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CONSTRUCTING A CORRECTED STATIONS NETWORK USING SOME GEOMATIC TECHNIQUES

Amal MAHDI ALI[1,*], Maha AL-SOUDANI[2], Faten MEZHER RADHI[3]

[1] Civil Engineering Department, College of Engineering, University of Baghdad, Baghdad, Iraq.
[2] Civil Engineering Department, College of Engineering, Mustansiriyah University, Baghdad, Iraq.
[3] Musayyib College of Technology, Al Furat Al Awsat Technical University, Najaf 54003, Iraq.
[*] corresponding author: amal.mahdi@coeng.uobaghdad.edu.iq.

Abstract

The major objective of this study is to establish a network of Ground Control Points-GCPs which can use it as a reference for any engineering project. Total Station (type: Nikon Nivo 5.C), Optical Level and Garmin Navigator GPS were used to perform traversing. Traversing measurement was achieved by using nine points covered the selected area irregularly. Near Civil Engineering Department at Baghdad University Al-jadiriya, an attempt has been made to assess the accuracy of GPS by comparing the data obtained from the Total Station. The average error of this method is 3.326 m with the highest coefficient of determination (R^2) is 0.077 m observed in Northing. While in the Easting the average error is 4.634 m with (R^2) 0.099 m observed. The average error 5.513 m with (R^2) is 0.071 m is observed in Reduced Level. The accuracy assessments of the interpolation methods (Total Station and Level) have been calculated using the average error 0.240 m with (R^2) is 0.735 m is observed in Reduced Level. The GIS 10.3 program can automatically transform the saved data to text format and produce digital plans with attribute.

Keywords:

GCPs;
GIS software;
GPS Navigator;
R^2;
Traversing.

1 Introduction

Today, total station is the surveying tool that is most frequently employed. Three parts form total station systems: an internal CPU, the theodolite, and the distance measurement unit, also known as the EDM [1]. The quickest digital data collection techniques today use electronic total stations. The amount from topographic information that may be gathered each day has risen because to total stations. Traverses are built stations linked via angle and distance [2]. Utilizing a total station and GPS for both vertical and horizontal traversing are major new uses. The traverse's linear disclosures need to be modified. There are various ways to modify traverse, but the compass rule is the one that is most frequently employed. The GIS 10.3 program can generate digital plans with attributes and instantly convert the saved information to text format [3, 4]. A computer then processes the Total Station data to generate a coordinate file that comprises the point digits, site code, NEZ locations, and point descriptions. In order to be used in GIS and CAD software, data are transformed into a graphic file. These applications have the ability to convert data into two- or three-dimensional design files [5].

The control network is a set of stations for surveying containing precisely identified locations that is commonly thought to be error-free. The quality of the tools and the quantity of observations needed would be determined by how accurate the control network performed [6, 7]. The final three-dimensional topographic model's accuracy is highest when the ground controls (GCPs) are used. GCP density and number are generally correlated with model accuracy [8-11]. A powerful network of ground-based control points (GCPs) and the use of oblique images should result in a self-calibration that is more precise [12]. Numerous studies have concentrated on the strategies for improving survey control alignment [13-15].

Traverses are built stations joined together by direction and distance [2]. Traverses are classified into two types: locked traverses as well as open traverses. Polygon and link are the two subcategories of closed traverses. When traversing a polygon, the lines go back to where they started. Link traverses conclude at an alternative location that must have a positional precision that is at least as accurate as the starting point. A closed reference direction must be present in the link type [16]. An open traversing neither makes a closed geometrical figure nor comes to an end at a given spot [17].

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The control network is a system of survey stations with precisely known coordinates that are frequently regarded as being infallible. The quality of the tools and the quantity of observations needed would be determined by how accurate the control network performed. [6]. Traversing was used to inspect the horizontal control network. It comprises of a single main traversal control network.

The most popular technique for creating a network or sequence of monument with known locations on the ground is now a traverse [18]. These structures are known as horizontal control points, and together they form the project's horizontal control [19- 21]. Link traverses end at a different station, whose positional accuracy should be at least the same as the starting point. There must be a closing references direction for the link type [22]. An open traversal does not end at a known spot or form a closed geometric figure [23, 6].

As a traverse misclosure, closure errors were expressed. The digital total station's built-in software helped with the manual traversal adjustments. Data readjusting was done using the Compass rule [22].

