Comparing Elevation Accuracy: GNSS Positioning Systems and Conventional Leveling Approaches

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ABSTRACT

The paper includes the study of the accuracy of the measurement of heights and levels of points on the surface of the earth using the Global Navigation Satellite System (GNSS) to study the possibility of replacing the Conventional Method (CM) which is one of the most cost-effective and requires a lot of time, effort and cost. GNSS monitoring made a qualitative development in the implementation of cadastral work. The three dimensional coordinates of Y, Z and X is obtained for points on the surface of the earth directly and with acceptable accuracy. These coordinates are calculated on the surface of the reference Ellipsoid (WGS-84). However, the heights used in all surface and mapping work are calculated from the mean sea level (MSL) and this surface is not compatible with GNSS measurements. To convert the measurement of altitude between the reference surfaces mentioned above, it is necessary to know the difference between the height of the geoid (h) and the height of the ellipsoid (H) at the point of measurement required. This difference is called Geoid Undulation and is denoted by (N).

Geoid elevations are taken from the Global Geoid Models (GGM) available on the Internet. Such as the Global Geoid Model (EGM2008) currently used to improve the accuracy of the height measurement results by (GNSS). However, the accuracy of these models does not suit the precision work of engineering projects. The possibility of raising the accuracy of the numerical separation calculus (N) was carried out by creating additional field observations in the limited area of work and calculating the Local Geoid Model (LGM) and thus raising the accuracy of the measurement results of the height of the satellite system.

KEYWORDS: GNSS - Measurement accuracy - Conventional leveling - Positioning.

I. INTRODUCTION

The Global Navigation Satellite System (GNSS) allows the user to obtain the components of the spatial coordinates of the location (X, Y, Z) of the site. These are Geocentric Coordinate coordinates whose center is the center of the earth and its axes are aligned with the earth during its rotation, (Δx, Δy, Δz) between two points.

From these measurements, the spherical geometrical coordinates (φ, λ, H) can be calculated on the Ellipsoid or coordinate difference, ($\Delta\varphi$, $\Delta\lambda$, ΔH) and vice versa.

In spite of the large expansion in the use of positioning techniques in the satellite system in the survey and geodesy works, including the applications of engineering survey construction, the measurement of heights and levels by Conventional methods, especially the exact, such as Direct Leveling method Optical or digital methods, as well as trigonometric leveling using Theodolite or Total Station, are still prevailing in the settlement work in the implementation of engineering projects and scientific studies that require high accuracy for arithmetic. These Conventional methods need time, efforts .Their cost effective is high compared to GNSS techniques, which give high precision when measuring the horizontal position of the point (X, Y). However, the vertical position of this point is not exactly the required accuracy. GNSS vertical measurements, the study of the reasons for the low precision of the system and the possibility of reaching the accuracy of Conventional methods of settlement are the subject of this research.

II. Modern techniques in Measurement of heights

There is a perception among specialists that the availability of GNSS dual-frequency receivers for level and geodesy, as well as the use of accurate observation methods and techniques and specialized meteorological analysis, can be approximated to the same accuracy as conventional methods. However, achieving this goal still requires many scientific studies and experiments. GNSS measures the height of the point from the Earth's ideal mathematical surface, the Reversion Ellipsoid. This reference is not constant and its component values are checked with the evolution of observing devices and methods.

GNSS is attributed to the surface of the ellipsoid not to the natural surface of the earth, is called Geodetic or Ellipsoid Height. The elevations and levels used in all the works of the area and the maps are measured from the level of the comparison surface Mean Sea Level (MSL) The level of the sea at a certain point is obtained from the Conventional settlement work. These elevations and levels are called Orthometric Heights or Geodetic

Height relative to the Geoid surface, which is also an imaginary surface equivalent to the level of sea level in the seas and oceans. The rest state extends the surface difference between the two types of heights is called Geoid Undulation (N): the value by which the surface of the geoid has deviated from the surface of the ellipsoid.
If we want to calculate the level of a point on the surface of the earth measured by the GNSS system, we must know the value of the geoid diffraction at this point. In order to obtain a precise value for the geoid (N), there must be a precise model of the Global Geoid Model (GGM) for its calculation. There are several models for Global Geoid. The US Department of Survey has launched the latest (EGM2008) model, which is available for all through the Authority Internet site. The accuracy of this model (35 - 25 cm) means that the value of (N) contains this error and therefore the required level of the point will be different from its actual level in tens of centimeters. In many cadastral applications, this accuracy is not appropriate, but this method is free and the accuracy of the N value can be increased by making additional spatial observations in the required area and calculating the Local Geoid Model (LGM) to reach the accuracy of several centimeters.

