EVALUATION OF REFRACTION BY GEODETIC MEASUREMENTS

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Abstract: The merits of two refraction methods are discussed with the result that the line refraction method is appropriate for elaboration of trigonometric leveling traverses whereas the station refraction method is comparatively more convenient for trigonometric and three-dimensional networks of a larger extent especially those designed in high mountain regions.

Problem of the superiority of the methods

The following two approaches can be made for the evaluation of refraction by geodetic measurements

i) The line refraction method which determines a special coefficient of refraction for each line by reciprocal zenith distances.

ii) The station refraction method estimating one coefficient of refraction for each observation station by the adjustment of vertical angles, inclined distances and other observables.

Advantages of one method over the other were discussed by professor Ramsayer at the IAG Symposium held at Stockholm in 1974. He found the line refraction method as superior to the station refraction method because the distances between the stations of the traverse were nearly equal and therefore the separation of station refraction from the elevations of the stations was very poor. The statement was indeed correct. However, the examples as given were unfavorable for the station refraction method because the trigonometric leveling traverses which are commonly observed for vertical angles between the neighboring points or a network consisting of equilateral triangles are not relevant for testing of the station refraction method. Also a three-dimensional net without a certain number of slope distances which are inclined over 15^{o} is not relevant for the

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complete checking of three-dimensional procedures. Infact the station refraction method requires both shorter and longer lines of sight radiating from each station and the inclined distances over 15^{o} are necessary in three-dimensional nets for the determination of vertical scale and also for the elimination of systematic errors due to the refraction.When designed with respect to the evaluation of station refraction, the three-dimensional and trigonometric nets can separate the station refraction from the elevation of the station and yield nearly the same accuracy in vertical coordinates as in horizontal ones (Hradilek 1977). When additional observations of vertical angles for longer lines are performed, the station refraction may be estimated even in trigonometric leveling traverse. However, such an observation procedure may have a practical significance for traverses with longer lines of sight (over 3 km) which are designed in high mountain areas without an adjustment to the spirit leveling (Blažek and Hradilek 1978).

Superiority of the line refraction method

Results obtained by Ramsayer (1978), Brunner (1974) and others have indicated that the line refraction method corresponds better to the nature of trigonometric leveling traverses and it yields more realistic mean refraction value over the distance than the station refraction method.Application of the line refraction method by trigonometric leveling traverses in Czechoslovakia resulted in an accuracy which is comparable to that of a lower order spirit leveling.Special sighting targets fitted to the telescopes of the theodolites were used for simultaneous reciprocal pointings.Such an observation procedure eliminates the eccentricity errors and provides an immediate information on the mean value of refraction over the distance.

Superiority of the station refraction method

The three-dimensional and trigonometric leveling nets of a larger extent observed for simultaneous reciprocal zenith distances may prove to be uneconomical especially in high mountain regions.The station refraction methods corresponds better to the nature of such nets and it has additional power for separating refraction from the deflections of the vertical and determining the latter at most of the stations (about 70%) as proved by the elaboration of eight three-dimensional and trigonometric leveling networks (Hradilek 1972,1973).In this regard,the following conditions for the design,observation and elaboration of such nets should be fulfilled

i) All the lines of sight radiating from the same station should differ significantly both in their azimuths and their lengths and they sould be observed within one hour.The observations are repeated at least twice after intervals of two hours or more.The observation stations should be situated at the mountain peaks or at the observation towers at least 15 m above the ground.
ii) The changes in refraction by the repeated angular measurements are used for testing of the station refraction model and refining the latter for each individual line of sight as and when necessary (Hradilek 1973).

Conclusions

Above studies indicate that the line refraction method is superior to the station refraction approach when elaborating trigonometric leveling traverses whereas the station refraction method is more convenient for trigonometric and three-dimensional networks of a larger extent, especially those designed in high mountain regions.

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