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Assessment of positioning accuracy using DGPS in Iraqi survey work

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Abstract

Due to the importance of survey work and positioning in any construction project, the opportunity of using new technology is vital to observe high accurate information. Differential Global Positioning Systems (DGPS) represents of most recent innovation in positioning systems. This tool used two types of methods to reduce the error, firstly the gather information from geographic position systems satellites (GPS) comparing it with real fixed ground locations. DGPS can not only improve project accuracy but it can reduce the total survey work in terms of time and cost considerably. However, the high initial cost to buy this kind of equipment prevents many public and private organizations in Iraq from start using this new technology. This research will aim to give real evidence of how accurate DGPS can be. This aim has been achieved via implementing DGPS in a real project and show the real results and compared with standards errors derived from using common survey tools such as Total Station and GPS.

Keywords: Gps, Dgps, survey, accuracy, positioning and Iraq.

Introduction

Survey work represents one of the most important and vital steps in project initiation Clough et al [1]. The kind of work is responsible to give the exact location and elevation to thousand of elements for a single construction project Mill et al [2]. Any kind of error in perceived location will definitely cause a huge impact on project performance, delays, and cost overrun Werbrouck et al [3]. Therefore, numerous efforts have been used up to improve survey work via implementing new technologies and methods. These studies and research start from refining the measuring productions using tapes by using new tools like Laser measurement devices or using theodolite or Total station equipment to advance the overall survey work outputs Kavanagh and Slattery [4]. The enhancement in technology using the digital satellite in marine force navigation motive the professional to use this advantage and start to use this modification in survey work Pradhananga and Teizer [5]. Global Position System (GPS) represents one of modern method that implementing satellites signals to produce accurate locations Li et al [6]. GPS can be defined as a navigation system using satellites, a receiver and algorithms to coordinate location, velocity and time data for air, sea and land travel. The satellite system that GPS depends on is contains of an assemblage of 24 satellites in six Earth-centered orbital planes providing information 24 hour around the year. This technology has been first used in Iraq after the War in 2003, where USA army start to teach Iraq employee how to use this technology to find the location for different purposes. Subsequently, GPS has been used widely by engineering to perform survey work and find the boundaries of different elements and projects Kalaf et al [7]. Lack of understanding GPS limitation as equipment such as unserviceable in indoor environments due to the lack of access to the radio waves which will be blocked by physical barriers. Correspondingly, regular GPS cannot identify positions to greater than 3-m accuracy Marko [8]. Therefore, using GPS in accurate survey work will have the potential to produce considerable errors that will cause native impact of project quality. To overcome such kind of difficulties, new technology has been produced call Differential Global Position System (DGPS). DGPS can basically be defined as an augmentation to the GPS which affords enhanced location accuracy, in the range of processes of each system, from the 15-metre normal GPS accuracy to about 1 centimeter in best implementation environment [9]. The accuracy in DGPS is upgraded via using two receivers the base and the rover instead of one in GPS, which produce the accurate location using relative positions. Fig. (1) shows the basic concepts and tools using DPGS in survey work.

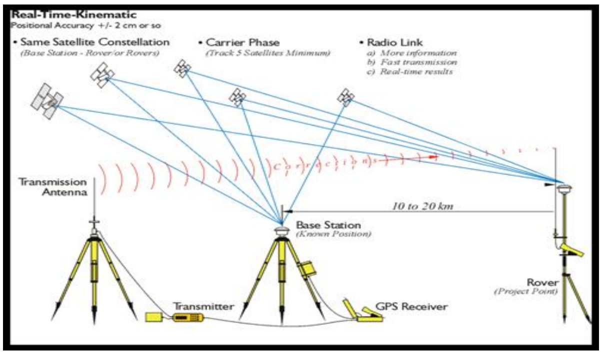


Fig (1) DGPS equipment and concept

Despite the significant accuracy of the DGPS, it is still lack of using this tool in Iraq construction project due to its expensive initial cost. This study will presents real evince of accuracy of this tool to motivate Iraq client to start demands this equipment in their construction project.

