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Climatic Effect on Horizontal Distance Measurement with the Electronic Distance Measuring Instruments

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Abstract: **Electromagnetic measurement of global distances has not merely replaced other forms of distance measurements but has also caused considerable change in survey technique. Electronic Distance Measuring Instrument has had considerable applications in other areas of survey measurements such as the provision of ground controls for aerial photography. Accuracies determined for distance measurements in traversing as presented by their fractional misclosure have currently improved tremendously with the use of these Electronic Distance Measuring Instruments. Calibration of the instrument for maximum operational condition is dependent on the adjustment and prevailing weather conditions under which the instrument is to be used. In most cases, weather conditions at the period of operation remain a major factor in the achievement of the desired accuracy for the measurement intended.**

This paper analyses measurements. The effect of weather conditions on the accuracy of horizontal distances measurement with Electronic Distance Measuring Instrument in the tropics, emphasizing on the precision of repeated.

Keywords: **Electronic Distance Measuring Instruments (EDMIs), Calibration, Electromagnetic measurement, Ground controls**.

1. INTRODUCTION

Conventionally, accurate distance measurement was the most difficult part of a surveying operation, but the introduction of the Electronic Distance Measurement Instrument has completely revolutionized this. Electromagnetic measurement of a distance depends on the fact that electro-magnetic waves, of which radio and visible light are examples, travel through air with a velocity v of about 300 x 10^6m/sec (Schofield, 1993).

By definition:

$$D = v \times t$$

Where

D = Distance measured
v = velocity
t = time in seconds.

An unknown distance may be found by measuring the travel or transit time if the velocity is known (Allan et al,. 1968).

The Electronic Distance Measuring Instrument is an electromagnetic micro-processor controlled instrument that can measure long distances to within a few kilometers at the press of a button. Two groups of instruments can be identified.

- Electromagnetic or microwave types;

- Electro-optical types - which normally works with an infra-red beam.

The velocity of the electromagnetic wave in air must be known precisely for the accurate determination of distances. In the atmosphere the velocity of light varies with temperature, humidity and the partial pressure of water vapour and corrections for these factors are essential (Raymond et al,. 1981). Measurement technique with the instrument is basically having a transmitter set up at one end of the length to be measured and sending out a continuous wave to a receiver at the other end. This wave (the carrier wave) is then modulated to have the length determined (S.K. Roy, 2008).

Modulation is a process whereby certain characteristics of the carrier waves are varied or selected in accordance with another signal. The carrier signal does not have to be at a precisely determined frequency but must be produced efficiently and in such a form that, it can be modulated easily (Bannister et al., 1981).

This distance measurement by the Electronic Distance Measuring Instrument use two options, either by pulse transit times or phase changes measure. The Electronic Distance Measuring Instrument system adopt a technique of either retransmitting the signal back to the transmitter (microwave type) or reflecting the signal back (electro-optical) and making the phase comparison for distance determination. Distance determination in the instrument is thus made by double path measurement.

2. FIELD MEASUREMENTS

In theodolite traverses that have been made with the Electronic Distance Measuring Instrument, low order accuracy could be expected when the instrument was not well calibrated. Similarly, it has also been observed that in situations where the appropriate calibration has been effected and low order accuracies have occurred, the defect could be attributed to changing weather conditions encountered during the course of the surveying.

This may cover a good part of the day as the velocity of light in the atmosphere varies with temperature, humidity and pressure.

In order to test and prove this fact, an Electronic Distance Measuring Instrument was calibrated over a base line formed by two control stations (OSP 9S and OSP 10S) established along sport complex road on the Rufus Giwa Polytechnic, Owo campus, this horizontal distance has previously been measured by catenary chaining.

An instrument calibration constant was input into the Electronic Distance Measuring Instrument, and shots taken every 20 minutes in the morning (between 7.00am and 11.00am), in the afternoon (between 12.00 noon - 3.00pm) and in the late evening (between 3.00pm - 6.00pm) respectively. These shots were taken to compare the distances measured on the Electronic Distance Measuring Instrument with that of the catenary measured length of the same base, over the changing weather conditions throughout the day.

Repeated measurements on similar hours of the day were done over different seasonal periods, noting the changing weather conditions during the day and its effect on the measured lengths of the base.

Results obtained were being shown below, indicating measured distances, precision of the measurement and the variances.

Table 1: Results of measurements taken during first day

TIME OF DAY	MEAN DISTANCE (METERS)	PRECISION	VARIANCE
MORNING (07.00am – 11.00am)	192.981	+0.022	1.76×10^{-6}
AFTERNOON (12.00pm -03.00pm)	192.959	0.000	0.000
EVENING (03.00pm -06.00pm)	192.964	+0.005	3.0×10^{-7}

Table 2: Results of measurements taken during second day

TIME OF DAY	MEAN DISTANCE (METERS)	PRECISION	VARIANCE
MORNING (07.00am – 11.00am)	192.979	+0.020	1.90×10^{-6}
AFTERNOON (12.00pm -03.00pm)	192.959	0.000	0.000
EVENING (03.00pm -06.00pm)	192.971	+0.012	1.46×10^{-1}

From the above, values obtained between the hours of 07.00 am and 3.00pm showed closeness of the measured lengths to that of the mean as measured by the catenary techniques (which is the most reliable, as this type of linear distance measurement considered the prevailing weather conditions at the time of the measurement).

3. CONCLUSIONS

Electronic Distance Measuring Instrument depends on the fact that the electromagnetic waves travel through air. This is an indication that when the temperature, humidity and pressure changes during the period measurements are being taken, definitely the changes in the weather condition is bound to affect the propagation of the electromagnetic waves that determine the distances measured. As such when the instrument is calibrated in a particular weather condition, it is appropriate that it is used in that similar weather condition on which the calibration was done, if the desired high order of accuracy is to be achieved. However, a better result could be obtained if the instrument is calibrated or the calibration checked immediately before using it for the measurements. The other alternative is to have measurements done between the hours of 08.00am in the morning and 03.00pm in the afternoon, in which case it is evident that measurement should not be carried out beyond these hours, especially in the tropics. Work could be stopped for the day when the time approaches 03.00pm and commenced the next day from 08.00am in the morning when the weather conditions are suitable in the tropics to ensure that the desired high order of accuracy is achieved.

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