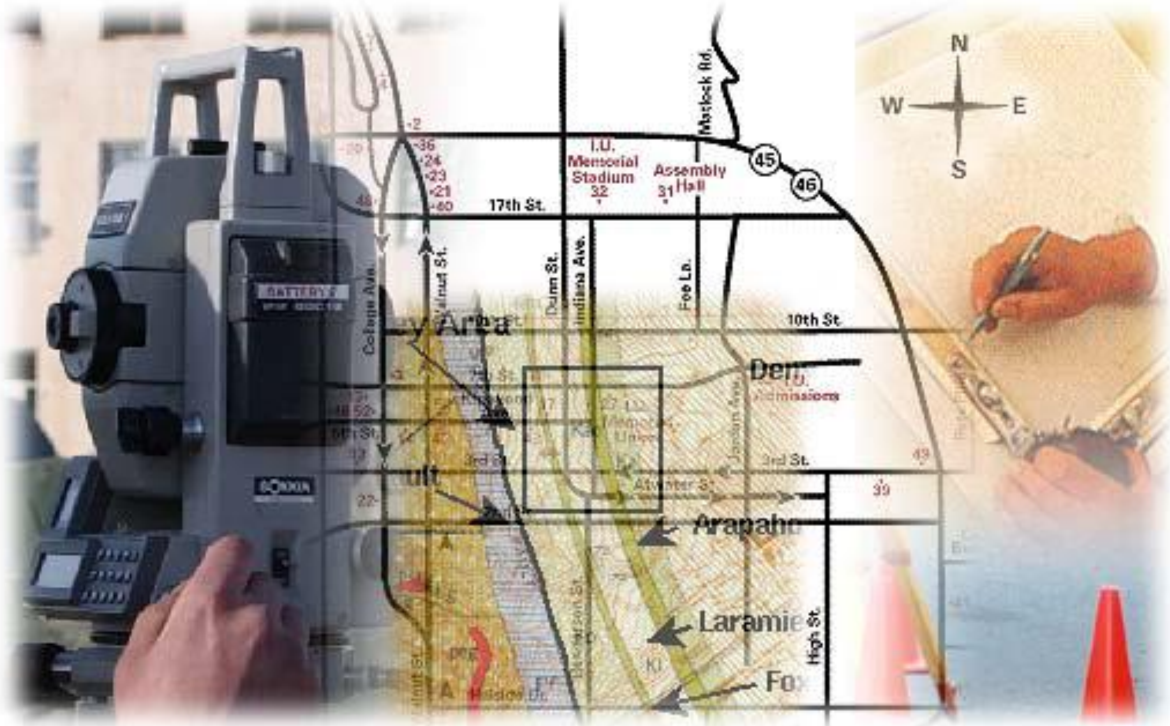
CE 370

Surveying I



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Chapter 3 Measurement of Horizontal Distances

Measuring distances between different points of the earth's surface is one of the principle operations in the field of surveying. For example, to determine the location of a certain point, distances and/or angles are usually measured. For this reason, measuring distances is very important to determine the location of the points or the required quantities. The horizontal distance is determined by direct measurement or by measuring the inclined distances and projects them into their corresponding horizontal distances. It is also possible to determine the horizontal distances by using the measured distances and some mathematical laws. Always remember, whatever the way you are using to measure the distance (horizontal, vertical or inclined) it is important to calculate its equivalent horizontal distance.

3.1 Measurement of Horizontal Distance

It is important to distinguish between two ways of distance measurements:

