To Experimental Study for Comparison Theodolite and Total Station

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Abstract— *This research paper with how to facilitate and manage surveying instrument theodolite and total satiation and take more accuracy for civil works methods to accomplish modernized and cost effective urban survey with best achievable accuracy. This is done by surveying methods with modern methods from both theoretical and practical point of view. At first, a theoretical assessment process on a tradition urban planning project in India is performed by replacing other instrument of surveying techniques previously used with more applicable surveying techniques as theodolite and total stations, regarding different matters such as applicability, cost and accuracy. After approving the main idea of this modernization process, a practical urban planning case study is performed using total station, geodetic GPS receivers and GPS navigators, on a private sectors The applied surveying techniques showed high efficiency regarding cost and effort, while saving observation time reaching to 80%. Accordingly, the adopted practical application proved to be beneficial for all civil sites.*

Keywords— Surveying techniques, theodolite, Horizontal Measurements Distances, total station, Stadia, vertical Measurements Distances, receiver.

I. INTRODUCTION

A theodolite is an important instrument used for measurement horizontal and vertical angle in surveying. it is an extremely useful instrument to a surveyor. it can also can used for a number of surveying operations, such as prolonging a line measurement distance indirectly and leveling. in fact a theodlite is the key surveying instrument in most of engineering projects. total station is a combination of an electronic theodolite and electronic distance meter .this combination makes it possible to determine the coordinates of a reflector by aligning the instrument cross hair on the reflector and simultaneously measuring the vertical and horizontal angles and slope distance .a micro processor in the instrument takes care of recording reading, reading and the necessary computations. the data is easily transferred to a computer where it can be used to generate a map.

II. THEODOLITE

The theodolite is the most precise instrument designed for the measurement of horizontal and vertical angles and has wide applicability in surveying such as laying off horizontal angles, locating points on line prolonging survey line establishing grade, determining difference in elevation setting out curves. The early theodolite were manufactured with long telescopes which could not be inverted by revolving the telescope on a horizontal axis through 180° in the vertical plane. Later the theodolites with shorter telescopes were manufactured which could be inverted by revolving the telescope in the vertical plane on a horizontal axis

2.1 Classification of Theodolites

- Transit Theodolite.
- Non Transit Theodolite.
- Vernier Theodolites.
- Micrometer Theodolites

2.2 Main parts of a theodolite

2.2.1 Upper Plate

It is the base on which the standards and vertical circle are placed. For the instrument to be in corrent adjustment it is necessary that the upper plate must be perpendicular to the alidade axis and parallel to the trunnion axis.

2.2.2 Telescope

It has the same features as in} a level graticule with eyepiece and internal focussing for the telescope itself.

2.2.3 Vertical Scale (Circle)

It is a full 400g} scale. It is used to measure the angle between the line of sight (collimation axis) of the telescope and the vertical axis.

2.2.4 Vertical Clamp and Tangent Screw

This allows free transiting of the telescope. When clamped, the telescope can be slowly transited using vertical tangent screw.

2.2.5 The Lower Plate

It is the base of the whole instrument. It houses the foot screws and the bearing for the vertical axis. It is rigidly attached to the tripod mounting assembly and does not move.

2.2.6 Horizontal Scale (Circle)

It is a full 400g scale. It is often placed between the upper and lower plates It is capable of full independent rotation about the trunnion axis.

The Upper Horizontal Clamp and Tangent Screw: used during a sequence or “round” of horizontal angle measurements.

