Surveying Equipments

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Abstract - The research deals with evaluation and comparison of precision, accuracy and time expenditure of three surveying methods. These methods are total station (TS), Global positioning system (GPS), Theodolite etc.
Surveying is the technique and science of accurately determining three-dimensional position of points and the distances and angles between them. Various surveying methods (GPS, total station, Theodolite etc.) are in use. In this research only these instruments have been used.
Today, the role of surveying got much attention to be used in many applications with better accuracy. The term accuracy is common in many applications to express the quality of observations, measurements and calculations.

Keywords - Total Station, Global positioning System (GPS), Theodolite and other equipments.

I. TOTAL STATION (BY USING [1])

- A total station is an electronic transit and an EDM combined into one instrument.
- Add in a microprocessor, laser plummet and other options and you have the instrument of choice for ground based surveying.
- Some may require a prism, but others are reflector less**.**

A. Measurement accuracy (By using [2])

Total station measurements are affected by changes in temperature, pressure and relative humidity, but it can be corrected for atmospheric effects by inputting changes in temperature, pressure and relative humidity. Shock and stress result in deviations of the correct measurement as a result decreases the measurement accuracy. Beam interruptions, severe heat shimmer and moving objects within the beam path can also result in deviations of the specified accuracy by the manufacture as specified in Table. It is therefore important to check and adjust the instrument before measurement.
The accuracy with which the position of a prism can be determined with Automatic Target Recognition (ATR) depends on several factors such as internal ATR accuracy, instrument angle accuracy, prism type, selected EDM measuring program and the external measuring conditions. The ATR has a basic standard deviation level of ± 1 mm but above a certain distance, the instrument angle accuracy predominates and takes over the standard deviation of the ATR manual. Leica 1201 total station instruments have standard deviation of 0.3 mgon in both angles which affect the quality of measurement (Leica 1200+ TPS manual). Typical Leica 1200+ instrument accuracy (horizontal and vertical angles) stated by the manufacturer are given in the Table:-

Type of instrumnt	Standared devation (Horizontal and Vertical angles)	
	[arcsecond]	[mgon]
1201+	1	0.3
1202+	2	0.6
1203+	3	1.0
1205+	5	1.5

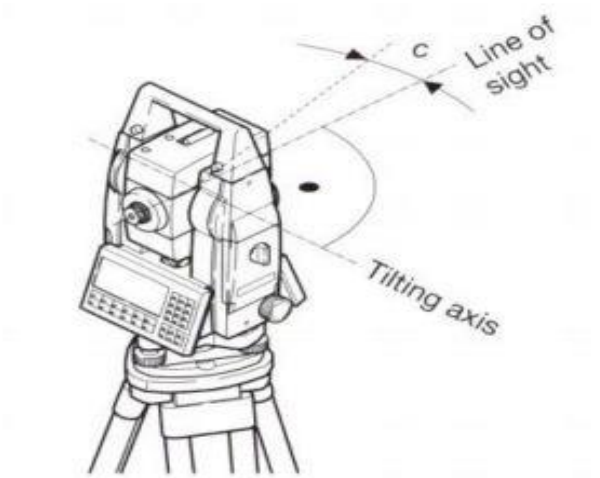
Using different prisms other than the intended prism may cause also deviations and therefore it is important to use a Leica circular prism as the intended target.

B. Measurement Errors (By using [3]

Some errors, those associated with the instrument, can be eliminated or at least reduced with two face measurement. Table shows instrumental errors which influence both horizontal and vertical angles, and their adjustment method.

Instrument error	Affects Hz angle	Affects V angle	Eliminated with two face measurement	Corrected with instrument calibration
Line of sight error	Yes	No	Yes	Yes
Tilting axis error	Yes	Yes	Yes	Yes
Compensator errors	Yes	Yes	No	Yes
V-index error	Yes	Yes	Yes	Yes

Collimation axis error (line of sight error) affects the horizontal angle to be deviated and resulting in poor accuracy measurement. This axial error is caused when the line of sight is not perpendicular to the tilting axis. It affects all horizontal circle readings and increases with steep sightings, but this effect can be corrected by taking average of two face measurement in two rounds. For single face measurements, an on-board calibration function is used to determine collimation errors, the deviation between the actual line of sight and a line perpendicular to the tilting axis



Vertical axis error (tilting axis error) errors occur when the titling axis of the total station is not perpendicular to its vertical axis. This has no effect on sightings taken when the telescope is horizontal, but introduces errors into horizontal circle readings when the telescope is tilted, especially for steep sightings. As with horizontal collimation error, this error is eliminated by two face measurements.