1.1.1 Direct Method

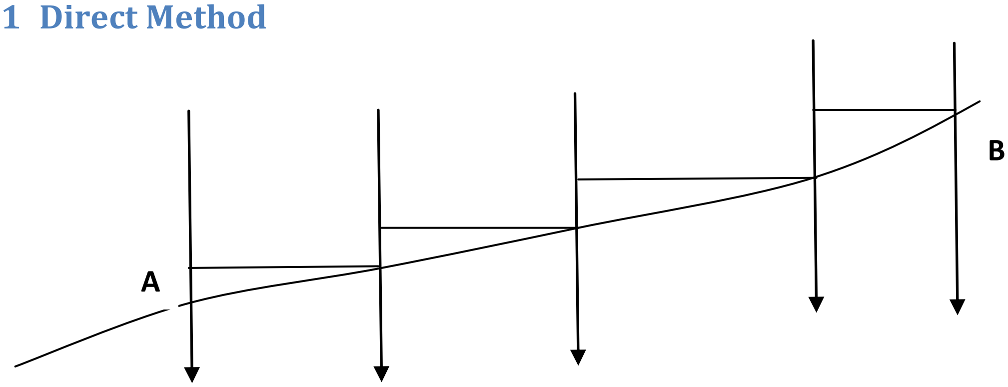


Fig. (3.1): Measuring the distance in case of inclined land

1.1.2 Indirect Method

I. **Using the inclined distance and vertical angle:** See Fig. 3.2

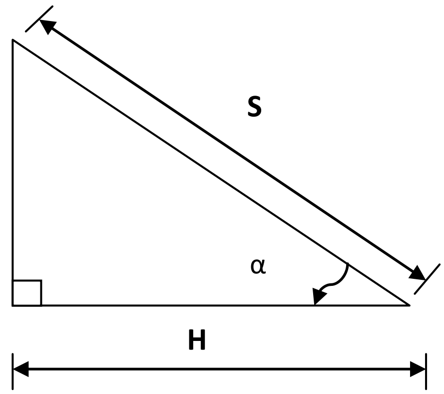


Fig. (3.2): Measuring the horizontal distance using the inclined distance and vertical angle

H = Horizontal distance S = Inclined distance α = Vertical angle

$$H = S \cos a$$

Example 3.1: If the inclined distance equals 141.216 m and the vertical angle is $1^0\ 20'$. Determine the horizontal distance?

Solution:

$$\cos a = \frac{H}{S}$$

$$H = S \cos a = 141.216 \cos 1^0\ 20' = 141.178 \text{ m}$$

II. **Using the inclined distance and the head difference:** See Fig. 3.3

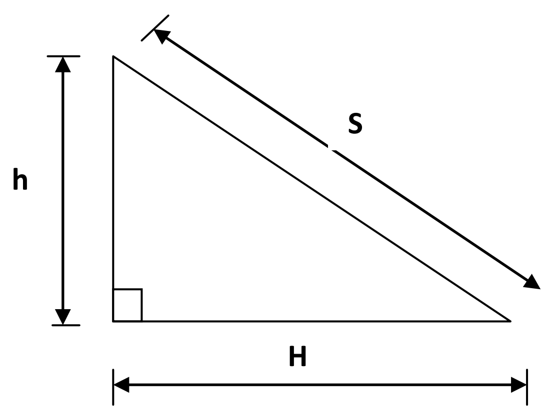


Fig. (3.3): Measuring the horizontal distance using the inclined distance and the head diff.

$$H^2 + h^2 = S^2$$

$$\boldsymbol{H = \sqrt{S^2 - h^2}}$$

Example 3.2: If the inclined distance equals 253.101 m and the head difference equals 3.721 m. determine the horizontal distance?

Solution:

$$\boldsymbol{H = \sqrt{S^2 - h^2}}$$

$$\boldsymbol{H} = \sqrt{(253.101)^2 - (3.721)^2} = 253.074\, m$$

III. **Using the Vertical angles and the head difference:** See Fig. 3.4

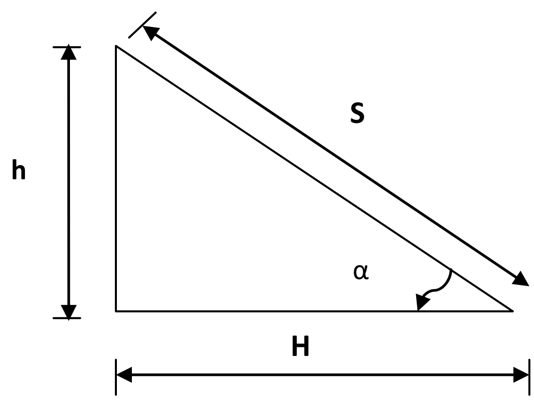


Fig. (3.4): Measuring the horizontal distance using the vertical angle and the head diff.

$$cotan\ a = \frac{H}{h}$$

$$\boldsymbol{H = h.cotan\ a}$$

Example 3.3: If the head difference equals 1.5 m and its corresponding vertical angle is 0.85937^o determine the horizontal distance?

Solution:

$$\boldsymbol{H = h.cotan\ a} = 1.5\ cotan\ (0.85937^o) = 113.268\ m$$

3.2 Errors in measuring distances using tapes and its corrections

There are several errors that could be occurred during the measurement of distances by using the tapes. Some of these errors are due to the accuracy of the tape and its stiffness and others are due to the nature of measurement.

