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A Review of Topography in Fish Culture in Nigria Part Three

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Abstract: A review of topography in fish culture in Nigeria is aimed at enlightening fish culturist more topographical principles. The fish culturist can discuss his plans, projects and understand books on topography, engineering and surveying. Good fish farm construction can only be possible with the right topography. The fish culturists need to understand more principles in topography for good site selection in fish culture. The fish farmer can design and build fishponds, reservoirs and small dams and use existing topographical maps. Deciding the type of pond which could be built, Laying out fish ponds , Measuring horizontal angles, Graph meter, Measurement of angles with in accessible summit, Measurement of consecutive angles, Magnetic compass, Azimuth measurement of horizontal angle, Horizontal angle measurement with compass, Azimuth measurement of a line, Surveying a polygonal site, A protractor, The right angle method of measuring horizontal angles, Theodolite, Right angles and perpendiculars, Method of dropping a perpendicular, The full circle method, The half circle method, The Mid Point Method, The intersection method, Short line intersection method, Long line intersection method, The 3:4:5 rule method, Right angle measurement using the short 3:4:5 lines, Right angle measurement using the medium 3:4:5 lines, Right angle measurement using the long 3:4:5 Lines, Right angle measurement using tape, a cross staff and parallel Line are very important topography principles in pond fish culture, reviewed in this part to enlighten fish culturist more topography principle to facilitate fish farming.

Key words: Fish pond building, horizontal angles, parallel lines, perpendiculars, right angles, survey

INTRODUCTION

Topographical method can be used for maps showing the different kinds of soil present in an area of land. The commonly used topographical methods are reconnaissance surveys and detailed soil surveys (FAO, 2006).

Most topographical methods are based on lines. Lines are of two types:

- Lines of measurement
- Lines of sight

Lines of measurement can be horizontal or vertical or follow the ground level (FAO, 1980). These lines are clearly plotted in the field with markers to show the exact path measured. A line of measurement can be:

- A straight line drawn in one direction between two marked end-points
- A broken line drawn in more than one direction between two marked points, with each point in the new direction
- A curved line, marked like a broken line, but with closely spaced marker, that clearly follows the curve

A line of sight is an imaginary line starting from the surveyors' eye to a fixed point; lines of sight are either horizontal or oblique (between horizontal and vertical). Lines of measurement are always plotted on the ground either as one straight-line or as many interconnected straight lines. Pegs, small concrete pillars, simple wooden stakes or ranging poles are used as markers to indicate the direction of the line (FAO, 1980).

Lines of sight are straight lines. The reference point is marked with either a ranging pole or a leveling staff. Vertical lines of measurement can be formed with a plumb line. Straight pieces of wooden pegs with diameter ranging from 3 to 8 cm and length ranging from 0.1 to 1.0 m can be used for pegging the line. Shape the pieces at one end with a knife to make the ground. Pegs carved from hard wood last longer and when coated with engine oil, prevents rotting (FAO, 1994).

Apart from wooden pegs, iron pegs made of cut pieces of iron rod or tube of diameter ranging from 1.3 to 2.0 cm, and long wire nails can be used. Iron pegs last

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longer than wooden pegs, but are more expensive and less portable for fieldwork. Mark any long-term reference point with a small, upright pillar made of concrete. Such pillars should range from 15 to 30 cm^2 and 10 to 60 cm high. The pillars can be placed on a small concrete base built on the site. The peg or pillar need marked point for accurate measurements because; the marked point determines the measurement position or measurement instrument placement position. A nail can be driven into the flat top of the wooden peg or set a nail into the concrete pillar top (FAO, 2002).

Ranging poles are the most commonly used markers in topographical surveys. Ranging poles are long, thin poles used in marking a point on the ground seen from a distance. A personal ranging pole can easily be prepared from a wooden pole of length ranging from 2 to 3 m and thickness 3 to 4 cm. Shape the lower end into a point for easy penetration into the ground. Cut a slit 5 cm deep into the topside of the other end. Paint from the top in alternating red and white sections to the end of the pole.

A ranging pole can be sighted from a long distance. Fasten two small flags of different colors, one above the other, near the pole top. A 15 × 25 cm piece of white cardboard in the slit at the pole top can also be used. Ranging poles are driven vertically into the ground. Walk few steps backwards and watch to ensure that the poles are vertical. Walk one-quarter the distance around the pole and check from the side for straightness. Adjust it until both front and side views are vertical (FAO, 2002).

A ranging pole can be centered over a marker and placed in position for a period of time. This can be done using a series of guys. Guys are ropes or wires tied around the poles and fastened to pegs in the soil. Guys can also be used with poles on hard soil, difficult to drive deep in a vertical position (Wilcox, 1985).

Distances are measured in different ways. Long distances are measured and maintained along a straight line. Slopes are determined through horizontal distances rather than ground distance. The best choice for a dam site is a narrowing valley with sleep slope walls and small gradient. In the absence of an existing topographical map to detect such a valley, it can be measured to determine its suitability for a good dam site. If the best site is chosen, topographical methods unveil the level of work on site. Survey the site in the desired plan by measuring the distances, directions, areas, slopes and heights. Draw a detailed topographical plan to make these measurements. The plan shows the position of boundaries, different heights of landforms such as hills and location of existing physical features (Hem, 1989).

The features include paths, roads, streams, spring, forest, rocks and buildings. Such a plan is very important because it provides information on the basic horizontal and vertical elements of the area, facilitating the fish farm design. It provides information on the direction of water flow, position of water supply canal and pond drainage ditches. This forms the basis for estimating the quantity and cost of mud to be excavated.

All physical features of fish farms depend directly on the site topography. These features include the type, number, size, and shape of the fishponds and how they are placed in relation to each other. Water supply and drainage type also depend on the site topography. Topographical methods guide a detailed site survey and fish farm design. Ensure a regular adequate water supply. A Water supply canal with an appropriate size and bottom slope can solve the problem. Stake out water supply canal along its centre line. Maintain a definite width, depth and canal length; and estimate the level of soil to be removed at each point (FAO, 2002).

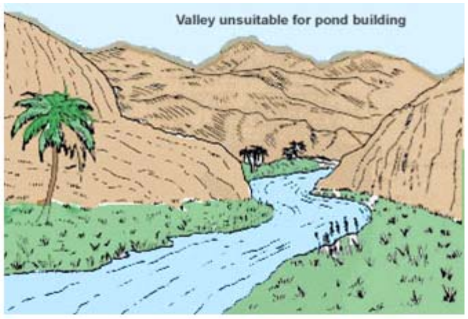
Stake out the bottom area of each pond for proper disposal of the excavated soil. This allows a natural drainage of all water out from the ponds, for effective fish harvest and pond management. Stake out the dykes of each pond and determine where to add or remove soil. There is need to mark the location, height and width of each dykes as well as the slopes of their walls. Perpendicular (crossing) and parallel (side-by-side) lines can do the job.