The recognized Bowditch and/or Transit procedures are used to manually process (with a pocket calculator) the location of the control traversing stations. Also, tachometric field observations were used to calculate the spot heights [6]. The calculation using the rod intersect and vertical angle can then be used to determine the altitude of any given place. If desired, a levelling loop can be used to determine and verify the heights of multiple points [24].

2 Experimental Work

The network of stations was represented by the Ground Control Points (GCPs) and the suitable locations for these nine stations were selected at Baghdad University in Al-Jadiriya. The traversing method was chosen to survey the selected stations by using the Nikon Nivo total station at first, Elevations for the traversing points were computed by the level instrument and the stations of the traversing which were collected by using the (Garmin- eTrex) navigator GPS instrument. By using appropriate mathematical methods for each system, the corrected coordinates of the points are arrived, see Fig. 1.

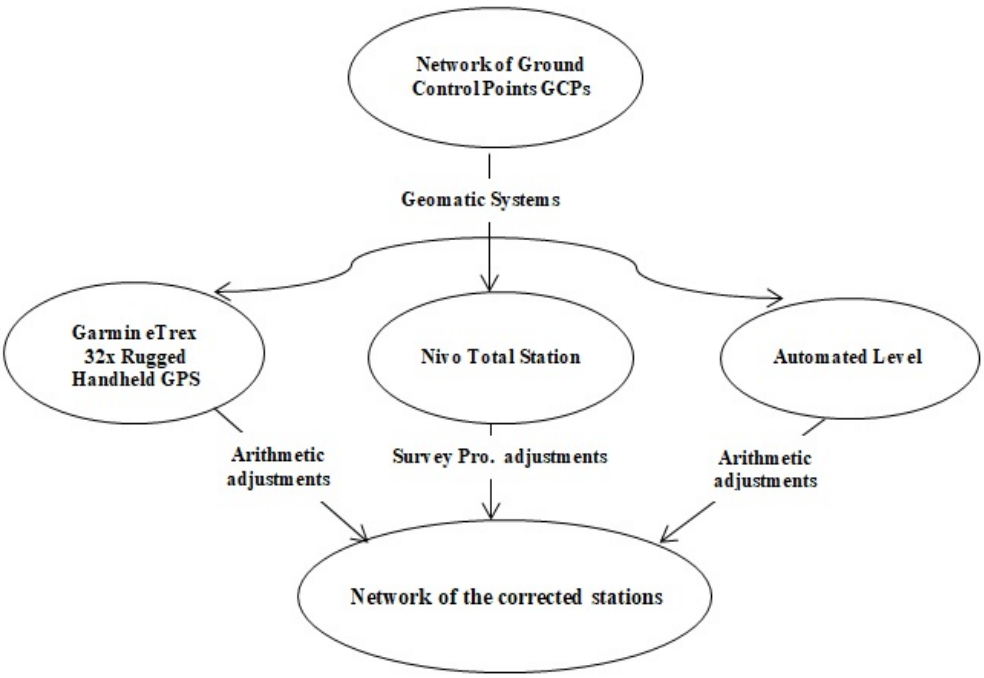

Fig. 1: Methodology and Procedures.

3 Results and Adjustment

A Closed Traverse can be adjusted using simple, with the computed error either being distributed equally among all of the setup instruments in the loop, or being distributed based on the foresight and backsight distances of each turn.

3.1 Adjustment of the Traverse by using Total Station

The horizontal and vertical adjustments of the closed traverse were done manually aided with the Survey Pro. Software was onboard on the total station itself. The observed values Northing, Easting and Elevation of the traverse stations were adjusted arithmetic equations. Table 1 which illustrates the output results of the horizontal and vertical traversing adjustment by Total Station.

Table 1: The Results of the Horizontal and Vertical Traversing Adjustment by Total Station.

Station ID.	adjusted Easting (E′)	adjusted Northing (N′)	adj.Elev. (Z′)
P1	441702.700	3681109.611	36.18
P1	441599.404	3681147.402	36.21
P2	441450.757	3681163.662	38.06
P3	441462.014	3681369.414	37.89
P4	441598.785	3681375.002	36.80
P5	441600.082	3681301.954	36.71
P6	441549.028	3681287.621	36.18
P7	441565.551	3681230.268	36.20
P8	441599.323	3681197.714	36.35
P9	441702.700	3681109.611	36.18
P1	441702.700	3681109.611	36.18

Misclosure in the horizontal = 0.007 m, misclosure in the vertical = 0.006 m.

Acceptable error = 12 √k = 12 √ 0.97087 = 11.82 mm = 0.012 m.