III. Leveling Surfaces: attributed elevations and levels

In general In Geoscience and Geodesy science, engineers deal with the implementation and the processing of meteorology with three types of reference surfaces:
• Topographic Surface: the real form of the earth and the weather, this surface is winding and irregular. Cannot be represented by mathematical equations and therefore cannot be necessarily based for calculations.
• The surface of the ellipsoid: an imaginary mathematical surface that is closest to the shape of the earth but does not fully apply to it. This surface cannot be measured and used only for calculations.
• Geoid surface: is equivalent to the average sea-ocean level in the case of stillness and extends in the land under the continents and the thread of gravity (the direction of gravity) perpendicular to any point in which this surface cannot be calculated and measured. It can be obtained as a result of a set of measurements Geodetic as a reference for the calculation of elevations from the sea surface in Fig. 1 Explanation of the three reference surfaces.

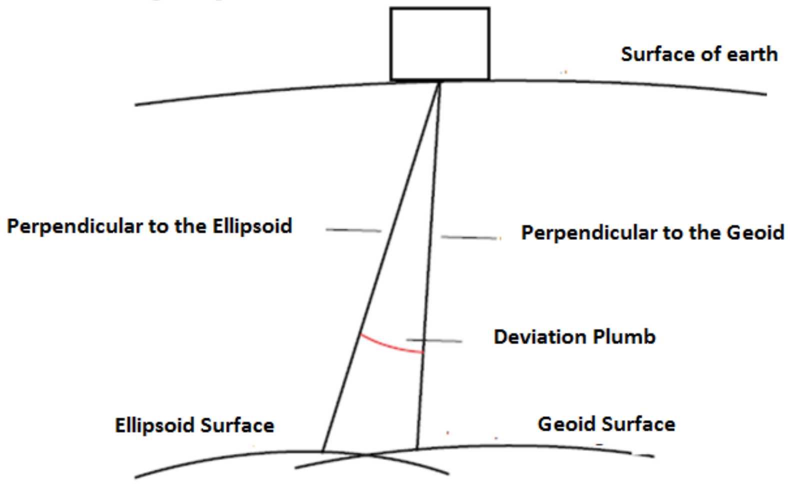

Figure 1: The reference surfaces and the deviation of the Plumb

The surface of the geoid is the reference surface for the measurement of altitudes above the mean sea level (MSL). These elevations are called Absolute Heights and are usually obtained from conventional settling works and when elevations are attributed to another reference level called Relative Heights.

The surfaces of the settlement are physical surfaces whose definition depends on the direction of the thread of gravity. It's called the direction of gravity. They are usually replaced by mathematical surfaces:
The surfaces of the small spherical Ellipsoids or compensated with spheroid balls, when working in relatively small areas, the surfaces can be considered horizontal or balls and the distance between the surfaces of two parallel levels is constant. In this case, we can deduce the following properties:
• All points on one level surface have the same level.
• The two-point difference is the vertical separator between the Marin settlement surfaces with the two points.
• The difference between absolute height and relative elevation are constant, the vertical distance between the two surfaces of the settlement.

IV. Reference measurements in GNSS

When the surfaces of the settlement are considered the Ellipsoids, the distance between them is not equal, inversely proportional to the direction of the force of gravity. as well as when considering the surfaces of the settlement according to the physical concept and the above properties are not achieved, the levels of points on the surface of the settlement One is unequal. GNSS measured in the World Reference Geodetic System (WGS-84) as a reference surface of measurements. The altitudes above the sea level obtained from the Conventional settlement start from the Benchmark (BM) point where the average sea level is measured for a long period of time (several years) and used as a reference for the work of level networks within the country (In Yemen e.g., Al Hudaydah and Aden cities). The national level networks are then intensified to local networks at the governorate level, the Directorate and so on, so that each specific area has the sufficient number of secondary reference points. Fig. 2 shows altitude and geoid levels.