The exact plan of the fish farm need be followed. Do this by ensuring the position to build each structure. Check these locations during construction. Height differences between different parts of the farm need be measured to ensure natural water flow in the right direction. Water will have to flow from the water source to the ponds, from pond inlets to the outlets and from the outlets into drainage ditch, which transports water away from the farm site (FAO, 1980).

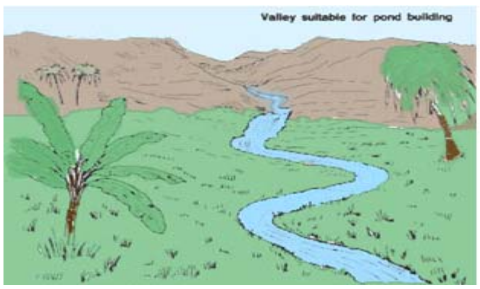
It is important to learn the use of simple topographic methods for:

- Estimating the surface area and water volume of ponds
- Determining the water flow system of a steam
- Using a weir
- Measuring water head pipes and siphons
- Dam site selection
- Estimating the volume of a reservoir

Soil quality varies and depends on the topography of the area. Shallow soil is found on sloppy land and deep soil is found on flat land, for instance, alluvial soil which is found in sedimentation plains, contains large amounts of clay. The clay in this soil aids in water retainsion and buffers the materials for building of dams. In this part: Deciding the type of pond which could be built, laying out fish ponds, measuring horizontal angles, graph meter, measurement of angles with in accessible summit, measurement of consecutive angles, magnetic compass, azimuth measurement of horizontal angle, horizontal angle measurement with compass, azimuth measurement of a line, surveying a polygonal site, a protractor, the right



(a)



(b)

Fig. 1: Valleys for pond building

angle method of measuring horizontal angles, Theodolite, Right angles and perpendiculars, method of dropping a perpendicular, the full circle method, the half circle method, the mid point method, the intersection method, short line intersection method, Long line intersection method, the 3:4:5 rule method, right angle measurement using the short 3:4:5 lines, right angle measurement using the medium 3:4:5 lines, right angle measurement using the long 3: 4: 5 lines, right angle measurement using tape, A across staff and parallel Lines are discussed to enlighten fish culturist more topography principle to facilitate fish farming.

MATERIALS AND METHODS

Deciding the type of pond which could be built: If the valley (Fig. 1) is deep, steep and narrow, do not build ponds (Ajana, 2003), (a) If the valley bottom is 50 to 100 m wide, barrage ponds might be appropriate; if the valley bottom is more than 100 m wide, diversion ponds could be built, (b) A more detailed study should confirm your choice, based on the longitudinal profile and on the cross-section profile of the valley.
Select the type of ponds to build:

- Either according to the shape of the valley and its profiles (Table 1).
- According to the slope of the longitudinal profile (downhill) and the cross-section profile of the valley (Table 2).

Laying out fish ponds: Several structures may be required for the good functioning of fish ponds, particularly if the plan is to have several of them in production (Fig. 2). It is important to understand the different possibilities which exist for the layout of ponds and their structures (Amarnighe, 1987) (Fig. 3).

It will always be easier to lay out your ponds if the land selected slopes slightly (Fig. 4) and can supply water along its highest contour line, i.e. at the top end of the site. (Glover, 1986).

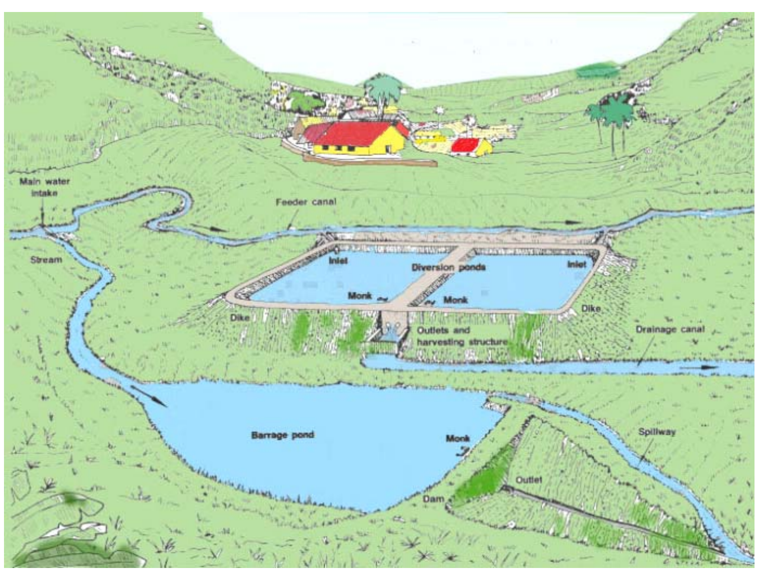


Fig. 2: Pond layout

Table 1: Selection of pond type according to shape of valley

Type of pond	Shape of Valley cross-section profile			
	V	Rounded V	Centrally truncated V	Laterally truncated V
Shunken pond	—	Whenever groundwater (spring or seepage) or runoff is available		
Barrage pond	If longitudinal profile of valley has slope less than 5%	—	—	If longitudinal profile has slope less than 5% and cross-section profile has slope 5-10%
Diversion pond: cut-and-fill type	—	Where cross-section profile has slope less than 5%	Where cross-section profile has slope 0.05-5%	
Diversion pond: paddy type	—	—	Where cross-section profile has slope less than 0.5%	

Table 2: Selection of pond type according to valley slope

Valley longitudinal profile (Down hill)	Valley cross-sectional profile	Possible type of pond
Slope greater than 5%	Slope greater than 5%	None
	Slope less than 5%	Diversion pond Sunken pond
Slope less than 5%	None	Barrage pond Sunken pond
	Diversion pond Sunken pond	Diversion pond Paddy pond Sunken pond

