Journal of Engineering and Development, Vol. 15, No. 2, June (2011) ISSN 1813-7822

Methods evaluation of volumes computation in project site

Asmaa Abdul Jabbar
Assistant Lecturer
Al-Mustansiriya University
College of engineering
Department of Civil Engineering

Abstract

One of the important steps for civil engineer in the construction sites the estimations of the earthwork and construction materials which may decrease construction costs. Conventional method for volume estimation includes methods of surveying using to acquisition data on site, plotting and calculation of volume. The search consist ground surveyed and land leveling to constructed building by fined the reduced level for all the points and selected the final elevation that leveling the ground .

Two method Used to calculate the volumes. First method used points as across-sections to calculate the areas and volumes with (Excel 2003). Second method used points as Grid and calculates the volumes. The method accuracy depended on the shape of the project

الخلاصة

ان من اهم الاعمال التي يحتاجها المهندس المدني في المواقع الانشائية هوتخمين الحجوم سواء كانت للاعمال الترابية او المواد الانشائية والتي توثرفي تقليل كلفة الانشاء. والطريقة التقليدية في تخمين الحجوم تتضمن استخدام طرق مسح الموقع وجمع البيانات وتمثيلها بخرائط تساعد في حسابات الحجوم .

تضمن البحث مسح منطقة وتسويتها لاقامة بناية عليها عن طريق استخراج مناسيب النقاط فيها وتحديد منسوب معين لتسوية المنطقة له.واستخدام طريقتين لحساب الحجوم .الاولى على اساس ان المناسيب المقاسة لمقاطع عرضية تم حساب مساحتها ومن ثم حساب حجمها باستخدام برنامج (Excel 2003). والطريقة الثانية اعتبار نفس النقاط على اساس شبكة مربعات Grid وحساب حجمها والمقارنة بين نتائج الطريقتين .والتوصل الى اي الطريقتين ادق في تمثيل الحجم على اساس طبيعة شكل المشروع.

Introduction

Earthworks are engineering works created through the moving of massive quantities of soil or unformed rock .Earthwork volumes are one of the most important factors in the delivery of a major civil engineers project. From when feasibility estimates are generated at the concept stage of a project, until when volumes become a vital component of the contractual agreements between owners and contractors it is essential they are within a reasonable range of accuracy. **[1].**

Earthwork volumes represent the basis on which contractors are paid for construction. The earthwork volumes between successive roadway stations are also used in determining the economic distribution of earthwork. It is essential that the volumes should be accurately computed because disagreements related to earthwork volumes often cause the owner and the contractor to look to the courts for settlement. **[2].**

An Important part of roadway design is the determination of the amount of earthwork needed to construct a given roadway .Earthwork refers to the determination of amount (volume)of excavation of existing earth material and the placement of fill material needed to establish the required profile and cross-section of planned roadway. One of the essential tasks of the land surveyor is to measure and calculate accurately areas of land and volumes of materials. **[3].**

In highway projects, economic considerations are as important as other design controls and elements of design. As a result, the highway designer should consider cut and fill balance along with minimizing earthwork which may significantly decrease construction costs. [4] Volume calculation is an important factor on the budgetary estimate of project cost and choosing the best project, which also is an imperatives part of project designee. Only the accurate earthwork can arrange reasonable earthwork, reduce the project cost, quicken the project plan and heighten the project quality.

1- Computation of Volume.

The computation of volumes is classified into direct measurement and indirect measurement. Direct measurement of volumes is rarely employed in civil engineering, since it is difficult to actually apply a unit of measure to the materials involved. Indirect measurements are applied by measuring line length and cross-section areas for the volume computation. Three principal approaches of the indirect methods are used:

1. By cross-section.
2. By contours.
3. By spot heights.

The cross-section method is widely employed in civil engineering, especially for computing volumes of linear construction projects such as highways, railroads, and canals. Cross sections are a series of elevation taken at right angles to a baseline at specific station. The elevation determined can be plotted on sketch or plans either as spot elevations or as contours. As in offset, the baseline interval is 20-30m, although in rapidly changing terrain the interval is usually smaller 10-20m. Cross sections are useful in determining quantities of cut and fill in construction design. Spot height is especially useful in determination of volumes of large open excavations for tanks, basements, and for ground –leveling operation such as playing fields and building sites.

