LEVELING

Leveling is the process of directly or indirectly measuring vertical distances to determine the elevation of points or their differences in elevation.

It is a vital and important aspect of surveying since leveling operations are undertaken to provide necessary data for engineering design and construction, and the production of topographic maps.

Level Surface – It is a curved surface which is at any point perpendicular to the direction of gravity or the plumb line. It is best represented by the surface of a large body of still water.

Level Line – A level line is a curved line in a level surface all points of which are normal to the direction of gravity and equidistant from the center of the earth

Horizontal Surface – It is a plane that is tangent to a level surface at a perpendicular point. The horizontal surface is also perpendicular to the plumb line at the same point

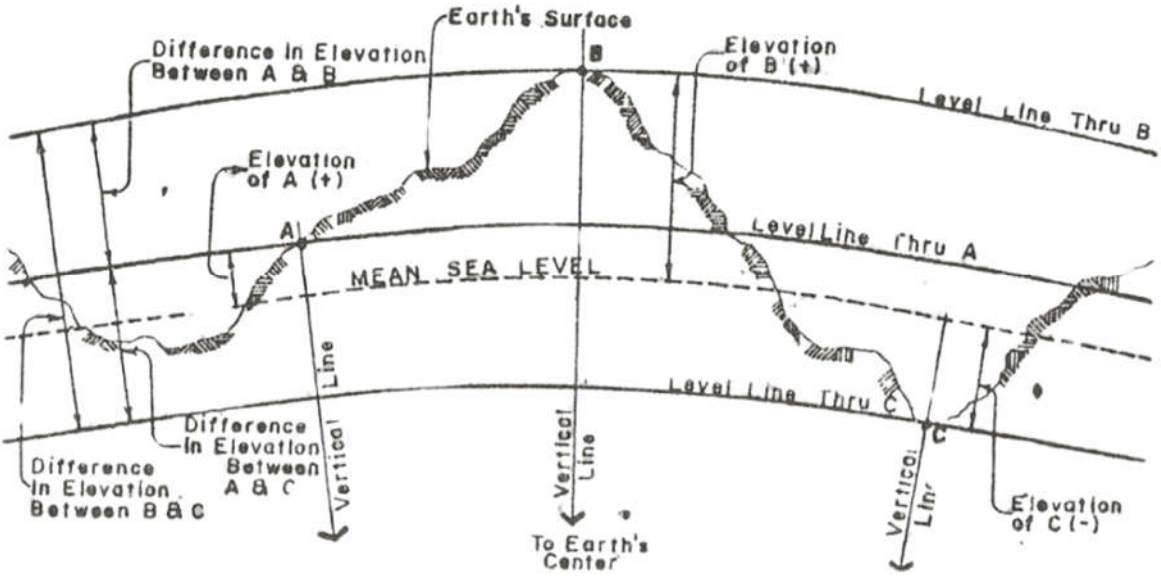
Horizontal Line – A straight line in a horizontal plane which is tangent to a level line at one point. This line is perpendicular to the direction of gravity at the point of tangency.

Vertical Line – A vertical line at any point is a line parallel to the direction of gravity. It is exemplified by the direction taken by a string supporting a suspended plumb bob passing through a point.

Mean Sea Level – is an imaginary surface of the sea which is midway between high and low tides. It is taken as the reference surface to which most ground elevations are referred.

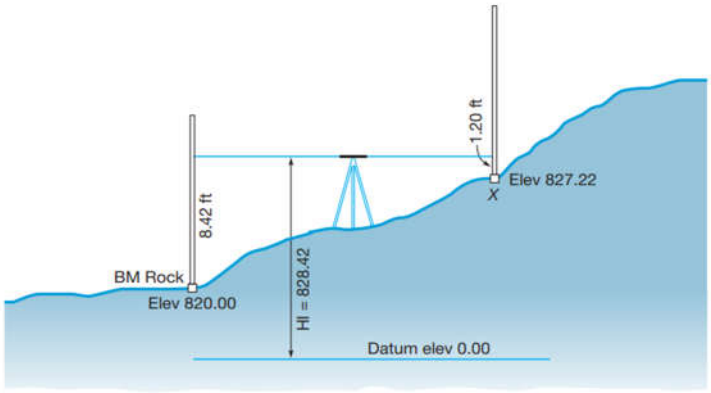
Elevation – For a particular point, its elevation is the vertical distance above or below mean sea level or any other selected datum. Points on or near the surface of the earth have either positive or negative elevations, depending if the point is above the or below mean se level.

Difference in Elevation - The difference in elevation between two points is the vertical distance between the two level surfaces in which the points lie.