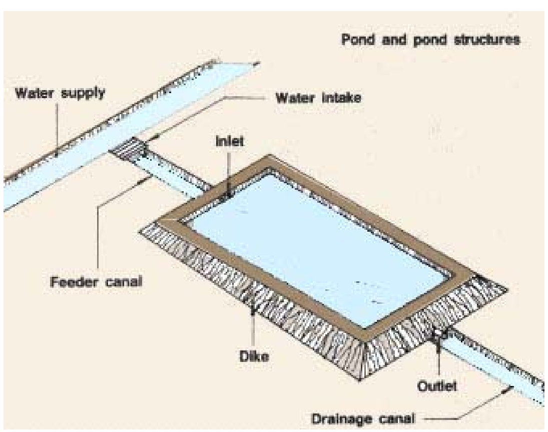


Fig. 3: Pond and pond structures

Measuring horizontal angles : In topography, the angle made by two ground lines is measured horizontally. This angle is called horizontal angle. These ground lines can be represented by two lines of sight, AB and AC. These lines of sight are directed from the eyes, which form the summit A of the angle BAC, towards permanent landmarks such as rock, a tree, a termite mound, a telephone pole or the corner of a building. Horizontal

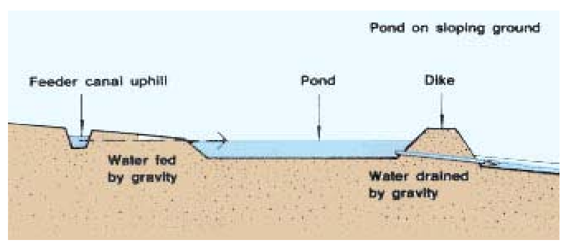


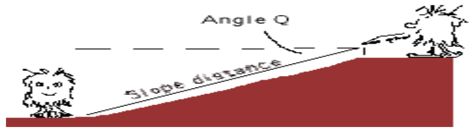
Fig. 4: Pond on sloping ground

angles are expressed in degrees. A full circle is divided into 360º, abbreviated as 360º. Note the two perpendicular values:

- A 90° angle, called a right angle, is made of two perpendicular lines. The corners of a square are all right angles.
- A 180° angle is made, by prolonging a line. In fact, it is the same as a line.

Each is divided into smaller units:

- 1 degree = 60 min (60′)
- 1 minute = 60 sec (60″)



These smaller units can only be measured with high precision instruments. There are some general rules about angles:

- A rectangular or a square shape has four straight sides and four interior 90° angles. The sum of these four interior angles equal 360°
- The sum of the four interior angles of any four-sided shape equals 360°, even when they are not right angles.
- The sum of the interior angle s of any polygon (a) shape with several sides) equals to 180° multiplying the number of side (N) minus 2. Sum of interior angles of a polygon = 180° (-2)

Example:

- A piece of land has five sides. The sum of its interior angles equals 180°(5-2) = 540°
- The graph meter should be built with a graduated circle. Make a photocopy of it or draw a copy of it with a tracing paper.
- Provide a wooden board, 1cm thick and 22 cm^2.
- Draw two diagonal lines on the board opposite corners. The point of intersection is the exact centre of the board.
- Obtain a nut and a bolt 1.5 cm long. At the centre of the board, drill a hole to tightly fit the bolt. On the bottom side of the board, drill the outside of the hole slightly larger to fit the nut.
- Create a hole of similar size at the centre of the line-graduated circle. Glue the sheet of paper to the wooden board. Carefully align the central hole in the board and the circle. Make sure the four sides of the sheet are parallel to the sides of the board. This can be easily done, by matching the two diagonal axes drawn on the board with the circle graduations of 45°, 135°, 225° and 315°, respectively.
- Protect the sheet of paper. To do this, provide a piece of transparent plastic sheet bigger than the board, and stretch it over the front side of the board. Attach it to the back with several thumbtacks.
- Build the sighting device, called the mobile alidade. Take a thin wooden ruler, 16 cm long and 3.5 cm wide. Determine its centre, by drawing two diagonal lines from opposite corners. Draw a line through the centre point parallel to the long sides of the ruler. At the same point, drill a hole a little larger than the diameter of the bolt. Drive a thin headless nail, 4 to 5 cm long into the ruler near each of its ends of the drawn line. Be careful not to let the nails break through the other side of the ruler. Ensure that the nails are driven in vertically. The alidade is ready for use.
- To attach the alidade to the base, place a thin washer over the hole in the board prepared. Align the washer above the alidade and one below the wooden board, aligned with the central holes. Push the bolt through all the washers and holes; and tighten the nut, so that the alidade turns around under slight pressure.

On the board, along the 0° to 180° lines, outside the graduated circle, drive in two headless nails similar to the ones placed in the alidade. These form a second line of sight. Clearly mark the top half of the line of sight with an arrow pointing the 0° graduation.

At one end of the alidade, draw an arrow from the centre-bolt, along the median line, and through the nail at the end. The arrow tip should point to the end of the median line above the nail. When read, the arrow aids in determining the graduation. For more accurate measurements, provide a stake 1.20 m high and sharpen one end into a point. Drive the end into the ground and

Table 3. Horizontal angle measurement methods

Method	Horizontal angle	Accuracy	Remark	Equipment
Home-made graph meter	Medium to large	Low	Best for 40-80 m. For angles greater than 10°	Graph meter
Magnetic compass	Medium to large	Medium	Best for 40-100 m. For angles greater than 10°. No magnetic disturbances	Compass
Compass or protractor	All sizes	Low to medium	Dry weather only	Simple compass, protractor, drawing sheet
Plane table	All sizes	Low to medium	Dry weather only	Plane table, drawing sheet
Right angle method	Small	Medium to high	Perpendicular to be set out	Measuring line
Theodolite or transit	All sizes	High	Useful on long distances	Transit level with graduated horizontal circle various
Miscellaneous	Right angle only	Medium to high	Adapt method to length of perpendicular	

FAO (2006)

rest the graph meter on the other end as measurement continues.

Orient the graph meter with its 0° to 180° sighting line on the left side AB of the angle to be measured. Position the graph meter so that its centre, the bolt is above point A on the ground, the station from which the horizontal angle BAC is measured.For more accuracy a plumb line can be used. If the graphmeter isbeing attached to a stake at its centre, drive the pointed end of the stake vertically into the ground at the angle's summit A.

Ensure that the graph meter is horizontal. To do this, place a pencil on the board. If the pencil does not roll off, turn it to 10° and observe. If the pencil does not roll off in either direction, the graph meter is horizontal.

Ensure that the 0° to 180° sighting line is properly aligned with the left side, AB of the angle measured. Adjust it if necessary, ensuring stability of the horizontal position of the graph meter.

Move the mobile alidade towards the right until its sighting line lines, up with the right, AC of the angle BAC. Read the graduation above the arrow on the central line of the mobile alidade. This is the value of angle BAC in degrees.

It is easier to position the graph meter above the station on the ground and make it horizontal without sighting with the 0° to 180° lines. Make sure that the left side AB of the angle equals the right angle of the 0° to 180° lines. Take two readings, using the mobile alidade for both left side AB and right side AC of the angle. The value of the angle equals the difference between these two readings.