2- Field works.

The Table **(**1**)** shown the reduced level of points computed after taken reading by level (Topcon.AT-G6) with distance measured between the points 20m in Al-Mustansiriya University College of engineering to land leveling for construction building. Figure (1) shows all the cross-sections.

Table (1) The reduced level of cross-section.

CS1	CS2	CS3	CS4	CS5	CS6	CS7	Distance(m)
32.42	31.65	31.96	30.96	32.75	30.95	30.77	0
32.24	31.48				32.18	30.87	32.67
31.85	30.96	31.96	31.04	32.53	31.12	30.92	40
31.78	30.68	31.92	31.12	32.57	31.08	31.05	60
31.96	30.68	32.14	31.76	32.72	30.9	30.72	80
31.58	30.75	31.97	31.83	32.49	30.85	31.1	100
31.87	31.05	31.65	32.15	32.52	30.88	31.05	120

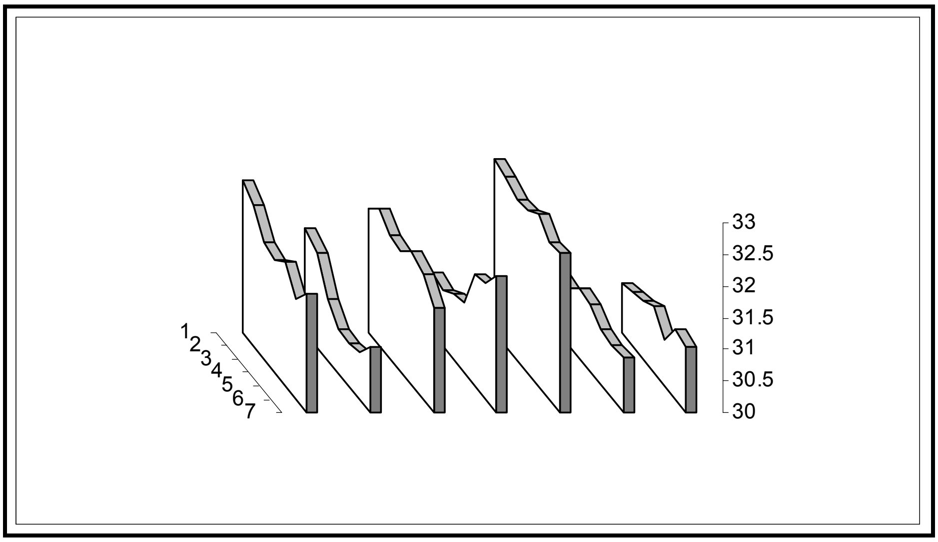


Figure (1) ALL Cross-Sections.

Every cross section is plotted after choose the reduced 30m which is the based to calculate the areas. The figures bellow from figure (2) to figure (8) shows the plotting areas of each cross-section:

