is minimum.
- Self weight of the gate as far as possible should be lighter but not sacrificing the structural requirements. It should require minimum additional foundation depending upon the soil characteristics and should be economical and easy to construct.
- It should be firmly situated at the bottom of pond or channel and linked with the dikes to prevent seepage and possible collapse.
- It should be easy to operate and maintain, and should have proper provision for filtering predatory fishes, their eggs and other organism

Main gate

The main gate connects the main channel of the pond system to the source of water. In a tide fed farm, it regulates the exchange of water. It is the biggest gate in the pond system and is usually made of reinforced cement concrete (R.C.C.). Depending upon the local site conditions and on the size of farm number of main gate may be more than one. Main gates may have one or more openings, size of each opening being usually 1 to 1.2 m in width for easy handling. A gate with wider opening will require a lifting mechanism for operation of the gate. The height of the main gate depends on the combine height of highest tide and the river flood. Generally the height of main gate is taken as that of the main or peripheral dike. It is located at a place where fresh sea water can be obtained most of the time. A typical design of main supply gate is shown in fig. The various components of the main gate are floor, apron, cut off walls, side walls, wing walls, walking plat form, flash boards and screens.

Main gate

The gate rests on a floor which serves as its foundation. The elevation of the floor should be lower than the lowest pond bottom elevation inside the pond system of the farm. Preferably it should be lower than lowest tide to ensure complete drainage of the pond system. The gate foundation must be rigid and stable. Often bamboo poles or coconut timbers are used as piles for providing foundation for the structures. Sometimes layers of boulders and gravel are also used along with the piles. The extended and clear part of the floor upstream and downstream of the gate is known as apron. It provides protection against scouring action of flow.

Cut off walls are necessary at both ends of the gate floor if it lies over alluvial soils, for its safety against seepage and consequent piping action. Side or breast walls are used as a retaining wall for the dike fill. In the side walls, grooves are made for fixing screens and flash boards. Most of the main supply gates are provided with 4 grooves two at each sides. Usually the top of the walls are made the same height as that of the dike. Sometimes buttress supports are also built for strengthening the side walls and to reduce seepage flow along the side walls.
Wing walls in the main gate provides transition of the flow from water source such as tidal creek to the gate and then from gate to the channel. They also help in retaining the earth on both sides of the gate. Cat walks or walking plat forms are provided between the two side walls. Usually they are made of RCC slabs or wooden planks. Screen made of high density polyethylene or nylon meshes are attached to a wooden rectangular frame which fits into the two outer grooves of the gate–one at channel side and the other towards the water source. They prevent entry of predators along with incoming water and exist of cultured fish. Amount of water flowing through the gate is controlled by the flash boards. They are generally made of wooden planks of size 5 cm thick and 30 cm wide inserted into the

remaining two grooves of the main gate. A one meter wide opening of the main supply gate needs a channel bed of at least 3 m wide.

Secondary gates

Secondary gates regulate the flow of water from the main feeder channel to the secondary feeder channels. In many farms, they are also used to convey water from the secondary feeder channel into the ponds. Generally they are made of concrete, R.C.C., brick masonry or wood. A typical design of secondary gate is show in fig. The secondary feeder channel bed should be wider than its supply gate by at least 0.5 m on both sides to minimize scouring.

Pond inlet gates

Pond inlet gates regulate the flow of water from feeder channel into the various ponds. The two most commonly used pond gates are P.V.C. pipe made and open type. They are usually designed for allowing free fall of water from feeder canal into the ponds. A typical design of P.V.C. pipe made pond inlet gate is shown in Fig. It consists of P.V.C. elbow or bend and two pieces of P.V.C. pipes. The top edge of the elbow or bend is usually flushed with the bed of the feeder channel and at the bottom; a P.V.C. pipe is horizontally fixed into it. The vertical P.V.C. pipe piece fits into the top edge of the elbow or bend fitting and is detachable. The length of this vertical stand pipe should be higher than the maximum designed depth of water above the particular inlet gate in the feeder channel. The flow of water into the pond is accomplished by taking out the vertical pipe and is checked by pressing it to its original position. The outer diameter of both P.V.C. pipe pieces and the inner diameter of the bend or elbow should be same. The discharge capacity of this type of pond inlet gate can be computed by using the equation.

D = Internal diameter of the pipe (m)
g= Acceleration due to gravity 9.81 m/sec^2
H = The vertical height of the water at its free surface in the feeder canal above the central axis of the horizontal pipe (m)
C_d = Co-efficient of discharge, value of which may be taken equal to 0.81 for length of pipe equal to 3 times the diameter i.e., for L = 3 D
C_d= 0.71 for L = 25 D, C_d= 0.64 for L = 50 D

Pond inlet gates

A typical design of open type pond inlet gate is shown in Fig. It is generally made of R.C.C. or wood. Usually two rows of grooves are made vertically in the side walls, one for mounting wooden planks or cast iron plate shutter and the other facing towards feeder canal for mounting screen shutter. Flow of water into the pond is regulated by sliding the wooden planks or cast iron plate shutter vertically up or down. The free fall discharge through open type of pond inlet gate can be computed by using the following equation.

Where,
Q = Discharge through the open type inlet gate m^3/sec
b= breadth of the inlet gate or width of flow (m)
H_2=Height of pond water above the bottom or floor of the gate (m)
H_1 =Height of pond water above the top of the shutter or vent opening (m)
C_d = Discharge co-efficient value of which may be taken equal to 0.62

A typical design of open type pond inlet structure

Unless the head over the upper sill is less than the depth of the shutter opening value of Q can be obtained by using the expression $Q = CdA(2gh)^{1/2}$. The head is being measured to the centre of the opening. Sometimes pipes are used instead of rectangular vents in the pond inlet gate. The size for one ha pond inlet gate should not be less than 300mm of the pipe diameter.