Example: Two lines, X and Y, form an angle XAY at station A.

- Clearly define lines X and Y, placing ranging poles at B and C
- Position the graph meter at station A, with its 0° to 180° sighting line oriented to the left of AB
- With the mobile alidade, sight at ranging pole B and read the graduation, AB = 23°
- Turn the mobile alidade to ranging pole C and read the graduation, AC = 75°. The angle: BAC equals 75°-23° = 52°.

Measurement of angles with in accessible summit: To measure an angle with inaccessible summit, the summit A of the angle must be read. When the summit is not reachable, two alternative methods are available.

Set out a line CB from any point on one of the angle's side to any point on its other side, making a triangle within the angle. Measure the two angles made by the new line and the angle's sides. The angle at the inaccessible summit of the triangle made equals the difference between 180° and the sum of the other two angles.

Example: Summit A cannot be reached to measure angles XAY. From point B on line AX, set out line BC, where point C is on line AY. At station B, measure angle CBA = 60° at station C, measure angle BCA = 73°. Calculate angle XAY = 180 - (60° + 73°) = 47°or layout two perpendicular lines from two points on one of the angle's sides. On each of these new lines, measure an equal distance. Join these two points with a line parallel to one of the angle's sides. Prolong the line until it intersects the other side of the original angle. At the intersection point, measure the new angle. The new angle equals the summit angle.

Example: The summit, A cannot be reached to measure angle XAY. On line AX, mark two points B and C. From these, measure, segments BD and CE of equal length from line AX. Connect points E and D to form a line parallel to AX. Extend line ED until it intersects line AY at point F. Measure angle EFY from point F. Its measurement equals angle XAY.

Measurement of consecutive angles: Several angles formed by series of lines meeting at one point (converging lines) can be measured. The angles formed are called consecutive angles. To measure consecutive angles from a site, first measure all the angles using the furthest left as reference line. By simple subtraction, calculate the individual angles.

Example: At station P, measure three consecutive angles, XPA, APB and BPC. Take PX (furthest to the left) as reference line and align the 0° graduation of the graph meter with it. Keeping the graph meter fixed in that position, move the mobile alidade around and measure each angle. The results were: < XPA = 40°, <XPB = 70° and <APB = <XPB-<XPA = 70°-40° = 30°; <BPC = <XPC–XPB = 85°-70° = 15°.

Magnetic compass (Fig. 5): A simple magnetic compass is a magnetic needle swinging freely on a pivot at the centre of a graduated ring. The magnetic needle orients itself towards the magnetic north. The needle is enclosed in a case with a transparent cover protecting it.

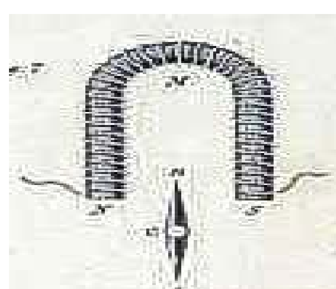


Fig. 5: Magnetic compass

Orientation compasses are often mounted on a small rectangular piece of hard transparent plastic. They have a sighting line in the middle of a movable mirror. Both compass and ground line can be seen when the mirror is being tilted.

Prismatic compasses are more accurate. It can be read when held in front of the eyes. With the aid of a prism, the scale can be seen through a lens. Turn the compass horizontally until the cross hair is aligned with the ground mark. An optical illusion makes the hairline appear to continue above the instrument's frame. At the same time, the reading is shown on the compass graduated circle behind the actual hairline. Since the graduated ring automatically orients itself, these measure the angle between magnetic north and the line of sight.

A magnetic needle points in the same direction, the magnetic north. Hence, compasses are often used for orientation in the field and mapping surveys. The part of the compass needle pointing to the magnetic north is clearly marked in red and dark color. The outside ring of a compass is graduated in 360°. The 0° to 360° graduation is marked N (North).

In most compasses, the graduation increases clockwise and the following letters can be read on the circle:

- At 90° E for East
- At 180° S for South
- At 270° W for West

Intermediate orientation, such as NE, SE, SW and NW are sometimes shown which should differ by 180°. The difference may not be exactly 180°. If the difference is very small, ignore it or correct it through the mean of two readings. If it is large, there is an error and need correction.

Example: To determine the azimuth of line XY, marked by ranging poles B and C, stand the compass station A in the middle of the line. Sight forward with the compass at ranging pole B and read azimuth AB = 65°. This is the forward azimuth. Check this value by turning around; sight back ward with the compass at ranging pole C and read the rear azimuth, AC = 245°. The difference between the two azimuths is 245°-65° = 180°. This implies that the measurements are accurate.

Azimuth measurement of horizontal angle: To measure a horizontal angle, stand at the angle's summit and measure the azimuth of each of its sides. Calculate the value of the angle as follows: if the magnetic north falls outside the angle, calculate the value of the angle between the two lines of sight as equal to the difference between their azimuths. Subtract the smaller number from the larger one, irrespective of a azimuth read first. Be sure that the magnetic north is not inside the angle.

Example: Angle BAC; AZA_b = 25°; AZAc = 64°; BAC = 64°-25° = 39°. Measure angle XAY: Measure the azimuth of AX = 265°; Measure the azimuth of AY = 302°; the angle XAY Measure the angle, 302°-265° = 37°.

If the magnetic north falls inside the angle, the angle between the two lines of sight is equal to 360 min the difference between their azimuths.

To calculate the angle, find the difference, then, subtract this number from 360°.

Horizontal angle measurement with compass: Since the needle of a compass points the magnetic north. To use this direction as a reference, make sure that the 0, graduation lines up with it. If the 0 graduation of the compass does not line up exactly with the magnetic north, turn the external ring until it does. This is the only condition the compass can be used as described below.

At any station, the angle formed by the magnetic north and a straight line is called the azimuth of the line. The magnetic azimuth from north, called azimuth or AZ is measured clockwise from the magnetic north of the line.

Example: Azimuth OA = 37, AZOB = 118; AOC = 230º, AZOD = 340º

Azimuth measurement of a line: To measure the azimuth of a line, take a position at any point on the line. Holding the compass horizontal, sight at another point on the line, such as a ranging pole. To do this, align the sighting mark of the compass with this point. If necessary, as with the same orientation compasses, align the 0° graduation N exactly with northern point of the magnetic needle. At the intersection of the sighting line and the graduated ring, read the azimuth of the line from the point of observation. For more accurate result, limit the length of the sighting line to 40 and 120 m. Place more ranging poles on the lines as needed.

