UNIT 2

BASIC PRINCIPLES IN SURVEYING

PRINCIPLE OF WORKING FROM WHOLE TO PART

- It is a fundamental rule to always work from the whole to the part. This implies a precise control surveying as the first consideration followed by subsidiary detail surveying.
- This surveying principle involves laying down an overall system of stations whose positions are fixed to a fairly high degree of accuracy as control, and then the survey of details between the control points may be added on the frame by less elaborate methods.

- Once the overall size has been determined, the smaller areas can be surveyed in the knowledge that they must (and will if care is taken) put into the confines of the main overall frame.

- Errors which may inevitably arise are then contained within the framework of the control points and can be adjusted to it.

Surveying is based on simple fundamental principles which should be taken into

consideration to enable one get good results.

(a) Working from the whole to the part is achieved by covering the area to be surveyed with a number of spaced out control point called primary control points called primary control points whose pointing have been determined with a high level of precision using sophisticated equipments. Based on these points as theoretic, a number of large triangles are drawn. Secondary control points are then established to fill the gaps with lesser precision than the primary control points. At a more detailed and less precise level, tertiary control points at closer intervals are finally established to fill in the smaller gaps. The main purpose of surveying from the whole to the part is to localize the errors as working the other way round would magnify the errors and introduce distortions in the survey. In partial terms, this principle involve covering the area to be surveyed with large triangles. These are further divided into smaller triangles and the process continues until the area has been sufficiently covered with small triangles to a level that allows detailed surveys to be made in a local level. Error is in the whole operation as the vertices of the large triangles are fixed using higher precision instruments.

(b) Using measurements from two control parts to fix other points. Given two points whose length and bearings have been accurately determined, a line can be drawn to join them hence surveying has control reference points. The locations of various other points and the lines joining them can be fixed by measurements made from these two points and the lines joining them. For an example, if A and B are the control points, the following operations can be performed to fix other points.

i) Using points A and B as the centers, ascribe arcs and fix (where they intersect).

ii) Draw a perpendicular from D along AB to a point C.

iii) To locate C, measure distance AB and use your protractor to equally measure angle ABC.

iv) To locate C the interior angles of triangle ABC can be measured. The lengths of the sides AC and BC can be calculated by solving the triangle.

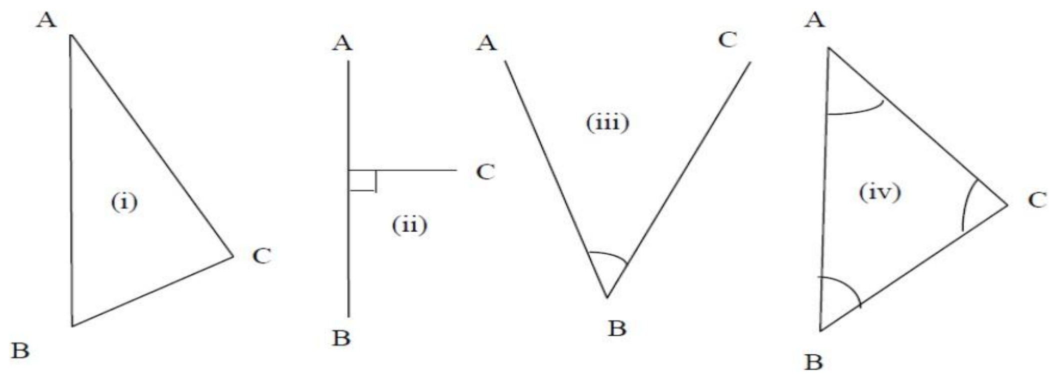


Fig. 6.1: Fixing the third points using two points

The process of surveying:

The survey process passes through 3 main phases – the reconnaissance, field work and measurements, and, the office work.

(a) Reconnaissance survey

This is a pre-field work and measurement phase. It requires taking an overall inspection

of the area to be surveyed to obtain a general picture before commencement of any serious survey. Walking through the site enables one to understand the terrain and helps in determining the survey method to be adopted, and the scale to be used. The initial information obtained in this stage helps in the successful planning and execution of the survey.

(b) Field work and measurement:

This is the actual measurements in the field and the recordings in the field notebook. To get the best results in the field, the surveyor must be acquainted with the functions of the equipments and take good care of them.

(c) Office work: This is the post field work stage in which data collected and recordings in the field notebooks are decoded and used to prepare the charts, planes and maps for presentation to the clients and the target audience.

LECTURE 7

IMPORTANCE OF SCIENTIFIC HONESTY

- Honesty is essential in booking notes in the field and when plotting and computations in the office. There is nothing to be gained from cooking the survey or altering dimensions so that points will tie-in on the drawing. It is utterly unprofessional to betray such trust at each stage of the survey.
- This applies to the assistants equally as it does to the surveyor in charge. Assistants must also listen carefully to all instructions and carry them out to the later without questions.