Computation of discharge through sluices

While water flows though a sluice or gate following three conditions are possible

- Free flow condition
- Submerged flow condition
- Partially submerged flow condition

When discharge from the gate at its outlet (downstream side) falls free into atmosphere it is called free flow condition. It is said to be submerged if out let of the gate discharges under the water.

Computation of discharge under free flow condition

Free discharge taking place through a monk sluice as shown in fig. can be computed by using the equation.

g = Acceleration due to gravity $9.81m/sec^2$
H = Height of water (on u/s) above the central axis of the pipe (m)
D = Internal diameter of the pipe (m)
C_d = Co-efficient of discharge.

The value of C_d for the corresponding length of the pipe in terms of its diameter (D) has been given below

Values of C_d under free flow condition for various conditions of sluice are given below.

Unit 12- Management of ponds

It emphasise the importance of aeration and principles of aerator, the purpose of using aerator. It also deals with different types of aerators used in aqua farm and exact location of aerator to increase the efficiency of the aeration.

It gives an idea about pump, purpose of pumping is needed in Aqua farms, types of pumps used in aqua farm. What are the important points to be considered to select the best pump for aqua farm. It also helps to understand the important points to be considered for designing pumping station.

It briefs about the purpose of filtration required in aqua farm. It describe about types of filters to be used in aqua farm and their working operation. It also compares the types of filters used in aqua farm.

Aerators

The decomposition of organic matter greatly reduces the oxygen content in the pond water. The depletion in the level of dissolved oxygen has a serious effect in the fish life. A fall in the level of dissolved oxygen content below 4 ppm is fetal for fish production. Aeration is the process of mixing of air with water to increase the quantity of oxygen in water.

Purpose of aeration

The following are the purpose of aeration.

- To enrich pond water with oxygen
- To remove hydrogen sulphide
- To nullify the activity of harmful bacteria
- To remove carbon dioxide
- Decomposition of organic matter which may other wise lead to bad smell.

Principle of aeration

Atmosphere contains 21% oxygen. The rate of oxygen transfer into the pond water is an important parameter that governs the intensity of aeration. According to Dalton's law, total atmospheric pressure (also known as barometric pressure) is the sum of partial pressures of the gases in the atmosphere.

$$BP = P(O_2) + P(N_2) + P(A_r) + P(CO_2)$$

The partial pressure of each gas in a mixture of gases is directly proportional to the mole fraction of the gas. For example, partial pressure of oxygen in dry air is, When air is in contact with water oxygen enters the water until the pressure of oxygen in the water equals the pressure of oxygen in the air. This stage is called as equilibrium stage. The concentration of oxygen is normally given as the concentration (expressed in mg/lt) at equilibrium for water in contact with dry air at standard pressure (760 mm Hg) and specific temperature and salinities. Oxygen concentration is generally expressed as "C_s".

If water contains the amount of dissolved oxygen that it should hold theoretically at a given temperature, pressure and salinity then it is said to be saturated with oxygen. But due to numerous factors, it may be saturated or super saturated with oxygen.Percentage of saturation is calculated as follows,

Types of aerators

Aerators are classified into following groups.

- Gravity aerators
- Surface aerators
- Turbine aerators
- Cascades or Falls

Gravity aerators

Gravity aerators are simple to construct and are reliable. These are the most common type of aerators used in small semi-intensive shrimp farms. In this method water is allowed to rise above, the pond/tank level and then to fall freely in the pond or tank through atmosphere, where water comes in contact with oxygen and thus aeration is done. In simple water falling and splashing into pond and aeration is done.

During the process of water raising or falling, potential energy is converted into kinetic energy. That serves to break apart the falling water. When water is broken into droplets, the area over which the diffusion can take place is increased, thereby increasing the dissolved oxygen of the water.

Perforated tray model

The water falls through a screen or perforated plate that breakup the falling stream of water and there by aeration is done. One meter tall aerator can usually aerate water to 70-80% saturation.

Plastic rings or wheel model

A recent and some what popular aeration system includes the use of specially designed plastic rings or wheels. These rings have a fringed interior walls or spokes. As water passes through a column or drum filled with these, the water is effectively broken up and the aeration is done.

Surface Aerators

Surface aerators increase the surface area of culture medium by agitating it again some sort of mechanical device. Dissolved oxygen rises when the surface water is thrown up and mixes with the air above the water and then falls back down into the pond or tanks. There are three commonly used surface aerators.

- Nozzles
- Spray aerators
- Floating paddle wheel aerator

Nozzles

Nozzles are generally used in round tanks water from a pump is sent downward through a nozzle towards the surface water. When this water hits the surface water, there is considerable amount of turbulence on the water surface. This turbulence is due to transfer of energy of water leaving the nozzle. Besides increasing the dissolved oxygen in pond water, nozzle aerators also set up circular water flow.

Spray aerators

Spray aerators are generally built as floating propellers. The propeller is beneath the water surface and as it turns it brings sub surface water up and into the air. The rate of oxygen transfer depends upon size and depth of the propeller and the speed at which the propeller turns.

Floating paddle wheel aerators

Floating paddle wheel aerators are very popular in semi-intensive shrimp farms. They are considered as one of the most energy efficient device for increasing dissolved oxygen. They splash water into the air as the paddle wheel rotates. The splashed water comes in contact with air and falls back into the pond and thereby increasing the dissolved oxygen. Besides increasing the dissolved oxygen they also increase both horizontal and vertical movement of pond water. The amount of oxygen that is transferred to the water increases with size and speed of paddle wheel.

