Contribution of GPS in Surveying Quarries

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SUMMARY

Quarries involve an important industrial activity providing important materials for building and public works. They contribute to economic development and land planning as well as they are a great source of income.

For several years, terrestrial surveying methods have been used as the main tools of the surveyor. Therefore, their use in construction sites is limited by several disadvantages such as the problem of visibility between ground points, observation duration and their limits for long range measurements. Such problems could involve time lost and decrease in production.

The purpose of this study is to experiment the use of GPS positioning in quarries in order to determine the volumes of rubble; and test its contribution in improving the quality and performance in this kind of work.

For this purpose, we conduct two experimental tests using GPS and total station to survey two quarries and determine their volumes. The Volumes calculations are performed using two different methods: prism and profile methods. The Followed methodology is based on three points:

- Use the GPS and total station to survey a career.
- Perform a comparison between the GPS and total station surveying results.
- Find a surveying method to quantify volumes of quarries.

Found results show that the use of GPS to survey quarries is appropriate in certain circumstances. It is recommended that there are complementarities between the total station and GPS in this type of survey.

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1. INTRODUCTION

The Global Positioning System (GPS) and total station play an important role in collecting geographic data. In first, GPS has been conceived to respond to some specific military positioning needs, but it has brought a great revolution in geodesy and surveying as well.

GPS system offers a three-dimensional positioning in a global reference frame, at any time, regardless of the meteorological conditions and over the globe. Compared to the conventional methods, GPS offers several advantages, concerning mainly the production, the cost, the precision and time saving. However, the altimetric positioning GPS quality remains influenced by the existence of a precise geoid.

On the other hand, quarries involve an important industrial activity providing important materials for building and public works. They contribute to economic development and land planning as well as they are a great source of income.

For several years, terrestrial surveying methods have been used as the main tools of the surveyor. Therefore, their use in quarries is limited by several disadvantages such as the problem of visibility, observation duration and number of people needed. Such problems could involve time lost and decrease in production.

The main objective of this paper is to experiment the use of GPS in surveying quarries in order to determine the volumes of rubble; and test its contribution in improving the quality and performance in this kind of surveying. The total station is also used in this study in order to compare the results in terms of volumes determinations.

2. GPS AND LEVELLING

We know that the ellipsoidal height is the vertical component provided by GPS. whereas, for the orthometric height, we need to know the geoid which is the surface of reference for these heights.

The EGM96 global model gives a good approximation of the geoid, but it is not precise enough for leveling.

The inaccuracy of the GPS system in determining orthometric heights is due to the geometry of satellites, the tropospheric refraction and the knowledge of the geoid.

In order to use GPS for leveling, we should convert GPS ellipsoidal heights to orthometric heights, for that purpose, it is necessary to define a precise local geoid.

3. EXPERIMENTAL STUDY

3.1 The study sites

The study sites are two quarries of marble (or limestone) located in the northern region of Morocco: (career 1 and career 2). These careers are open, and were operated over last twenty years.

3.2 Method of survey

Both quarries are located in a very hilly area, so, for their surveying, it is essential to do a random survey. To make surveys of these two careers, we needs two reference points. For that purpose, we have used known traverse points in the region.

3.2.1 Survey using total station

The survey of these two careers was done by conventional methods using a total station. The monitoring of these two careers is done every six months. For each career, several new points were determined in order to fully cover the career by known points in three dimensions (x, y and H).

3.2.2 GPS Survey

The reference GPS receiver was installed on a reference known point. The characteristics of this reference point are:

- Highest point of the route
- Stable: there is no mining in its closure
- Free of obstacles to assure good reception of GPS signal
- Far from site's installations

The GPS observations are done respecting the following standards:

- Number of satellites> = 4
- PDOP <7
- Stop and go mode for mobile receiver
- Initialization time is 20 minutes.
- Observation time: each point is observed for 15 seconds

4. DATA PROCESSING

In both cases, TGO software was used for processing GPS data. Once the elevations of points are determined, Covadis 2008 software was used for the determination of cubature. The cubature is determined using two methods: the profile method and the prisms method.