2.2.7 The Lower Horizontal Clamp and Tangent Screw

These must only be used at the start of horizontal angle measurements to set the first reading to zero

2.2.8 Circle Reading and Optical Micrometer

The vertical and horizontal circles require illumination in order to read them. This is usually provided by small circular mirrors

2.3 Adjustment of theodolite

- Setting over the station
- Levelling up
- Elimination parallax

2.4 Measurements

- Horizontal angles
- Vertical angles

2.5 Measurement of horizontal angle

- The instrument is set over B.
- The lower clamp is kept fixed and upper clamp is loosenedTurn the telescope clockwise set vernier A to 0° and vernier B to approximately 180°.
- Upper clamp is tightened and using the upper tangent screw the vernier A and B are exactly set to 0° and 180°.
- Upper clamp is tightly fixed, lower one is loosened and telescope is directed towards A and bisects the ranging rod at A.
- Tightened the lower clamp and turn the lower tangent screw to perfectly bisect ranging rod at A.
- Loose the upper clamp and turn the telescope clockwise to bisect the ranging rod at C tightened the upper clamp and do the fine adjustment with upper tangent screw.

- The reading on vernier A and B are noted. Vernier A gives the angle directly and vernier B gives the reading by subtracting the initial reading (180°) from final reading

There are three methods of measuring horizontal angles

1. Ordinary Method
2. Repetition Method.
3. Reiteration Method

1. Ordinary Method

- Set up the theodolite at station point O and level it accurately.
- Set the vernier A to the zero or 360^0 of the horizontal circle. Tighten the upper clamp.
- Loosen the lower clamp. Turn the instrument and direct the telescope towards A to bisect it accurately with the use of tangent screw. After bisecting accurately check the reading which must still read zero. Read the vernier B and record both the readings.
- Loosen the upper clamp and turn the telescope clockwise until line of sight bisects point B on the right hand side. Then tighten the upper clamp and bisect it accurately by turning its tangent screw.
- Read both verniers. The reading of the vernier a which was initially set at zero gives the value of the angle AOB directly and that of the other vernier B by deducting 180^0 .The mean of the two vernier readings gives the value of the required angle AOB
- Change the face of the instrument and repeat the whole process. The mean of the two vernier readings gives the second value of the angle AOB which should be approximately or exactly equal to the previous value.
- The mean of the two values of the angle AOB ,one with face left and the other with face right ,gives the required angle free from all instrumental errors**.**

2. Repetition Method.

- Set up the theodolite at starting point O and level it accurately.
- Measure The horizontal angle AOB.
- Loosen the lower clamp and turn the telescope clock – wise until the object (A) is sighted again. Bisect B accurately by using the upper tangent screw. The verniers will now read the *twice* the value of the angle now.
- Repeat the process until the angle is repeated the required number of times (usually 3). Read again both verniers . The final reading after *n repetitions* should be approximately n X (angle). *Divide* the *sum* by the *number of repetitions* and the result thus obtained gives the *correct value of the angle* AOB
- Change the face of the instrument. Repeat exactly in the same manner and find another value of the angle AOB. The *average* of two readings gives the required precise value of the angle AOB**.**

3. Reiteration Method.

- Set up the instrument over station point O and level it accurately.
- Direct the telescope towards point A which is known as referring object. Bisect it accurately and check the reading of vernier as 0 or 360^0 . Loosen the lower clamp and turn the telescope clockwise to sight point B exactly. Read the verniers again and The mean reading will give the value of angle AOB.
- Similarly bisect C & D successively, read both verniers at- Procedure. each bisection, find the value of the angle BOC and COD.
- Finally close the horizon by sighting towards the referring object (point A).
- The vernier A should now read 360^0. If not note down the error .This error occurs due to *slip* etc.

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

2.6 Measurement of Vertical Angles.

2.6.1 Vertical Angle

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

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

- Set up the theodolite at station point O and level it accurately with reference to the altitude bubble.
- Set the zero of vertical vernier exactly to the zero of the vertical circle clamp and tangent screw.
- Bring the bubble of the altitude level in the central position by using clip screw. The line of sight is thus made horizontal and vernier still reads zero.
- Loosen the vertical circle clamp screw and direct the telescope towards the object A and sight it exactly by using the vertical circle tangent screw
- Read both verniers on the vertical circle, The mean of the two vernier readings gives the value of the required angle.
- Change the face of the instrument and repeat the process. The mean of of the two vernier readings gives the second value of the required angle.
- The average of the two values of the angles thus obtained, is the required value of the angle free from instrumental errors**.**

For measuring Vertical Angle between two points A &B.