CHECK ON MEASUREMENTS

- The second principle is that; all survey work must be checked in such a way that an error will be apparent before the survey is completed.
- Concentration and care are necessary in order to ensure that all necessary measures are taken to the required standard of accuracy and that nothing is omitted. Hence they must be maintained in the field at all times.

- Surveyor on site should be checking the correctness of his own work and that of others which is based on his information.
- Check should be constantly arranged on all measurements wherever possible. Check measurements should be conducted to supplement errors on field. Pegs can be moved, sight rails altered etc.

- Survey records and computations such as field notes, level books, field books, setting out record books etc must be kept clean and complete with clear notes and diagrams so that the survey data can be clearly understood by others. Untidy and anonymous figures in the field books should be avoided.

- Like field work, computations should be carefully planned and carried out in a systemic manner and all field data should be properly prepared before calculations start. Where possible, standardized tables and forms should be used to simplify calculations. If the result of a computation has not been checked, it is considered unreliable and for this reason, frequent checks should be applied to every calculation procedure.

- As a check, the distances between stations are measured as they are plotted, to see that there is correspondence with the measured horizontal distance. Failure to match indicates an error in plotting or during the survey.

- If checks are not done on observations, expensive mistake may occur. It is always preferable to take a few more dimensions on site to ensure that the survey will resolve itself at the plotting stage.

ACCURACY AND PRECISION

These terms are used frequently in engineering surveying both by manufacturers when quoting specifications for their equipments and on site by surveyors to describe results obtained from field work.

- Accuracy allows a certain amount of tolerance (either plus or minus) in a measurement, while;

- Precision demands exact measurement. Since there is no such things as an absolutely exact measurement, a set of observations that are closely grouped together having small deviations from the sample mean will have a small standard error and are said to be precise.

ECONOMY OF ACCURACY AND ITS INFLUENCE ON CHOICE OF EQUIPMENTS

- Survey work is usually described as being to a certain standard of accuracy which in turn is suited to the work in hand. Bearing in mind the purpose for which the survey is being made, it is better to achieve a high degree of accuracy than to aim for precision (exactness) which if it were to be altered would depend not only on the instrument used but also on the care taken by the operator to ensure that his work was free from mistake.

- Always remember that, the greater the effort and time needed both in the field and in the office, the more expensive survey will be for the client. The standard accuracy attained in the field must be in keeping with the size of the ultimate drawings.

- The equipment selected should be appropriate to the test in hand. An important factor when selecting equipment is that the various instruments should produce roughly the same order of precision. A steel chain best at an accuracy of 1/500 to 1/1000 would be of little use for work requiring an accuracy of 1/1000. Similarly, the theodolite reading to one second would be pointless where a reading to one minute is sufficient.

- Having selected the equipment necessary, the work should be thoroughly checked and if found wanting should be adjusted, repaired or replaced or have allowance calculated for its deficiencies. This task will be less tedious if field equipment is regularly maintained.

Horizontal Distance Measurement

One of the basic measurements in surveying is the determination of the distance between two points on the earth's surface for use in fixing position, set out and in scaling. Usually spatial distance is measured. In plane surveying, the distances measured are reduced to their equivalent horizontal distance either by the procedures used to make the measurement or by applying numerical corrections for the slope distance (spatial distance). The method to be employed in measuring distance depends on the required accuracy of the measurement, and this in turn depends on purpose for which the measurement is intended.

Pacing: – where approximate results are satisfactory, distance can be obtained by pacing (the number of paces can be counted by tally or pedometer registry attached to one leg). Average pace length has to be known by pacing a known distance several times and taking the average. It is used in reconnaissance surveys& in small scale mapping

Odometer of a vehicle: - based on diameter of tires (no of revolutions X wheel diameter); this method gives a fairly reliable result provided a check is done periodically on a known length. During each measurement a constant tyre pressure has to be maintained.

Tachometry: **-**distance can be can be measured indirectly by optical surveying instruments like theodolite. The method is quite rapid and sufficiently accurate for many types of surveying operations .

Taping (chaining): - this method involves direct measurement of distances with a tape or chain. Steel tapes are most commonly used .It is available in lengths varying from 15m to 100m. Formerly on surveys of ordinary precision, lengths of lines were measured with chains.

Electronic Distance Measurement (EDM): **-** are indirect distance measuring instruments that work using the invariant velocity of light or electromagnetic waves in vacuum. They have high degree of accuracy and are effectively used for long distances for modern surveying operations.

LECTURE 8

CHAIN SURVEYING

This is the simplest and oldest form of land surveying of an area using linear measurements only. It can be defined as the process of taking direct measurement, although not necessarily with a chain.