Turbine Aerators

Turbine aerators are also called as propeller diffuse aerators. A turbine aerator is basically a submerged propeller. Rather than injecting air into water it is simply a device that increases the circulation in the pond or tank, which results in greater surface aeration. A turbine aerator consists of a rotating hollow shaft attached to an electric motor. A diffuser and a propeller (impeller) are located at one end of the shaft and are submerged. The unit is supported at the water surface with a float assembly so that a hole in the opposite end of the shaft near motor remains above the water surface.

Cascades or Falls

Water is allowed to fall down in a series of steps or falls, over with water tumble in a thin sheet and discharge as a fountain into the pond.

Placement of the aerators

Proper placement of aerator in ponds plays an important role in efficient mixing of water throughout ponds. In rectangular pond, the best position is to place the aerator at the middle of one of the long sides of the pond directing water parallel to the short side of the pond. Placement of aerator in the corner of the pond to direct water diagonally across the pond should be avoided. Depending upon size and shape of the pond, the placement pattern of the aerators aimed to achieve the best water circulation will vary. Water circulation in the pond is important in breaking up the stratification of water parameters such as oxygen, temperature and salinity. Positioning of the aerators in the pond should be decided taking into consideration the prevailing wind direction so as to effectively distribute the oxygen saturated water all over the pond and to promote the water circulation in it.

Pumps

Pump is a mechanical device by which water is caused to flow at increased pressure. The process of using pump is called as pumping.

Purpose of pumping

The following are the purpose of pumping

- To increase the pressure at certain points in the distribution system.
- To lift the water from lake, reservoir, wells and any other water bodies
- To remove the water from the ponds

Choice of pump

The following points to be considered while selecting the pump.

- Capacity of pump
- Initial cost
- Maintenance cost
- Quality of water to be pumped
- Head of water
- Type of power available
- Working condition
- Importance of water supply scheme

Classification of Pumps

Pumps are basically classified as positive displacement pumps and variable displacement pumps. Positive displacement pumps discharge the same volume of water regardless of the head against which they operate. They are of two types

- Reciprocating pump
- Rotary pump

While the farmer is commonly used in home water supply system, while the later is used for pumping liquids having lubricating qualities. Because of low discharge capacity these pumps are not used in aquaculture.

In case of variable displacement pumps as the pumping head increases, the rate of pumping decreases. They are classified into the following types.

- Centrifugal pumps
- Propeller pumps
- Jet pumps
- Air lift pumps

Among the above, propeller pumps and centrifugal pumps predominantly used in aquaculture for farm water supply.

Points to be considered for design of pumping station

The following points to be considered while designing the pumping station

- Pumps should be placed as low as practicable near the source of supply and it may be in pits to minimize the length of suction pipe. Motors can be fixed high up connected by vertical shafts to reduce the danger of flooding. Suction lift should as far as possible be avoided. Where suction lift is must provision has to be made for priming the pumps or vacuum pumps installed to exhaust air from the suction line.
- No point of suction line should be at a higher level than the suction eye of the impeller as this will form air pockets. This may however be permitted where a vacuum pump is used. Horizontal suction line is practical up to 300 m length and the suction pipe should be given a gradual rise of at least 1 in 180 (towards the pump) to prevent air pockets forming which seriously interfere with the flow of water. The suction line should be made perfectly air tight and it should be so arranged that any air in it can be easily let off through suitably placed valves. The end of the suction pipe should be submerged in water at least three times its diameter to prevent admission of air. Suction pipes are usually larger than delivery pipe. Usual practice is to have the suction pipe at least one commercial size larger than suction connection size of the pump. The diameter of suction pipe is about 10 mm bigger for 32 mm to 80 mm pipe than the delivery pipe and for 100 mm and above the size of suction and delivery pipe is generally the same on long suction lines the pumps should be driven at slower speed and should have a vacuum chamber to assist the suction and prevent pounding. Both suction and delivery pipes should be free from bends as practicable.
- In order to keep the water in the pump whilst standing and to facilitate priming, a foot valve is necessary which should have an area of minimum two times the area of the suction pipe depending upon how much foreign matter is carried in the water. A foot valve should be used at the foot (supply end) of the horizontal suction line.

- Gate valves should be provided on discharge side. The gate valve should be placed after the cheek valve if any mainly to permit repairs to check valve.
- In order to prevent of entrance of living organisms and other foreign particles while pumping the water from a river or tidal creek etc., a strainer is generally fitted with the foot valve at the end of the suction pipe, strainer should be at least 0.60 m away from the sides and bottom of the river bed. The strainer should have a total area of holes at least equal to four times the area of the suction pipe. Where no strainer is necessary,the suction pipe should preferably have bell mouth entry.
- In order to reduce running cost it is desirable to install pumps unequal capacities e.g one-third and two-third of the total flow desired which will work according to variation of demand.

Computation of Horse power requirement of the motor driving the pump

The actual horse power (HP) required to be supplied by the engine or electric motor for driving the pump is called brake horse power (B.H.P). This is computed by using the following expression.

The product of KW and the number of operational hours H of pump motors gives the energy consumption E by the pump motor in Kilowatt hours or unit.
E = Kw x H (Kilowatt – hours or unit).
For flat belt drive, drive efficiency varies from 80 to 90 percent for v–belt drive it varies form 90 to 95 percent and for right angle gear head drives it is about 95 percent.
Efficiencies of electric motors Em usually vary from 80 to 90% and that of diesel engines from 70 to 80 percent. Pump efficiencies Ep usually vary from 50 to 70 percentage. Large pumps are more efficient.

Computation of water requirement

Computation of water requirement for a given aquaculture pond involves following steps.