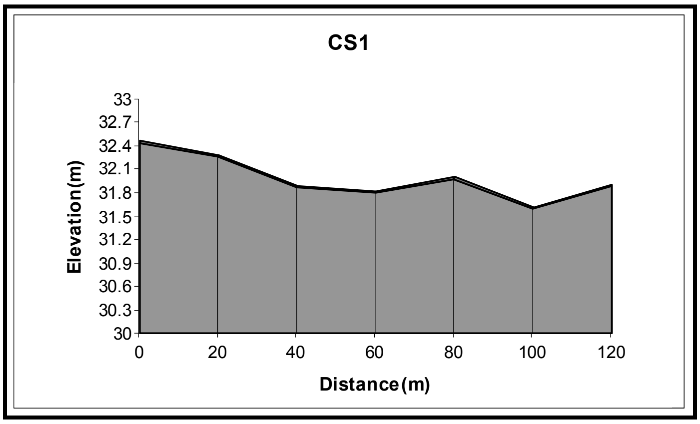


Figure (2) Cross-Section 1

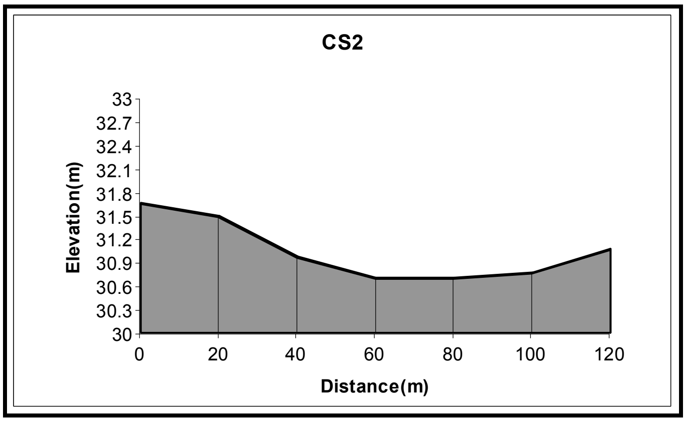


Figure (3) Cross-Section 2

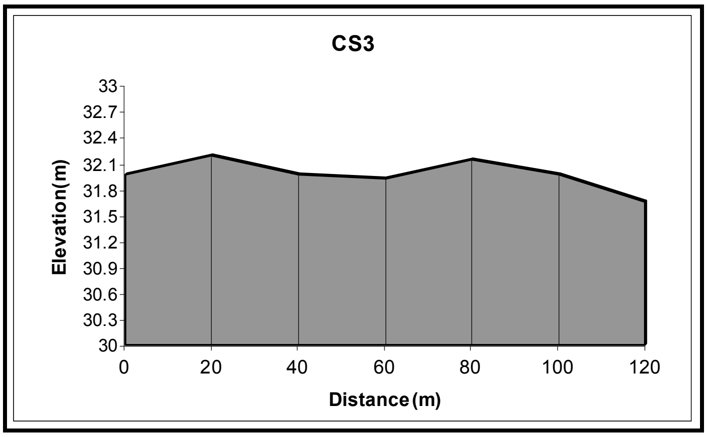


Figure (4) Cross-Section 3

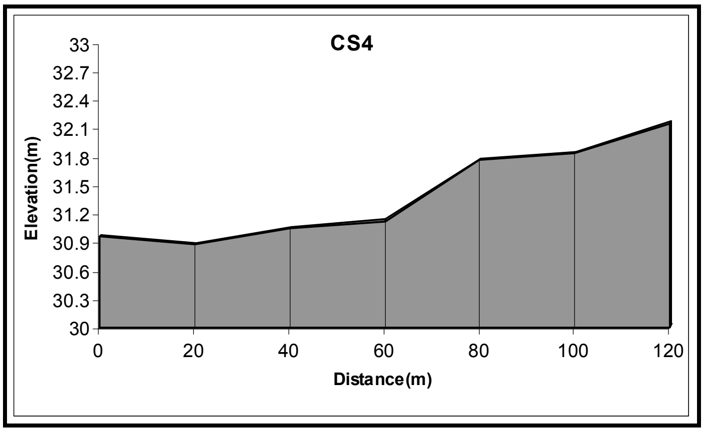


Figure (5) Cross-Section 4

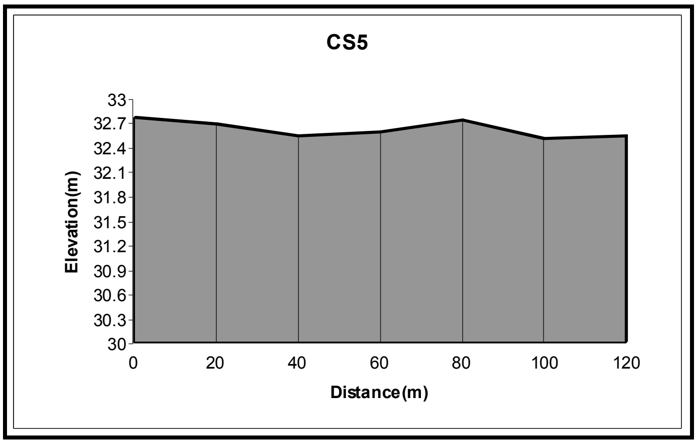


Figure (6) Cross -Section 5.