To check the value of an azimuth, turn around and look in the opposite direction at another point on the same line. Read the measurement of the azimuth.

Example: Measure angle EAF; measure the azimuth of AE = 23°; measure the azimuth of AF = 310°; angle EAF measures 360º-(310-230°) = 73°.

For improved accuracy, repeat each measurement three times from the same station. These measurements should have similar results.

If this summit of the angle is inaccessible, measure the azimuth of each line from another point situated on it separately; and calculate the angle.

Example: Measure angle BAC, but the summit A is inaccessible at point X on AB, measure azimuth XB = 39; at point Y on AC, measure azimuth CY = 142°. Since the

Table 4: Summits of polygon

	Observed Azimuths forward A_z Rear Az			Calculated Azimuth forward A_z Rear A_z	
			Large Azimuth -180		
Summit of polygon	1	2	3	4	5
A	1. AB = 40	4. BA = 222	42	AB =41	BA = 221
B	3. BC = 110	6. CB = 288	108	BC = 109	CB = 289
C	5. CD = 185	8. DC =5	5	CD = 185	DC = 5
D	7. DE = 246	10. ED = 68	66	DE = 247	ED = 67
E	9. EA = 300	2. AE = 120	120	EA = 300	AE = 120

FAO, 2002

magnetic north falls outside BAC, calculate its measurement: 142° - 39° = 103°.

Surveying a polygonal site: In surveying a polygonal site, measure the azimuth of two sides from each summit. Determine one forward and one rear azimuth for each side of the polygon. Check on the accuracy of the azimuth, which should differ by 180°. If not, subtract 180° from the largest azimuth and calculate the average between the value and the smallest azimuth. To do this, add the two numbers and divide by two. Do this for other pairs and calculate the interior angles of the polygon.

To confirm the result, add all the interior angles. The sum should equal 180 (N-2), N being the number of sides of the polygon.

Example: Survey polygon ABCDEA. From summit A, measure forward AZAB = 40° and rear A_ZAE = 120°. Move clockwise to summit B and measure rear A_ZBA = 222° and forward A_ZBC = 110°. Proceed in the same way from the other three summits C, D and E. The total measurements are ten. Record the measurements in a field notebook. See column 1 and 2 where the order of measurements are shown in Table 4.

Calculate the values of column (3) by subtracting 180° from the largest azimuth measured at each summit. The value obtained should be equal to the smallest observed azimuth written in either column 1 or 2, according to the position of the summit.

When the values are equal to the smaller observed azimuth (summit C, E), transfer these measurements to column 4 or 5, according to the type of azimuth they represent. When they are equal (summit A, B, D), use columns 1 or 2 and 3 to calculate the average smallest azimuth. To do this, add the measurement of the smallest AZ from column 1 or 2 to the number in column 3. Divide the total by 2.

At summit A, forward A_ZAB = (42° + 40° = 41°)/2
At summit D, rear A_ZED = (66° + 68° - 67°)/2

Enter a forward A_Z in column 4 and a rear A_Z in column 5.

Add 180 to the smallest calculated azimuth to calculate the remaining azimuths. For example, at summit A, rear A_ZBA = 41° + 180° = 221° and at summit D forward A_ZDE = 67 +180 = 247°. Enter a forward A_Z in column (4) and a rear A_Z in column (5).

Calculate interior angles, combining the calculated azimuths (column 4 and 5) two by two as follows with the aid of a little sketch:

- <EAB = AZAB–A_zAB = 120° – 41° = 79°
  - < ABC = AZAB–AZBC = 221°– 109° = 112°
  - < BCD = AZBC–AZCD = 289°– 185° = 104°
  - < CDE = 360°– (A_zDE–AZDC) = 360°– (247°–5) = 118°
  - < DEA = 360°–(AZAE–AZED) = 3600–(300–67°) =127°

Check: The sum of interior angles should be equal to 180° (5-2) = 540. The calculation: 79° + 112° +104° +118° + 127° = 540. This confirms the results. If the angles measured are consecutive angles, proceed as described earlier.

When using a magnetic compass to measure horizontal angles, the following points should be carefully checked.

- The magnetic needle swings freely on its pivot. Keep the compass horizontal in one hand and, with the other hand bring an iron object close to the magnetized needle's point. Shift the needle to the left with the iron; its original position. Repeat the movement in the opposite direction to double check.
- The magnetic needle must be horizontal when the compass is horizontal. Lay the compass on a horizontal wooden surface and ensure that the needle remains horizontal. If it does not, the case of the compass should be opened and add a lightweight to the needle. To do this, wind some cotton sewing threads around the part of the needle that is highest, and move the needle back and front until it is balanced and horizontal.
- Do not keep iron objects close to the compass. Iron, attracts the magnetic needle and falsify the measurements. Distance measuring lines made of metal, such as steel bands, steel tapes and chains, should be kept 4 to 5 m away from the compass during measurement. Remove eyeglasses with metal frames from the compass. Remember that, concrete structures (towers, bridges etc) are built with iron

bars. This can deflect the compass needle.
- Avoid using a compass during thunder. It affects the needle.
- Avoid using a compass near an electric power line.
- The compass should be kept horizontal when used for measurement.

There is need for repeated measurement to check the measurement azimuth due to possible magnetic disturbance caused by iron present in the ground. The graphical method can be used as an alternative in such cases.

To use the graphic method for measuring horizontal angles, draw the angle on paper. Measure the angle with a protractor. Repeated procedure discovers possible errors.

A simple compass and protractor can also be used in the field. With this method, a simple magnetic compass shows the direction of the magnetic north. Provide a 30 x 30cm piece of stuff cardboard or thin wooden board, and several sheets of square ruled paper. A millimeter paper is preferable. Glue each sheet at its four corners to the board, on top of the other. On the upper left-hand corner of the top sheet, attach the compass with a string or rubber band or within a small wooden frame, so that its 0° to 180°-reference line is parallel to one of the rules on the paper. With a pencil, draw an arrow straight up towards the top of the sheet and mark it North. To draw the horizontal angle BAC, measured, stand at the angle's summit A and look at a ground line AB, which forms one of the sides of the angle. Keeping the board horizontal on the palm of one hand held in front, turn it slowly around until the northern point of the compass needle reaches the 0° graduation. This orients the sheet of paper with its arrow, facing north. It is easier when the board rests on a stable support such as a wooden pole driven into the ground. Without moving the board any more, trace on the pencil with free hand, a line AB ahead in the direction of the ground line AB. Repeat the procedure described above, as looking at the ground line AC, which forms the other side of the angle and draw line AC.