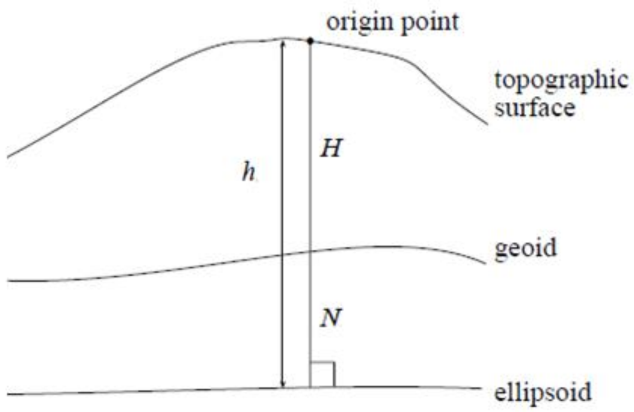

Figure 2: Elevation types and geoid diffraction

V. Traditional Leveling Methods

The level of a point can be measured by the difference in height between this point and another point with a known (or assumed) level, and this difference is algebraically added to the known or assumed level, this is done in several ways:

i. **Differential or Geometric Leveling**:

The Optical Level or Digital Level is used and varies in its accuracy from normal to medium and accurate. In this type of adjustment, the device is placed in the middle of the distance between the two points. The known point of level A and the unknown point of level B and the reading is taken on the two positions and the difference is calculated as the difference for the readings as in Figure 3.

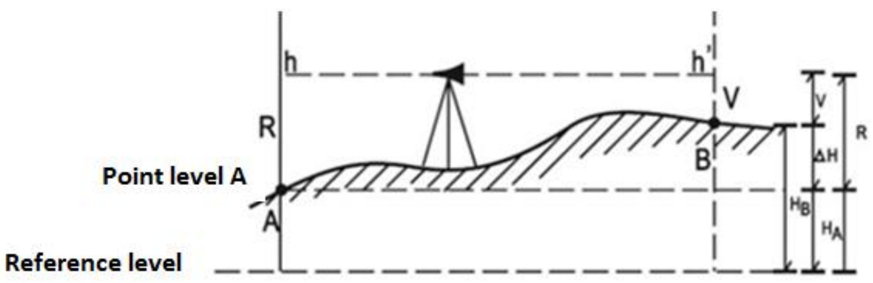

Figure 3: Differential settlement

Difference between the two points: $\Delta H = R - V$

Point level required: $H_B = H_A + \Delta H$ …………………….... (1)

Differential settlement is the most accurate among the traditional methods, but it is limited in its use in terms of dimensions and topography. The main disadvantages of differential settlement can be summarized in the following:

• The need to use the Staff and the associated errors in the dimensions and the reflection of these errors on the results of the calculation of levels.
• The difference between the reference point and the required point is limited and cannot exceed 2.4 - 2.8 m.
• There must be a requirement of easy access to all the points required to put them upright.

ii. Trigonometric Leveling

In this method, the two-point height difference is calculated by measuring the vertical angle of the two-point line between the two points of the theodolite or total station and measuring the Slope distance or horizontal distance or the line connecting the two points as Figure 4. The difference between the two points is calculated by the equation:

$h = d * \tan(v) + f$ ………………….. (2)

The previous equation requires that the height of the device (hi) equals the height of the reflector or the pillar (ht). If this condition is not available, equation (2) is as follows:

$h = d * \tan(v) + (h_i - h_t) + f$ ....(3)

