COMPARATIVE STUDY ON METHODS FOR 3D MODELLING WITH TRADITIONAL SURVEYING TECHNIQUE AND TOTAL STATION TECHNIQUE

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Abstract - Three-dimensional modelling of the natural surface of the Earth is very important in understanding the irregularities of the Earth surface. It is a vital tool in planning large development projects such as designing of high ways, airports, hydropower plants, reservoirs; building sites etc. Two technical approaches are being used for the above task in conventional land surveying. The first step is to carry out horizontal surveying and producing a survey plan which depicts the horizontal projection of the area of interest. The second step is to carry out levelling in order to obtain heights with reference to datum over evenly spread grid points covering the required area. With the introduction of Electro-Magnetic Distance Measurements, a new equipment known as total station is available for land surveyors to capture three dimensional coordinates of points on the ground. This new technology is comparatively much faster than the conventional two-fold technique of collection of horizontal coordinates through surveying and obtaining heights through levelling. This research paper evaluates accuracies of conventional surveying and levelling methodology and the modern Electro-Magnetic Distance Measurements. It also compares the precision of the output of the conventional surveying contour plan and the digital terrain model empirically and statistically in order to evaluate pros and cons of conventional and modern surveying techniques. For this evaluation, a total station and an automatic level was used to survey the study area, employing both methods and analysing data from each method empirically, statistically and comparing the outcome of aforesaid methods. After the analyses of data it was revealed that both techniques are comparatively equal in precision but the total station is far more efficient than the conventional surveying and levelling method. The final outcome of the study is that the total station is more suitable for an engineering survey done for general purposes.

Keywords: Digital Terrain Model, Evaluation of accuracy of contour plans, Three-dimensional modelling

I. INTRODUCTION

This research paper assesses conventional and modern method of data collection required for three-dimensional modelling of the surface of the planet earth. It is useful in finding out the lay out of the terrain which is an essential prerequisite for large scale construction works and large-scale development projects such as air ports, sea ports, high ways, and lot more other types of construction projects. This methodology of three-dimensional modelling commonly known as engineering surveys carried out prior to any large-scale construction or development project. It is defined by the American Society of Civil Engineers (ASCE) "as those activities involved in the planning and execution of surveys for the development, design, construction, operation and maintenance of civil and other engineered projects" (The American Society of Civil Engineers (ASCE), 1987). Engineering survey is the point of beginning of any large construction project. If the engineering survey is delayed the whole project may get delayed or worse the whole project may get cancelled before the construction even starts. Therefore, it is important that the Engineering survey or the three-dimensional modelling of the terrain is done as fast as possible.

The traditional way of executing engineering survey is a twofold method. Those two methods are horizontal survey done using the theodolite traverse or the total-station traverse and then measuring the spot heights using running level lines using levelling instrument.

The conventional way of executing engineering survey is a twofold method. Those two methods are horizontal survey done using the theodolite traverse or the total-station traverse and then measuring the spot heights using running level lines using levelling instrument. The associated problem with this method is that it takes long time to complete. This type of survey is associated with blunders and systematic errors such as booking errors and computational errors. But with the introduction of the GNSS (Global Navigation Satellite System) and the modern total-station it is possible to observe three dimensional coordinates of the points in one step. This research paper discusses the usability of the modern total station as a tool of collecting three dimensional coordinates of the points on the earth surface by using the in-built method called TOPO which is available in most of the modern total stations. Horizontal coordinates obtained through modern total stations are very accurate of and widely used by land surveyors. But surveyors are somewhat reluctant to use total station to collect heights. This research assesses the height accuracy of the total station and the automatic level. It evaluates the possibility of using total station as a tool for collecting coordinates of points for three-dimensional modelling.

II. EXPERIMENTAL DESIGN

The experiment was design in way that both total station and the level instrument are being used to measure the same land plot to collect data on same points in the same day to minimize the effect of the other external factors such as temperature, humidity weather and time.

III. METHODOLOGY

In order to compere the height accuracy an automatic level and a total station was selected. The sokkia CX-101 Total Station and the sokkia B-30 Automatic levelling instrument was selected to carry out the data collection. All instruments and accessories used are shown in the following table.