Using a protractor, measure the azimuths of the lines traced as the angles forward with any of the paper rules, parallel to the North. Remember to measure the angle clockwise from the North to the pencil line. Measure only angles smaller than 90°, since the square ruled paper shows 90°, 180° and 270° directions. Take the azimuth of the two sides of the horizontal angle, and calculate the values of the angle. A plane table is preferable because it is easier to measure the drawn angles with a protractor.

A protractor: This is a small instruments used for drawing. It is graduated in degrees or fractions of degrees. The semi-circular protractor is the most common type, but a full circular protractor may be best for measuring angles greater than 180°. Protractors are made of plastic or paper. It is relatively cheap and available in stores that sell school equipment. The arrow at point A indicates the exact position of the protractors center.

Align the 0° to 180° straight edge of the protractor with one of the angle's sides AB. Move the protractor so that its center is positioned exactly on the summit A of the angle, keeping the 0° to 180° straight edge on the angle's side AB. Look for the point where the angle's other side AC intersects the graduation on the round edge of the protractor. Read the value of the angle from the graduation. The value must be expressed in degrees and minutes. Remember that half degree equals 30 min. If the sides of the angles are too short to intersect the protractor edge, extend them before measurement (Fig. 6).

The right angle method of measuring horizontal angles: The right angle method is best for measuring angles smaller than 10 degrees in the field; since, the preceding methods are not accurate. The right angle method is based on the geometrical properties of right angle triangles. From the angles summit A, measure 10 m along one of the sides AC of the angles. Clearly mark point D with a ranging pole. From point D, layout a

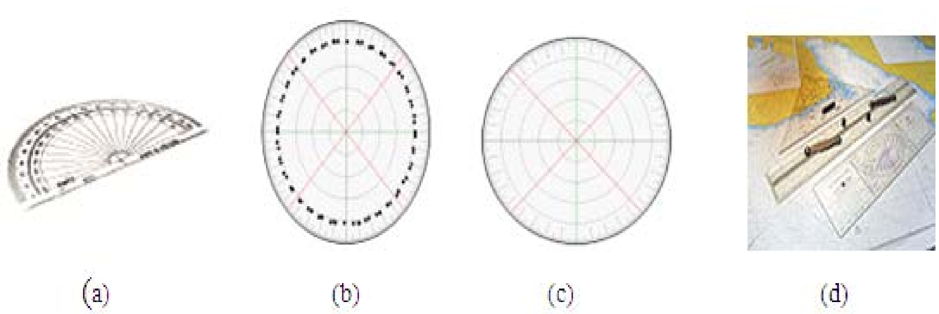


Fig. 6: (a) A half circle protractor marked in degrees (180º), (b) A 360º protractor marked in degrees, (c) Another 360º protractor marked in degrees, (d) A "Cras Navigation Plotter" double-protractor, in foreground

perpendicular line and prolong it until it intersects the second side of the angle. Clearly mark intersection point E. Accurately measure the length in meters of the perpendicular DE. Divide the length by 10 to obtain the tangent of the angle. Look for this value in four figure Table and find the measurement of the angle BAC in degrees and minutes.

Examples:

- Measure the small angle XAY
- From summit A, measure 10 m on line XA and mark point B at the Point C
- Measure distance BC = 1.12 m
- Dividing the value by 10, the tangent of the angle XAY = 0.112
- Looking for 0.112 in four figure table. The closest value is 0.1110. Based on the value, angle XAY = 620

Theodolite: A theodolite (transit) is an expensive instrument used for the precise measurement of horizontal angles. It is like a graph meter, but more complicated. Most theodolites are designed to measure vertical angles as well. The theodolite's basic features for measuring horizontal angles are: A typical theodolite (http://upload.wikimedia.org/wikipedia/commons/3/30soviet thodolite.jpg)

- A horizontal circle, graduated in degrees, which may be rotated and clamped in any position,
- A circular plate which may be rotated inside the circle and which shows additional graduations on the circle with greater precision.
- A telescope which is attached to the circular plate, and turns with it, and which can also be turned up and down in the vertical plane, and
- A tripod on which to place the theodolite during measurement

To measure a horizontal angle BAC with a theodolite, place the theodolite on its tripod at summit A. Set the index on the horizontal graduated circle at zero and extend a sighting line to B. Clamps the circle in position turn the telescope and its circular plate to extend a sighting line to C, while rotating through the angle BAC. Read the angle measurement directly from the circular plate index.

Right angles and perpendiculars: A right angle is a 90° angle. Two lines intersecting each other at a right angle are called perpendiculars. Right angles are often used in fish culture. In constructing rectangular ponds, two things are required to estimate the volume of the land area. Rule 7 by 5 = 35.

- Drop a perpendicular from a given point A to a line XY.
- Layout a perpendicular XY to another line AB from a given point X.

Method of dropping a perpendicular:

The full circle method: Set out line XY with ranging poles, and point A above and below it with a marking pin. Drop the perpendicular from point A or XY. Provide a simple line (a liana or rope) or a measuring line (a tape or chain), slighting longer than the distance from point A to line XY. Attach one end of the line to the marking pin at point A near the ground. Walk with other end of the measuring line to the line XY and stop at 2 m beyond the point it crosses (FAO, 2006).

Holding the line with hand, trace an arc with it on the ground. To do this, swing the line in a curve to the left until it intersects XY. Mark the point; B. Swing the line in a curve to the right until it intersects XY. Mark the point, C. Measure on XY the distance between two marked points. Divide the distance by 2 and measure the new distance from point B. Mark the point, D. It will be exactly in the middle of BC. Connect point D and the original point, A to form a new line AD perpendicular to XY.

The half circle method: Set out line XY and point A as described above. Prepare a measuring line a little longer than half the distance from point A to the line XY on which the perpendicular will be dropped. From any point B on line XY, measure distance AB to point A. Divide the distance by 2 and mark the center C. Attach one end of the measuring line to point C near the ground.

Walk with the other end of the line to point B on XY, and clearly mark the distance CB on the measuring line. Trace an arc on the ground with the line CB. To do this, swing the line on a curve to the right until it intersects XY again. Mark the point D. Join D to the original point A to form a new line AD perpendicular to XY (FAO, 1980).

The mid point method: The easiest way of setting out a perpendicular from a fixed point A on line XY is using a simple line clearly marked at its mid point with a knot. The line can be a liana, a rope or a string or a measuring tape. For accurate results, the line should be at least 8 cm long. A longer line makes measurement more accurate. In the absence of an assistant, make a small loop at each end of the line.

Set out line XY and mark point A from which the perpendicular will be set out. On either side of point A and along line XY, measure the equal distances AB = AC = 2 cm. Part of the measuring line can be used to do this.