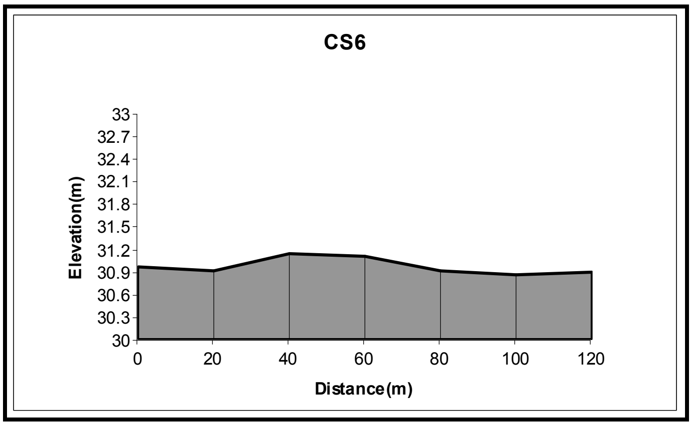


Figure (7) Cross-Section 6

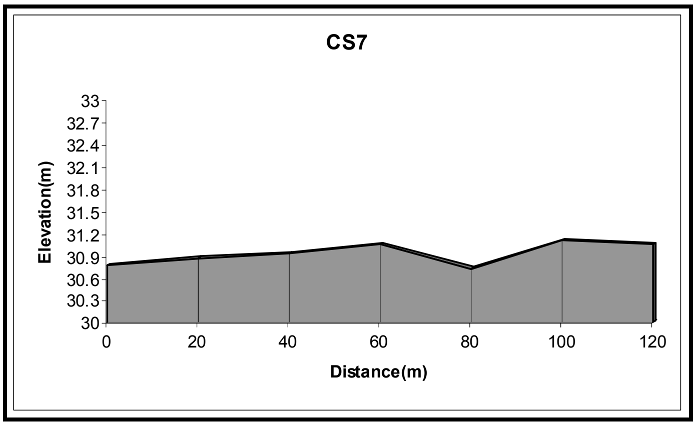


Figure (8) Cross-Section 7

3- Computation Cross- sections Areas and Volume.

The calculation connected with the measurement of areas of land, and of volumes and other quantities connected with engineering and building works .Areas is considered first of all because the computation of areas is involved in the calculation of volumes.

3-1 Area by Simpson's rule

This method, which gives greater accuracy than other methods, assumes that the irregular boundary is composed of series of parabolic arcs. It is essential that the figure under consideration be divided into an even number of equal strips, and an odd number of offsets is involved and that the lines joining the ends of three successive offset lines are parabolic in configuration as show in figure (9).

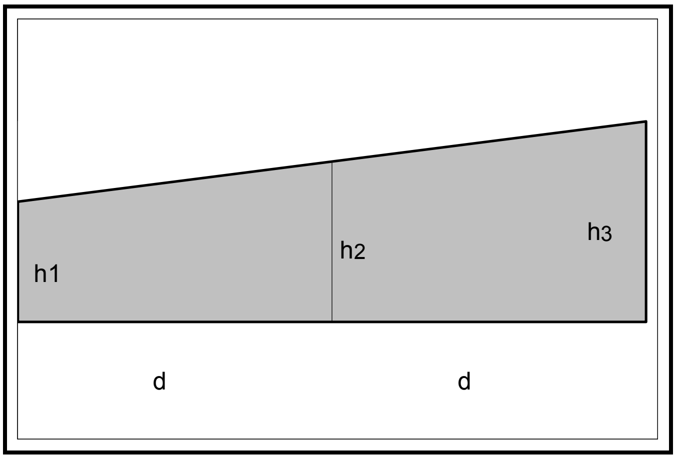


Figure (9)The computation of areas by Simpson's rule

Simpson's one-third rule is stated as follow:

