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Linear Measurements

Contents

- ✓ Tape and optical square
- ✓ Optical distance measurement
- ✓ Electronic distance measurement.

Tape and Optical Square

The measurement of distance is one of the fundamental operations in surveying and is carried out by taping, Optical Distance Measurement (ODM) or Electromagnetic Distance Measurement (EDM) techniques. Whichever of these is used, the usual requirement in surveying is for ***horizontal distances***.

Taping

Taping involves measuring distance by use of tapes. There are a number of types of tapes in use with different sizes ranging from 20m 30m, 50m or 100m. The most common types of tapes are steel, invar, glass fiber and synthetic material. Taping comes with errors that are systematic in nature due to the atmospheric conditions and the conditions under which tape is being used.

Corrections are required for:

- *Standardization*
- *Temperature*
- *Sagging*
- *Slope*
- *Tension*

Optical Distance Measurements

This technique has advantages over taping. These are

- ✓ Less time taken to measure long distances.
- ✓ Since distance measurement is not done on the ground, it is a little bit easier to measure on undulating grounds.

There are two systems under the ODM, namely

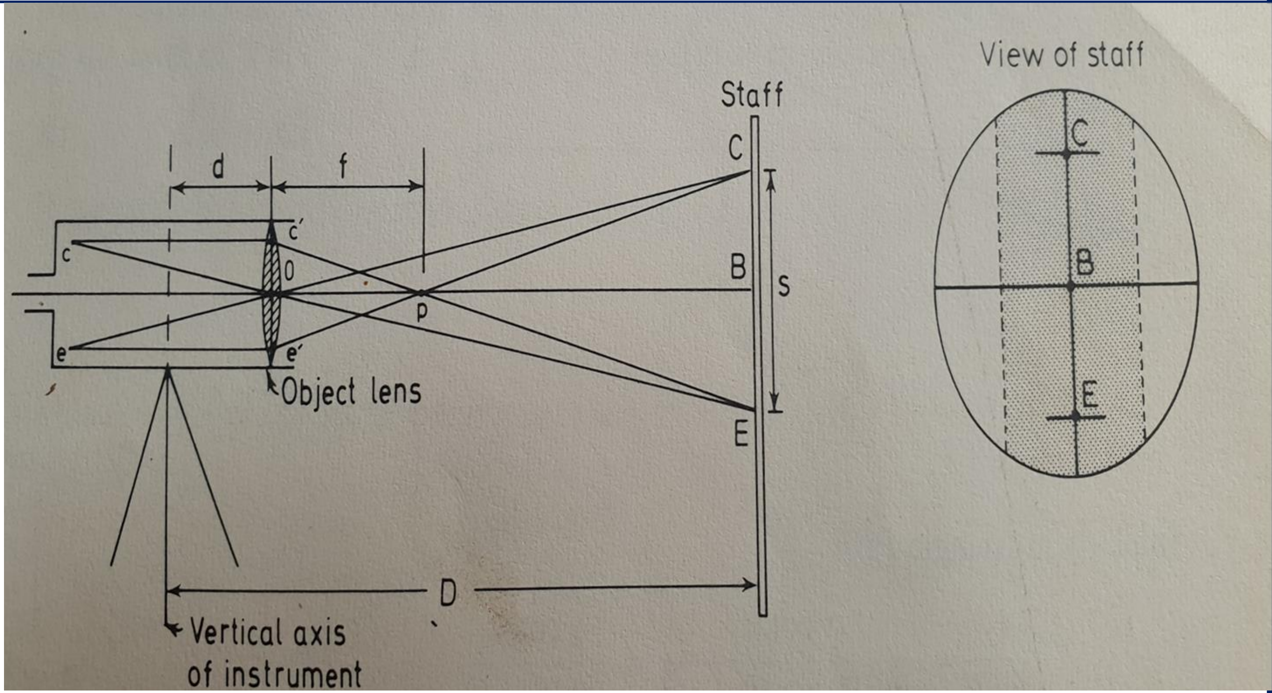
- the stadia system – uses a combination of a Level, theodolite and a leveling staff.
- the sub tense system- uses the theodolite and a sub tense bar.

STADIA SYSTEM

With the combination of a standard theodolite or level with stadia lines on the telescope diaphragms and the leveling staff the distance is determined by way of reading the stadia intercepts. The stadia lines define a parallactic angle θ and the measurement process involves observing the staff intercepts subtended by this fixed angle over the required distance.

