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Electronic Distance Measurement an Overview

Manoj Nallanathel, S. Needhidasan, S. Sahieen, S. Sudarshan
Department of Civil Engineering, Saveetha School of Engineering, Chennai
***Corresponding author: E-Mail: jonamcivil@gmail.com**

ABSTRACT

Conventional surveying has used analogue methods of recording data. Now the present scenario is to use electronic digital surveying equipment for fieldwork. Electronic Distance Measuring instruments like total stations have surprisingly increased the topographical data that can be surveyed and collected during survey process. Modern total stations can do wonders like stakeout of construction works highway profile works, even sophisticated equipment give the electronic sketch of the field surveyed. The introduction of total station survey has made it possible to accurately collect enormous amount of survey measurements quickly. This paper deals with an overview of Electronic Distance Measurement giving potential to Total station its classifications, working principle and its applications.

KEY WORDS: EDM, Total Station, Wave Length.

1. INTRODUCTION

EDM (Electronic distance Measurement) was first introduced in the mid-1950s and has undergone several modifications. The early versions of the EDM instruments were very heavy, complicated and expensive. Latest versions of EDM instruments are being used as a modular component of total stations. Some earlier versions of EDM instruments used natural light for the calculation of distances, but the latest version of EDM uses infrared light, laser light or microwaves.

Total stations are widely used now a day for all engineering surveys for the fact that an accuracy of 1 in 10^5 can be achieved for sights up to 100km, which in turn improved the quality of work, construction phase.

Geodimeter: The geometer is a distance-measuring instrument based on electronic-optical principles. The very high accuracy of the geometer, however, provides an extremely useful means of measuring starting base lines of triangulation networks, thus eliminating laborious measurements with tapes suspended over ground stakes.

The geodimeter is phase-intensity comparer. Essentially, it transmits pulses of light at a rate which is synchronous with the sensitive-intensive periods of a receiving photo tube. The transmitted pulses of light travel from the geodimeter to a mirror at the opposite end of the line to be measured and are reflected back to the receiving photo tube. Depending upon the round distance travelled, the pulses of light will return during the sensitive, intermediate or insensitive phase of the photo tube. The amount of electrical current resulting indicates the proportion of one sensitive-intensive period that the light pulses required over and above an integral number of periods.

The accuracy of the more precise model is within 1 part in 300,000, or better, which is probably as accurate as the best conventional triangulation itself.

Tellurometer: The tellurometer is a portable electronic phase-comparison instrument designed to measure relatively short distances with high accuracy. Unlike conventional optical survey instruments, it can measure through under bush and even small trees, and operate by day as well as night .Airborne tellurometer is measure longer lines.

Basically the equipment consists of a master unit which transmits the modulated carrier from one end of the line to the remote unit at the other. The units focus the signal with parabolic antennas. The remote unit receives, amplifies and retransmits the modulated wave back to the master with only infinitesimal internal day. The internal signal is then compared in phase to the outgoing to the master. As in other electronic systems, corrections to the theoretical velocity of light must be applied in accordance with meteorological conditions not only at the end sites, but also in between, if possible. Most important, the ground characteristics cannot be overlooked, since flat bare ground as well as smooth water surfaces are likely to produce strong reflected waves which give longer apparent distances at first, the error cyclically reducing to zero and increasing again as longer lines are measured, as noted in the "Tellurometer Handbook".

Electronic Distance Measurement: Electronic distance measurement instruments (EDMI) determine lengths using phase changes that occur as electromagnetic energy of known wavelength travels from one end of a line to the other end and returns.

Basic principle & common Errors in EDM: In EDM instruments, the electromagnetic waves are generated and transmitted. The distance is measured indirectly using the characteristics of these waves. The knowledge of exact velocity of the waves generated is required in the usage of EDM. The Fig.1 shows the frequencies of three types of waves commonly used in EDM.

