

Volume computing using geodetic survey method: an approach emphasizing the search for better accuracy

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Keywords: Engineering survey; Geodetic survey; Quantity surveying

SUMMARY

Research has shown numerous studies in search of better accuracy for each type of project. The volume calculation is being used in studies, engineering projects such as road, mining companies, geological and civil works. In some volume calculations are determined in a simple, but determining the precise value of the volume would be determined by mathematical methods, it may be because of the difficulty of lack of knowledge or lack of proper technical software and hardware. Given the needs of engineering works on aspects of precision, time and cost, the volume calculation has shown the importance of developing algorithms and methodological procedures for determining the value quickly and with high precision. This paper aims to carry out a survey of volume calculation with high precision for both geodetic survey method will be applied. With the advancement of research developed with Surveying and Geodesy, show that progress is not far for the determination of these methods with accuracy in the calculation of volume. The acquisition of spatial data is as follows: survey using Total Station with the withdrawal method and irradiation processing in Sufer10 and AutoCad. On completion of the work will be a discussion about the method and procedures, in order to contemplate the details for obtaining and processing the data. The relevance of this work is based on the need to develop an accurate algorithm for the calculation of volume and that all projects that require engineering can use.

VOLUME COMPUTING USING GEODETIC SURVEY METHOD: AN APPROACH EMPHASIZING THE SEARCH FOR BETTER ACCURACY

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1. INTRODUCTION

Great are the human needs to measure, mark and quantify. Since ancient times humans feel the need to acquire data and through analysis of these data, can determine and make inferences, whether qualitative or quantitative. With the growth of research and engineering courses that involve precision measurements. Several researchers are working on designs in order to contemplate the data acquisition techniques to obtain accurate volume calculation. Thus, the science that deals with measurement technique are: Geodesic, Topography, Cartography, Photogrammetry and other.

The Topography this word comes from the Greek "Topus" (place) and "graphein" (description), so Topography means "Description of Place." Thus, topography is the science that deals with describing accurately the details in the existing natural and artificial surface. And this description is made via linear and angular measurements. And these in turn will determine the shape, size, and relative position of a particular portion of the earth regardless of the curvature resulting from its sphericity. (ESPARTEL, 1973)

The topography appears as an instrument for the implementation and monitoring of works, being one of the first to be held in the project. In terrestrial applications of the methods of measurements you can determine boundary of properties, topography, terrain detail and others.

The applications of the methods of ground based measurements of total station vary according to the need of the project and can be utilized for various engineering projects such as:

- Buildings in general, airports, docks, housing;
- Tunnels, bridges, viaducts;
- Drainage system, galleries, channels;
- Urban Planning, and agriculture among others.

This work seeks to determine through science Topography calculating volume of an object, performing the data acquisition and processing in Total Station software Sufer 10 and AutoCad and then comparing with the classic method with direct support for Mathematical formulas.

2. LITERATURE REVIEW

2.1. Topography

In these sub-items will be addressed following the definitions of topography, methods with total stations and local system adopted in this work.

2.1.1 Definitions of Surveying

The Geodesy is the science that is concerned with studying the shape and dimensions of the earth, including the Earth's gravity field. The geodetic surveys involving joint operations aimed at measurements and observations of the shape and dimensions of the Earth, so the Geodetic surveys are classified into three categories: High Precision Geodetic Surveys (National Level), Precision Geodetic (National Level) and Survey geodesic for Topographic (Local). And in Surveying operations that are intended for measurements in order to know the relative position of points on the surface of the earth relative to the plane of the horizon, ie, topographic horizon (approximately the radius of a circle of 10 km), IBGE(2010).

Therefore in this work it is geodesic survey for topographic (Local) to determine the coordinates of the volume of the objects of study.

The equipment typically used in topographic surveying are: beacons, sights, pickets or stakes, electronic level, theodolites, total stations, GNSS receiver.

2.1.2 Methods with total stations

The surveys are divided into two parts: The Planimetry, to worry about determining the plane coordinates and Altimetry, which determine the height or altitude of the points covered. This work will be handled from the planimetric and some of their methods of surveying, such as intersection and traverse the fore.

2.1.2.1 Traverse

The traverse is a widely used method for determining coordinates of points, especially for defining support points planimetric. A polygon is a series of consecutive lines which are known to the lengths and directions, obtained through field measurements.