1- ***Manufacturing errors***

   Those are referring to the tape itself, its type, stiffness, accuracy, and errors in the divisions of the tape.

2- ***Natural errors***

   Such errors are raised from the difference between the conditions of weather, temperature, winds, and moisture, during the measuring in the field and those that measured during the calibration of the tape when it originally manufactured.

3- ***Personal errors***

   Usually these errors occur due to the less experience and efficiency of the surveyor, and sometimes due to the psychological problems or expenses.

3.2.1 Error in the length of the tape

It should be corrected or the distance must be measured again, and the correct length of the line could be calculated using the following equation.

Example 3.4: A line measured using a tape that its length is less by 10 cm from its nominal length, so the length of the line was 198 m. what is the true length of the line?

Solution:

Nominal length of the tape = 20 m

True length of the tape = 19.90 m

Measured length of the line = 198 m

True length of the line = x

$$\frac{x}{198} = \frac{19.90}{20} \rightarrow \quad x = 197.01\ m$$

3.2.2 Correction of temperature

This error could be positive or negative. The amount of correction for temperature is determined by the formula.

$$C_t = L \propto (T - T_s)$$

Where:

C_t = is the correction to be applied

L = length of the tape actually used

$\propto$ = is the coefficient of thermal expansion = 11.2 x 10^{-6} C^o

T = is the temperature at which the measurement is made

T_s = is the temperature at which the tape is standardized

3.2.3 Incorrect tension

If a tape is used in the field under a tension different from the standard tension used in calibration, the tape will change length a slight amount according to the relationship between stress and strain. The amount to be added or subtracted from the measured length in order to accurate for the difference in tension is a function of the *measured length*, *the field tension*, *the standard tension*, *the cross-sectional area of the tape*, and *the modulus of elasticity* of the material of which the tape is made. This is referred to the *correction for pull or tension* and is given by:

$$C_p = \frac{(P - P_s)L}{AE}$$

In which:

C_p = is the correction per tape length,

P = is the tension applied,

P_s = is the standard tension,

L = is the length

A = is the cross-sectional area

E = is the modulus of elasticity of the steel = 20 x 10^4 $\frac{N}{mm^2}$

E = is the modulus of elasticity of the invar tape = 14.5 x 10^4 $\frac{N}{mm^2}$

3.2.4 Marbling (الترخيم)

$$C_m = \frac{8\,m^2}{3L}$$

In which:

C_m = is the error in the tape length,

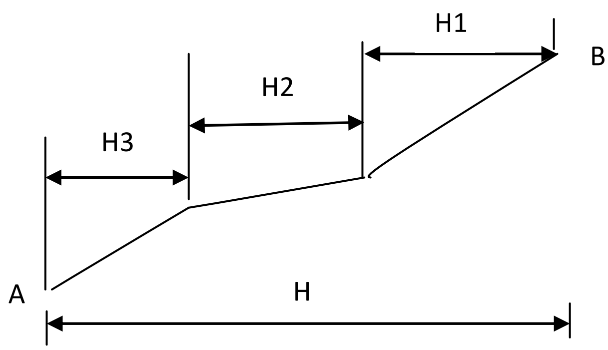
m = marbling value,

L = length of the tape,

True length = length of the line - C_m x (number of complete nominal distances)

If the distance is less than 20 m, we ignore the marbling in this distance.

3.4.5 Error due to measuring on inclined land (خطأ القياس على ارض منحدرة)



If the inclination angle is known as γ

H = L cos γ

If the slope of the land is given:

$$\gamma = \tan^{-1}\left(\frac{v}{h}\right)$$

H = L cos γ

Remember:

$$\frac{True\ lenght\ of\ the\ line}{measured\ lenght\ of\ the\ line} = \frac{True\ lenght\ of\ the\ tape}{nominal\ lenght\ of\ the\ tape}$$

$$\frac{True\ area}{Calculated\ area} = \frac{(True\ length\ of\ the\ tape)^2}{(nominal\ length\ of\ the\ tape)^2}$$

Example 3.5: A steel tape with a nominal length of 20 m is used to measure the area of a piece of land. Its area was found as 8378.65 sq. m. the used tape is calibrated and it was found that its length decrease by 10 cm of its nominal length. Find the true area of that land.

Solution:

Nominal length of the tape = 20 m

True length of the tape = 19.90 m

$$\frac{True\ area}{Calculated\ area} = \frac{(True\ lenght\ of\ the\ tape)^2}{(nominal\ lenght\ of\ the\ tape)^2}$$

True area of the piece of land = 8295.073 square meter