Problem

1. Determine the number and capacities of freshwater and sea water pumps required for a shrimp farm having 10 ponds, each with water spread area of 1 ha. Assume the following data.

Average depth of water in the ponds = 1 m
Anticipated maximum water exchange rate in a day - 50%
Sea water salinity - 35 ppt
Required salinity in the pond water - 15 ppt

Available period for pumping freshwater and seawater =12 hrs/day
Also, assume average water area of each pond to be nearly equal to its water spread area i.e., 1 ha. Values of precipitation and losses due to seepage and

evaporation are negligible.
Volume of water in each pond =Average area of pond x Average depth of water in the pond = 10,000x1 = 10,000 m^3
Total volume of water (V) = 10 x10,000 = 1,00,000m^3 (10 No. of ponds)

Filtration

Aquatic cultural systems contain living organisms in a medium of water. These organisms require inputs, such as food and they excrete other materials. The inputs must be mixed with or dissolved in water to be available to the organisms. Whose outputs will also become mixed with or dissolved in the water. Excessive out put and /or inputs can become toxic if the concentration is allowed to increase in the culture water. The process of removing excess materials is called filtration. Thus filtration may be defined as the separation of a mixture or solution into component parts. The resulting components may be pure or may be solutions or mixtures composed of two or more constituents.

Classification according to form of materials

Filtration system are classified into following groups according to the form of materials they handle

- Liquid–Liquid systems
- Liquid–solid systems
- Liquid–gas systems
- Gas–solid systems
- Gas–gas systems
- Solid–solid systems
- Solid–liquid–gas systems

Thus a liquid–liquid system is one in which filtration is used to separate two or more liquids, where as in a liquid–gas system separation of a liquid and a gas is desired. Although there are seven groups, filtration in aquatic cultural systems usually falls into 1, 2, 3 or 7 groups with the first two groups being the most common. Filtration is accomplished by identifying properties of the materials to be separated, then using the differences in properties to devise a separation procedure. Material properties often useful in filtration are listed below.

- Density
- Particle size
- Electrical properties
- Chemical properties
- Magnetic properties

Filters are classified as mechanical, gravitational, chemical or biological.

Mechanical filters

Mechanical filters in aquatic cultural systems are used primarily for the separation of liquids and solids. Under some special circumstances, they can be used for liquid–liquid separations. Mechanical filters utilize the differences in particle size of the solution (or mixture) components to extract one part from the other. They are usually simple in operation and relatively easy to maintain, if correctly used. They can be designed to extract particles from any given size upward. They will not extract a specified particle size range while allowing larger and smaller particles to pass. They extract all particles larger than a specified size. Their operating and/or cleaning cost becomes excessive if the concentration of suspended material exceeds reasonable values.Following are the different types of mechanical filters,

- Stationary screens
- Rotary screens
- Chain type rotary screen
- Vibratory screens

Stationary screens

Screens are probably the most widely known mechanical filters. The simplest form consists of a stationary screen placed across the fluid flow path such that the fluid must pass through it. Particles larger than the screen mesh cannot pass through the screen and are collected on it. Stationary screens are rarely used for particles smaller than 1.5 mm in diameter or in circumstances of high particle concentration. Rigid plugging occurs if the concentration of suspended particles is too high. Cleaning consists of removing the screen from its operating position and back washing it. (i.e. forcing water though the screen in the reverse direction) with high pressure water or mechanically cleaning it by hand, brush or other means.

Stationary screens are in expensive, easy to install and operate and capable of removing particles larger than the screen mesh. If the fluid contains a high concentration of suspended materials, however screens cleaning labour costs are high. If not properly cleaned, the screens seriously impede flow. Screen mesh sizes are available from several centimetres to few microns. Screen cost rises rapidly as mesh size is reduced below 1.5 to 3 mm. Screens are available in variety of materials such as carbon, steel, brass, stainless steel and cloth fabrics of various types. Plastics are available for use in corrosive fluid, but these require special attention in design because of their low strength characteristics.

Rotary screens

Axial flow rotary screens

Fluid enters from the left-most chamber and passes through the screen in an axial direction. Screen rotation causes the partially clogged screen to pass in front of the backwash unit, where high pressure water sprayed against the down stream screen face forces particles out of the screen. The contaminated backwash water is captured by a trough on the upstream screen face and conducted to a disposal area.

Axial screens are relatively in expensive and easily operated and do not require much labour for maintenance. They are more or less automatically cleaned and will take a much higher concentration of particulate materials in the influent stream than stationary screen. The maximum size particle the screen will pass is determined by the screen mesh selected. Mesh size ranges available for rotary screens are comparable to that of stationary screens. Flow rate is determined by the screen mesh size, head loss across the screen, cleaning efficiency, amount and characteristics of particulate materials in the influent stream and cross–sectional area of the screen. Mesh size selection is based on the maximum particle size that can be allowed in the effluent.

Radial flow rotary screens

Radial flow screens consist of a cylinder, the periphery of which is covered with a screen mesh. Fluid enters the screen axially at one end and exits radially through the mesh. The backwashing unit is placed on the outside of the screen at the top. Influent level in the screen is maintained low enough to permit the backwash trough to clear the water. The backwash trough catches the backwash water and carries it to a drain.

Vibratory screens

Vibratory screens are also used for removal of particles from water. Two types are commonly used (a) Radial flow (b) Axial flow. In the basic design of an axial flow vibratory screen influent enters one end of the screen and the particulate materials are moved along the screen length by the vibratory motion of the screen. Water flows through the screen and is discharged at the outlet. The screen is mounted on springs and is given vibratory motion by an electromagnetic vibrator, an electric drive or other suitable means.