The lifting is accomplished through a polygonal method pathway, covering up the contour of an itinerary defined by a series of points by measuring all angles and sides and an initial orientation. From these data and a coordinate of departure, it is possible to calculate the coordinates of all points forming this polygonal.

According JORDAN (1981) and the polygon are classified into three types:

Open: are known only the coordinates of the starting points;

Closed: are known coordinates of the points of departure and arrival, as they are the same points;

Framed: known are the coordinates of the points of departure and arrival points being different.

These last two types of polygonal enable error checking defechamento angular and linear.

2.1.2.2. The intersection Vante

It consists in determining points through the intersection of angles. These angles are obtained from the intersection of two stations strategically to facilitate targeted.

2.1.3. Location System

According to the Brazilian Association of Technical Standards in NBR 14.166 (1998, p.05), sets up Topographical Location System (Figure 01) as:

Representation system, in plan, the relative positions of points in a survey with a point of origin in geodetic coordinates known, where all angles and distances of their determination are represented in true greatness on the plane tangent to the reference surface (reference ellipsoid) the geodetic system adopted, the origin of the system, on the assumption that there is, in the area covered by the system, the coincidence of the reference surface with the tangent plane, without errors, resulting from the abstraction of curvature earth, exceeding the errors inherent in the operations of determining the topographical survey points, comprising the elements defined in Figure 01 and the elements described later in this chapter.

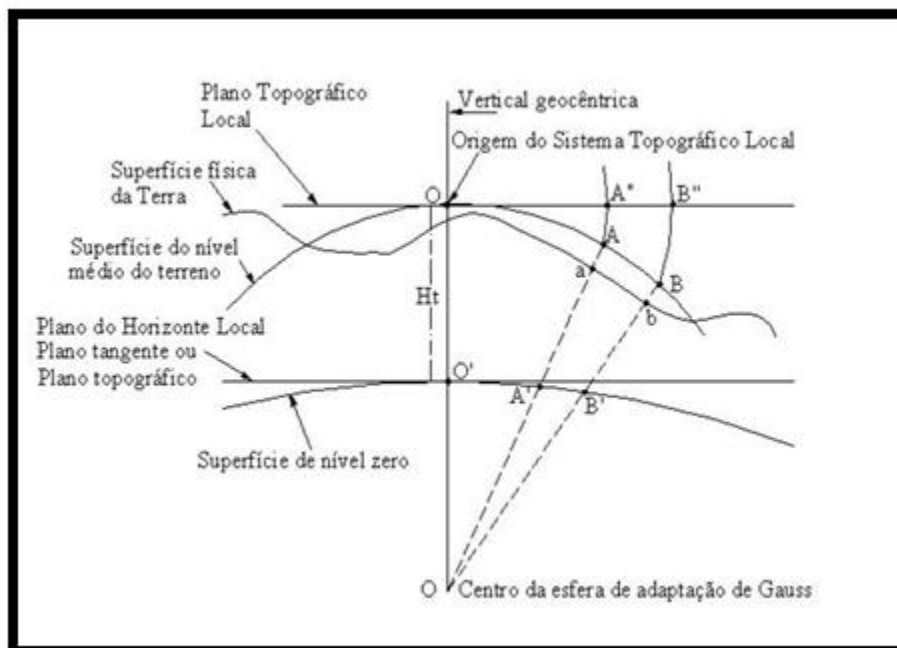


Figure 01 - Elements System Local Topographic.

SOURCE: (MARCOUZOS , 1997, p.41)

Where:

$A''O$: is the representation of the arc OA on the Topographical Location;

OB'' : is the representation of the arch on the OB Topographical Location;;

$A''B''$: the projection (representation) into true greatness of AB on the PTL;

H_t : average elevation of the land;

ab : distance between the inclined and b ;

$A''B''$: horizontal distance between A and B , and

$AB > A'B'$.

2.2 Volume Calculation

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There are numerous methods for determining volume. Why is this at all, mathematics, allows us to use procedures and techniques in solving problems in many different areas of knowledge. The volume can be determined by the product of the base area by height in turn, this base area depends greatly on the shape of the object.

$$V = S_b * H \quad (1)$$

V is the volume;

S_b is the area of the base;

H is the height.