Area = d / 3 (h 1+ h n+ 2∑ h odd + 4∑h even) ------------------- (1)

where:

d= Interval between offsets; h 1 = Height of first offset; h n = Height of last offset

To calculate the areas of the cross-section to elevation 30m using (Microsoft office Excel 2003) the offsets become as show in the Table (2) and the results of areas computed by equation (1) :

Table (2) The areas calculation results:

h1	h2	h3	h4	h5	h6	h7	Areas(m^2)	
2.42	1.65	1.96	0.96	2.75	0.95	0.77	179	A1 For CS1
2.24	1.48	2.18	0.87	2.67	0.9	0.86	172	A2 For CS2
1.85	0.96	1.96	1.04	2.53	1.12	0.92	161.53333	A3 For CS3
1.78	0.68	1.92	1.12	2.57	1.08	1.05	155.53333	A4 For CS4
1.96	0.68	2.14	1.76	2.72	0.9	0.72	171.73333	A5 For CS5
1.58	0.75	1.97	1.83	2.49	0.85	1.1	168.8	A6 For CS6
1.87	1.05	1.65	2.15	2.52	0.88	1.05	183.86667	A7 For CS7

3-2 Volume by Simpson's Rule.

In addition to calculating areas under a curve as indicated above, Simpson's Rule can be further developed and applied to calculate the volume of earth cut contained between two parallel cross-sections, separated by a distance d=20m. If the cross-sectional area of one section is A1 and that of the other A2 then the volume of them are calculated by equation (2).

Volume = d / 3 (A 1+4 A 2+A 3) ----------------- (2)

where: d= Interval between areas; A =Area cross-section

The distance between the cross sections are divided in equal spacing d, and the cross-sectional areas determined, by physical measurement and calculation, at each section A1, A2, A3, A4 A5.A6 A7. The volume between each three cross-section calculated using Simpson's Rule.

Hence:

Total volume = d/ 3 (A **1**+4A **2**+A**3**) + d2/ 3 (A **3**+4 A **4**+A**5**)

So the total volume would be:

Total volume = d / 3 (A 1+ A n+ 2∑ A odd + 4∑A even) ------------------- (3)

The result of calculation volumes by equation (3) using (Microsoft office Excel 2003) are shown In the table (3) bellow:

Table (3) the results of total volumes.

A1	A2	A3	A4	A5	A6	A7	Total volume (m^3)
179	172	161.533	155.533	171.733	168.8	183.867	20098.20667

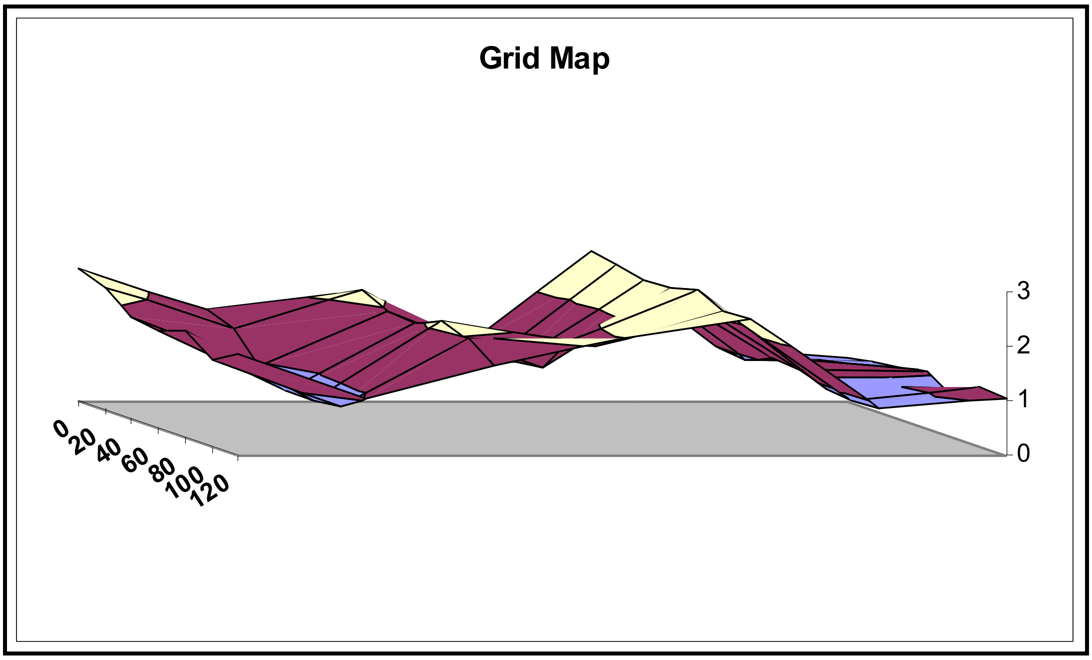
The accuracy of the overall calculation will depend on the accuracy of the calculation of the cross sectional areas, the number of chosen cross-sections and the distance d.