Sand filters

Sand filter consists of a layer of sand or other particulate material through which water is forced to flow. Filtering is a mechanical process whereby particles too large to pass through the space between sand grains are trapped in the sand. The maximum particle size the filter will pass is determined by the sand grain size. Larger sand grains allow larger particles to pass through the filter. Sand particle sizes commonly range from 2.0 to 0.02mm. However replacing the sand with rocks, coal, gravel or other material extends the particle size to any desired larger size diatomaceous earth, clay or similar material may be used to reduce the lower particle size to the micron level. However flow rates are so slow though the finer particles that these are rarely used for sand filters.

Flow rate through a filter and rate of clogging are dependent on filter medium particle size and on the concentration and characteristics of particulate materials in the influent. Smaller filter particle sizes results in lower flow rates for similarly constructed filters operated at the same head loss. The more particulate material in the influent, the quicker the filter will plug or the more often it must be backwashed. Since backwash water must be discarded, greater quantities of makeup water must be supplied for frequent back washing.

Types of sand filters

- Pressure sand filters
- Vacuum sand filters
- Diatomaceous (cm) earth filters

Gravitational separation

Gravitational separation utilizes the force of gravity to extract particles from a fluid. Density differences between the particles and fluid cause the particles to travel down ward in a quiescent fluid column. There are three types of gravitational separation system.

- Sedimentation
- Centrifuge
- Hydro clone

Sedimentation

Sedimentation is the process of allowing particulate materials having density greater than that of the suspending liquid to settle out under gravitational forces in a quiescent or slowly moving liquid. Plain sedimentation is sedimentation under natural forces only. Aggregation of finely divided particles by addition of chemicals and/or other materials to increase settling velocity is referred to as coagulation. Chemical precipitation may be defined as the addition of chemicals to waste water, resulting in a chemical reaction that produces an insoluble compound. This insoluble material then settles out by sedimentation.

Centrifuge

Centrifuges are used to increase the gravitational force experienced by particles during settling the principal advantage being the increased settling rates.

Chemical filters

Chemical filters are primarily adsorption units. Adsorption may be defined as a process of accumulation or concentration of substances at a surface or interface. The interface may be between two liquids, between a liquid and gas, between a liquid and solid and so on. In waste water treatment adsorption usually occurs at a liquid –solid interface, such as in activated carbon-water or ion exchange resin–water interface or at a liquid–gas interface, such as an air- water interface in foam fractionation.

Biological filters

Biological filtration is defined as the bacteriological conversion of organic nitrogenous compounds into nitrate. The several steps in this process are collectively referred to as the nitrogen cycle. Although the nitrogen cycle begins with conversion of nitrogen containing organic compounds into ammonia, this step usually is best completed before the material reaches the biological filter. Some ammonification and de-amination occur in all biological filters unless the filter influent is from a pure inorganic source. The primary purpose of a biological filter is conversion of ammonia to nitrite and nitrite to nitrate. This conversion is of great importance in culture of aquatic organisms because ammonia is a highly toxic metabolic waste discharged directly by many cultured organisms and generated as a by-product by many bacteria. Nitrite is somewhat less toxic than ammonia, although nitrite toxicity may occur in concentration of less than 2.5 ppm for some species. Nitrate is considered relatively non-toxic to most aquatic organisms.

Practical - 1

Experiment No 1 - Folding and unfolding of chain

Folding and unfolding of chain

Two chain men are required for measuring the length of a line, which is greater than a chain length. The more experienced chainman remains at the zero ends or the rear end of the chain who is called as the follower. The other chainman holding the forward handle is known as the leader.

Unfolding the Chain

To unfold a chain, the chainman keeps both the handles in the left hand and throws the rest of the chain in forward direction with his right hand. The other chainman assists in removing the knots, if any for making it straight.

Folding a Chain

Bring the two halves of the chain so as to make them lie along each other by pulling the chain in the middle. Then, starting from the middle portion take two pairs of links at a time with the right hand and place them obliquely across, with the left hand.

Experiment 2 - Line marking

Line marking

The follower holds the zero end of the chain at the terminal point while the leader proceeds forward with the other handle in one hand and a set of 10 arrows and a ranging rod in the other hand. When he is approximately one chain length away, the follower directs him to fix his pole in the line with the previous pole. When the point is ranged, the leader makes a mark on the ground, holds the handle with both the hands and pulls the chain so that it becomes straight between the terminal point and the point fixed. The leader then puts an arrow at the end of the chain, swings the chain slightly out of the line and proceeds further with the handle in one hand and the rest of the arrows and the ranging rod in the other. The follower also takes the handle in one hand and the ranging rod in the other and follows the leader until the leader has approximately traveled one chain length. The follower puts the zero end of the chain at the first arrow fixed by the leader and ranges the leader who in turn stretches the chain straight in the line and fixes the second arrow in the ground and proceeds further.

Experiment 3 - Ranging

Ranging

While measuring the length of a 'Survey Line' or 'Chain line', the chain or tape must be stretched straight along the line joining its two terminal stations. If the length of the survey line is less than the length of the chain, there will be no difficulty in doing so. If the length of the survey line exceeds the length of the chain, intermediate points have to be established in line with the two terminal points before chaining is started. "The process of fixing or establishing such intermediate points is known as Ranging".

Ranging Code Signals

Direct ranging by eye

Direct ranging is done when the two ends of the survey lines are intervisible. In such cases ranging can either be done by eye or through some optical instruments such as line ranger or Theodolite.

Let A and B be the two points at the ends of a survey line. One ranging rod is erected at the point 'B' while the surveyor stands with another ranging rod at point 'A' holding the rod at about half meter length. The assistant then goes with another ranging rod and establishes the rod at a point approximately in the line with AB, at a distance not greater than one chain length from 'A'. The surveyor at 'A' then signals the assistant to move transverse to the chain line, till he is in line with A and B. Similarly other intermediate points can be established.