For our objects of study, determining the volume will give by the following formulas:

CASE 1: Calculate volume of a water reservoir, $V = a * b * c$

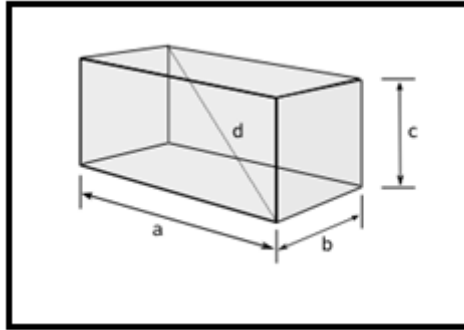


Figure 02: Parallelepiped shape of the water tank.

CASE 2: Ride of sand in the shape of half of a sphere, $V = \frac{4}{3} \pi r^3$

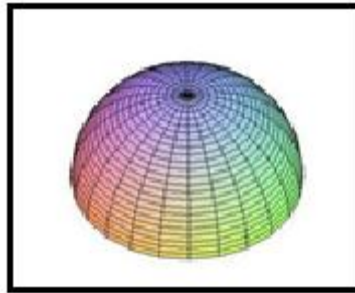


Figure 03: Model of a sphere

3. MATERIALS AND METHODS

3.1. Materials

The materials used for making the desired product of this study were:

- Total Station Topcon GPT 3205N
- Trena
- Prism
- Sony Camera photography
- *Software Topograph 98 e Surfer 10*

3.2. Methods

Based on the topographic area was achieved recognition of the study area, which was the water tank and the mountain of organic waste. Follow the following methodology.

3.2.1 Recognition of areas of study:

STUDY I:

The first case study was that reservoir which is applied the irradiation points using a total station, with a closed polygonal and trigonometric leveling. In order to obtain the points to make the data processing. The dimensions of the reservoir are: 1.255m, 0.73m 1.09me. Soon the volume is $V = 1.255 * 109 * 73 = 998,6035m^3$.



Figure 04: Water Tank

STUDY II:

The second object of study was a lot of organic waste. Photo was taken and calculated the weight and estimated value mathematically. As the model approximates to surface of a cap of a sphere using the formula, then the volume is $V = \frac{4}{3} \pi * (1.313)^3 = 9,4816m^3$ organic waste.



Figure 5: Monte organic waste

3.2.2 Planning Method

In areas of study was prepared in a closed polygonal each situation.



Figure 6: Areas of study with closed polygonal

3.2.3 Survey Points

With the acquisition of data by surveying methods were generated the following products:

- Polygonal location of areas I and II studies in Excel table;
- The share of polygonal areas of study I and II was from 10 meters;
- Digital Surface Model Surfer in the study area I and II;
- Comparison of the results of the methods applied.

3.2.3 Data Processing

The processing of data will be done in Excel, Topcongraph98 and Surfer 10 Software and digital surface models sites.

4. ANALYSIS OF RESULTS

By processing the data acquired in the field, the generated results were as follows:

4.1 Trigonometric leveling

In trigonometric leveling, was the instrument measures the height of the prism with the bat and were arbitrarily the initial quota of 10 m. Seen in the results table of trigonometric leveling held on September 15, 2012.

TABLE 01: Trigonometric Leveling From Area I

ESTAÇÃO	PV	ΔI	ΔP	Cota do inicio	ΔN	COTAS PONTOS
E1	E4	1,5	1,6	10	-0,100350242	9,899649758
	E2		1,6			

E2	E1	1,652	1,6	9,899649758	0,052184255	9,951834014
	E3		1,6			
E3	E3	1,65	1,6	9,951834014	0,049599758	10,00143377
	E4		1,6			
E4	E3	1,59	1,6	10,00143377	-0,0100396	9,991394173
	E1		1,6			

With the use of NBR13133 that sort in Class IIIN-trigonometric leveling for determining altitudes or quotas on polygonal lifting, lifting profiles for preliminary studies and / or feasibility projects and using an area of 100 m², which is reached to a range of between 0.00142 and 0.01897 error. As the trigonometric leveling had a discrepancy of 0.008605827 m, ie, in the house of a millimeter, and is within the range given.