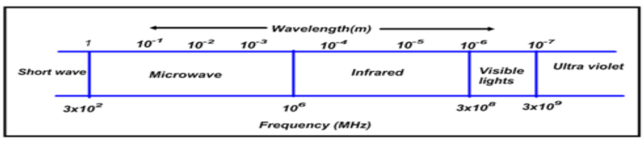

Figure.1. Frequency – wavelength of EDM waves

Distance measurement in EDM is mainly done in two ways (i) Transit time (ii) Phase Difference, by using Transit time and the velocity the distance between two points is calculated automatically in EDM as

$$\text{Distance} = \text{Velocity} \times \text{transit time}$$

For a distance of 1000m, the transit time is about $3\text{x}10^{-6}$ seconds. For this case wave emitted from the transmitter at the starting point and it is received by the receiver at the target point. To achieve this a high amount of synchronization is required between the transmitter & receiver side, in practice it is highly difficult to achieve this, because of this in modern EDM instrument the transmitting side and receiving side will be from the same machine and at the target side a reflector will be used, Due to this the distance is calculated as

$$\text{Distance} = \frac{\text{VelocityxTime Taken}}{2}$$

Now a days in most of the sophisticated instruments the distance is measured using calculating the phase difference and not by transit time. The phase difference is equal to the difference of the phase angle of the reflected signal and the phase angle of the transmitted signal thus

$$\Delta\phi = \phi\mathbf{2} - \phi\mathbf{1}$$

Where, $\Delta\phi$ = Phase difference, $\phi 2$ = Phase angle of the transmitted signal, $\phi 1$ = Phase angle of the reflected signal.

The phase difference is usually expressed in terms of wavelength is shown in table.1 below.

Table.1. Phase differene details

$\Delta\phi$	0^0	90^0	180^0	270^0	360^0
Length	**0**	**λ/4**	**λ/2**	**3λ/4**	**λ**

EDM Equipments: EDM equipment can be classified based upon the type of wave used, ie. M (Microwave), DM and EO (electro-optical) DM equipment. The first type uses low-frequency short radio waves while the second type uses high –frequency light waves. They can also be classified upon the range as follows.

a) Short-range equipment such as tellurometers and mekenometers with a range of up to 3000m.

b) Medium-range equipment such as geodimeters with a range up to 25km. The range is about 5km during the day and can go up to 25km at night.

c) High-range equipment with a range up to 150km. Tellurometers and distomats come under this category.

The accuracy varies with the range of the instrument. All types of equipment using electromagnetic waves perform the following functions.

a) Generation of two waveforms for carrier and measurements functions.

b) Modulation and demodulation of waves.

c) Measurements of phase difference.

d) Computation and display of distance or results of measurements.

Total Station: Uses of total station surveying equipment for monitoring structures movement with good results were reported by many. Components of a normal total station machine are as: EDM, Electronic Theodolite, On board Microprocessor, Data Collector/Data Storage, Prism.

When aimed at an appropriate target a total station measures three parameters (Figure.2): a) The rotation of the instrument's optical axis from instrument north in a horizontal plane (horizontal angle), b) the inclination of the optical axis from local vertical (vertical angle), and c) the distance between the instrument and the target (slope distance). All other numbers that may be provided by the total station are derived from these three fundamental measurements.

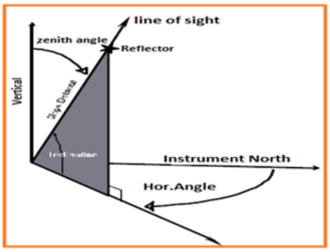

Figure.2. Fundamental Measurements by Total Station

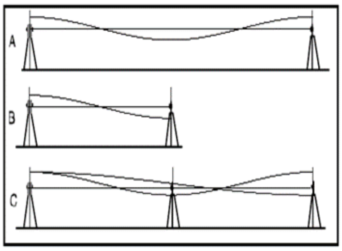

Figure.3. Distance Measurement using EDM

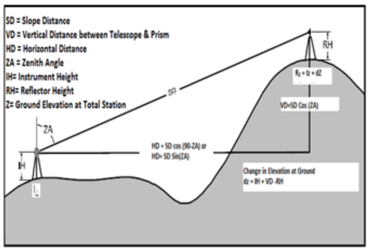

Figure.4. Diagram showing geometry of the instrument and reflector at vertical plane

What a Total Station can do: Total station is considered as the versatile instrument which replaces all the conventional surveying techniques and instruments like chain surveying, compass surveying, plane table surveying, theodolite surveying, Tachometric surveying etc. Major measurements / applications that can be done using total station are; Horizontal Angle, Vertical Angle, Slope Distance, Horizontal Distance, Vertical Distance, Coordinate Calculations, Contour Measurements, Elevation Calculations, Area Calculations, Volume Calculations, Re fixing works.