Optical Distance Measurements

Where d = distance from instrument centre to object lens
i or ce = stadia interval
f = focal length,



By similar triangles:

$$\frac{Bp}{CE} = \frac{Op}{c'e'}$$

$$\therefore Bp = S\left(\frac{f}{i}\right)$$

$$D = Bp + (f + d) = S\left(\frac{f}{i}\right) + (f + d)$$

$$D = K_1 S + K_2$$

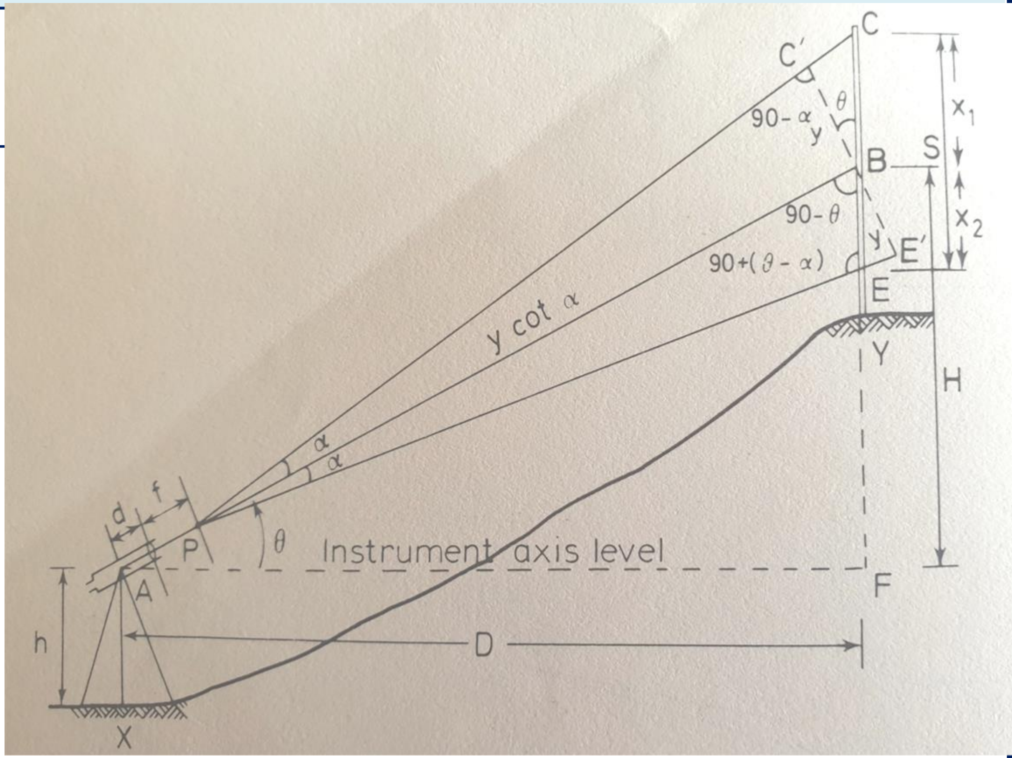
The value (f+d) is called the **Additive Constant**, K_2

$\left(\frac{f}{i}\right)$ is called the **multiplying constant**, K_1

equal to 100 in modern instruments

ODM Continues

To generalize the formula, for inclined sights: Consider the figure.
By sine rule of triangle PCB:



$$\frac{x_1}{\sin\alpha} = \frac{y\cot\alpha}{\sin[90° - (\theta+\alpha)]} = \frac{y\cot\alpha}{\cos(\theta+\alpha)}$$

$$cross\_multiply$$

$$x_1\cos(\theta+\alpha) = y\cot\alpha\sin\alpha = \frac{y\cot\alpha\sin\alpha}{\sin\alpha} = y\cot\alpha$$

$$From\_which$$

$$y = x_1\cos\theta - x_1\sin\theta\tan\alpha$$

ODM Continues

Similarly in triangle PBE

$$\frac{x_2}{\sin\alpha} = \frac{y\cot\alpha}{\sin[90^\circ + (\theta-\alpha)]} = \frac{y\cot\alpha}{\cos(\theta-\alpha)}$$

$$x_2\cos(\theta-\alpha) = y\cot\alpha\sin\alpha = y\cos\alpha$$

$$and$$

$$y = x_2\cos\theta + x_2\sin\theta\tan\alpha \qquad x_1 \approx x_2$$

$$adding\_(a)\_and\_(b)$$

$$2y = (x_1 + x_2)\cos\theta - (x_1 - x_2)\sin\theta\tan\alpha$$

$$i.e.\_C'F' = S\cos\theta - (x_1 - x_2)\sin\theta\tan\alpha$$

NB: max. value of sin θ would be 45° and for tan α as 1/200 while generally majority of work in practice $x_1 \approx x_2$, the second term may thus be neglected for all but the steepest sights