Indirect ranging or Reciprocal ranging

Indirect ranging is resorted to when both the ends of the survey line are not intervisible either due to high intervening ground or due to long distance between them. In such a case, ranging is done indirectly by selecting two intermediate points M1 and N1 very near to the chain line in such a way that from M1 both N1 and B are visible, while from N1 both M1 and A are visible.

Two surveyors station themselves at M1 and N1 with ranging rods. The person at M1 then directs the person at N1 to move to a new position N2 in the line with M1B. The person at N2 then directs the person at M1 to move to new position M2 in line with N2A. Thus the two persons are now at M2 and N2 which are near to the chain line than the positions M1 and N1. The process is repeated till the points M and N are located in such a way that the person at M finds the person at N in line with MB and the person at N finds the person at M in line with NA. After having established M and N other points can be fixed by direct ranging.

Experiment 4 - To erect a perpendicular to chain line

To erect perpendicular to a chain line from a point on it

AB is the chain line. It is required to erect a perpendicular to the chain line at point 'C' on it. Establish a point 'E' at a distance of 3m from 'C'. Take 10m tape and put the zero (0) end of the tape at 'E' and the 10m end at 'C'. The 5th and 6th meter marks of the tape are brought together to form a loop of 1m. The tape is now stretched tight by fastening the ends E and C. The point 'D' is thus established. Angle DCE will be 90°.

To drop a perpendicular to chain line from a point outside it

AB is the chain line. It is required to drop a perpendicular to a chain line AB from point 'D' out side it. Select any point 'E' on the chain line. With 'D' as center, and DE as radius, draw an arc to cut the chain line at F. Bisect EF at 'C' and then CD is perpendicular to chain line AB.

Experiment 5 - To run a parallel to chain line through a given point

To run a parallel to chain line through a given point

AB is the chain line; C is the given point through which parallel line is to be drawn. Through 'C' drop a perpendicular CE to the chain line. Measure CE. Select any other point F on the line and erect a perpendicular FD. Make FD=EC. Join CD.

Practical – 2

Experiment 1- Obstacle to chaining and ranging

In chain surveying, sometimes the chainman is unable to measure the distance between two points directly, due to obstacles. Hence it has to be found out by indirect measurements. Basically there are three types of obstacles

- Obstacle to ranging but not chaining
- Obstacle to chaining but not ranging
- Obstacle to both chaining and ranging

Experiment 1: Obstacle to ranging but not chaining

In this type of obstacle the ends are not intervisible and it is quite common, except in a flat country.

AB is the line in which A and B are not visible from intermediate point on it. Through A, draw a random line AB1 in any convenient direction but as nearly towards B as possible. The point B1 should be chosen in such a way that B1 is visible from B and BB1 is perpendicular to the random line. Measure BB1. Select C1 and D1 on the random line and erect perpendicular C1C and D1D on it. Join CD and prolong.

Experiment No 2 - Obstacle to chaining but not ranging

There are two types of obstacle in this case

- When it is possible to chain round the obstacle. E.g., pond.
- When it is not possible to chain round the obstacle. E.g., river

When it is possible to chain round the obstacle

PQ is the chain line. Select two points A and B on either side of the obstacle. Setout equal perpendiculars AC and BD. Join CD and measure it. AB = CD.

When it is not possible to chain round the obstacle

AB is the chain line. Select a point ‘C’ on the line and draw perpendicular CD to it. Bisect it at E. Erect a perpendicular to the line CD at ‘D’. Range ‘F’ in line with GE and measure DF. Then GC = DF.

Experiment 3 - Obstacle to both chaining and ranging

Obstacle to both chaining and ranging

A building is the typical example for this type of obstacle. Select two points A and B on one side of the obstacle. Erect perpendiculars AC and BD of equal length. Join CD and prolong it past the obstacle. Choose two points E and F on the line CD and erect perpendiculars EG and FH equal to that of AC or BD. Join GH and prolong it. Measure DE. BG = DE.

Practical - 3

Experiment No 1 - Determination of area of a plot

Aim:

To plot the boundaries of a field and to determine its area. Equipments: Chain, Tape, Ranging rods, Arrows, Cross staff etc.

Procedure:

- Fix the ranging rods at each end of the straight line portion of the boundary and also where the boundary takes a curve, and then fix rods at constant interval.
- A chain line is run through the center of the plot from one end to the other, so that the offsets to the boundaries on either side of it are fairly equal.
- The chain is stretched along the chain line starting from one end.
- The cross- staff is moved along the chain line and offsets are takenat the points where the ranging rods occur.
- The chainages and offsets are noted in the field book. Chainages are entered in the central column and offsets are entered opposite to chainage on the right or left of the chainage depending on where they occur.
- To check the accuracy of the fieldwork, the chainages of the points of intersection of the chain line and the boundaries should be noted and the lengths of the boundary lines determined by the direct measurement. After the field work is over, the survey is plotted to a suitable scale.

Practical - 4

Experiment No 1 - Determination of distance between two points

Aim:

To determine the distance between the two inaccessible points by using a compass.

Apparatus:

Compass and its accessories, Tape, Ranging rods, Arrows etc.

Procedure:

Practical - 5

Experiment No 1 - Determination of elevation of different points

Aim

To find out the elevation (reduced levels (R.L.)) of different points shown on the ground with respect to a given arbitrary bench mark (B.M.) Apparatus: Dumpy level with accessories, Levelling staff etc.

