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Original Article

Methods for Calculating the Volume of Filling Material in Road Rehabilitation Sites

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Abstract

Calculation of volumes on a road rehabilitation site is one of the most important responsibilities of a constructor. It must respect the project and execute site works correctly as possible, using as possible the exact amount of material at the dimensions and elevations required by the designer. There are cases where material quantities are exceeded with the permission of the beneficiary and the designer, but those volumes must be justified by high precision measurements, tables of calculations and other documents demonstrating quantities exceeding reasons. In this paper we analyze and compare two methods of calculating the volume: tabular method and the 3D method, using specialized software. I took as example calculations resulting from data before and after the execution of crushed stone fill in a roadside box.

Keywords: crushed stone, roadside box, volume calculation.

1. Introduction

One of the methods of expanding the road width is by executing roadside box.

This method is most common when there is enough room for expansion and you have the possibility of execution of excavation at the edge of the existing road. For this paper I made measurements on the site during the rehabilitation of national road DN 66 which connects the city of Targul Jiu to the city of Petrosani.

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We attended the execution of each phase of the roadside box which is located from KM 112+174 to Km 112+251 on the right side, I measured each stage of the work and I chose to do the comparative on the volume of the crushed stone filling of the roadside box.

2. Material and Method

The work itself consists in removing the existing asphalt layers from the cutting line to the edge of the existing road than excavating to specified widths and elevations by the surveyor so the filling layers will fit in height and width. These layers of filling represents the foundation of the road (Fig. 1).

Territorial conquest has become the main problem for all companies and particularly for retail companies.

Figure 1. Excavation of roadside box

The layers of filling materials used in a roadside box are:

- layer of foundation of ballast (35 cm)
- layer of crushed stone (20 cm)
- layer of asphalt mixture type AB2 (6cm) (Fig. 2).

After each phase of execution of the roadside box, topographic measurements were made with Leica TCRA 1203 total station. After processing the measurements, we can determine and control the volume of each layer of filling material form the roadside box. So to calculate the exact amount of crushed stone used in this road side box, I used 2 measurements: one before paving, and one after paving and compacting the layer of crushed stone.

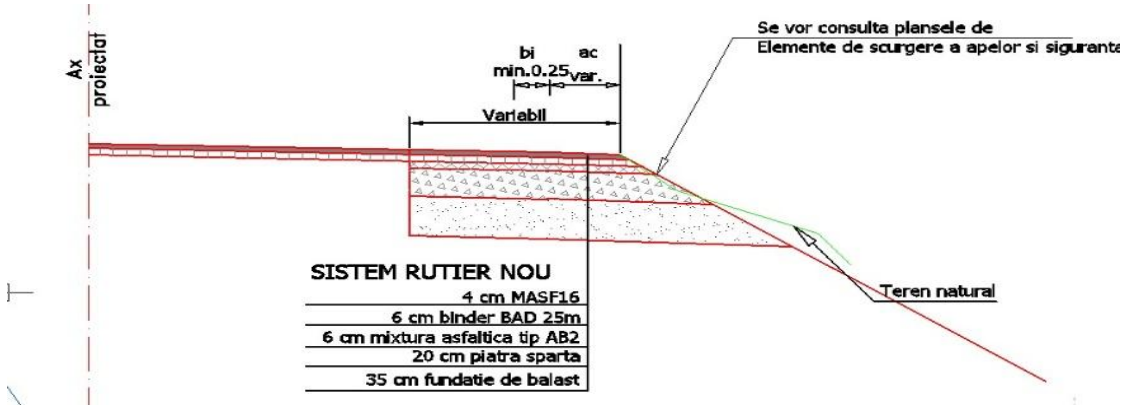

Figure 2. Cross section and dimensions of a roadside box

3. Results and Discusions

After completing the measurements on the site, I processed the data at the office. First, I imported both measurements to the processing program AutoCAD, then I followed different steps for each method of calculation. The calculation methods that I have used for volume calculation were the tabular method and 3D modeling method.