EQUIPMENTS USED IN CHAIN SURVEYING

These equipments can be divided into three, namely

(i) Those used for linear measurement. (Chain, steel band, linear tape)

(ii) Those used for slope angle measurement and for measuring right angle (Eg. Abney level, clinomater, cross staff, optical squares)

(iii) Other items (Ranging rods or poles, arrows, pegs etc).

1. Chain:-

The chain is usually made of steel wire, and consists of long links joined by shorter links. It is designed for hard usage, and is sufficiently accurate for measuring the chain lines and offsets of small surveys.

Chains are made up of links which measure <u>200mm</u> from centre to centre of each middle connecting ring and surveying brass handless are fitted at each end. Tally markers made of plastic or brass are attached at every whole metre position or at each tenth link. To avoid confusion in reading, chains are marked similarly form both end (E.g. Tally for 2m and 18m is the same) so that measurements may be commenced with either end of the chain

There are three different types of chains used in taking measurement namely:

i. Engineers chain

ii. Gunter’s chain

iii Steel bands

2 Steel Bands:

This may be 30m, 50m or 100m long and 13mm wide. It has handles similar to those on the chain and is wound on a steel cross. It is more accurate but less robust than the chain. The operating tension and temperature for which it was graduated should be indicated on the band.

3 Tapes:

Tapes are used where greater accuracy of measurements are required, such as the setting out of buildings and roads. They are 15m or 30m long marked in metres, centimeter and millimeters. Tapes are classified into three types;

i. **Linen or Linen with steel wire woven into the fabric;**

These tapes are liable to stretch in use and should be frequently tested for length. They should never be used on work for which great accuracy is required.

ii. **Fibre Glass Tapes:** These are much stronger than lines and will

not stretch in use.

iii. **Steel tapes:** These are much more accurate, and are usually used for setting out buildings and structural steel works. Steel tapes are available in various lengths up to 100m (20m and 30m being the most common) encased in steel or plastic boxes with a recessed winding lever or mounted on open frames with a folding winding lever.

4. **Arrows:**

Arrow consists of a piece of steel wire about 0.5m long, and are used for marking temporary stations. A piece of coloured cloth, white or red ribbon is usually attached or tied to the end of the arrow to be clearly seen on the field.

5. Pegs

Pegs are made of wood 50mm x 50mm and some convenient length. They are used for points which are required to be permanently marked, such as intersection points of survey lines. Pegs are driven with a mallet and nails are set in the tops.

6. Ranging Rod:

These are poles of circular section 2m, 2.5m or 3m long, painted with characteristic red and white bands which are usually 0.5m long and tipped with a pointed steel shoe to enable them to be driven into the ground. They are used in the measurement of lines with the tape, and for marking any points which need to be seen.

7. Optical Square:

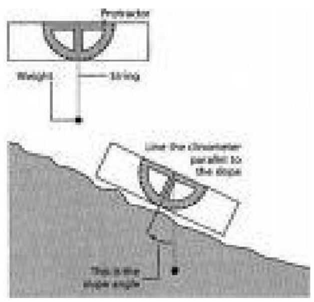
This instrument is used for setting out lines at right angle to main chain line. It is used where greater accuracy is required. There are two types of optical square, one using two mirrors and the other a prism.

- The mirror method is constructed based on the fact that a ray of light is reflected from a mirror at the same angle as that at which it strikes the mirror.
- The prism square method is a simplified form of optical square consisting of a single prism. It is used in the same way as the mirror square, but is rather more accurate.

8 Cross Staff:

This consists of two pairs of vanes set at right angle to each other with a wide and narrow slit in each vane. The instrument is mounted upon a pole, so that when it is set up it is at normal eye level. It is also used for setting out lines at right angle to the main chain line.

9. Clinometer



This instrument is used for measuring angles of ground slopes (slope angle). They are of several form, the common form is the **WATKING'S CLINOMETER,** which consist of a small disc of about 60mm diameter. A weighted ring inside the disc can be made to hang free and by sighting across this graduated ring angle of slopes can be read off. It is less accurate than abney level.

9 Abney Level

This instrument is generally used to obtaine roughly the slope angle of the ground. It consists of a rectangular, telescopic tube (without lenses) about 125mm long with a graduated arc attached. A small bubble is fixed to the vernier arm, once the image of the bubble is seen reflected in the eyepiece the angle of the line of sight can be read off with the aid of the reading glass.

LECTURE 9

NECESSARY PRECAUTIONS IN USING CHAIN SURVEYING INSTRUMENTS

1. After use in wet weather, chains should be cleaned, and steel tapes should be dried and wiped with an oily rag.
2. A piece of colored cloth should be tied to arrow (or ribbon – attached) to enable them to be seen clearly on the field.
3. Ranging rods should be erected as vertical as possible at the exact station point.
4. The operating tension and temperature for which steel bands/tapes are graduated should be indicated.
5. Linen tapes should be frequently tested for length (standardized) and always after repairs.
6. Always keep tapes reeled up when not in use.

