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Linear Measurements - ERRORS

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- ✓ Tape Errors and Corrections
- ✓ Optical distance measurement Errors and Corrections
- ✓ Electronic distance measurement Errors and Corrections.

Corrections for tape error measurements

Standardization correction

When a tape is bought and before it is used it is supposed to be standardized. Standardization in this case is the checking of the tape in conformity to the nominal values indicated on it. This also is done after a tape has been in use for some time. Usually this is done by measuring it against a standard tape in a workshop.

$C_{std} = l_m(l' - l_n)/l_n$ where

l_m = measured distance with tape

l' = actual tape length

l_n = nominal length of tape

OR

$l_{true} = l_m(l'/l_n)$ where

l_m = measured distance with tape

l' = actual tape length

l_n = nominal length of tape

Corrections for tape error measurements

Temperature correction

As the tape is being used in the field, it is affected by the change in temperatures. Normally, tapes are designed in such a way that they give the required length at the design temperature (nominal temperature). This affects the tape in two ways (expansion or contraction) depending on the temperatures. To counteract the effects that are brought about due to the tape operating at temperatures other than the nominal, the correction to the measured distance is determined:

$$C_{temp} = \alpha l_m (t_f - t_s)$$

where

l_m = measured distance with tape

t_f = field temperature

t_s = nominal temperature at which tape is operate

α = coefficient of expansion of the tape

This correction is either negative or positive. It all depends on the field temperatures.

Corrections for tape error measurements

Slope correction

When the tape is used on the ground or in catenary, the distance so obtained is slope distance. It is a well known fact that horizontal distances are the ones key to computations in surveying. These obtained distances are to be converted to horizontal values. If the distance is measured on the ground, the slope angle can be measured between the end points by way of an Abney level. If the distance is measured in catenary then the vertical angle can be measured using the theodolite.

$$C_{slope} = l_m(1-\cos\theta)$$

where

l_m = measured distance with tape

θ = the measured vertical angle between the end points

$$C_{slope} = \Delta H_{AB}^2 / 2l_m$$

where

l_m = measured distance with tape

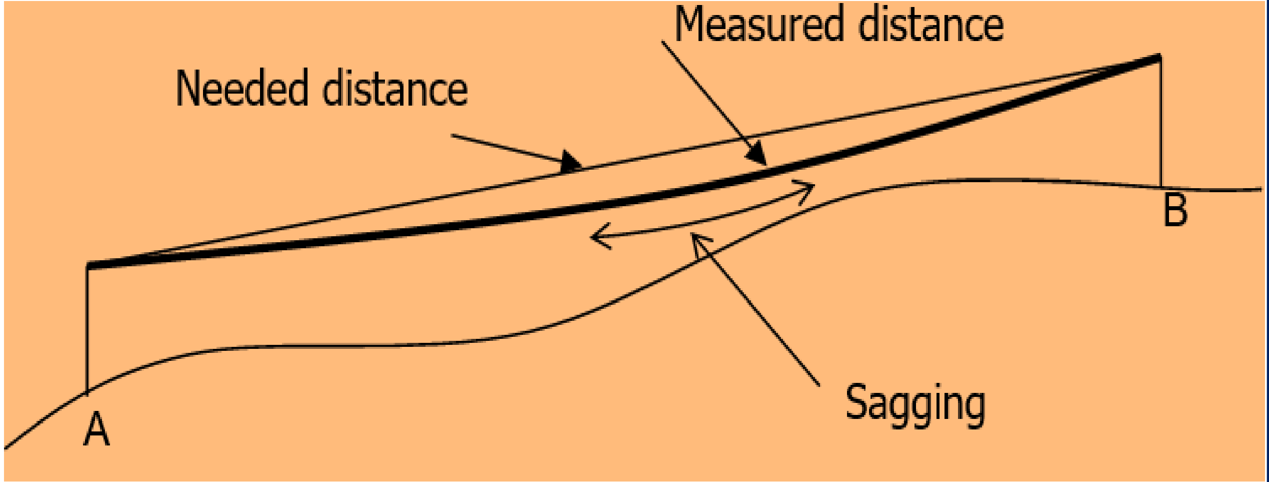
ΔH_{AB} = the difference in elevation between the end points

This correction is always negative since the slope distance is always longer than the horizontal distance.

Corrections for tape error measurements

Sag Correction

When the tape is used on the ground, sag correction is not applied. When used in catenary, the distance so obtained is longer than expected due to the sagging of the tape due to its weight. This correction is always negative since the measured distance is always longer than the needed distance (see figure above)



$$C_{sag} = w^2 l_m^3 \cos^2\theta / 24T_f^2$$

where

l_m = measured distance with tape

θ = the measured vertical angle between the end points

T_f = Tension applied to the tape.

w = weight of the tape per unit length

Corrections for tape error measurements

Tension correction

When the tape is used on the ground or in catenary, the tension that is applied to it usually is not the standard tension. These obtained distances are to be corrected for the effects of not applying the right tension. The sign of the corrections depend the applied tension in the field.

$$C_{Tension} = l_m(T_f - T_s)/AE$$

where

l_m = measured distance with tape

A = the cross-sectional area of the tape

E = Young's Modulus of elasticity.

T_f = Tension applied to the tape.

T_s = Nominal Tension of the tape.

Electromagnetic Distance Measurements

Sources of Errors

When distances are measured with the EDM instrument, atmospheric and instrumental effects may give rise to errors in the distances displayed and corrections are required to offset such.

Atmospheric effects.

When electromagnetic waves travel in the atmosphere the velocity does not remain the same due to the retarding effect of the atmosphere. Now since the value of V is varying with atmospheric conditions, the wavelength also varies. To correct for this, atmospheric conditions at the time of measuring the distance the following have to be determined, i.e. temperature and pressure. The correction can be determined based on measured values using the charts provided for by the manufacturers and the value usually in mm/km (parts per million = ppm) is entered in the EDM.

Electromagnetic Distance Measurements

Instrumental errors.

There are three basic instrumental errors:

Scale Errors (or frequency drift) – caused by variations in the modulation frequency, i.e./ the measuring frequency does not correspond exactly to the design value. This error is proportional to the distance measured.

Zero Errors (or index error) – these occur if there are differences in the mechanically, electrically and optical centers of the EDM instrument and the reflectors. These errors are independent of the measured distance.

Cyclic Errors (or periodic error) – these are caused by unwanted interference between electrical signals generated in the EDM unit.. The error is proportional to the measured distance.

Accuracy of measured distance

The accuracy of the distance measured by the EDM is usually quoted as

$\pm$ e (mm) $\pm$ ρ (mm/km)

Where **e** = Zero error and ρ **=** proportional error. Thus the resultant or overall standard deviation of a measurement is given by

$$\text{Standard error} = \sqrt{(\boldsymbol{\varepsilon}^2 + [\boldsymbol{D} * \rho * \mathbf{10}^{-6}]^2)},$$

where D is the distance measured expressed in mm

OR $$\text{Standard error} = \sqrt{(\boldsymbol{\varepsilon}^2 + [\boldsymbol{D} * \rho]^2)}$$

where D is the distance measured expressed in km

ODM Errors

Its obvious that its much easier to hold a staff vertically than holding it normal to the line of sight. This is one of the key sources of errors!

The principle sources of errors will not be dealt with in details but suffice to highlight them here.

- Staff readings, and hence staff intercepts
- Non-verticality of the staff
- Measurement of the vertical angle