Tabular method

In the processing software AutoCAD [3] I joined the measured points with 3D polylines, than I extracted in fix pickets the corresponding widths and the elevations and put them into a table (Table 1).

In a working sheet of the Microsoft Excel program I represented in a table in every picket from 10 to 10 meters the inferior and superior elevations of the crushed stone layer from both left and right sides of the roadside box (column 2, 3, 5 and 6). The difference between the crushed stone filling elevation and the ballast filling elevation is the height of the crushed stone (column 4 and 7).

Column number 8 represents the width of the crushed stone layer, and in column number 9 we have the distances between the pickets. In column number 10 I calculated the area of the cross section in each picket by multiplying the width with the arithmetic average of the heights of the crushed stone layer in the corresponding picket. In the last column (11) we have the volumes between 2 picket calculated by multiplying the distance between the 2 pickets with the arithmetic average of the areas of the cross sections of the layer of crushed stone in each picket. Totalizing the partial volumes we get the total volume of 45.77 cubic meters.

Table 1. Elevations, widths and volume calculation of the crushed stone layer of the roadside box.

Nr. Crt.	PK	BALLAST FILLING ELEVATION LEFT SIDE	CRUSHED STONE FILLING ELEVATION LEFT SIDE	HEIGHT (m)	BALLAST FILLING ELEVATION RIGHT SIDE	CRUSHED STONE FILLING ELEVATION RIGHT SIDE	HEIGHT (m)	CRUSHED STONE WIDTH (m)	PK DISTANCE (m)	SURFACE (sq.m)	VOLUME (cu.m)
a	1	2	3	4=3-2	5	6	7=6-5	8	9=1(a+1)-1(a)	10=(4+7)/2*8	11=[10(a)+10(a+1)]/2*9
1	112+174	438.040	438.240	0.200	437.983	438.300	0.317	2.53		0.65	
2	112+180	438.170	438.291	0.121	438.030	438.344	0.314	2.41	6.00	0.52	3.53
3	112+190	438.222	438.404	0.182	438.101	438.414	0.313	2.37	10.00	0.59	5.55
4	112+200	438.332	438.478	0.146	438.210	438.529	0.319	2.58	10.00	0.60	5.93
5	112+210	438.375	438.527	0.152	438.177	438.591	0.414	2.41	10.00	0.68	6.41
6	112+220	438.459	438.630	0.171	438.324	438.626	0.302	2.41	10.00	0.57	6.26
7	112+230	438.486	438.686	0.200	438.389	438.693	0.304	2.45	10.00	0.62	5.94
8	112+240	438.500	438.756	0.256	438.447	438.712	0.265	2.19	10.00	0.57	5.94
9	112+250	438.573	438.811	0.238	438.531	438.801	0.270	2.21	10.00	0.56	5.66
10	112+251	438.588	438.820	0.232	438.558	438.810	0.252	2.22	1.00	0.54	0.55
TOTAL VOLUME (cu.m)											45.77

3D Modeling

The second method I have used is 3D modeling with the help of TopoLT which is an extension of AutoCAD, a processing drawing and desinging software. I have separated the measurements that I made before and after the paving of the crushed stone layer and I have created separate 3D surfaces on both measurements (Fig. 3).

In Fig. 3 is shown the 3D model generated by the TopoLT [1] extension of the AutoCAD software. Also the TopoLT has a function for calculating volumes quickly and efficiently and it makes a report table which is represented in Fig. 4.