Mark points B and C with stake. Loop one end of the line over stake B and the other end over stake C. From the line mid-point D, sketch the line tightly, ensuring that the two ends are looped over stakes B and C. Mark the position of the mid-point D with a stake. Line DA will be perpendicular to line XY (FAO, 1980).

The intersection method: A simple line can be used for this method. This depends on the length of the line. Remember that:

- If the perpendicular is to be short, it is best to use the first method.
- If the perpendicular is to be long, it is best to use the second method.

Short line intersection method: This method requires a simple measuring line such as a liana or a rope 5 to 6 m long, a short pointed stick or thin piece of metal (such as a big nail) and five marking stakes. Set out the perpendicular, and mark it clearly with a stake. With part of the measuring line, measures 2 to 3 m distances to the left point A on XY. Mark the point B with a stake

Measure the same distance on XY to the right of point A. Mark this point C with a stake. Make a fixed loop at one end of the line and securely attach the pointed stick or piece of metal to the other end. Place the loop around marking stake B. With the line well stretched, trace a large arc on the ground with the other end of the line. The arc should extend beyond point A, and a long way on either side of XY.

Lift up the loop from stake B and place it around stake C. Trace another arc on the ground, intersecting the first arc at two points, D and E. Clearly mark these two points D and E with stakes. Lifting up the loop from stake C, place it around stake D, holding the other end of the line, walk to stake E and attach it there. Check to see if the line touches the central stake A. Remember that the perpendicular was originally to be set out from point A. If it does, line DE forms the perpendicular on the ground (FAO, 1983).

Long line intersection method: This method requires a simple line 55 cm long, a short pointed stick or thin piece of metal and four marking stakes clearly mark point A on line XY with a stake. Set out the perpendicular from this point. Measure 25 to 30 m to the left of point A on line XY, using part of the measuring line. Mark the point B with a stake.

Measure the same distance on XY to the right of A; mark the point C with a stake. Make a fixed loop or piece of metal on the other end of the line. Place the loop around marking stake B. With the other end of the line in one hand, walk diagonally away from line XY. When reaching a point above A where the line is well stretched, trace an arc 2 to 3 m long to the ground with the end of the line. Repeat the last step from the second stake C. The arc marked on the ground from the point should intersect the first arc at point D. At the intersection point D, drive a marking stake into the ground. The line AD joining D with the original points A perpendicular to XY. The intersection method is best applicable on grounds with clear large rakes and high vegetation because, the arc must be marked and seen clearly. Clear the ground while working (FAO, 2002).

The 3:4:5 rule method: The 3:4:5 rule is that any triangle with sides in the proportion 3:4:5 contains a right angle opposite the longest side. The method is based on this rule. The length of the simple line used for measuring depends on the length of the perpendicular set out. The length of perpendicular varies directly with the measuring line (FAO, 2006).

Example:

Measuring line	Perpendicular line
Very short 1.5	
Short 13 m	3 m + 4 m +5 m = 12 m
Medium line	38 m 9 m + 12 m +15 m = 36 m
Long line 65 m	15 m + 20 m +25 m = 60 m

To construct a simple line, provide a rope 1-15 cm thick. It is best if made from natural fibers, which seldom stretches or shrinks. An old sisal rope stretches or shrinks less than a new one. A measuring tape can also be used. Depending on the type of measuring line used and staff available, several ways of applying the 3:4:5 rule method exist. When using medium or long lines, it is best to work in a team of these people. A single person can work when using a short or very short line.

A simple line usable with the 3:4:5 rule methods can easily be made. This line is sometimes referred to as a ratio rope. Take a piece of rope 13 m long. A few centimeters from one end, tie a metal ring to it with heavy string. Measure a length of 3 m along the rope from the ring, and attach a second ring to the rope. Using a measuring tape, ensure that the distance from the first to the second ring is 3 m. If it is not, adjust it. Measure a length of 4 m from the second ring and attach a third ring. With a measuring tape, ensure that the distance is 4 m. Adjust it if necessary. Measure a length of 5 m from the third ring. Attach the end of the rope to the first ring. Check the length with a measuring tape and adjust it if necessary. A shorter or longer line can be made in the same way.

Right angle measurement using the short 3:4:5 lines: Set out straight line XY on which the right angle is to be constructed using a short line. Obtain several wooden or metal stakes. Pin or stake the ring between the 3 m and 4 m segments of the short ratio rope at point A and XY. This point can be the corner of a rectangle pond to be built. Stretch the 3 m segment tightly along line XY, and pin or stake it at point B, using the ring between the 3 m and 5 m segments. Hold the ring between the 4 and 5 m segments, and pull the ratio rope into the shape of a triangle, ensuring that the 4 and 5 m segments are tightly stretched. Using the ring, stake the rope at C. The angle formed at A between the 3 and 4 m segments of the ratio rope is a right angle. A 3: 4:5 ratio rope can also be used with much shorter segments for instance, a 30 cm: 40 cm: 50 cm line, is ideal for measuring angles of smaller areas, for laying out a V-notch weir.

Right angle measurement using the medium 3:4:5 lines: Using a line 36 m long with section 9, 12 and 15 m long, start form point A, the right of angle point. Stretch the 12 m segments along line XY. At this point, attach the ring on the line to stake B. With the 15 m segments, walk away from B while the assistant returns to the original point A with the 9 m segments of the line. When the last two sides of the triangle are fully stretched, mark the point C connecting the 9 and 15 m lengths. This point forms perpendicular AC at A.

Right angle measurement using the long 3: 4: 5 Lines: On a rope 65 m long, clearly mark the 0, 15, 35, and 60 m lengths. Work in a team of three people when using the line. The first person holds the rope at the 15 m marks at point B on line XY from which the perpendicular is set out. The second person holds the 0 and 60 m marks together at point A along XY (FAO, 1994).

The third person takes the rope at the 35 m mark and walks away from XY. Adjust the position until the two sides of the triangle are stretched. When this is done, the position point C is marked. Joined to point B, this forms perpendicular BC to XY. Always double-check distances to ensure error free.

Right angle measurement using tape: Set the center - line WZ of a dyke perpendicular to the centerline XY of another dyke. Using a measuring tape at least 80 m long and working in a team of three, proceed as follows: Form the intersection point A of the two dyke center lines, measure 40 m along XY, the known center line. Mark the point B, while one-person holds the 0m graduation of the tape at point A, where the two centerlines intersect. The third person, holding the tape at the 50 m graduations, walks away from XY unit. The tape is fully stretched. The assistant marks the place of standpoint C. This point defines the second centerline WZ perpendicular to the first one (FAO, 1980).