- Sight A as before , and take the mean of the two vernier readings at the vertical circle. Let it be α
- Similarly, sight B and take the mean of the two vernier readings at the vertical circle. Let it be
- The sum or difference of these dings will give the value of the vertical angle between A and B according as one of the points is above and the other below the horizontal plane. or both points are on the same side of the horizontal plane Fig b & c.

2.7 Reading Magnetic Bearing of A Line.

- Set up the instrument over A and level it accurately
- Set the vernier to the zero of the horizontal circle
- Release the magnetic needle and loosen the lower clamp.
- Rotate the instrument till magnetic needle points to North. Now clamp the lower clamp with the help of lower tangent screw .Bring the needle exactly against the mark in order to bring it in magnetic meridian. At this stage the line of sight will also be in magnetic meridian.
- Now loose the upper clamp and point the telescope towards B .With the help of upper tangent screw bisect B accurately and read both the verniers .The mean of the two readings will be recorded as magnetic bearing of line.
- Change the face of the instrument for accurate magnetic bearing of the line and repeat .the mean of the two values will give the correct bearing of the line AB.

2.8 Prolonging A Straight A Line

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

1. Fore sight method,
2. Back Sight Method

1. **Fore Sight Method**

- Set up the theodolite at A and level it accurately .Bisect the point b correctly. Establish a point C in the line beyond B approximately by looking over the top of the telescope and accurately by sighting through the telescope.
- Shift the instrument to B, take a fore sight on C and establish a point D in line beyond C.
- Repeat the process until the last point Z is reached**.**

2. **Back Sight Method**

- Set up the instrument at B and level it accurately.
- Take a back sight on A.
- Tighten the upper and lower clamps, transit the telescope and establish a point C in the line beyond B
- Shift the theodolite to C ,back sight on B transit the telescope and establish a point D in line beyond C. Repeat the process until the last point (Z) is established.

2.9 Sources of errors in theodolite

Instrumental errors

- Non adjustment of plate bubble
- Line of collimation not being perpendicular to horizontal axis
- Horizontal axis not being perpendicular to vertical axis
- Line of collimation not being parallel to axis of telescope
- Eccentricity of inner and outer axes
- Graduation not being uniform
- Verniers being eccentric

Personal errors

Natural errors

- High temperature causes error due to irregular refraction.
- High winds cause vibration in the instrument, and this may lead to wrong readings on verniers

III. TOTAL STATION

Although taping and theodolites are used regularly on site – total stations are also used extensively in surveying, civil engineering and construction because they can measure both distances and angles The appearance of the total station is similar to that of an electronic theodolite, but the difference is that it is combined with a distance measurement component which is fitted into the telescope Because the instrument combines both angle and distance measurement in the same unit, it is known as an integrated total station which can measure horizontal

and vertical angles as well as slope distances Using the vertical angle, the total station can calculate the horizontal and vertical distance components of the measured slope distance.As well as basic functions, total stations are able to perform a number of different survey tasks and associated calculations and can store large amounts of data. As with the electronic theodolite, all the functions of a total station are controlled by its microprocessor, which is accessed thought a keyboard and display.

3.1 Total station instruments combine three basic components into one integral unit.

- An electronic distance measurement (EDM) instrument
- An electronic angle measurement component
- A computer or microprocessor

3.2 Working Part of total station.

- Vertical axis
- Handle
- Collimator
- Objective lens
- Vertical circle
- Vertical circle lock
- Horizontal axis
- Vertical tangent screw
- Optical plummet lens focus
- Circular level vial
- Optical plummet eyepiece
- Horizontal circle tangent screw
- Horizontal circle lock
- Eyepiece focus
- Display & Keyboard
- Base
- Tribrach
- Tribrach lock
- Tribrach levelling screws

3.3 Features of total stations.

Total stations are capable of measuring angles and distances simultaneously and combine an electronic theodolite with a distance measuring system and a microprocessor.