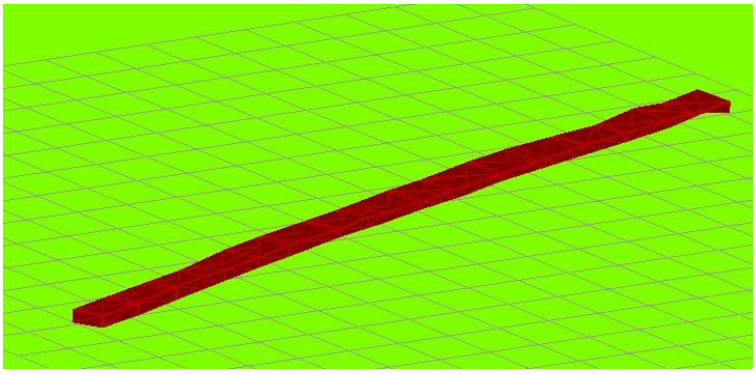

Figure 3. 3D model generated by the 2 surfaces

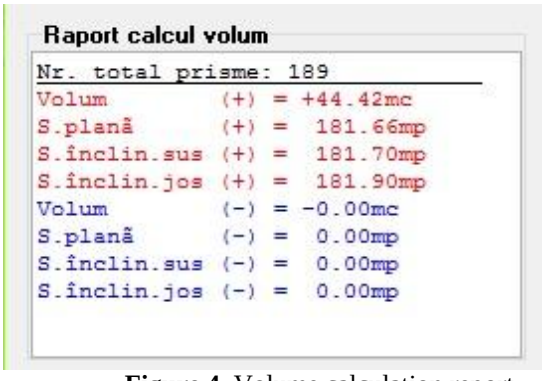

Figure 4. Volume calculation report

Result of tabular method: 45.77 cubic meters;

Result of 3D modeling method: 44.42 cubic meters.

As we can see there is a difference of 1.35 cubic meters between the 2 methods. This difference occurs because of the density of measured points used to both methods differ.

In the tabular method we used measure points only from 10 to 10 meters while in the 3D modeling method we used greater density of measured points, even from 5 to 5 meters.

With the help of ProfLT [2], a profile generator, calculator and drawer extension of AutoCAD, I draw a longitudinal profile on which are represented through 2 lines the crushed stone filling elevations from the left side of the roadside box (Fig.

5). The blue line represents the elevations used in the tabular method, and the red dashed line represents the elevations used in the 3D modeling method. We can notice small differences between the two lines, which are due to the much higher density of points used in creating the 3D model (Fig. 5). If the 2 line coincided, the volumes calculated by the 2 presented methods would be equal.

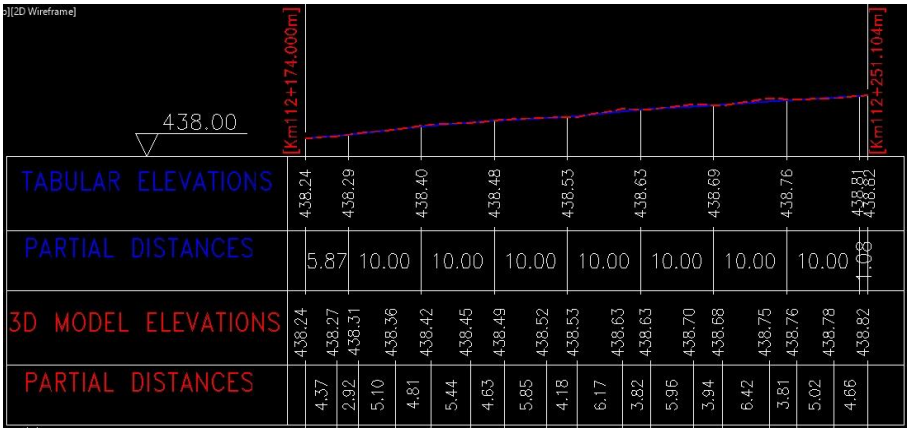

Figure 5. Longitudinal profile of a 3D line in both methods:
Blue line – tabular method
Red dashed line – 3D modeling method

4. Conclusions

Although the construction engineers use more tabular methods and tables in the documentations and quantity justification, 3D modeling represents a quicker and more efficient method that is usually used by them as a control measure because 3D modeling is more precise as long as the topographic surveys on site are made with high precision and stringency. Getting the exact volume of a filling means that the created 3D models must be as much as possible the same as it is in reality. Creating 3D models similar to the existing work executed by the constructor depends on the surveyor. He must measure as many points as necessary in every change of direction of an alignment and in every change of slope to represent the 3D model as the closest version of the reality.

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