A cross staff: For setting out right angles, several models exist. The octagonal brass cross staff has sighting slits cut at right angles to each other and the fore sights/back sight model. When used, cross staff must be firmly fastened to a support, a stake driven vertically into the ground. Their useful range does not exceed 30 to 40 m. The octagonal cross staff also has additional sighting slits cut at 45° and is useful for setting out 45° angles.

A cross staff can be prepared from metal or wooden strip 2 to 3 cm wide and 20 to 25 cm long. Find the centers of the strips at the intersection of two octagonal lines. Drill a small hole at the center point found on each strip. These are the crosspieces. To do this a wooden strips drive in one small headless nail, centered, near each end of strip. On metal strips, weld or glue small nails or metal points near the ends of the strips. Place the cross piece approximately at right angles and with a screw, attach the item loosely in that position to the top of a 1.50 m vertical stake. It will be easier to tighten the strips securely if washers are used between the wooden cross pieces and the stake (FAO, 1983).

The home made cross staff can be adjusted by laying out a right angle on the ground using a long 3:4:5 ratio rope. The sides of the triangle will be 15, 20 and 25 m long. Put a short stake at point A, the corner of the right angle between the 15 and 20 m sides. Put ranging poles at point B and C to mark the sides of the angle. Position the cross staff and its vertical support at point A. Align one cross piece along side AB and sight towards point B.Without moving the vertical support, align the second cross piece along the other side AC of the angle and sight towards point C. Tighten the screws a little to keep the cross pieces in place (FAO, 2002).

Rotate the vertical support 90° to ensure that the cross piece are truly at a right angle. Sight at point B and C again and correct the position of the cross piece if necessary. Repeat this process until each cross piece is aligned with one side of the right angle. When both cross piece are properly aligned, firmly tighten the screw holding them to the vertical support check both sighting lines again after tightening the screw to ensure that the cross piece have not slipped. To adjust the cross piece later, cut or engrave marks with a large nail in the wood or metal of the bottom cross piece when the top piece is in position (FAO, 2006).

When using the cross staff to set out a right angle, use an assistant. Lay out straight line XY on the right angle at point A. Place the support of the cross staff in a vertical position at point A. The assistant holds a ranging pole in a vertical position at point B, near to the end of XY. Sight along the crosspieces and rotate the vertical support until the sighting line is aligned on B.

Without moving the cross staff and its vertical support, sight along the other cross pieces. At the same time, direct the assistant to stand with a ranging pole close to the sighting line. The assistant holds the ranging pole in front and walk to the right or left until the pole is on the sighting line AZ. When the assistant is on the line AZ, the position should be marked with stake C. The angle BAC determined at point A, where the cross staff is placed, is a 90° angle.

A cross staff can easily be used in the determination of rectangular areas for a fishpond layout. A grid of squares can also be built by determining intermediate angles along straight lines. This method estimates reservoir volumes (FAO, 1980)

Parallel lines: Parallel lines, also called parallel are lines equally distant from each other at every point. Parallel lines run side by side and will never meet. They are very important in fish culture and are often used in designing fish farms, building dams and setting out water canals. Parallels are also useful when laying out lines under difficult conditions (FAO, 1983).

One way to set out a parallel line uses the 3:4:5 rules. It works like so. On a given line XY, select two point A and B, fairly distant from each other, and mark them with pegs from each of these points, set out a perpendicular using the 3:4:5 rule method. Remember that the length of the line used depends on the length of the perpendicular set out. Prolong these two perpendiculars as required. Measure an equal distance from the given line XY on each of them. Mark these two points C and D. Set out line WZ through these two points. This line will be parallel to XY (FAO, 1994).

To use the crossing line method is setting out parallels. Do not set out perpendicular but measures distances. However, this method cannot be used to measure the exact position of the parallel set out. It is useful when the distance of the parallel is not important. For instance, in prolonging a line over an obstacle, proceed as follows; lay out line XY. Select any point, ‘A’ belonging to the parallel line set out. Clearly mark point A with a peg. From point A, set out an oblique line AZ. Mark point B where AZ intersects the original line XY. An oblique line is neither parallel nor perpendicular. Measure the length of the oblique line AB. Divide the length by 2, measure the distance from point A, and mark the central point C. On the original XY, select point D, set out a straight line, DW passing through point C. Measures a distance equal to distance DC. Mark the end of the segment point E. Connect points E and A with a line KL. This is parallel to line XY (FAO, 2006).

To build a fish farm, a series of rectangular plots need to be set out on the ground. These plots are future sites of ponds or the other constructions. First, select the main dyke center direction line XY. Set it out on the ground with ranging poles. Using the measurement along this line, the points, A, B and C can be marked where center lines of the secondary dykes will be set out. To do this, proceed as follows;

Select out a few perpendiculars on XY from two extreme points, A and B near the end points of XY and form one intermediate point C. Starting from points A and B, measure equal distance AF and BG along their perpendiculars. This distance should be equal to the selected distance between the main dyke centerline XY and the centerline of the opposite dyke. Mark the two points on the perpendiculars, F and G with ranging poles. Clearly set out line WZ through points F and G using ranging poles (FAO, 1994).

Starting from point B on line XY, measure intermediate distance BE, EC and CD. Walk back to line WZ. Starting from point G, measure intermediate distances GH, HI and IJ equal to BE, EC and CD, respectively. Mark points ‘H’, ‘I’ and ‘J ‘with pegs. Ensure that point ‘I’ falls exactly on the intermediate perpendicular set out from point ‘C’. If the difference is small, adjust the perpendicular position and point I’. If the difference is large, check previous work for errors. Be sure that the last measurement JF lines up with the point ‘F’ (FAO, 1983).

CONCLUSION

Deciding the type of pond which could be built, laying out fish ponds , measuring horizontal angles, graph meter, measurement of angles with in accessible summit, measurement of consecutive angles, magnetic compass, azimuth measurement of horizontal angle, horizontal angle measurement with compass, azimuth measurement of a line, surveying a polygonal site, a protractor, the right angle method of measuring horizontal angles, Theodolite, Right angles and perpendiculars, method of dropping a perpendicular, the full circle method, the half circle method, the mid point method, the intersection method, short line intersection method, Long line intersection method, the 3:4:5 rule method, right angle measurement using the short 3:4:5 lines, right angle measurement using the medium 3:4:5 lines, right angle measurement using the long 3: 4: 5 lines, right angle measurement using tape, A across staff and parallel Lines are important aspects of topography the fish culturist need to know to facilitate the setting fish farm.

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