5. RESULTS AND DISCUSSION

In this study we calculated the cubature of the two quarries from different dimensional drawings (GPS survey and total station survey) using two methods cited below: the prism method and the profiles method.

In this study, we proceed as follow:

- First, we compare the results of cubature using the two methods above.
- Second, we compare the results of cubature from the two surveys: GPS survey and total station survey.

5.1 Comparison between the methods of calculating cubature (prism & profile)

First career:

For the survey by total station: The differences between cubature obtained for various levels by both methods vary between 1 m^3 and 188 m^3.

Using GPS, the differences between cubature obtained for various levels by both methods vary from 2 m^3 to 12 m^3.

After analysis, we can see that the results of cubature for each kind of survey, using the two methods (Method of prisms, and profile method) are very closer. So for the same survey we can say that the methods of calculating cubature by profiles or by prism lead to similar results.

5.2 Comparison between results of two survey methods (GPS vs total station)

<u>5.2.1. First Career</u>

Figure 1 and table 1 show the results of cubature from the two surveys (GPS survey and Total station survey). They show the differences between level P5, the current state of the this career and the precedent surveys (levels P4, P3 , P2 and P1).

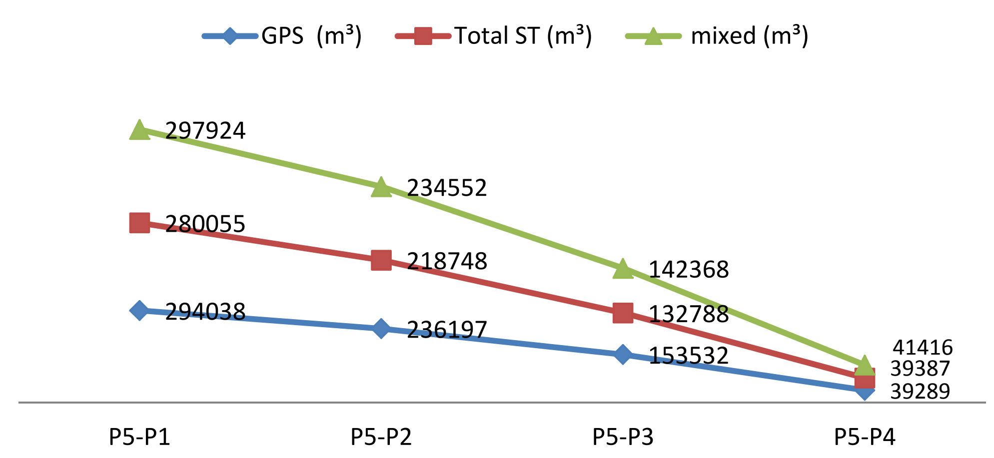
Table 1: **Cubature using GPS & Total station**			
	GPS (m³)	Total ST (m³)	mixed (m³)
P5-P1	294038	280055	297924
P5-P2	236197	218748	234552
P5-P3	153532	132788	142368
P5-P4	39289	39387	41416

The analysis of these results shows that:

- Results of cubature from the two surveys are different.
- The result obtained by GPS survey is greater compared to that obtained by total station.
- Results of cubature between levels P4 and P5 are closer to each other
- The difference between the results of cubature using GPS and total station is close to 2 ‰.

We have combined GPS survey with that of the total station to have a mixed survey, and take it as the best representation of the career. Therefore, we can consider the results of this mixed survey cubature as a reference (Table 1 & figure 1):