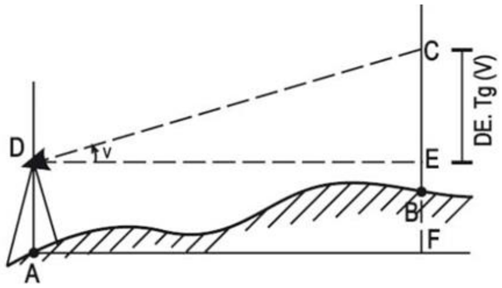

Figure 4: The settlement trigonometric

Where:
d - Horizontal distance between the two points
f - Correlation coefficient of the spheres earth and its value is calculated when the distance between the two points exceeds (300m) by the following equation:
$f = 0.42 * d/R$ Where: R - radius of the earth (6378 km).
To increase the accuracy of the results of the settlement, the measurement shall be repeated twice, back and forth again, but the difference shall not exceed: (± 0. 04 * D). The distance (D) here is expressed in hundreds of meters (e.g. 150m taken 1.50)
Trigonometry is a more flexible method of geometric settlement where it can be used in mountainous terrain and for longer distances and at the expense of hard-to-reach point levels, which are normally monitored in the way of the intersection or the resection. One of the main drawbacks of a trigonometric settlement is that the measurement of the vertical angles required to calculate the planes is usually less accurate than the measurement of the horizontal angles where additional conditions are needed to determine the vertical axis and the scoring is also a single one (medium) and may not be fully applicable to the target.
The modern Total station equipment such as (Sokkia-Setx2) provides vertical angle measurement at (2" sec) and measures the distance up to (500 m) without the reflector and precision $md = (3 + 2*10^{-6} D)$. From the experiments, it was found that the accuracy of the trigonometric settlement reaches (mh = 0.4mm) for the distance (D = 60 m).

iii. Accuracy Of Conventional Leveling

The accuracy required to calculate the levels of the points depends on the traditional methods of the importance of the project to be implemented and the types of devices available. The settlement works shall be applied to roads, railways, channels, and sewers. All projects that require the embodiment of the paths on the ground according to specific tendencies related to the topography. The earthwork of drilling and embankment and the creation of topographic and cartographic maps that show the terrain in an area on the surface of the earth.
The leveling work is rated in accuracy to four degrees. The first and second degrees are highly accurate and are usually used in the work of ground geodetic constants, scientific studies such as monitoring the changes of the crust and some geophysical studies. The third and fourth degrees are used for engineering works in construction,

infrastructure projects, in monitoring the deformities (Landing and displacement) and Large and important existing such as bridges, tunnels, high buildings, airports, and others.
Some engineering works which do not require high accuracy, normal leveling is used. Table 1 provides an explanation of the degree of settlement and accuracy expected of each grade as well as the permissible error for each grade.

Table1 the Class of Settlement

Class of Settlement	Average square error MSE (mm)	The allowed error for each 1km (mm)	Number of meteorological courses
Settlement Class I	**0.50**	$\pm 3\sqrt{L_{km}}$	**2 (Round-trip)**
Settlement Class II	**0.80**	$\pm 5\sqrt{L_{km}}$	**2**
Settlement Class III	**1.60**	$\pm 10\sqrt{L_{km}}$ or $\pm 2.6\sqrt{n}$	**2**
Settlement Class IV	**6.60**	$\pm 20\sqrt{L_{km}}$ or $\pm 5\sqrt{n}$	**1**
Ordinary settlement (Technology)	**16.60**	$\pm 50\sqrt{L_{km}}$	**1**

Where: L- is the length of the settlement line in kilometers.
If the number of stations (n) per kilometer is more than 15 stations, $n \geq 15$ you can use the number of stations instead of the length of the line.