Table 1. The Equipment Used in Field Work

No	Equipment	Amount	Type
1	Total Station with accessories	1	Sokkia CX-101
2	Prism Poles with prism	1	Sokkia
3	Automatic Level	1	Sokkia B30
4	Levelling Staves	2	~
5	Foot Plates	2	~
6	Tri Pod (Wooden)	1	~
7	Tri Pods (Aluminium)	1	~
8	50M Steel Tapes	2	~
9	Gig Umbrella	1	~
10	Hammer	1	~

IV. PRACTICAL PROCEDURE

A plot of land with moderate slope was selected. The approximate size of the selected area was about 2500 m2 with vertical height variation of about 6 m. A 40 m by 54 m rectangular grid on the land was set out using the total station and prism pole by marking the four corners of the gird. A 50 m steel tape is used to set out pickets in 10-meter interval on the ground and marked on the ground with help of a marker pen. A prospection diagram is prepared to show pickets and numbered those points consecutively from 1 to 90. The south west corner of the grid was assigned coordinates as 1000N, 1000E. Coordinates of all grid points were computed as the gird distance between points are known related to the south-east corner. A level line was running from each grid corner to the next grid corner and obtained heights of the pickets in between them. After words level lines were ran to obtain heights of all points marked on ground. Three-dimensional coordinates of all 90 points were computed and added to a table.

Then the total station was setup and carried out the temporary adjustment to eliminate systematic errors of the instrument. Afterwards three-dimensional coordinates of all marked points were obtained using the TOPO mode of the total station. Heights of all points were tabulated in new column of the same table to complete practical procedure.

V. RESULT

After collection of data two contour plans were created to depict the terrain model collected through each instrument. The contour plans were created with the same contour interval of 0.1 m because most of the general-purpose engineering surveys only required to output a contour in 0.5 m to 1.0 m contour intervals. If there is no visible difference between two maps at 0.1 m contour interval there is not going to be a difference 0.5 m or 1.0 m contour interval maps.

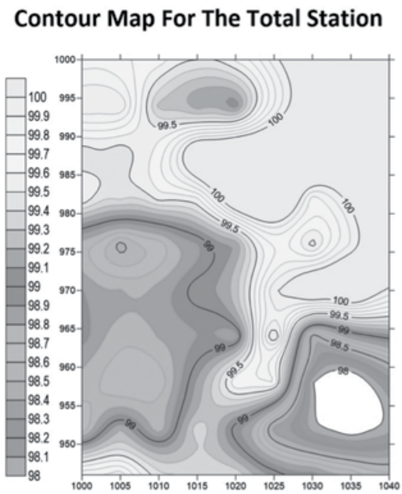


Figure 9. Contour Map for The Total Station

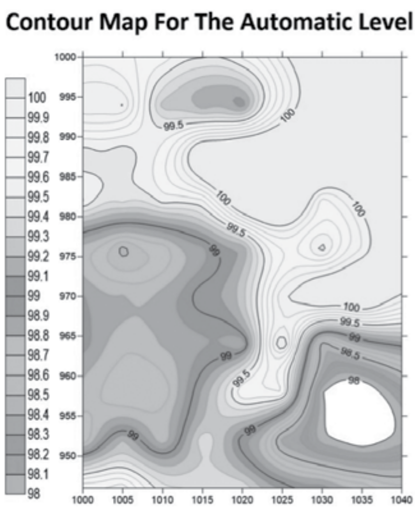


Figure 10. Contour Map for The Automatic Level

When comparing two contour plans there is not much difference between those two contour plans even at 0.1 m contour interval.

For further clarification two 3D models were created using same set of data.