Figure 1: Cubature using GPS & total station
First case



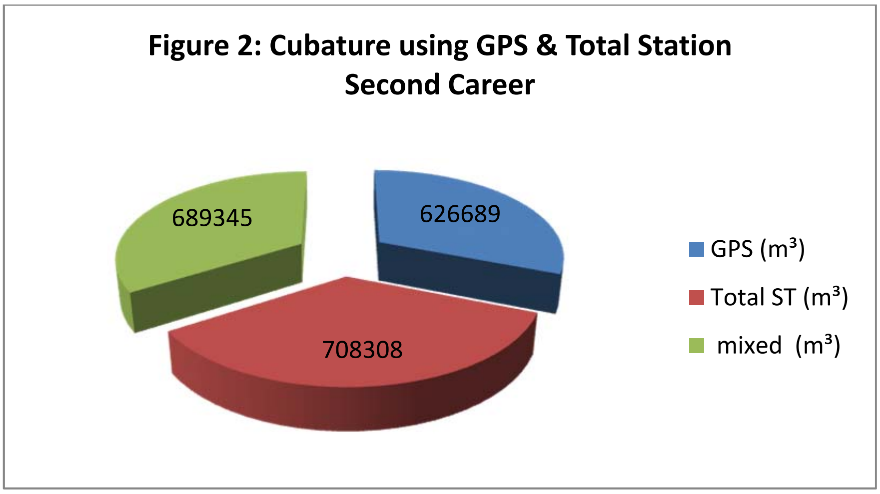
After analysis of figure 1 we can deduce that:

- Results of cubature obtained by GPS survey and mixed survey are close to each other. The difference does not exceed 5% of the total cubature.
- Differences between cubature of levels P4 and P5 are the smallest ones.

After these remarks we can say that the GPS survey compared to the total station survey, represents better the first career.

5.2.2 Second Career

Figure 2 presents the results obtained after calculating the cubature using GPS survey and total station survey. Differences represented here are between levels P1 and P5 only.



Because of the considerable difference between the results of GPS survey and total station survey, we combined GPS with total Station surveys to get a mixed survey. We can therefore consider the results of the mixed cubature survey as a reference.

The analysis of this figure 2 shows that:

- There is 12% difference between cubature obtained using GPS survey and that obtained using total station survey.
- GPS data are insufficient compared to that of total station, so it is not adequate to represent this career.

After these remarks we can conclude that the total station survey, compared to GPS survey, represents better this second career.

On the other hand, we can add that the major problems encountered during the survey of this career by GPS, were caused by satellite geometry. There was a very large area of the career not surveyed because of the depth of certain of its zones. Consequently, the PDOP was increasing rapidly. For that purpose we need to know the density of surveyed points in each case.

5.3 Analysis of density of points

The accuracy of a Digital Elevation Model (DEM) depends on the density of measures adapted to the variation of the terrain. In a rough terrain, for a good accuracy of the DEM, we need a survey that describes better its characteristics.

In this study we have assessed the density of the two quarries surveyed. In the first career the density of points over 400 m, is 2.41 for GPS survey, but it is only equal to 1.07 for the total station. In the second career the density of points over 400 m, is 1.80 using GPS, while it increases to 2.02 using total station survey. Therefore, the density of points in the first case is better with GPS survey, while it is better using Total station in the second career.

We can therefore explain that the differences in results of cubature between the total station and GPS are due to the density of the surveyed points. When density is good the cubature defines well the terrain.

6. CONCLUSION

In this paper, we have used total station and GPS to survey two different quarries. Considering the obtained results we can draw the following conclusions:

The profiles and prism methods of calculating cubature lead to similar results.

The use of GPS to survey a career has certain advantages:

- In a clear and less rugged career, the use of GPS to survey will save a significant amount of time. The rate of survey is limited by the speed of displacement of the mobile receiver.
- Using a single fixed reference station for multiple mobile receivers reduces costs and time.
- The GPS represents the advantage that the intervisibility is not necessary to make any survey.
- The GPS also minimizes the number of people needed during survey operations.

On the other hand, we can say that the use of GPS for surveying a career is limited by problems like the multipath and the interruption of signals for deep career.

The use of a total station to survey a career presents certain disadvantages:

- we need several stations to cover a very large area of a career.
- The use of total station is handicapped by problems of intervisibility which influences on time and cost operations. In this method it is essential to have intervisibility between the station and the prism, which is difficult to obtain in certain circumstances.

– The total station survey is time consuming.

We can conclude that complementarities between the total station and GPS will certainly give best and complete density of the terrain, therefore good cubature results.

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BIOGRAPHICAL NOTES

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1979: Diploma of engineer in surveying from IAV Hassan II, Rabat, Morocco
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Principal areas of interest are: GIS, geodesy and surveying.
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