3- 3 Volume by Spot level

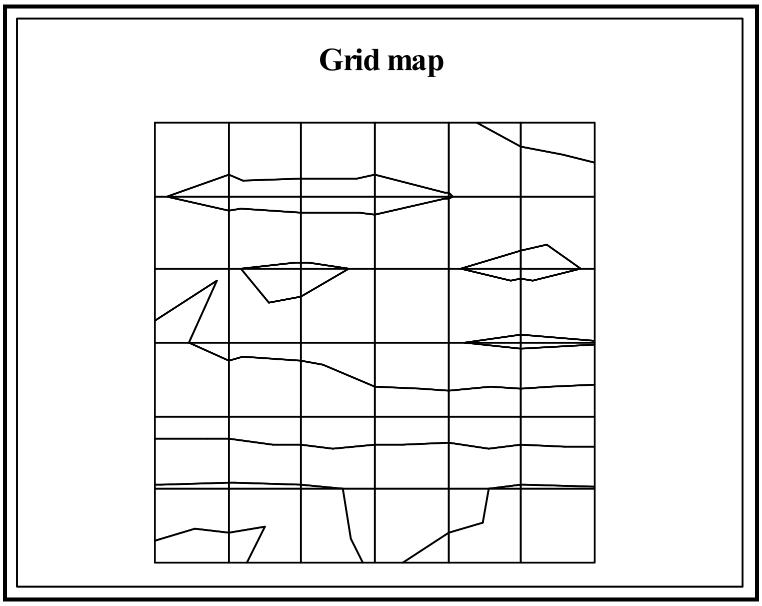
In this method the ground divided into squares with dimensions (20m* 20m) and the same height of all points used as height of the corner to the base 30m the height of points shown in the table(4) .And the shape of the points as grid map shown in figure (10).

Table (3) Height of points.

2.42	1.65	1.96	0.96	2.75	0.95	0.77
2.24	1.48	2.18	0.87	2.67	0.9	0.86
1.85	0.96	1.96	1.04	2.53	1.12	0.92
1.78	0.68	1.92	1.12	2.57	1.08	1.05
1.96	0.68	2.14	1.76	2.72	0.9	0.72
1.58	0.75	1.97	1.83	2.49	0.85	1.1
1.87	1.05	1.65	2.15	2.52	0.88	1.05



a) Front view



b) Top view

Figure (10) The grid map of points. a) Front view, b) Top view

The results of the average of heights depth using Microsoft office Excel (2003) are shown in table (5):

Table (5) The result of heights average.