3.2 Adjustment of The Traverse by using Level Instrument

The closed traverse is balanced by distributing the error of closure over the traverse. The closure error is computed by the difference between the elevations of the same bench mark. The loop finished a level traverse on a known station (P1) or benchmark and closed the level traverse; this enables the level traverse to be checked, see Table 2.

Table 2: The Results of the Horizontal and Vertical Traversing Adjustment by LEVEL.

Station ID.	Measured Elevation	Corrected Elev. (Z′)
P1	36.185	36.185
P2	35.925	36.001
P3	38.375	38.307
P4	38.080	38.115
P5	36.255	36.544
P6	36.055	36.462
P7	35.827	35.960
P8	35.757	35.956
P9	36.392	36.607
P1	36.177	36.185

Misclosure in the vertical = 0.008 m.

Acceptable error = 12 √k = 12 √ 0.97087 = 11.82 mm = 0.012 m.

3.3 Software Application

Tables at Excel files can be added to ArcMap (Arc GIS) just like any other type of data. The "Source" tab of a table of contents is used to access the added table. Plotting the image using a GIS tool is important for location, design, and construction considerations. This cannot be done, therefore, until the distribution of any misclosure has been adjusted. Fig. 2 shows the image data display and attributes table of a traverse using a GIS application.

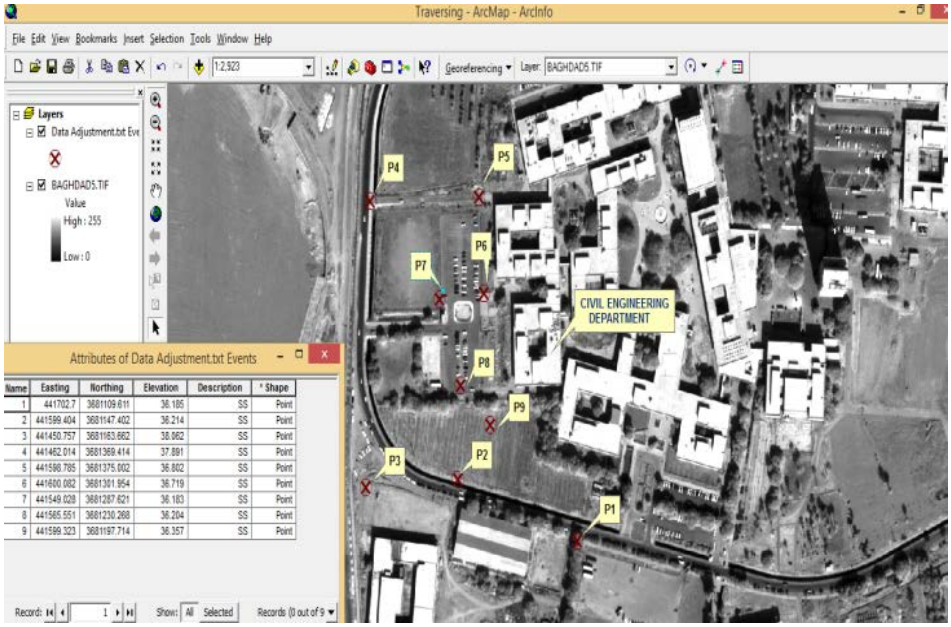

Fig. 2: Image Data View and Attribute Table of Traverse using GIS program.

3.4 Data Analysis

Total station traversing involves gathering field data, communicating that data, and delivering that data to a computer application for processing. These processes ensure that the data was displayed in the best possible way and provide a great deal of flexibility. The number of points, their distribution, and their method of observation all has a significant impact on traverse misclosure.

Analyses are done on the data from the Navigation GPS and Total Station. 3D coordinates of the points collected by GPS and Total Station. The error in their Northing and Easting coordinates was computed. The details of error calculated are given in Table 3.

Table 3: Horizontal and vertical error collected by using Total Station and GPS.

Station ID.	Error in Easting (m)	Error in Northing (m)	Error in Elev.
P1	3.300	2.389	5.185
P2	4.404	4.598	4.214
P3	5.757	3.338	5.062
P4	5.014	2.586	7.891
P5	4.215	4.998	2.802
P6	5.918	0.046	6.719
P7	4.972	2.379	6.183
P8	4.449	3.732	5.204
P9	3.677	3.286	6.357
Average Error	4.634	3.326	5.513

The maximum error is 4.998 m, minimum error is 0.046 m and average error is 3.326 m with R^2 of 0.077 m is observed in Northing, see Fig. 3. In Easting maximum error is 5.918 m, minimum error is 3.3 m and average error is 4.634 m with R^2 is 0.099 m is observed, see Fig. 4. Whereas the maximum

error is 7.891 m, minimum error is 2.802 m and average error 5.513 with R^2 is 0.71 m is observed in elevations, see Fig. 5.