Errors in Total Station: There is a misconception that a total station does all the calculation automatically even the error correction also. So the knowledge of correction and application of correction is based on the correct survey techniques. For instance the total station works on the principle of optics there are lot of atmospheric factors which affect the total station measurements. The refraction of light through air will cause of deviation from the line of sight and might cause error, similarly the curvature of earth cause the errors in elevation of the point and the distance between two points also. Thus the appropriate corrections are also to be made depends upon the source of error and surveying conditions. Normal errors are briefed; a) Operator Errors, b) Systematic Errors, c) Random Errors, d) Atmospheric pressure, e) Error due to relative humidity, f) Reflector constant errors, g) Curvature errors, h) Refraction errors, i) Collimation error, j) Vertical Index Error, k) Centering Errors.

The shape & form of the total station is being modified year by year by the manufactures introducing more user-friendly components and options. And in the world around not less than manufacturing companies are there who manufacture total station. Front runners among them are Leica, Sokia etc. Figures depicting the basic and detailed components of Total station machine are shown in Figures.5 & 6.

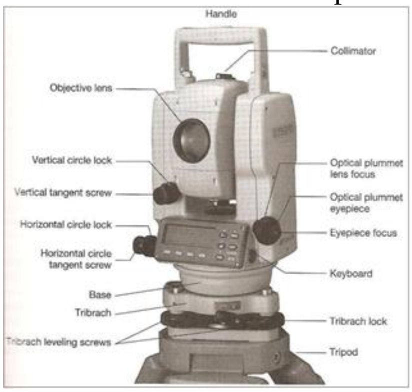

Figure.5. Total Station Parts an Overview

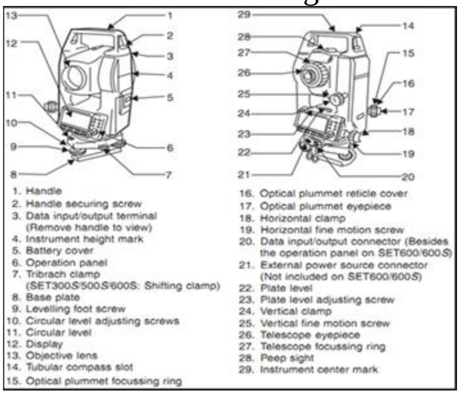

Figure.6. Total Station Components in Detail

Advantages of Total Station: In every walk of civil engineering Total station has become a vital instrument due to its versatility. The main advantages of total station are not an exhaustive list still few are listed: a) Reduced error, b) Time Saving, c) Accuracy in measurement, d) Precise Data, e) Total station needs line of site, but it does not need visibility of the sky. Total station can be used indoors, in a mine, or under tree, f) Total station is suited to take ground measurements, g) No complex calculations as most of the things are done automatically, h) Total station is that you don't necessarily need to occupy the point you are trying to measure. Using more advanced functions like offsets, resections, etc. you can measure a point indirectly though combinations of multiple angular and/or distance measures, i) Option for exporting the data in universal software’s like Auto CAD, j) Multiple applications can be performed at one set up.

Disadvantages of Total Station: a) Line of sight is the principle disadvantage of EDM measurements, b) Cumulative errors, c) Measurements are not geodetic, d) Initial Cost is high, e) Very delicate instrument, careful handling is required, f) Proper calibration of the instrument is must, g) Accuracy of vertical distance is relatively low, h) Horizontal coordinates are calculated on a rectangular grid system, whereas in actual practice this needs to be done in geographic coordinates.

2. CONCLUSIONS

EDM has become a boon to the surveying community and the situation is such that every field of civil engineering is not free from EDM based machines. The most popularly used EDM based instrument is Total station. It is a valuable tool for civil engineering community. Although it is capable of great precision, very fast, capable of handling voluminous data, its precision is only ensured through the correct survey procedures. In this paper it was discussed about the basic working principle of EDM equipment, basic principles of total station survey, its advantages, and disadvantages etc. Knowledge of how this equipment works operates what are the errors to be considered how these errors are to be corrected etc. are most important. More sophisticated equipment / modifications in the present machines with more advanced options are being happened year by year. Whatever form it comes out basic knowledge of survey, the expertise of the surveyor etc. are most important for the right outcome.

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