TABLE 02: Trigonometric Leveling From Area II

		NIVELAMENTO TRIGONOMÉTRICO				
ESTAÇÃO	PV	ΔI	ΔP	Cota do inicio	ΔN	COTAS PONTOS
E1	E4	1,4	1,5	10	-0,100275036	9,899724964
	E2		1,5			
E2	E1	1,445	1,5	9,899724964	-0,117793833	9,781931131
	E3		1,5			
E3	E3	1,55	1,5	9,781931131	0,037629077	9,819560208
	E4		1,5			
E4	E3	1,53	1,5	9,819560208	0,178573789	9,998133997
	E1		1,5			

With the use of NBR13133 that sort in Class IIIN-trigonometric leveling for determining altitudes or quotas on polygonal lifting, lifting profiles for preliminary studies and / or feasibility projects and using an area of 100 m², which is reached to a range of between 0.00142 and 0.01897 error. As the trigonometric leveling had a discrepancy of 0.001866003 m, ie, in the house of a millimeter, and is within the range given.

4.2 Traverse

Study I: To make a local system was performed using a polygonal four (4) corners with the following names: E1, E2, E3 and E4. The angular and linear measurements were performed in conjunction with targeted direct and inverse of each point.

Table 03: Angles Horizontal, Vertical and Distances of Polygon I.

		HZ (PD)			V(PD)			SD(PD)
ESTAÇÃO	PV	°	'	"	°	'	"	m
E1	E4	0	0	2	89	20	1	8,167

	E2	96	36	43	88	38	57	3,905
E2	E1	276	37	7	88	37	47	3,907
	E3	351	48	18	89	4	49	8,083
E3	E3	170	3	59	89	23	20	8,078
	E4	281	1	7	88	10	47	2,799
E4	E3	136	11	2	88	9	58	2,794
	E1	213	26	0	89	39	1	8,168
		HZ (PI)			V(PI)			SD(PI)
ESTAÇÃO	PV	°	'	"	°	'	"	m
E1	E4	179	58	51	270	41	9	8,167
	E2	276	36	43	271	21	40	3,905
E2	E1	96	37	42	271	20	50	3,906
	E3	171	48	56	270	55	2	8,083
E3	E3	350	3	5	270	37	19	8,078
	E4	101	1	32	271	51	12	2,798
E4	E3	316	11	35	271	51	1	2,793
	E1	33	26	19	270	21	1	8,168

The angular accuracy obtained in the data collected in the field was 0.0187500000 degree decimal points earned divided by the value of 0.0046875000 decimal degree, and now the linear 0.003498399 m. The precision linear polygonal was 7.62187 E-05 m.

Generating the local system with the following coordinates:

Tabela 04: Coordinates of Local Study Area I (LOCAL COORDINATES)

X final	Y final	Z
10,000	10,000	9,89965
13,879	9,550	9,951834
12,727	17,550	10,00143
9,998	18,168	9,991394
9,998	10,000	

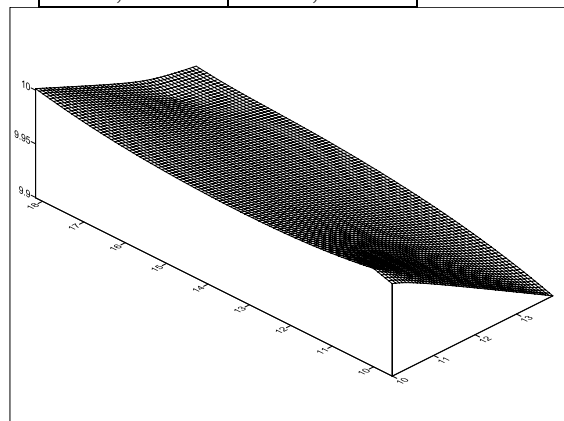


Figure 7: Digital Surface Model of Closed Polygonal Area of Study I

STUDY II: To make a local system was performed using a polygonal four (4) corners with the following names: E5, E6, E7 and E8. The angular and linear measurements were performed in conjunction with targeted direct and inverse of each point.

Table 05: Angles Horizontal, Vertical and Distances of Polygon II.