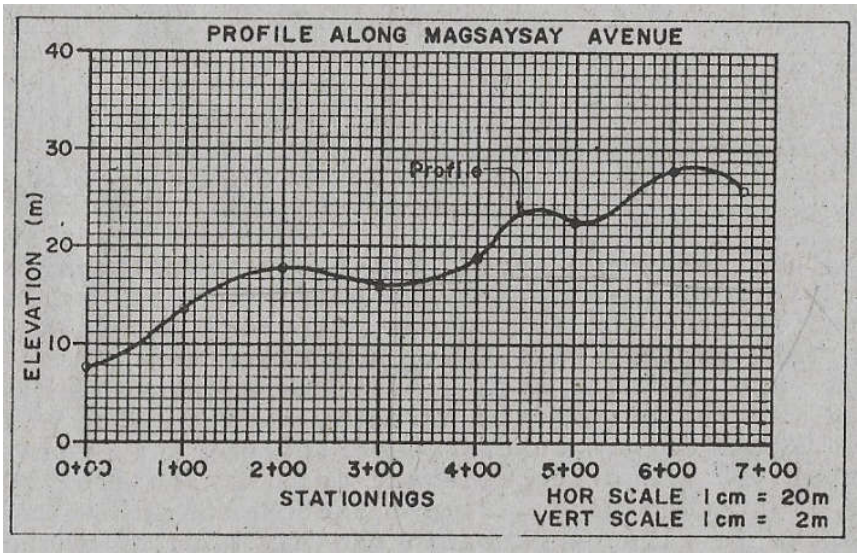
LEVELING METHODS

Direct or Differential Leveling - Direct leveling is the commonly employed method of determining the elevation of points some distance apart by a series of set ups of a leveling instrument along a selected route. In direct leveling, vertical distances are measured above or below a level line and these values are used to compute the elevation of points or their differences in elevation.



STA	BS	HI	FS	ELEV
BM_1	1.256	128.389		127.133 m
TP_1	1.116	127.619	1.886	126.503
TP_2	1.228	127.320	1.527	126.092
BM_2	1.189	126.263	2.246	125.074
BM_3	1.070	125.316	2.017	124.246
TP_3	1.831	124.491	2.656	122.660
BM_4			2.765	121.726

Profile Leveling – This method of leveling is used to determine differences in elevation between points at designated short measured intervals along an established line to provide data from which a vertical section of the ground surface can be plotted. In design of roads, railroads, canals, drainage systems, and transmission lines, it is necessary to first obtain a profile of the existing ground surface.



STA	BS	HI	FS	IFS	ELEV
BM_a	0.95	126.45			125.50m
0 + 00				3.0	123.5
+ 10				2.3	124.2
TP_1	3.13	128.94	0.64		125.81
0 + 22				2.7	126.2
+ 30.5				2.8	126.1
+ 34.2				3.1	125.8
+ 39.3				0.5	128.4
+ 42.5				0.8	128.1
TP_2	2.16	129.82	1.28		127.66
+ 45				0.9	128.9
+ 48.6				1.2	128.6
+ 50				1.7	128.1
+ 53.7				2.8	127.0
TP_3	0.82	128.27	2.37		127.45
TP_4	1.35	126.12	3.50		124.77
+ 75				3.0	123.1
BM_b			1.99		124.13

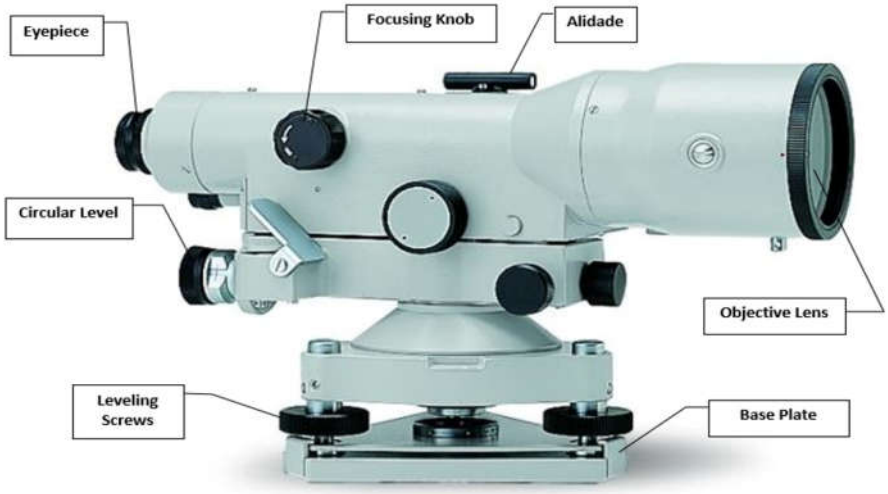
Trigonometric Leveling – This method of leveling is employed in determining by trigonometric computations the difference in elevation between two points from measurements of its horizontal or slope distance and the vertical angle between the points. The required distances are usually obtained by stadia, triangulation, or by direct taping.

Stadia Leveling – Stadia leveling combines features of direct leveling with those of trigonometric leveling. It can provide reasonable accuracy for preliminary surveys, mapping, and rough leveling where quick measurements are needed. In stadia leveling, differences in elevation between points are computed from observed vertical angles and the three intercepts on a rod held at each point backsighted and foresighted.