iv. Measurement of Elevations with GNSS System

The term GNSS is a relatively recent and the predominant was the GPS system, which is the US system. After the entry of the Russian system GLONASS and the European GALILEO came into operation, a common label was launched for all GNSS systems. The user was able to use all the satellites of these systems one time when reception signals are received by receivers, especially in which the global reference for measurements is standardized and it is WGS-84 (World Geodetic System 84). The basic principle of the operation of the system is the measurement of distance between the receiver antennas installed at a point required to locate its location (unknown) and between the satellite known location and high accuracy (Satellite Positions, by knowing the distance to several satellites (at least four)). The satellites of this system are at a height of 20,200 km, which takes the satellite signal to pass it (0.06") of a second. When using GNSS (Geostationary System), specialized frequency monitoring devices (Dual Frequency Receiver L1, L2, L2c) are called "Survey Mode GNSS System" , used in geodesic work such as constants Horizontal control of various levels and the monitoring of the movement construction (Deformation monitoring) , the topographic mapping, the Cadastral, construction survey ...etc.
These devices provide relatively high accuracy ($\pm$ 3mm + $1*10^{-6}$ D). where D is the distance between the reference point and the observed point. This accuracy is for horizontal coordinates (X, Y). For the height difference between the two points, the average square error (MSE) is about (10 - 30 mm) and can increase by increasing the distance between the points to tens of kilometers. The accuracy of GNSS horizontal measurements is greater than the height measurement accuracy. This property is one of the most important defects of satellite monitoring.
From all of the above, it can be concluded that high altitude measurement in the satellite system is theoretically and practically still an urgent scientific issue to be achieved, given the great advantage in terms of saving time, effort and money compared to traditional settlement methods.
The reasons for the low accuracy of GNSS height measurements are not yet fully known to the specialists, but there is a widely held, scientifically uncertain view that the reason lies in the properties of the geodetic rise and the arithmetic elevation. The geodetic coordinates obtained by GNSS are binary (φ, λ) which depend on ellipsoid as a reference, whereas the elevation, which is the third coordinate (h) above sea level, is geoid as a reference. In order to raise the accuracy of the measurement of altitudes in the satellite system, there must be a precise model of GGM.

VI. Global Geoid Models

The scientific bodies specialized in geodetic surveying and geological measurements such as astronomical observations, gravity measurements, meteorology (GNSS), satellites and others in all regions of the world and into specialized programs for the development of Global Geoid Models (GGM). The GNSS system depends on one of these models, where the programs calculate the percentage of points observed based on this model. It is necessary to know the accuracy of the model used to estimate the accuracy of the height measurement. Some of the most currently and freely available user models are on the ICGFM website:

http://icgem.gfz-potsdam.de/ICGEM/ICGEM.html is:

- Model (EGM 96) provides raising accuracy up to (± 40 cm).
- Model (EGM 2008) (the latest) provides accuracy up to (± 25 cm).

When one of the previous models is used to compute the arithmetic heights and heights of the points, the error in the value of the height or relative is within the specified accuracy limits of the model. Therefore, global geodesic models cannot rely solely on geodetic and geodetic applications, but additional observations and measurements are made in the work area. The EGM 2008 model developed by the USGS is a huge development of global geoid models, where the resolution is high and the average geoid height is calculated for 9.2 km2. This model is available on : http://earth-info.nima.mil/GandG/wgs84/gravitymod/egm2008.
For the application of the Global Geoid Model (EGM 2008) to calculate the geoid diffraction (N) at any point on the Earth's surface, there are several methods and programs that can be obtained from the USGS website or using a small program (7M) prepared by a German engineer. The program (Altrans EGM2008) is available in the Internet and can be downloaded from : http://www.allsat.de/download/Software/ALLTRANS/alltranse.
Geodetic coordinates or (coordinate file) are inserted into points in the form of (φ , λ , H) the program calculates the value of the geoid diffraction N at this points and then this difference can be added to the geodetic height to obtain the arithmetic height of the point or points according to the famous equation:
h = H – N …………(4)
Where:
h- Height Orthometric.
H- Height Geodetic.
N- Height of the geoid (geoid diffraction).

i. Calculation of Heights by GNSS

Geodetic height is calculated by the following equation:

$$H = \frac{R}{cos\varphi} - N \dots\dots\dots\dots\dots\dots. (5)$$

Where: $R = \sqrt{x^2 + y^2}$

This equation is valid and suitable for calculation of elevations in the Southern Hemisphere regions where latitude ($\varphi < 60^{\circ}$).
In the northern regions, the following equation is used:

$$H = \frac{Z}{sin\varphi} - (1 - e^2)N \dots\dots\dots\dots\dots\dots\dots\dots\dots.. (6)$$

In the middle regions in terms of Latitude one can be used one of the previous equations.
To calculate the expected accuracy of the two-point height difference (reference and unknown), it is necessary to know the accuracy of the coordinates of the reference point. This accuracy is the main effect of the average square error (MSE) of the height difference (H).
The average squared error in coordinates (absolute) reference point averaged = ±5 m
The average squared error in the coordinate teams (relative) between two points along the base line between the two points as in Fig. 5 = ±5 mm.