GENERAL PROCEDURE IN MAKING A CHAIN SURVEY

1. ***Reconnaissance***: Walk over the area to be surveyed and note the general layout, the position of features and the shape of the area.

2. ***Choice of Stations:*** Decide upon the framework to be used and drive in the station pegs to mark the stations selected.

3. ***Station Marking:*** Station marks, where possible should be tied - in to a permanent objects so that they may be easily replaced if moved or easily found during the survey. In soft ground wooden pegs may be used while rails may be used on roads or hard surfaces.

4. ***Witnessing***: This consists of making a sketch of the immediate area around the station showing existing permanent features, the position of the stations and its description and designation. Measurements are then made from at least three surrounding features to the station point and recorded on the sketch.
The aim of witnessing is to re-locate a station again at much later date even by others after a long interval.

5. ***Offsetting:-*** Offsets are usually taken perpendicular to chain lines in order to dodge obstacles on the chain line.

6. ***Sketching*** the layout on the last page of the chain book, together with the date and the name of the surveyor, the longest line of the survey is usually taken as the base line and is measured first.

CRITERIA FOR SELECTING A SURVEY LINES/OFFSETS

During reconnaissance, the following points must be borne in mind as the criteria to provide the best arrangement of survey lines,

a. Few survey lines: the number of survey lines should be kept to a minimum but must be sufficient for the survey to be plotted and checked.

b. Long base line: A long line should be positioned right across the site to form a base on which to build the triangles.

c. Well conditioned triangle with angles greater than 30º and not exceeding 150º: It is preferable that the arcs used for plotting should intersect as close as 90º in order to provide sharp definition of the stations point.

d. Check lines: Every part of the survey should be provided with check lines that are positioned in such a way that they can be used for off- setting too, in order to save any unnecessary duplication of lines.

e. Obstacles such as steep slopes and rough ground should be avoided as far as possible.

f. **Short offsets to survey lines (close feature preferably 2m) should be selected:** So that measuring operated by one person can be used instead of tape which needs two people.

g. Stations should be positioned on the extension of a check line or triangle. Such points can be plotted without the need for intersecting arcs.

Ranging:

Ranging involves placing ranging poles along the route to be measures so as to get a straight line. The poles are used to mark the stations and in between the stations.

LECTURE 10

ERRORS IN SURVEYING

- Surveying is a process that involves observations and measurements with a wide range of electronic, optical and mechanical equipment some of which are very sophisticated.

- Despite the best equipments and methods used, it is still impossible to take observations that are completely free of small variations caused by errors which must be guided against or their effects corrected.

TYPES OF ERRORS

1. Gross Errors

- These are referred to mistakes or blunders by either the surveyor or his assistants due to carelessness or incompetence.
- On construction sites, mistakes are frequently made by in – experienced Engineers or surveyors who are unfamiliar with the equipment and method they are using.
- These types of errors include miscounting the number of tapes length, wrong booking, sighting wrong target, measuring anticlockwise reading, turning instruments incorrectly, displacement of arrows or station marks etc.

- Gross errors can occur at any stage of survey when observing, booking, computing or plotting and they would have a damaging effect on the results if left uncorrected.

- Gross errors can be eliminated only by careful methods of observing booking and constantly checking both operations.

2. Systematic or Cumulative Errors

- These errors are cumulative in effect and are caused by badly adjusted instrument and the physical condition at the time of measurement must be considered in this respect. Expansion of steel, frequently changes in electromagnetic distance (EDM) measuring instrument, etc are just some of these errors.

- Systematic errors have the same magnitude and sign in a series of measurements that are repeated under the same condition, thus contributing negatively or positively to the reading hence, makes the readings shorter or longer.

- This type of error can be eliminated from a measurement using corrections (e.g. effect of tension and temperature on steel tape).

- Another method of removing systematic errors is to calibrate the observing equipment and quantify the error allowing corrections to be made to further observations.

- Observational procedures by re-measuring the quantity with an entirely different method using different instrument can also be used to eliminate the effect of systematic errors.

3. Random or Compensating Errors

- Although every precaution may be taken certain unavoidable errors always exist in any measurement caused usually by human limitation in reading/handling of instruments.

- Random errors cannot be removed from observation but methods can be adopted to ensure that they are kept within acceptable limits.
- In order to analyze random errors or variable, statistical principles must be used and in surveying their effects may be reduced by increasing the number of observations and finding their mean. It is therefore important to assume those random variables are normally distributed.