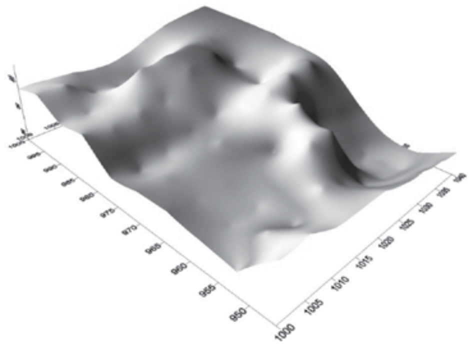


Figure 11. 3D model of the data collected by levelling instrument

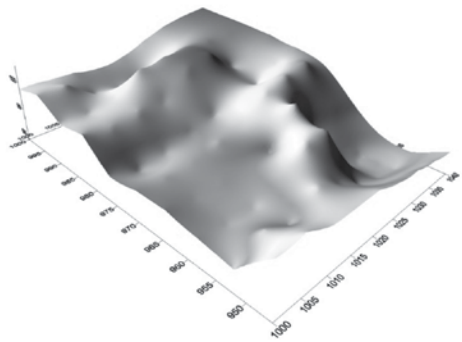
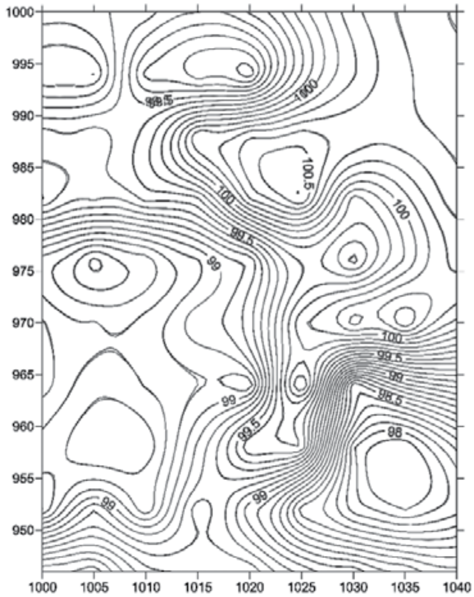


Figure 12. 3D model of the data collected by the Total Station

It is evident that the terrain is not depicted much differently in both 3D models so the quality of data collected from both instruments are nearly the same.



Blue-Total Station
Red - Automatic Level

Figure 13. Over lapped contour plans

VI. DISCUSSION

From this research, it was proved that the difference between two contour plans produced for the study area of 50 m by 50 m at contour intervals 1 m and 0.5 m does not have a significant difference. when overlapping contour plans the difference about each contour is about the 1 cm to 5 cm at maximum.

Reasons for above discrepancy as follows. When the total station is in operation the standard prism pole was used to collect height data. At the time of using the prism pole the pole should hold very steady and vertically so the height of the pole is the actual height of the target that entered to the total station. But when using the automatic level, the level staffs are mech easy to keep level and much more accurate. Disadvantage of automatic level is that reading is limited to maximum of 40 m. Level staff are impossible read at more than 40 m so at that situations level line to be ran in order to measure the height to a point that is far than 40 m. There for it is required a close circuit level line to be measured to ensure the accuracy of the heights obtained through level.

That is the reason why when running long level line, optimal distance between the level instrument and the level staff should near 30m. But for the total station there is no such short distance limit because it is possible bisect the prism from a distance at 500 m easily. But it is not possible to read about 500 m to get height using the total station because in the total station there is a drop of height accuracy of the total station with distance. It was tested and accuracy was found to be less than 1 cm in distance range between 0 to 50 m when using the prism pole to measure the height. But when the distance is ranged between 50 m to 100 m the height accuracy drop is about 1 cm to 3 cm. So, it is suitable measure heights when distance is up to 100 m. The total station measure heights much longer than the level instruments with adequate accuracy.

In using total station there are no booking errors and computational errors as recording of data and computation is carried out by the microprocessor of the instrument. This is an advantage of using total station as it minimises human blunders and errors in computing. So, simply the total station is much faster at collecting data and it is much efficient method of data collection.

VII. CONCLUSION

This research proves that the modern total station is an efficient tool in collecting three dimensional coordinates for three-dimensional modelling or an engineering surveying. But still the most accurate tool for getting height data is the level instrument. Typical engineering surveying the total station is the best instrument because the speed at which the data can be collected with the instrument is comparatively very high so the work can be completed very fast.

In any large-scale engineering or development project the first step is to complete engineering survey to generate a realistic over view of the terrain. Therefore, it is necessary to get work done faster as possible hence it was proved that the total station is the best instrument for any typical engineering survey with an average accuracy.

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