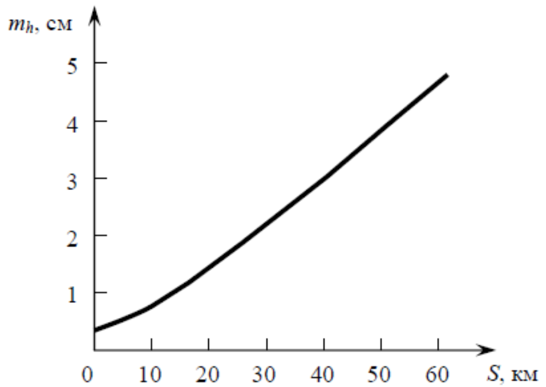

Figure 5: Relationship between base line length and average squared error

The average square error value for the two-point difference can be calculated from the following relationship:

$$m_h = \sqrt{\frac{S^2}{R_3^2} m_k^2 + m_\Delta^2} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots .. (7)$$

Where:

m_k - Average square error of reference point.

$m_y = m_x = m_\Delta$ - Average squared error of coordinate's difference.

$m_h -$ Average squared error of the difference between reference point and unknown point (on geoid).

S- The distance between the two points.

R_3 - Average Earth Radius.

VII. Experimental Work

The observations of the conventional methods and the GNSS system were conducted in 2009 at the Moscow State University of Geodesy and Cartography (MIIGAIK) on three points in a triangle shape as shown in Fig. 6. The appropriate geometric shape was chosen so that we could adjust the corrections for some elements. This research, finding is concerned with the difference in height and the point of starting is the point (2) where it is consider the level of zero. Measurements of the traditional methods are calculated by the vertical difference on the geoid surface and the GNSS height measurement is also calculated as the vertical difference on the surface of the ellipsoid. Since geoid and ellipsoid are different legal surfaces, the vertical elevation on each of these surfaces are going to be different from the other at each point on the surface of the earth. This is called vertical deviation.

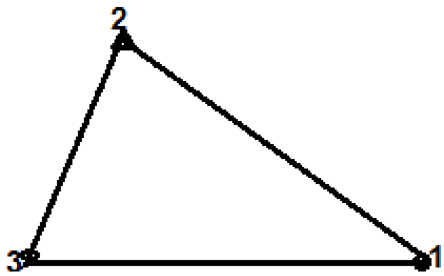

Figure 6: The experience points of measurement

The difference in height difference between the two points in both cases depends on the value of the deviation of the distance between the two points and equals the value of the vertical deviation of the lines in the work area, the distance between the two points. In the current experiment, the maximum distance does not exceed (30 m) and the value of the vertical deviation of the poles in the city of Moscow does not exceed (8 ") seconds and the result of beating them will be small by (1 mm), can be neglected and consider the difference in height in both ways equal.

VIII. Traditional measurements and results of calculations

To implement the conventional settlement, the digital Level DINI 10, the two Total Stations, Leica TCR and Pentax325N terminals are used. Through measurements with traditional instruments, are obtained the inner angles of the triangle, the lengths of the ribs and the difference between points. When we use the GNSS system to assign the coordinates of the three points, we obtain a free triangle and therefore the calculated angles of the heads of this triangle will be at values different from the angles measured by conventional devices. We calculate the angles between directions (1 - 2) and (1 - 3) using traditional measurements, such as we created the quadratic coordinates of the local system, where we make the starting point of the coordinates (O) and the axis (YOZ) passing point 3. Thus, using the algebraic equations we obtained the results shown in Table 2. The coordinates of the points in the local reference are shown in Table 3.