Procedure

- Set up the instrument at a convenient place so that all the points and Bench mark is visible properly.
- Do the "Temporary adjustments" properly and make the line of sight exactly horizontal.
- First take a back sight by focusing the telescope towards the staff held on the bench mark, the R.L. of which can be assumed suitably (50 m, 100m) and enter the staff reading in the back sight (B.S) column of the level book.
- Calculate the elevation of the line of sight as height of instrument (H.I) H.I. = R.L of B.M + B.S
- Now focus the telescope towards the staff held on different points on the ground and note down their corresponding readings and enter them in the intermediate sight (I.S) column of the level book. The reduced levels of these points can be calculated as R.L. of given point. R.L. = H.I – I.S. or F.S.
- The last reading should be entered in the fore sight (F.S) column, so as to have a proper check on the accuracy of the work. However R.L. is calculated in a similar manner.

Practical - 6

Experiment No 1 - Determination of elevation between water source and pond site

Aim

To find out the difference of elevation between water source and pond site and to draw the profile of the ground by levelling.

Apparatus

Dumpy level with accessories, Levelling staff, Tape, Ranging rods, Arrows, Chain etc.

Procedure

- Stretch the chain along the centre line of the plot from the water source to pond site.
- Mark the stations along the central line at equal intervals. (Say 5, 10, 20 mt depending upon the slope of the ground.)
- Set up the instrument near the water source in the proceeding direction of work. So that the Bench Mark (B.M.) should be visible clearly. Carry out temporary adjustments to the instrument to bring it properly leveled.
- Take the back sight (B.S) by holding the leveling staff on the B.M. Find out the height of instrument (H.I.) for that set up of the instrument. Take the intermediate sight (I.S.) at different points; calculate the reduced level (R.L.) of the same. Take fore sight (F.S.) on the first turning point for same set up of the instrument and find out the R.L.
- Now, shift the instrument to a new position in the direction of pond site, so that the staff held at turning point 1 is clearly visible.
- Set up the instrument and level it properly by carrying out temporary adjustments. Note that the staff should be kept at the turning point 1 itself.
- Now take the B.S. on the turning point 1 who's R.L. is previously determined with respect to first position of the instrument. B.S. + R.L. of turning point 1 will give new H.I.
- Continue the same procedure until the pond site is reached. However, staff readings on that point will be F.S. only. Enter the above readings in the level book and calculate the R.L. of water source, turning point, height of instrument and R.L. of the site. Draw the profile of the ground to suitable scale

Practical - 7

Experiment No 1 - Plotting of the position of objects by radiation method

Aim:
To plot the position of given ground points by radiation method.

Apparatus:
Plane table with accessories, Ranging rods, Tape, Arrows, etc.

In this method a ray is drawn from the instrument station towards the point, the distance is measured between the instrument station and the point, and the point is located by plotting to suitable scale the distance so measured. This method is more suitable when the distances are small and single instrument can control the points to be detailed.

Procedure:

- Set the table at 'T', level it and transfer this point on to the sheet by means of plumbing fork, thus getting't' representing 'T'. Clamp the table.
- Keep the alidade touching't' and sight to 'A'. Draw the ray along the fiducial edge of the alidade. Similarly sight different points B, C, D and E etc and draw the corresponding rays (A pin may be inserted at 't' and the alidade may be kept touching the pin while sighting the points).
- Measure TA, TB, TC, TD and TE etc in the filed and plot their distances to suitable scale along the corresponding rays thus getting a, b, c, d etc. Join these if needed.

Experiment No 2 - Plotting of the position of objects by intersection method

Aim
To determine the distance between two inaccessible points (Inter section method)

Apparatus
Plane table with accessories, Tape, Ranging rods, Arrows etc.

Procedure

- Set the table at the point 'A', level it and transfer the point 'A' on to the sheet by way of plumbing fork. Clamp the table.
- With the help of the trough compass, mark the north direction on the sheet.
- Pivoting the alidade about 'a' sight it to 'B', measure AB and plot it along ray to get 'b'. The base line 'ab' is thus drawn.

- Pivoting the alidade about 'a', sight the point 'X' and 'Y' and draw corresponding rays.
- Shift the table at 'B' and set it there and orient the table roughly by compass and finally by sighting 'A'.
- Pivoting the alidade about 'b', sight the point X and Y and draw the corresponding rays along the edge of the alidade to intersect with the previously drawn rays in 'X' and 'Y'. The positions of the points are thus mapped by way of intersection.
- Measure the distance xy on the sheet and convert it to same scale and which will give the distance between the points 'X' and 'Y'.

Practical - 8

Experiment No 1 - Drawing of contour lines by direct method

Aim

To draw the contour lines for given elevations (Direct method)

Apparatus

Dumpy level, Levelling staff, Tape, Plane table with accessories, Arrows etc.

Procedure

- Set up the level at a convenient place, so that all the points and bench mark are visible properly.
- Do the "temporary adjustments" properly and make the line of sight exactly horizontal.
- Take the back sight by focusing the telescope towards the staff held on the bench mark.
- Calculate the elevation of line of sight as height of instrument.
- The staff reading is calculated so that the bottom of the staff is at an elevation equal to the value of contour. Eg: when the height of instrument is 101.80mt, the staff reading to get a point on the contour of 100.00 m will be 1.8 m.
- Taking one contour at a time, the staff man is directed to keep the staff on the ground so that reading of 1.8 m is obtained every time (say A, B, C, D etc.)
- Set the plane table on the ground near to the levelling instrument at instrument station say 'X'. Level it. Transfer the ground point on to the sheet by means of plumbing fork, thus getting 'x' representing 'X'.
- With the help of trough compass mark the north direction on the sheet Clamp the table.
- Pivoting the alidade about 'x', sight it to the first point say 'A' on the ground. Draw a ray along the fiducial edge of the alidade.
- Measure the distance between ground station 'X' and the point A. Plot this distance to suitable scale along the ray marked.
- Similarly sight the other points on the ground. Measure their distance and plot it on the sheet for same scale (say B, C, D etc.)
- Join these points to get the contour line for an elevation of 100 m.
- By using same procedure draw the other contour lines.