ODM Continues

Finally $x_1 \approx x_2$

$$AB = K_1(C'E') + K_2 = K_1 S\cos\theta + K_2$$

$$\therefore AF = D = AB\cos\theta = K_1 S\cos^2\theta + K_2\cos\theta$$

Similarly

$$FB = H = AB\sin\theta = K_1 S\cos\theta\sin\theta + K_2\sin\theta$$

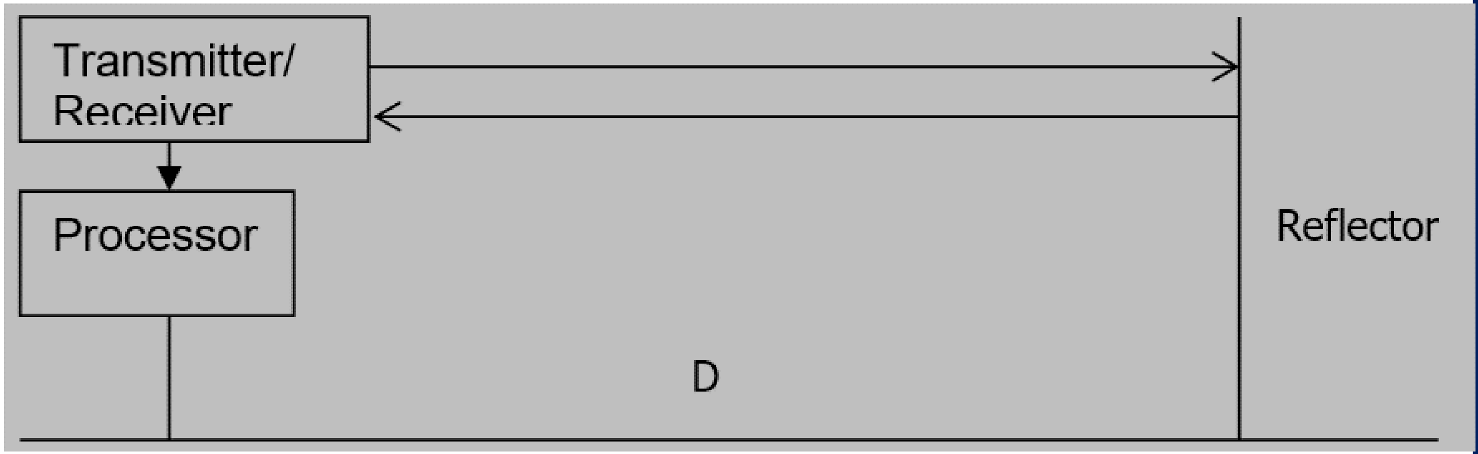
Electromagnetic Distance Measurements

An EDM instrument uses electromagnetic waves, which may be classified according to the type of electromagnetic radiation that carries the measuring signal. These are microwave EDM instruments that generally employ radio waves and the electro-optical EDM instruments which utilize visible or near-infrared radiation. The system has three major components: *the propagation timer; the transmitter/receiver and the microprocessor*.

- *The propagation timer is to determine the travel time of the wave to and from the reflector*
- *The transmitter transmits the wave and the same time the receives it.*
- *The microprocessor does the computations of the distance.*

Electromagnetic Distance Measurements

Now for the system to work, there has to be a reflecting surface on the other end of the line. In this respect reflecting prisms are used. Further more there has to be a clear line of sight (no blockages in the signal) between the transmitter and the reflector.



Therefore

$$D = V * t$$

Where D = distance between transmitter and reflector

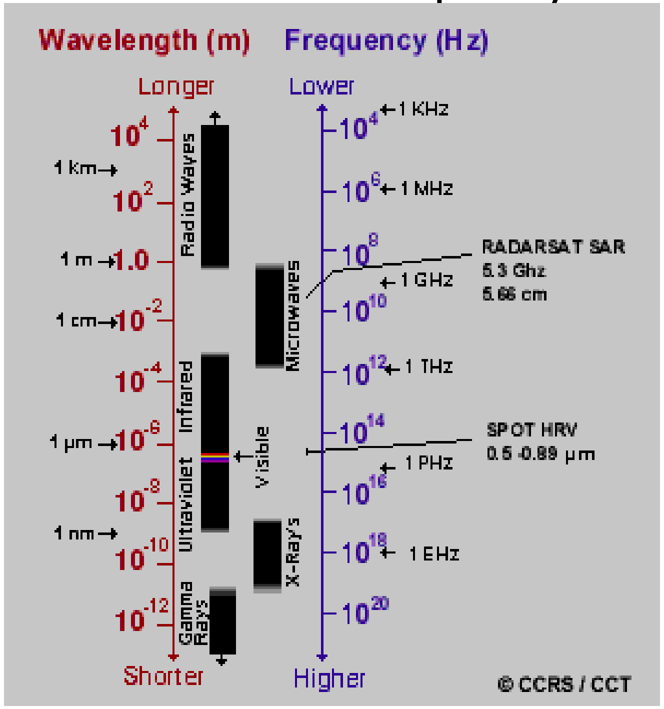
V = velocity of electromagnetic wave in air

t = half the time taken for the transmitted and the reflected wave.

Electromagnetic Distance Measurements

The wave from the transmitter is called the Carrier Wave which is at some frequency.

a) Radio waves (very low frequencies)
b) Microwaves (medium frequencies)
c) Visible and infra-red light (high frequencies)
d) Laser light (very low frequencies) -



Electromagnetic Spectrum

Instruments with:
Low frequencies offer a greater range of distance but require larger transmitters and are more affected by the atmosphere thereby giving less accurate results

while instruments that utilise high frequencies are portable and propagation through the atmosphere is stable however because the wavelengths are so small, it is impractical to use directly the waves for the measurements except by modulation. For accurate measurements (say in engineering, surveying, etc.) high frequency carrier wave instruments are used.