CURVATURE AND REFRACTION

Curvature and refraction effects should be accounted for in precise levelling work and also if the sights are too long. The effect of curvature is to cause the objects sighted, to appear lower than they really are. The effect of refraction is to make the objects appear higher than they really are.

CURVATURE

In case of a long sight the horizontal line is not a level line due to curvature of the earth. The vertical distance between a horizontal line and the level line represents the effect of curvature of the earth.

In Fig. let ABD be a level line through A, and O be the centre of the earth. A is the instrument position. AC, the line of collimation, will be a horizontal line. R is the radius of the earth.

The curvature correction, $C_c = BC$

Now $OC^2 = OA^2 + AC^2$ or $(R + C_c)^2 = R^2 + D^2$

or $R^2 + 2R \times C_c + C^2_c = R^2 + D^2$ or $C_c (2R + C_c) = D^2$

or $Cc = D^2/2R + C_c$

Since C_c is very small as compared to the radius of the earth R,

$C_c = D^2/2R$

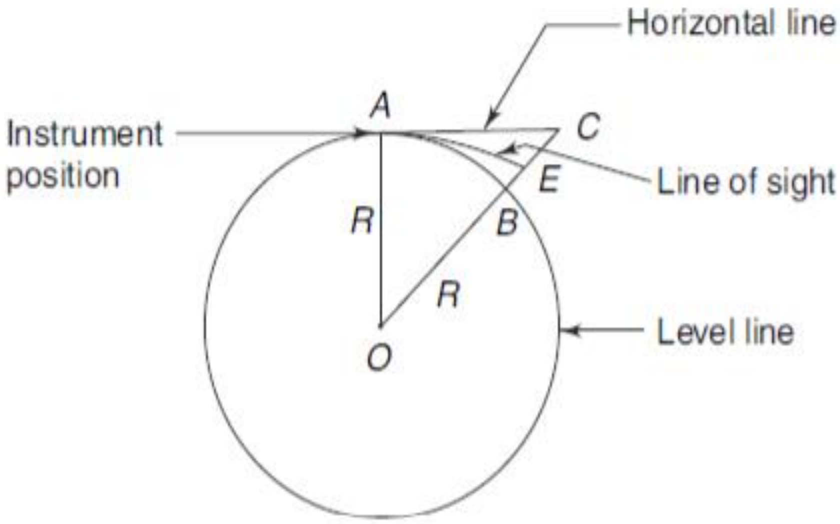
Taking the radius of the earth as 6370 km,

$C_c = 0.0785 D^2$

where D = distance in km

Since the curvature increases the staff reading, the correction is therefore subtractive.

True staff reading = observed staff reading – $0.0785 D^2$



Curvature and refraction

REFRACTION

Refraction of the ray passing through the atmosphere from the signal to the observer is the main source of external error. The rays of light while passing through layers of air of different densities refract or bend down. These densities depend upon the temperature and pressure at all points along the track of the rays. Consequently, ray from a staff follows a curved path, let us say AE (Fig.). CE is the amount of refraction correction and varies considerably with climatic conditions. The average refraction correction can, however, be taken as 1/7th of the curvature correction.

Refraction correction = $0.0785\ D^2/7 = 0.0112\ D^2$

The correction due to refraction is additive.

COMBINED CORRECTION

Since, the effect of curvature and refraction, when combined, is to make the objects sighted appear low, the overall correction is subtractive.

Combined correction = $0.0785\ D^2 – 0.0112\ D^2 = 0.0673\ D^2$

True staff reading = observed staff reading – $0.0673\ D^2$

Error due to curvature and refraction can be eliminated by equalising F.S. and B.S. distances or by reciprocal levelling.

For a length of sight of about 400 m, combined correction will be 1 cm and may be neglected when running indirect levelling.

Example:1 Calculate the combined correction for curvature and refraction for a distance of: (i) 5 km (ii) 500 m.

Solution: (i) 5 km: $C_c = 0.0673 \times (5)^2 = 1.6825$ m

(ii) 500 m:

$C_c = 0.0673 \times (500/1000)^2 = 0.016825$ m

Example:2 In order to find the difference in elevation between two points A and B, a level was set up on the line AB, 50 m from A and 1300 m from B. A and B being on the same side of the instrument. The readings obtained on staff held at A and B were 0.435 m and 3.950 m, respectively. Find the true difference in elevation between A and B.

Solution: The curvature and refraction corrections are applied only if the observations are taken for a length greater than 200 m. Therefore, corrections are not applied to the staff reading at A.

The combined correction for curvature and refraction at B = $0.0673\ D^{2} = 0.0673\ (1.3)^2 = 0.1137$ m, Hence, corrected staff reading at B = 3.950 – 0.1137 = 3.8363 m

True difference in elevation between B and A is = 3.8363 – 0.435 = 3.40126 m.