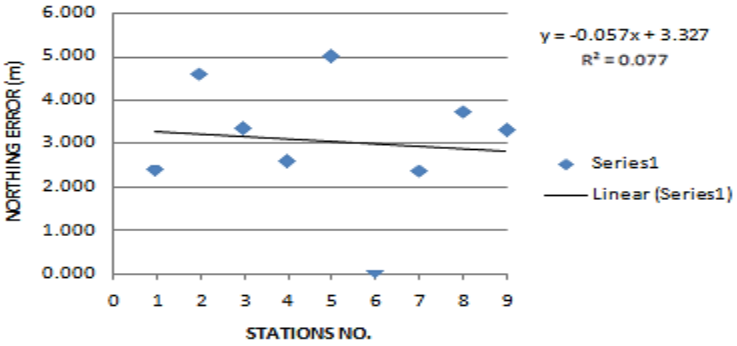

Fig. 3: Error in Northing by using Total Station and GPS.

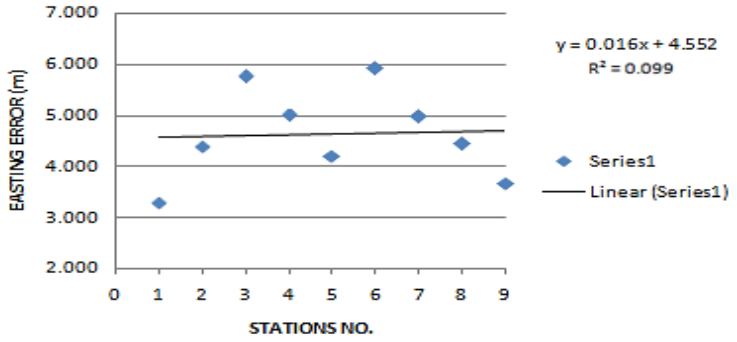

Fig. 4: Error in Easting by using Total Station and GPS.

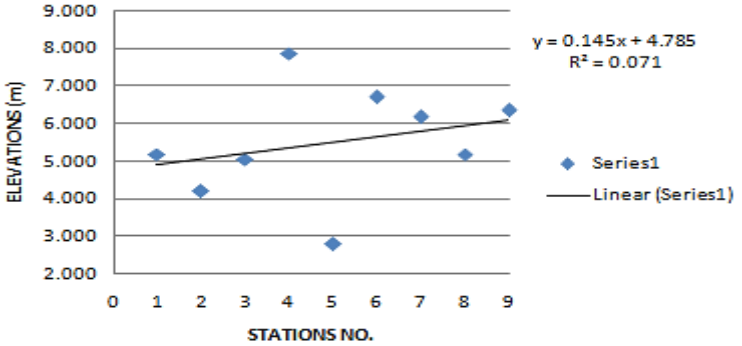

Fig. 5: Error in Elevations by using Total Station and GPS.

Fig. 6, Fig. 7 and Fig. 8 show the difference in measurements between the TS and GPS in relation to the Northing, Easting and Elevation, respectively.

This irregular difference in the elevations is due to a main reason, which is the accuracy of each device and the different reference datum for each of them.

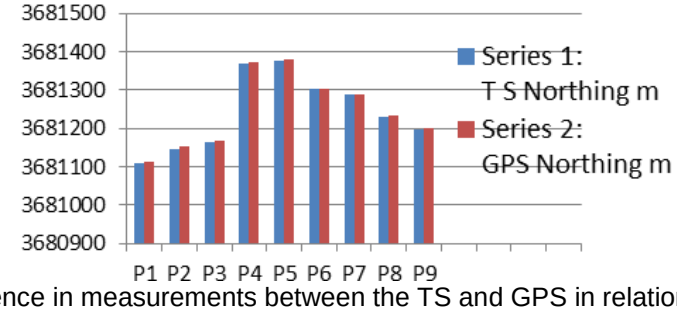

Fig. 6: The difference in measurements between the TS and GPS in relation to the Northing.

