

4.4 ERROR PROPAGATION

In surveying measurements, there are all possibilities for errors to creep in, irrespective of the precautions and precision exercised. This necessitates a proper control, assessment and distribution of errors. Error, mistake and discrepancy are few terms frequently encountered in surveying measurements. True error may be defined as the difference in measured and true value of a quantity. When a number of measurements are to fulfil a known condition, true error can be obtained. For example, the theoretical sum of exterior included angles in a traverse of N sides is $(2N + 4) \times 90^\circ$. Here, the error in the sum of observed angles is known, but the error in individual angles is not known.

The observed difference between two like measurements each of which may have an error, of a quantity, is termed as discrepancy. A discrepancy should not be regarded as an error. A small discrepancy between two measurements does not reflect that error is small. Whereas, a large discrepancy indicates a mistake in the observations.

Mistakes are the errors arising from carelessness, inexperience, poor judgment and confusion of the observer.

NATURE OF ERROR: Errors in a measurement may be positive if the measurement is too large, or negative if the same is too small as compared to its true value. Errors are classified as systematic errors and accidental errors.

SYSTEMATIC ERROR: The error due to sag of a tape supported at its ends can be calculated and subtracted from each measurement. However, the tape can be supported throughout its length at short intervals and the sag error may be reduced to a negligible quantity. It always has the same magnitude and sign so long as the conditions remain the same, and such an error is called *constant systematic error*. Whereas, if the conditions change, the magnitude of the error changes and is known as *variable systematic error*. A systematic error follows a definite mathematical or physical law and, therefore, a correction can always be determined and applied. These errors are also known as *cumulative errors*.

ACCIDENTAL ERROR:

These are the errors due to a combination of causes and are beyond the control of the surveyor. These can be positive or negative. Erroneous calibration of a chain is an example of an *accidental error*. There is in reality no fixed boundary between the accidental and systematic errors. Every accidental error has some cause, and if the causes were perfectly understood and the amount and sign could be determined, it would cause an accidental error, but would be classed as systematic. On the other hand, a constant or systematic error may be brought into the accidental class wholly or partially by varying the conditions, instruments, etc., such that the sign of the errors is frequently reversed.

LAWS OF ACCIDENTAL ERRORS

Accidental errors follow the law of probability and it is because of these accidental errors are also known as *probable errors or standard errors*. This law defines the occurrence of errors and when expressed in the form of an equation, it can be used to compute the probable value or the probable precision of a quantity. The probable error is the number of errors numerically greater than it is the same as that those less than it. It is always written after the observed quantity with the plus and minus sign, e.g., $25^{\circ}42' 30''$ plus or minus $3.16''$. Probable error serves two important purposes:

- (i) as a measure of the precision of any series of observations, and
- (ii) as a means of assigning weights to two or more quantities, and thus to find the weighted mean or the most probable value of each.

PRINCIPLE OF LEAST SQUARES

The principle of distributing errors by the method of least squares is of great help to find the most probable value of a quantity which has been measured for several times, perhaps by different methods and different observers and in calculating the trustworthiness of such a value. In the method of least squares, the discrepancies or errors of the discrepant

observations are assumed to be of accidental nature only. According to this principle, the most probable value of a quantity is the one for which the sum of the squares of the errors is a minimum.

The main objects of the method of least squares are

- (i) to determine the best values which can possibly be obtained from a given set of measurements,
- (ii) to determine the degree of dependence which can be placed upon these values,
- (iii) to enable us to trace to their sources the various errors affecting the measurements, and consequently,
- (iv) to increase the accuracy of the result by a proper modification of the methods and the instruments used.