Description of study area

Iraq authorities officially practices local system of coordinates titled Iraqi Karbala datum 1979. This system of coordinates is well-known in Iraq as POL SERVICE by the name of the operator – a polish company. The works were executed in 1974-1979.
Basic specifications for the system:

1. The basis line of the system is located west of Karbala city.
2. Spheroid - Clarck 1880,
3. Vertical control network is reduced to the mean sea level (MSL) of "AL-FAW" station in Arabic gulf as zero point.

The relation between the Local System and the WGS is as below: -

EWGS84 = E Clark - (287.55) and NWGS84 = N Clark + (278.47)

The following coordinates system has been used in the Topographical Survey Works for the territory of the Study Area in Barash province:

1. WGS 1984,
2. Geoid: EGM2008
3. UTM projection, Zone 38N,
4. Vertical control network is reduced to the mean sea level (MSL) of "AL-FAW" station in Arabic gulf as zero point

The Survey work has been executed in Basrah province near West Qurna Oil field with cooperation IGCC company. Fig. (2) shows the location of the control points that have been used to examine DGPS accuracy.

Fig. (2) Location of control points

Method of Observation for Topographical Survey

The method of observation which has been used for the Topographical survey works was the Real Time Kinematic (RTK). All topographic data has been observed using DGPS. Real Time Kinematic (RTK) satellite navigation is a technique used to enhance the precision of position data derived from satellite-based positioning systems, being usable in conjunction with GPS, GLONASS and/or Galileo. It uses measurements of the phase of the signal′s carrier wave, rather than the information content of the signal, and relies on a single reference station to provide real-time corrections, providing up to centimeter-level accuracy. With reference to GPS in particular, the system is commonly referred to as Carrier-Phase Enhancement, or CPGPS. It has application in land survey and in hydrographic survey. The method of observation for the control points was Static technique. The Static Technique is most often employed when conducting control surveys, where accuracy is of primary concern as this study aim to achieve. These surveys can be conducted to establish an azimuth pair (two indivisible marks) from which to base a conventional survey or many single marks over a large area for the purpose of network or photogrammetric control. In either case, accuracy and reliability are the key factors. Static DGPS observations require fairly extensive observation times as compared to some other methods such normal GPS. Table (1) represents the observation time for each control point along with its name. The ACC base existing control point coordinates are 719490.7431 m E and 3438379.531 m N and with elation equal to 9.512m. The accuracy of the base point is crucial for evaluation DGPS accuracy. Therefore, this study relies on existing point that have been checked and used by international oil companies that work in this area. Table (2) displays the topographical information for each control point before inspect location accuracy. Fig. (3) shows the location of control points with regards to the existing reference point.

Table (1) Observation time for control points.

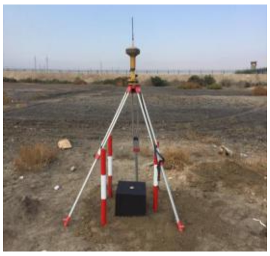
Control Points	Observed From (Existing GCP)	Observation Time (hrs.)
SMECP-BM-1	ACC Base	1.5
SMECP-BM-2	ACC Base	1.5
SMECP-BM-3	ACC Base	1.5
SMECP-BM-4	ACC Base	1.5

Table (2) Control point topographical information

<table>
<tr><th>Point Photo</th><th colspan="2">Point ID: SMECP_BM_4</th></tr>
<tr><td rowspan="8">
</td><td colspan="2">Point Description</td></tr>
<tr><td colspan="2">Country: Iraq Governorate: Al-Basra Date:3/10/2019 Material: Cylindrical metallic pipe frame Observation method: GNSS Static</td></tr>
<tr><td colspan="2">Coordinate System</td></tr>
<tr><td colspan="2">Iraqi Geospatial Reference System IGRS Datum: ITRF00
Ellipsoid: WGS84
Ellipsoid Height (Geoid): Derived via EGM2008
Projection UTM Zone 38N
Central meridian: 45o 00' 00.000" E Origin of latitude: 00o 00' 00.000" N False Easting: 500000.000 m.
False Northing: 0.000 m.
Scale Factor: 1.00019765538</td></tr>
<tr><td colspan="2">Location Information</td></tr>
<tr><td>Grid Easting (m.)</td><td>720110.0589</td></tr>
<tr><td>Grid</td><td>3432654.976</td></tr>
</table>