Practical - 9

Experiment No 1 - Drawing of contour lines by indirect method

Aim

To draw the contour lines for given elevation (Indirect method)

Apparatus

Dumpy level, Levelling staff, Tape, Arrows etc.

Procedure

- The area to be surveyed is divided into number of squares. The size of the square may vary from 5 to 10 m depending upon the nature of the contour and contour interval.
- Set up the level at a convenient place so that all points and bench mark are visible properly.
- Do the "temporary adjustments" properly and make the line of sight exactly horizontal.
- Take the back sight by focusing the telescope towards the staff held on the bench mark and find the height of instrument.
- Held the leveling staff on the corners of the square and find out its elevation.
- The contour lines may then be drawn by interpolation.

Practical - 10

Experiment No 1 - Earth work calculation for dyke preparation

Longitudinal section

A given section is said to be in cutting or excavation, when the formation line at that section is lower than the existing ground. On the other hand a given section is said to be in filling or embankment, when the formation line at that section is higher than the existing ground.

The slope of the ground along a given line is known as the longitudinal slope. On the other hand slope of the ground perpendicular to the given line is known as cross slope or transverse slope. Cross section of earthen channel / dykes either in banking or in cutting is usually in the form of a trapezium and the quantity of earthwork may be calculated by the following method.

Volume of earth work = Cross sectional area x Length

The Cutting or filling areas of trapezoidal sections are calculated by the given equation**,**

$A= BY + KY^2$

where,

A = Cross sectional area of the section

B= Width of the section

Y= Depth of cut or Height of bank

K= Slope of the section

Usually slope of the section is considered only horizontal to vertical.

Problems

1) An embankment is to be built to a length of 150 m, with top width 1 m and to a height of 3 m. The side slope recommended is 1:1. Calculate the quantity of soil required for it.

Given B=1mt. L=150 m.

Y=3mt K=1

$A = BY + KY^2 = 1x3 + 1x3^2 = 12\ m^2$

Volume of soil required = A x L = 12 x 150 = 1800 m^3

2) An embankment is to be built with 4 m. wide at the top with side slope 1 to 1 and. Height 3 m. Assuming the ground to be level, calculate the volume of earth required to construct an embankment if of 200 m. length.

Computation of volume of earth work in the ponds

1) Excavation is to be done to make a pond of 80 m. long, 50 m. width at the bottom and 3 m. deep. The side slopes of excavation is 1.5: 1 (H: V). Assuming the surface of the ground to be level, calculate the volume of earth work.

2) Excavation is to be made to dug a pond 30 m long, 20 m wide at the top and having side slope of 2:1 (H:V). Calculate the volume of excavation if the depth is 4 m. The ground surface is level.

Practical - 11

Experiment No 1 - Earth work calculation for channel making

Aim:
Computation of volume of earth work in the channels.

Problems:
1. Compute the depth of cut and height of bank at the various sections along the given line from the following data and draw the longitudinal section.

2. Calculate the quantity of earth work for 200 m. length channel in uniform ground with height of banks at the two ends being 1.0 m and 1.6 m. The formation width is 5 m, side slope is 2:1 (H: V). Assume that there is no transverse slope.
Use (i) Mid-sectional area method
(ii) Mean sectional area method.

3. Compute the volume of earth work along the given line from the following data

Assume the following
Formation width = 10 m.
Side slope = 2:1
Use

- Mid sectional area method
- Trapezoidal formula method
- Prismoidal formula method

4. Compute the volume of earth work from the following data

Formation width = 10 m
Side slope

- Embankment = 2:1
- Excavation = 1.5:1

Use

- Mid sectional area method
- Mean sectional area method

Practical - 12

Experiment No 1 - Distribution of grain size in coarse grained soil

Aim

To find out the grain size distribution of coarse grained soil by sieving.

Apparatus

IS sieves, Pans, Vibrating machine, Weighing machine, Weights etc.

Procedure

- Collect some quantity of soil sample received from the field and dry it in the oven.
- Take 5 kg oven dried soil sample, keep it in a tray and soak it with water.
- Puddle the sample thoroughly in water and transfer the slurry to a 4.75 mm sieve which separates the sample into gravel and sand fractions. Collect the materials in separate containers.
- Sieve the dried sample retained in 4.75 mm sieve through 63 mm 20mm, 10mm and 4.75 mm by hand sieving. The mass of the material retained on each sieve should be recorded.
- Wash the material passed through 4.75 mm sieve through a 75 micron sieve to separate the silt and clay particles from the sand fraction. Collect the material retained on 75 micron sieve in container and keep it in the oven.
- The dried material retained on 75 micron sieve is carefully placed on top of the sieve pan of 2 mm size followed by 1mm, 600, 425, 300, 212, 150 and 75 micron size respectively.
- After pouring the soil into the top most sieve it is closed tightly by a lid and the whole set of sieve is kept in a vibrating machine. It is allowed to vibrate for 10-15 minutes.
- The weight of soil retained in each pan is found out by weighing.
- Cummulative weight of soil retained, its percentage weight and the percentage of finer is calculated.
- The material passing through 75 micron sieve may be used for sedimentation analysis.
- A graph is plotted on a semi-logarithms graph sheet taking sieve size or particle size as abscissa percentage finers as the ordinate.