Vertical Collimation (vertical index) error: A vertical collimation error occurs if the 0o to 180o line in the vertical circle does not coincide with the vertical axis. This zero point error is present in all vertical circle readings and like the horizontal collimation error it is eliminated by taking two face measurements**.**

II. GLOBAL POSITIONING SYSTEM (GPS) (BY USING [7] & [8])

A GPS receiver measures the incoming phase of the satellite signals to millimeter precision. However as the satellite signals propagate from satellites to receivers they pass and are affected by the atmosphere. The atmosphere that influences the incoming signal consists of the -22- ionosphere and troposphere. Disturbance in the atmosphere cause degradation in the accuracy of the observations (GPS 500 user manual). GPS surveying is a differential method; a baseline is observed and computed between two receivers. When the two receivers observe the same set of satellites simultaneously, most of the atmospheric effects are canceled out. The shorter the baseline is the more these effects will be reduced, as more likely it is that the atmosphere through which the signal passes to the two receivers will be identical. Fig.3.4: GPS receiver Baseline precision depends on various factors including the number of satellites tracked, satellite geometry, observation time, ephemeris accuracy, ionospheric disturbance, multi path, resolved ambiguities, etc.

A. Comparison of GPS and Total Station (By using [7] & [8])

Total Station -

(i) Indirect acquisition of 3D coordinates
(ii) Both horizontal and vertical accuracies are comparable
(iii) The accuracy depends on the distance, angle and the used prism
(iv) More precise than GPS
(v) Satellite independent
(vi) Needed inter-visibility between the instrument and the prism
(vii) Day time data collection

GPS -

(i) Direct acquisition of 3D coordinates
(ii) The horizontal accuracy is better than the vertical accuracy
(iii) The accuracy depends on the satellite availability, atmospheric effect, satellite geometry, multipath
(iv) Less precise than total station
(v) Satellite dependent
(vi) Visibility is not needed
(vii) Day or night time data collection

B. Measurement Errors

There are three types of errors:
(i) Systematic errors
(ii) Gross errors
(iii) Random errors.

(i) **Systematic errors** are those errors which follow certain physical or mathematical rules. These kinds of errors are: calibration errors, tension in analogue meters, ambient temperature, etc. Those errors can be corrected by applying correction factors, calibrating instruments and selecting suitable instruments.

(ii) **Gross errors -** In most cases Gross errors can be caused by human mistakes such as carelessness. The instrument may be good and may not give any error but still the measurement may go wrong due to the operator. Those errors do not follow any physical or statistical rules. This can be corrected by carefulness during the measurement and two face measurements can also detect gross errors. Examples of those kinds of errors are: taking wrong readings, wrong recording of instrument or target height, reading with parallax error, etc.

(iii) **Random errors** are errors in measurement that lead to measured values being inconsistent when repeated measurements are performed. Those errors are random and affect the measurements in non-systematic way. Random errors can be caused by instrument errors, human factors, physical environment, etc. and they can be improved when frequency of measurement is increased, i.e., the same parameter is to be measured more often.

C. Checking accuracy

It is true that any measurement would not be free from errors. In most cases gross errors may happen in a measurement and therefore the accuracy of the measurement needs to be checked in order to avoid the gross errors. There are a lot of accuracy checking mechanisms, for instance, through two face measurement, adjustment, etc. Using these mechanisms, gross errors can be detected. As Csanyi et al, (2007) stated out, small magnitude errors of each individual measurement may affect the quality of the final result by considerable large amount. Therefore, the final result may depend on the quality achieved from each individual measurement.

D. Quality Control

The term quality control (QC) refers to the efforts and procedures that researchers put in place to ensure the quality and accuracy of data being collected using the methodologies chosen for a particular study (Roe, D., 2008). Quality control measure verifies the accuracy of the surveyed data by checking its compatibility with an independently surveyed data. For instance: in the comparison of TS and TPS, laser scaner targets were extracted from the range of scaning. The coordinates of the extracted targets are then compared with the independently TS surveyed coordinates using RMS analysis. Thus, the total station measurement controls quality of the TLS extracted points. As per Habib et al, (1999), the resulting RMS value is a measure of the external and absolute quality of the scaned derived surface.

III. THEODOLITE (BY USING [5] & [6])

A Theodolite is a precision instrument for measuring angles in the horizontal and vertical planes. Theodolites are used mainly for surveying applications, and have been adapted for specialized purposes such as meteorology and rocket launch.