Barometric Leveling - Barometric leveling involves the determination of differences in elevation between points by measuring the variation in atmospheric pressure at each point by means of a barometer. This leveling method depends on the basic principle that differences in elevation are proportional to the difference in atmospheric pressure.

TYPES OF LEVELING INSTRUMENT

There are various types of instruments used in leveling work.



Dumpy Level – the dumpy level shown in the figure is the most widely used direct leveling instrument. It has a long telescope which is rigidly attached to the level bar. The telescope, which can be rotated through 360 degrees, fixes the direction of the line of sight. Attached to the level bar is a level vial which always remains in the same vertical plane as the telescope.

Wye Level – The wye level is very identical to the dumpy level. The only distinct difference between these two instruments is in how their telescopes are attached to the supporting level bar. The wye level has a detachable telescope which rests in supports called wyes.

Fig. No. 7.—WYE LEVEL No. 2.

Builder's Level – The instrument is used primarily in the different phases of building construction where a high degree of precision is not a primary requisite. Engineers, architects, and builder use it in the setting of concrete forms, batter boards, and in establishing grades for earthwork.

Automatic Level – Self – leveling features are incorporated in automatic levels. This type of level has become popular for conventional leveling work because of the ease and speed of their operation. It does not use a level vial and its ability to level itself depends upon the action of a complex pendulum and prism device.

SOURCES OF ERRORS IN LEVELING

The accuracy of leveling work may be affected by numerous factors. However, it is not difficult to obtain accurate and precise measurements in leveling as there are different safeguards which could be taken against expected errors and mistakes. Accuracy in leveling operations is primarily influenced by the type of instrument used.

Instrumental Errors - These errors are attributed to imperfections in the instruments either from faults in their manufacture or from improper adjustment. In leveling work instrumental errors are usually due to a defective tripod, a leveling rod not of standard length, or when the instrument used is out of adjustment.

a. **Instrument Out of Adjustment –** The most common instrumental error is caused by the level being out of adjustment. Particularly significant is when the line of sight of the telescope is not parallel to the axis of the level vial.
b. **Rod not standard length –** It is possible to have inaccurate graduations or divisions on a rod. This is usually due to imperfections in their manufacture. Inaccurate rod graduations can cause errors in measured vertical distances similar to those resulting from incorrect markings on a tape.
c. **Defective Tripod –** The movement of the level due to the settling of the tripod legs can cause possible errors in leveling work. The tripod usually settles in soft ground or due to vibrations caused by passing vehicular traffic. It is important to always set up the tripod rigidly as this can lead to erroneous measurements and waste of time.

Personal Errors – Although personal errors occur largely due to limitations of the senses of touch, sight, or hearing of individuals, the skills, training, and teamwork of the members of a leveling party are also major factors to be considered. Personal errors are usually caused by erroneous manipulations and careless handling of instruments when making observations.

a. **Bubble not centered –** Rod readings will be in error when the bubble is not centered in the level vial. The magnitude of the error depends on how sensitive the vial has been designed. There are various conditions in the field which may cause the bubble not to remain centered.
b. **Parallax –** if a pre sure gauge or any graduated circular meter is viewed from different angles, one will notice that a number of slightly divergent values could be read. This is due to the effect of parallax. However, if the pointer and scale of the gauge were positioned at exactly the same plane, parallax would be totally eliminated.
c. **Faulty Rod Readings –** the instrumentman at times may misread the number of meter and decimalswhen taking a rod reading. An incorrect rod reading is usually the result of the length of sight, poor weather conditions, and the skill of the instumentman and the rodman.
d. **Incorrect setting of target –** It is important to always handle the leveling rod carefully. The rodman at times fails to set properly the target when a high rod reading is made with it. During use, the target may slip downward because it is not clamped firmly at the exact position signaled by the instrumentman.

Natural Errors – These errors which are due to natural sources and could not be totally removed but their effects can be reduced by applying corrections and using good judgement.

a. **Curvature of the Earth –** The effect of curvature of the earth is to increase the rod reading. From this source the error amounts to about 0.07cm per 1000 meters. This error is introduced even if the instrument used is in perfect adjustment. It, however, only occurs in extra long sights and when backsight and foresight distances are not made equal.
b. **Atmospheric Refraction –** The presence of heat waves on a hot day is a sign of rapidly fluctuating refraction in the atmosphere. Reading errors are likely to occur when heat waves are present since it makes the rod appear unsteady when a sight is taken on it. Sinc ethe refraction is usually larger when sights are taken close to the ground surface, the line of sight should be established at least one meter above the ground.
c. **Temperature Variations –** Changes in temperature causes leveling rods to either expand or contract and these could introduce errors when taking rod readings.
d. **Wind –** A strong wind can shake a leveling instrument making it difficult to center the bubble in the level vial. It can also exert sufficient amount of force to cause an extended rod to vibrate making it stand unsteady and hard to read or plumb.