	Northing (m.)	7
	Elevation EGM08 (m.)	1.2884
	Precise Level Elevation(m.)	1.2901

Point Photo	Point ID: **SMECP_BM_2**	
 	**Point Description**	
	Country: Iraq Governorate: Al-Basra Date: 3/10/2019 Material: Cylindrical metallic pipe frame Observation method: GNSS Static	
	Coordinate System	
	Iraqi Geospatial Reference System IGRS Datum: ITRF00 Ellipsoid: WGS84 Ellipsoid Height (Geoid): Derived via EGM2008 Projection UTM Zone 38N Central meridian: 45o 00' 00.000" E Origin of latitude: 00o 00' 00.000" N False Easting: 500000.000 m. False Northing: 0.000 m. Scale Factor: 1.00019765566	
	Location Information	
	Grid Easting (m.)	720109.8721
	Grid Northing (m.)	3432479.9334
	Elevation EGM08 (m.)	1.1902
	Precise Level Elevation(m.)	1.2033

Point Photo	Point ID: **SMECP_BM_3**	
 	**Point Description**	
	Country: Iraq Governorate: Al-Basra Date: 3/10/2019 Material: Cylindrical metallic pipe frame Observation method: GNSS Static	
	Coordinate System	
	Iraqi Geospatial Reference System IGRS Datum: ITRF00 Ellipsoid: WGS84 Ellipsoid Height (Geoid): Derived via EGM2008 Projection UTM Zone 38N Central meridian: 45o 00' 00.000" E Origin of latitude: 00o 00' 00.000" N False Easting: 500000.000 m. False Northing: 0.000 m. Scale Factor: 1.00019765566	
	Location Information	
	Grid Easting (m.)	720110.0299
	Grid Northing (m.)	3432379.8601
	Elevation EGM08 (m.)	1.1359
	Precise Level Elevation(m.)	1.1433

Point Photo	Point ID: **SMECP_BM_4**	
 	**Point Description**	
	Country: Iraq Governorate: Al-Basra Date: 3/10/2019 Material: Cylindrical metallic pipe frame Observation method: GNSS Static Surveyor :IGCC	
	Coordinate System	
	Iraqi Geospatial Reference System IGRS Datum: ITRF00 Ellipsoid: WGS84 Ellipsoid Height (Geoid): Derived via EGM2008 Projection UTM Zone 38N Central meridian: 45o 00' 00.000" E Origin of latitude: 00o 00' 00.000" N False Easting: 500000.000 m. False Northing: 0.000 m. Scale Factor: 1.00019765566	
	Location Information	
	Grid Easting (m.)	720110.010
	Grid Northing (m.)	3432159.583
	Elevation EGM08 (m.)	0.9108
	Precise Level Elevation(m.	0.9108

	)	

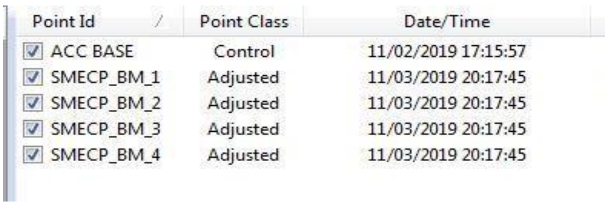
Table (2) Control point topographical information

Fig (3) Control points location with regards to the existing base point.

Analysis and results

In order to evaluate the accuracy of using DGPS to determine point location and elevation, Loop level method will be implemented to serve this study aim. The purpose of this loop leveling is to reach an error > 5 mm per 1 km of measurements reference to the work requirements, and it done by the following procedure:

1- Start from one point and close to itself or to another adjusted point, in this loop level method, it has been chosen to start from SMECP_BM_4 Point passing throw SMECP_BM_3, SMECP_BM_2, SMECP_BM_1. Fig (4) shows the observation time for each point.