Depth of excavation(m)	Number of used	Product(m)
2.42	1	2.42
2.24	2	4.48
1.85	2	3.7
1.78	2	3.56
1.96	2	3.92
1.58	2	3.16
1.87	1	1.87
1.65	2	3.3
1.48	4	5.92
0.96	4	3.84
0.68	4	2.72

0.68	**4**	**2.72**
0.75	**4**	**3**
1.05	**2**	**2.1**
1.96	**2**	**3.92**
2.18	**4**	**8.72**
1.96	**4**	**7.84**
1.92	**4**	**7.68**
2.14	**4**	**8.56**
1.97	**4**	**7.88**
1.65	**2**	**3.3**
0.96	**2**	**1.92**
0.87	**4**	**3.48**
1.04	**4**	**4.16**
1.12	**4**	**4.48**
1.76	**4**	**7.04**
1.83	**4**	**7.32**
2.15	**2**	**4.3**
2.75	**2**	**5.5**
2.67	**4**	**10.68**
2.53	**4**	**10.12**
2.57	**4**	**10.28**
2.72	**4**	**10.88**
2.49	**4**	**9.96**
2.52	**2**	**5.04**
0.95	**2**	**1.9**
0.9	**4**	**3.6**
1.12	**4**	**4.48**
1.08	**4**	**4.32**

0.9	**4**	**3.6**
0.85	**4**	**3.4**
0.88	**2**	**1.76**
0.77	**1**	**0.77**
0.86	**2**	**1.72**
0.92	**2**	**1.84**
1.05	**2**	**2.1**
0.72	**2**	**1.44**
1.1	**2**	**2.2**
1.05	**1**	**1.05**
	∑144	**∑223.95**

Average of height depth= ∑ No of square / ∑ Product

= 223.95/144

= 1.555m

Volume = (120*120)* 1.555= **22392 m³**

Or

The volume complete by equation.

Volume= d ² /4 (∑ h1+ 2∑ h2 +3 ∑ h3+4 ∑ h4) ---------- (4)

Where: d = length of side of square;

h1 =height used only once; h2 = height used twice

h3 = height used three times; h4= height used four times.

Volume= Volume= d ² /4 [∑ h1+ 2∑ h2 +3 ∑ h3+4 ∑ h4]

= (20)²/4* [6.11 + 61.16 + 0 + 156.68]

= **22395 m³**

Results and Conclusions

The results of two methods which are used for computations volumes are shown in table (6) below:

Table (6) The result of computation

Volume by Simpson's Rule	**20098.20667 m³**
Volume by Spot level	**22395 m³**

The results of computation volumes by two methods (Simpson's rule and Spot level) are not equal that's mean the accuracy of calculated the area is not the same because the Simpson's rule calculates area under the curve with the heights for each cross-section and assumes that the slope between two sections are the same with no chanced the result be small than the spot level method, which calculates the area as square areas and take the average of heights for all points.

The result became biggest than the first method but its accuracy more than it. So that the first method may be used when the slope is fixed or designed for long narrow works it mean the Liner project such as Highway, Rail road, Canal. While the second method may be used when the grounds have changes at the slope for large open area and need land leveling with equal volumes of cut and fill.

References

1. Hughes, Neil "Accuracy of volumes from MX (mass) design software, Transport Engineering. Civil Engineering.(2006).

2. Said M.Eais" Estimating Earthwork Volumes of Curved Roadways: Simulation Model. J. Surv. Engrg. Volume 129, Issue 1, pp. 19-27 (February 2003).

3. Milne P.H. " Basic Programs for Land surveying" .First Edition. (1984).

4. A. Burak Goktepe "Method for Balancing Cut-Fill and Minimizing the Amount of Earthwork in the Geometric Design of Highways" Journal of Transportation Engineering Vol. 129, No. 5, September/October 2003, pp. 564-571.

5. lixiyu "Application and Earthwork Calculation of Method of Square Grid in South "CASS2008 Software, 2008.

6. Khattak, Aemal J., Hallmark, Shauna;" Application of Light Detection and RangingTechnology to Highway Safety" Transportation Research Record, vol. 1836, no. 03-3332, pp. 7-15.

7. A. Bannister, S. Raymond and R. Baker "SURVEYING "Seventh Edition. LONGMAN. 1998.

8. Barry F. Kavanagh Surveying Principles and Applications. Eighth Edition. Pearson Education International. (2009).