Table 2 Results of conventional measurements

	Horizontal angles	Corrected horizontal angles	Level difference, m		Corrected Level difference m	Slope distance, m	
1α	**22° 45′ 22.6″**	**22° 45′ 16.7″**	**1 – 2**	**-0.5405**	-0.540	**1 – 2**	**19.065**
2α	**126° 02′ 29.2″**	**126° 02′ 23.7″**	**2 – 3**	**+0.0063**	+0.006	**2 – 3**	**14.222**
3α	**31° 12′ 25.5″**	**31° 12′ 19.6″**	**3 – 1**	**+0.5344**	+0.534	**3 – 1**	**29.745**
	∑=180° 00′ 00.0″	∑=180° 00′ 17.3″		∑= **-0.2mm**	∑= **0**		

$f = +17.3''$ $fh = -0.2\ mm$

Table 3 Point coordinates

Point	X,m	Y,m	Z,m
1	-11.213	15.410	0.540
2	0	0	0
3	14.222	0	0.006

By using the X, Y, Z spatial coordinates of the points we calculated the lengths of the measurement lines (radians) and the angles between them. The difference in height was taken from the results of the ground measurements. In these calculations (Table 4) we obtained the values that are going to be used for comparison later.

Table 4 GNSS measurements calculated by equations from conventional measurements

Line	Vector Coordinates	Slope distance, m	Level difference, m	Angles between Vectors
1 – 2	(11.213, -15.410, -0.540)	19.065	-0.540	$_{1}\alpha$ $22^{c}\,45'\,01.0''$
2 – 3	(14.222, 0.000, 0.006)	14.222	+0.006	$_{2}\alpha$ $126^{c}\,01'\,25.4''$
3 – 1	(-25.435, 15.410, 0.534)	29.745	+0.534	$_{3}\alpha$ $31^{c}\,13'\,33.6''$
			$\sum = 0$	$\sum = 180^{c}\,00'\,00.0''$

3.1 GNSS Measurements

Using the Leica GNSS device, two modes were observed: the dynamic survey and the static survey. The dynamic method is characterized by fast monitoring and direct access to results. The static method in which the receiver is fixed over the triangular carrier and is stationed on the observation point for a period of time not less than 30 minutes. This method is characterized by high accuracy compared to the dynamic way. The results of measurements in the dynamic method are shown in Table 5 and in the static method in Table 6.

Table 5 GNSS measurements are observed in the dynamic method

Line	Vector Coordinates	Slope distance, m	Level difference, m	Angles between Vectors
1 – 2	(4.254, -16.015, -0.540)	19.139	-0.518	$_{1}\alpha$ $22^{c}\,58'\,14.9''$
2 – 3	(11.920, 2.213, -7.340)	14.172	+0.002	$_{2}\alpha$ $125^{c}\,13'\,26.4''$
3 – 1	(-16.174, -18.228, 16.918)	29.666	+0.516	$_{3}\alpha$ $31^{c}\,48'\,18.7''$
			$\sum = 0$	$\sum = 180^{c}$

Table 6 GNSS measurements are observed in the static method

Line	Vector Coordinates	Slope distance, m	Level difference, m	Angles between Vectors
1 – 2	(4.373, 15.952, -9.565)	19.107	-0.518	$_{1}\alpha$ $22^{c}\,42'\,20.1''$
2 – 3	(11.905, 2.303, -7.380)	14.195	+0.002	$_{2}\alpha$ $125^{c}\,59'\,28.4''$
3 – 1	(-16.278, -18.255, 16.945)	29.755	+0.516	$_{3}\alpha$ $31^{c}\,18'\,11.5''$
			$\sum = 0$	$\sum = 180^{c}$

The results of comparison between conventional measurements and GNSS (dynamic and static) measurement of several elements (distance, angle, and height difference) in Table 7 and 8

Table 7 Comparison between GNSS dynamic and CM

Parameter	Result of conventional measurements	Result of GNSS measurements	Differences
Slope distance			
1 – 2	19.056 m	19.139	74 mm
2 – 3	14.222 m	14.172	50 mm
3 - 1	29.745 m	29.666	79 mm
Angles between Vectors			
1α	$22^{c}\,45'\,01.0''$	$22^{c}\,58'\,14.9''$	$13'\,13.9''$
2α	$126^{c}\,01'\,25.4''$	$126^{c}\,13'\,26.4''$	$48'\,19.0''$
3α	$31^{c}\,13'\,33.6''$	$31^{c}\,48'\,18.7''$	$34'\,45.1''$
Level difference			