3.4 Angle measurement

All the components of the electronic theodolite described in the previous lectures

are found total stations. The axis configuration is identical and comprises the vertical axis, the tilting axis

and line of sight (or collimation). The other components include the tribatch with levelling footscrews, the keyboard with display and the telescope which is mounted on the standards and which rotates around the tilting axis. Levelling is carried out in the same way as for a theodolite by adjusting to centralise a plate level or electronic bubble. The telescope can be transited and used in the face left (or face I) and face right (or face II) positions. Horizontal rotation of the total station about the vertical axis is controlled by a horizontal clamp and tangent screw and rotation of the telescope about the tilting axis.

3.5 Distance measurement.

All total stations will measure a slope distance which the onboard computer uses, together with the zenith angle recorded by the line of sight to calculate the horizontal distance. For distances taken to a prism or reflecting foil, the most accurate is precise measurement. For phase shift system, a typical specification for this is a measurement time of about 1-2s, an accuracy of (2mm + 2ppm) and a range of 3-5km to a single prism. Although all manufacturers quote ranges of several kilometres to a single prism.

3.6 Slope and horizontal distances

Both the phase shift and pulsed laser methods will measure a slope distance *L* from the total station along the line of sight to a reflector or target. For most surveys the horizontal distance *D* is required as well as the vertical component *V* of the slope distance.

Horizontal distance *D* = *L* cos_ = *L* sin z

Vertical distance = *V* = *L* sin_ = *L* cos z

3.7 Keyboard and display.

A total station is activated through its control panel, which consists of a keyboard and multiple line LCD. A number of instruments have two control panels, one on each face, which makes them easier to use. In addition to controlling the total station, the keyboard is often used to code data generated by the instrument – this code will be used to identify the object being measured.

3.8 Software applications.

The micro processor built into the total station is a small computer and its main function is controlling the measurement of angles and distances. The LCD screen guides the operator while taking these measurements.

The built in computer can be used for the operator to carry out calibration checks on the instrument. The software applications available on many total stations include the following:

- Slope corrections and reduced levels
- Horizontal circle orientation
- Coordinate measurement
- Traverse measurements
- Resection (or free stationing)
- Missing line measurement
- Remote elevation measurement
- Areas
- Setting out

TABLE 1
PERFORMANCE DATA FOR THEODOLITE AND TOTAL STATION

Performance data	Digital theodolite	Digital theodolite + EDM	Total station
Accuracy (standard deviation for 100m of measurement)			
Horizontal angle, Hz	0.35-7.9mm	0.35-7.9mm	0.16-4.7mm
Vertical, V	0.35-7.9mm	0.35-7.9mm	0.16-4.7mm
Measuring time	0.5sec	0.5sec-1.5 sec	0.5sec-1.5sec
Measuring range (min-max)	0.5m-100m	0.5m-100m(EDM with prism 3,000m with gray card 100m	0.2/1.9m-700/500m(range is dependent on prisms used)
Distance accuracy	0.2m-0.3m	3mm +3ppm	1-10mm+1-5ppm
Operation (number of persons needed to operate the instrument)	2	2	1-2

IV. CONCLUSION

- Before making the first set up of the day, visually inspect the instrument for damage. Check the machined surfaces and the polished faces of the lenses and mirrors. Try the clamps and motions for smooth operation.
- Transport and store instrument in positions that are consistent with the carrying case design. For example, total station should be carried and stored in their correct position. Theodolite cases indicate the position in which they should be transported
- Because the instrument combines both angle and distance measurement in the same unit, it is known as an integrated total station which can measure horizontal and vertical angles as well as slope distances.
- Using the vertical angle, the total station can calculate the horizontal and vertical distance components of the measured slope distance.
- As well as basic functions, total stations are able to perform a number of different survey tasks and associated calculations and can store large amounts of data.
- As with the electronic theodolite, all the functions of a total station are controlled
- The appearance of the total station is similar to that of an electronic theodolite, by its microprocessor, which is accessed thought a keyboard and display

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