Point Id	Point Class	Date/Time
ACC BASE	Control	11/02/2019 17:15:57
SMECP_BM_1	Adjusted	11/03/2019 20:17:45
SMECP_BM_2	Adjusted	11/03/2019 20:17:45
SMECP_BM_3	Adjusted	11/03/2019 20:17:45
SMECP_BM_4	Adjusted	11/03/2019 20:17:45

Fig. (4) Observation time for each point.

2- Post process for each point as shown in Figs. (5), (6), and table (3).

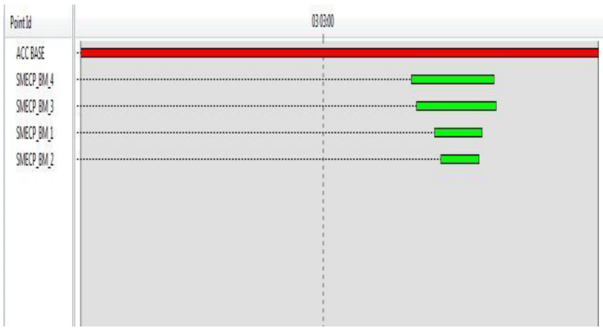


Fig (5). Occupation View

Table (3) Point observation Summary

Observation Summary	Base	BM1	BM2	BM3	BM4
Easting	719490.7431	720110.0589	720109.8721	720110.0299	720110..0100
Northing	3438379.5310	3432654.9767	3432479.9334	3432379.8601	3432159.5830
Ortho Hgt.	9.5123	1.2884	1.1902	1.1359	0.9108
Geoid. Sep	-14.7275	-14.7614	-14.7618	-14.7620	-14.7625
Ellip. Hgt.	-5.2152	-13.4730	-13.5715	-13.6261	-13.8517
Posn. +Hg	0.000	0.0026	0.0026	0.0018	0.0018
Sd. Easting	0.000	0.0008	0.0008	0.0006	0.0006
Sd. Northing	0.000	0.0009	0.0010	0.0007	0.0006
Sd. Hgt.	0.000	0.0022	0.0023	0.0016	0.0016
Posn. Qlty.	0.000	0.0013	0.0013	0.0009	0.0008
X	3708587.4131	3710219.7450	3710283.6087	3710319.9272	3710400.0725
Y	4018995.4512	4021502.5328	4021566.1277	4021602.6666	4021682.7726
Z	3271466.1190	3266547.6754	3266397.6586	3266311.8881	3266123.0432
Posn, Hgt.Qlty	0.000	0.0026	0.0026	0.0018	0.0018
Sd. X	0.000	0.0016	0.0017	0.0011	0.0011
Sd.Y	0.000	0.0016	0.0017	0.0012	0.0011
Sd.Z	0.000	0.0011	0.0011	0.0009	0.0009
Posn. Qlty.	0.000	0.0013	0.0013	0.0009	0.0008
DX	------	1632.3320	1696.1957	1732.5142	1812..6595
DY	-------	2507.0818	2570.6764	2607.2153	2687.3213
DZ	-------	-4918.4435	-4918.4435	-5154.2308	-5343.0758
Slope Dis.	-------	5756.8265	5930.8302	6030.3625	6249.4711
Hgt.	--------	1.2326	1.2627	1.2907	1.1524

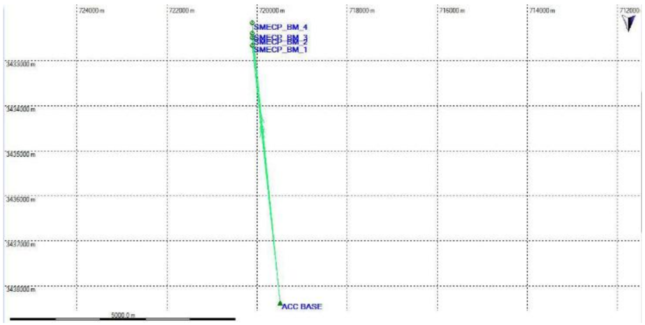


Fig (6) Map view

3- Loop level check

$\mathbf{C}=\boldsymbol{M}\mathrm{E}-\boldsymbol{A}\mathrm{E}$

$c : C/S \rightarrow for\ 1km$

Allowed error = ± 3 to 5 mm. per 1km

Where:

C: *Closure Error for all leveling loop*

ME : *Measured Elevation*

AE : *Actual Elevation*

It can be seen from the table (4) and (5) that the error for each control point is rang from -0.0003 to 0.0005 mm that has been produced using DGPS. These results give real evidence on the capability of DGPS as a survey tools and it can be used in different type of construction project. The high initial cost of the DGPS can be overcomes via its accuracy and its ability to reduce the field work and also the correction work that usually used in normal survey work.