H**1-2**	-0.540	-0.518 m	22mm
H**2-3**	+0.006	+0.002 m	4mm
H**3-1**	+0.534	+0.516 m	18mm
Maximum differences: ΔD=79 mm	**Δα**=48′ 19.0″		Δh=22mm

Table 8 Comparison between GNSS static and CM

Parameter	Result of conventional measurements	Result of GNSS measurements	Differences
Slope distance			
1 – 2	19.065 m	19.107 m	74 mm
2 – 3	14.222 m	14.195 m	50 mm
3 - 1	29.745 m	29.755 m	79 mm
Angles between Vectors			
1α	22ᶜ 45′ 01.0″	22ᶜ 42′ 20.1″	2′ 40.9″
2α	126ᶜ 01′ 25.4″	125ᶜ 59′ 28.4″	1′ 57.0″
3α	31ᶜ 13′ 33.6″	31ᶜ 18′ 11.5″	4′ 37.9″
Level difference			
H**1-2**	-0.540	-0.497 m	43mm
H**2-3**	+0.006	-0.023 m	29mm
H**3-1**	+0.534	+0.520 m	14mm
Maximum differences: ΔD= 42 mm	**Δα**=4′ 37.9″		Δh=42mm

From the results of the measurements of the different elements, including the height difference, it was found that the differences were greater than expected. However, it cannot be confirmed that GNSS measurements are less accurate than conventional methods because the precision of conventional measurements is not guaranteed. Results the internal consistency between GNSS measurements can be determined in both dynamic and static methods, but it is difficult to determine which is accurate. In the area and geodetic there are no good measuring methods, good equipment, bad measurement methods or bad equipment, all the equipment and measurement methods are excellent, but the important is to know which devices and methods of execution are best suited for each work and here highlights the role of the engineer in determining the devices and the appropriate methods in each case.

IX. Conclusions and Recommendations

By studying the requirements and accuracy of the GNSS settlement and comparing them with traditional settlement methods, the following main conclusions can be summarized:

1- When measurements were made by conventional methods, the lock error of the height variation was $fh = -0.2\,mm$ and the length of the settlement line was $0.063\,Km$, that is, the accuracy of the measurements in a conventional way was the first-class settlement and the differences between conventional measurements and GNSS measurements as well as between the two GNSS methods were greater than expected and were 43mm and 21mm respectively.

2- Accuracy the measurements for the difference in height of the GNSS system we estimated based on the internal consistency. The difference between the results of the 21mm methods reaches almost to the accuracy of the fourth degree. But the Precision of these results is difficult to confirm compared to traditional measurements because the same traditional measurements cannot be trusted in precise absolutely.

3- In the survey and geodesy, there are no good and bad measurement methods as well as in cadastral devices. The important thing is to know which method of measurement and which devices suit the project required. Here, the role of the surveyor is highlighted by determining the appropriate equipment and measurement methods in each case.

X. Recommendations

1- The settlement cannot be dispensed with in traditional ways, especially in the precise leveling of degree (1st, 2nd, and 3rd). As for the work with the accuracy of the fourth degree, the GNSS can be used for the construction of topographic maps of the site and the construction of infrastructure projects, roads, water and sewage systems, power lines and other projects that are commensurate with the accuracy of this system.

2- In precise survey measurements, such as the settlement, we cannot rely on the accuracy of the global geoid models to calculate the value of (N), where the average square error of MSE reaches tens of centimeters. Additional geodetic measurements should be made in the work area by intensifying and monitoring reference points and thus obtaining a local Geoid Model. In this case, the (N) value can be accurately reached to several centimeters.

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XII. Abbreviations

B.M	Bench Mark
MSL	Mean Sea Level
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GLONASS	Global Navigation Satellite System
GGM	Global Geoid Model
LGM	Local Geoid Model
WGS-84	World Geodetic System 1984

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