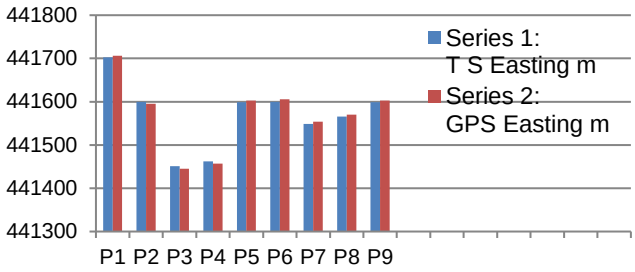

Fig. 7: The difference in measurements between the TS and GPS in relation to the Easting.

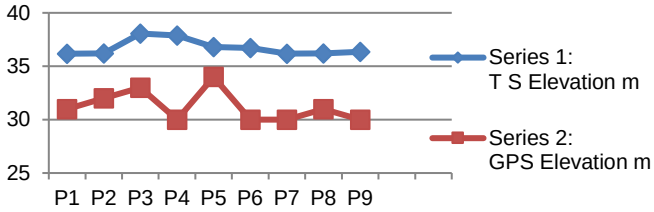

Fig. 8: The difference in measurements between the TS and GPS in relation to the Elevation.

The Elevations and the vertical error of the points that were collected by the level and Total Station are illustrated in Table 4. The maximum error is 0.258 m, minimum error is 0.213 m and average error is 0.240 m with R^2 is 0.735 m is observed in Elevations, see Fig. 9. The correlation of trigonometric levelling between level and the Total Station at the traverse stations is illustrated in Fig. 10.

Table 4: Comparison between Level and Total Station Elevations also, Error of Each Station.

Station ID.	Elevation by using Total Station	Elevation by using Level	Error in Elevation(m)
P1	36.185	36.185	0
P2	36.214	36.001	0.213
P3	38.062	38.307	0.245
P4	37.891	38.115	0.224
P5	36.802	36.544	0.258
P6	36.719	36.462	0.257
P7	36.183	35.960	0.223
P8	36.204	35.956	0.248
P9	36.357	36.607	0.250
Average Error	0.240 m		

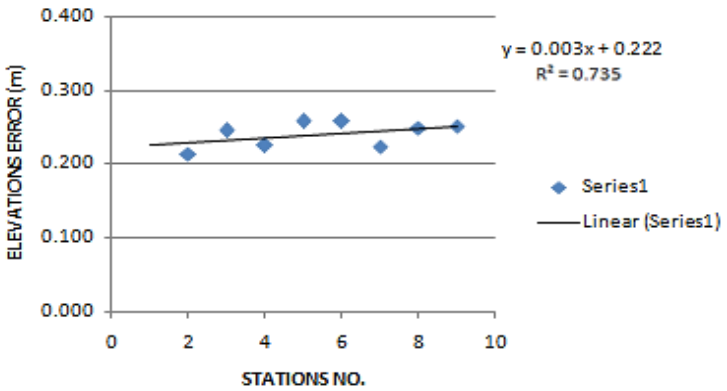

Fig. 9: Error in Elevations using Level and Total Station.

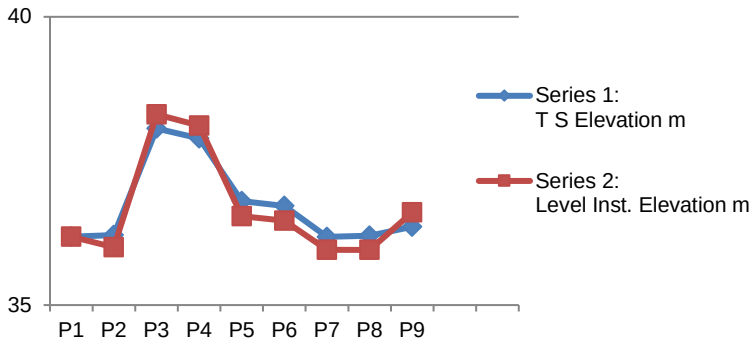

Fig. 10: The difference in measurements between the TS and level in relation to the Elevation.

4 Conclusions

The Nikon Nivo Total station is considered the most suitable for most geomatics works, including traversing because the total station contains the Survey Pro application, which can automatically execute traversing adjustments, in addition that the vertical and horizontal traversing accuracy of third order are reached in this study which are appropriate for the majority of engineering projects. Garmin GPS has only navigational accuracy and it is not possible to combine it with any geomatic systems, the horizontal or vertical networks obtained from it are not suitable for geomatic or geodetic purposes not for civil engineering. It is suitable only for navigation.

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