Table (4) Location and elevation error observation results.

PT	B.S	F.S	Rise/ Fall	Dis. From level to Sta		Dis. km
				to BS	to FS	
SMECR-BM4	1.50572	0	0.00	37.44	0.00	0.00
x1	1.64925	1.611400	-0.11	42.00	54.19	0.09
SMECR-BM3	1.31081	1.310810	0.34	71.46	71.46	0.11
x2	1.42848	1.591480	-0.28	33.00	30.00	0.10
SMECR-BM4		1.380040	0.05	0.00	26.99	0.06
SMECR-BM3	1.33400	0.000000	0.00	54.00		0.00
X3	1.10350	1.043570	0.29	55.00	35.05	0.09
SMECR-BM2	1.21200	1.334000	-0.23	32.00	41.00	0.10
x4	1.38300	1.142000	0.07	49.00	33.23	0.07
SMECR-BM3		1.513000	-0.13		56.00	0.11
SMECR-BM2	1.30679	0.000000	1.21	34.00	65.00	0.07
x1	1.54783	1.384860	-0.08	45	76.00	0.11
SMECR-BM1	1.38338	1.383100	0.16	43.00	23.00	0.07
X3	1.56800	1.657340	-0.27	45.00	41.20	0.08
SMECR-BM1		1.38100	0.19		34.10	0.08

Table (5) Location and elevation error observation results

PT	Accu.mulative Distance from start (KM)	Weight =Part dist. /Total length	Correction(m.)=Weigh x (-C)	Measured Elevation(m.)	Prices Elevation(m.)	Closure error (mm)
SMECR-BM4	0.00	0.000	0.0000	0.9108	0.9108	0.0005
x1	0.09	0.208	-0.0001	0.8051	0.8050	
SMECR-BM3	0.21	0.466	-0.0002	1.1436	1.1433	
x2	0.31	0.697	-0.0003	0.8629	0.8625	
SMECR-BM4	0.37	0.841	-0.0004	0.9113	0.9109	
SMEC	0.00	0.000	0.0000	1.1433	1.1433	-0.0

R-BM3						001
X3	0.09	0.247	0.0000	1.4337	1.4338	
SMECR-BM2	0.19	0.514	0.0001	1.2032	1.2033	
x4	0.25	0.695	0.0001	1.2732	1.2733	
SMECR-BM3	0.36	1.000	0.0001	1.1432	1.1433	
SMECR-BM2	0.00	0.000	0.0000	1.2033	1.2033	-0.0003
x1	0.11	0.324	0.0002	1.1252	1.1254	
SMECR-BM1	0.18	0.524	0.0003	1.2900	1.2903	
X3	0.26	0.771	0.0005	1.0160	1.0165	
SMECR-BM1	0.34	1.000	0.0006	1.2030	1.2036	

Conclusion

This study aims to give real evidence regarding using DGPS equipment as survey tool in Iraq to motivate Iraq construction client to implement this kind of technology. This research result reveals several conclusion points as follows:

1- DGPS as a tool can be used effectively in different type of survey work.
2- The accuracy of the DGPS can overcome the high initial cost of the equipment as the DGPS can reduce field work and also can reduce the correction rework due to an accurate coordinate.
3- This study gave real evidence to prove the accuracy of using DGPS in Basrah province.
4- The accurate work needs an existing accurate base point to start work. Many reference points with same characteristics available in different positions in Barash province.

This research also recommends to start teach this kind of equipment in Iraq engineering colleges and institutes to improve the total awareness of DPGS which will increase the implementation percentage.

Acknowledgement

This research has been done with the cooperation with IGCC company as it provides the equipment and all supporting sources to complete this research.

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