ESTAÇÃO	PV	HZ (PD)			V(PD)			SD(PD)
		°	'	"	°	'	"	m
E5	E8	0	0	5	88	10	1	24,673
	E6	92	34	38	87	38	57	3,067
E6	E5	272	14	23	87	33	40	3,067
	E7	345	15	2	88	21	18	26,433
E7	E6	163	19	27	88	19	27	26,433
	E8	280	25	5	87	10	47	3,599
E8	E7	191	31	42	87	32	37	3,598
	E5	268	50	12	88	9	35	24,675
ESTAÇÃO	PV	HZ (PI)			V(PI)			SD(PI)
		°	'	"	°	'	"	m
E1	E4	179	59	9	268	37	9	24,672
	E2	272	34	1	269	21	40	3,066
E2	E1	92	14	20	269	20	50	3,065
	E3	165	15	59	268	55	2	26,433
E3	E3	343	19	11	268	37	19	26,432
	E4	100	25	0	269	40	12	3,599
E4	E3	371	31	59	269	51	1	3,599
	E1	88	50	47	268	9	1	24,674

The angular accuracy obtained in the data collected in the field was 0.0038888889 degree decimal points earned divided by the value of 0.0009722222 decimal degree, and now the linear 0.001197841 m. The precision linear traverse rate was 1.03672 E-05 m. Generating the local system with the following coordinates:

Tabela 06: Coordinates of Local Study Area II(LOCAL COORDINATES)

X final	Y final
20,000	20,000
23,063	19,862
16,488	45,464
19,999	44,674
19,999	20,000

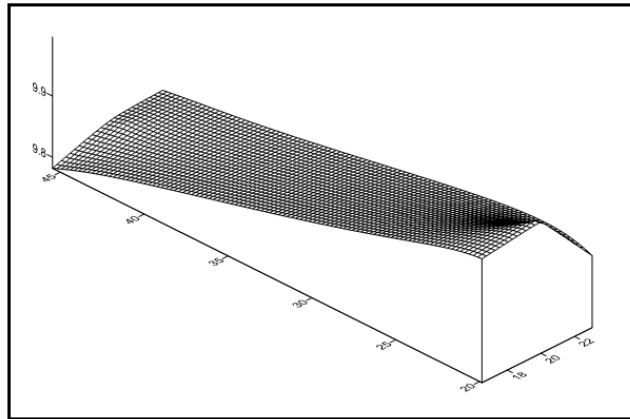


Figure 8: Digital Surface Model of Closed Polygonal Area of Study II

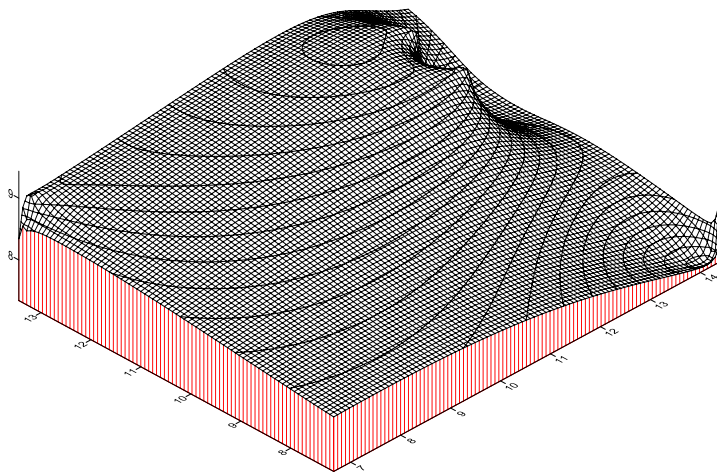


Figura 8: Modelo Digital de Superfície do Monte de lixo orgânico

5. CONSIDERATIONS FINAL

6.

The following research was to make a review of geodetic survey in order to obtain the best accuracy in the calculation of the volume which we can not determine because of some obstacle. They were shown some aspects such as the method is very labor intensive since the procedures and details can derail in decision making, although we had taken every care in planning, surveying and data processing. Although the method had reached a good accuracy of the survey points, we could not generate the perfect model that generated the volume calculation. There remains open a determination of an accurate model for determining the volume calculation.

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ACKNOWLEDGEMENTS

The authors thank Federal University of Pernambuco - UFPE, CAPES, the PROPESQ, the Graduate Program in Geodetic Sciences and Geoinformation Technology, the Secretaria de Estado da Segurança e Defesa Social (SEDS) and Núcleo de Análise Criminal e Estatística (NACE) and colleagues from the Graduate.

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