A. Operation in surveying (By using [10])

Triangulation method was invented by Gemma Frisius around 1533, consists of making such direction plots of the surrounding landscape from two separate stand points. The two graphing papers are superimposed, providing a scale model of the landscape, or rather the targets in it. The true scale can be obtained by measuring one distance both in the real terrain and in the graphical representation.

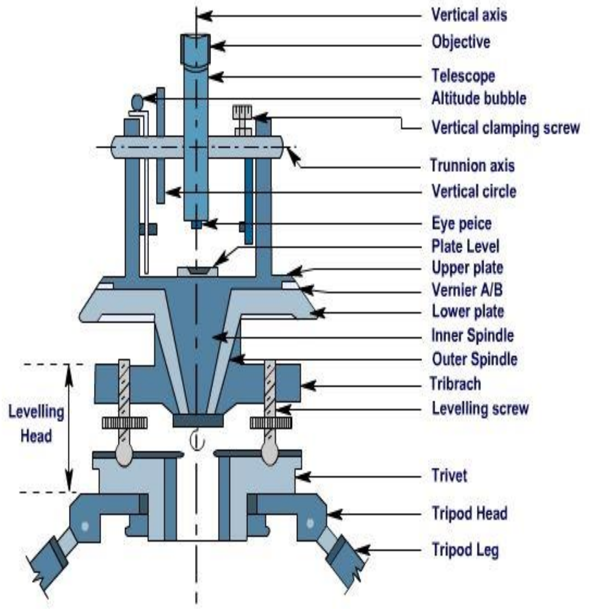
Modern triangulation as, e.g., practiced by Snellius, is the same procedure executed by numerical means. Photogrammetric block adjustment of stereo pairs of aerial photography is a modern, three-dimensional variant.

Triangulation is the process of determining the location of a point by forming triangles to it from known points. Specifically in surveying, triangulation per se involves only angle measurements, rather than measuring distances to the point directly as in trilateration; the use of both angles and distance measurements is referred to as triangulation.

B. Parts of Theodolite

Each type of Theodolite is peculiar in its construction and mode of operation. However, inherent fundamentals of all are same. In this course, the details will be considered for vernier type Theodolite which is most popular and is being

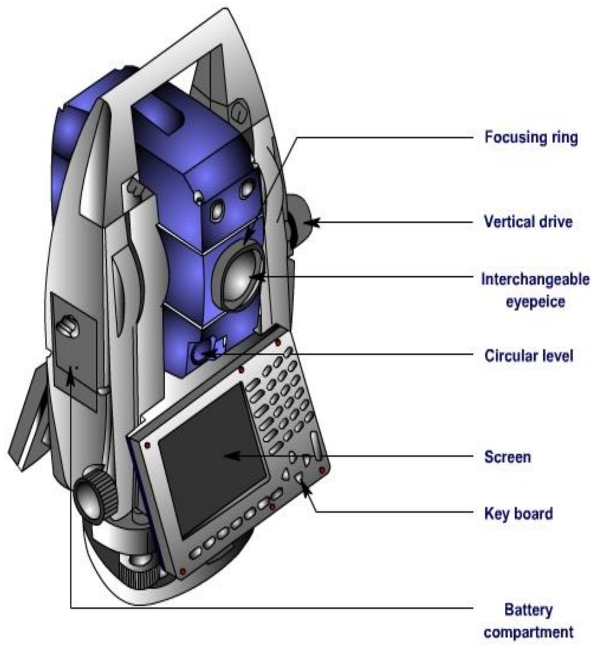
widely used. The salient parts of a vernier Theodolite have been discussed below:
(i) Leveling Head
(ii) Shifting Head
(iii) Lower Plate
(iv) Upper Plate
(v) Plate Levels
(vi) Standard (or a Frame)
(vii) Vernier Frame
(viii) Telescope
(ix) Vertical Circle
(x) Altitude Bubble
(xi) Screws
(xii) Tripod Stand



C. Types of Theodolite (by using [4])
There are different types of Theodolite available. It may be classified into three broad categories.
(i) Vernier or Transit Theodolite
(ii) Digital Theodolite
(iii) Total Station

(i) **Vernier or Transit Theodolite -** This is most commonly used. In this type of instrument, observations are taken by using the principle of vernier caliper. The precision of this type of instrument varies in the order of 10" to 20".
(ii) **Digital Theodolite -** This type of Theodolite provides the value of observation directly in viewing panel. The precision of this type of instrument varies in the order of 1" to 10".

(iii) **Total Station -** This is an electronic instrument. In this instrument, all the parameters required to be observed during surveying can be obtained. The value of observation gets displayed in a viewing panel. The precision of this type of instrument varies in the order of 0.1" to 10".



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