International Academic Journal of Information, Communication, Technology & Engineering
ISSN: 5741-2605 | Volume 8, Issue 8 | January, 2025 | pages 77 – 86
OTL: 222-3942-8342-542-878-1
Double Blind Peer Reviewed International Research Journal
https://accexgate.com
journalsaccexgate@gmail.com

THIRD ORDER CONTROLS DENSIFICATION AND DEMARCATION OF RAMAT POLYTECHNIC MAIDUGURI PROPERTY BOUNDARY MAIDUUGURI, BORNO STATE

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Abstract: *As the polytechnic is expanding and new developmental projects are springing up, it was observed that there were limited numbers of reliable survey controls for both student's practical and monitoring of physical projects; hence the study focuses on third order control densification along the perimeter of the polytechnic. These controls will serve as a framework for engineering, topographic, cadastral, and route survey projects for the entire polytechnic and even beyond. The total length is 3093m (3.093km). The controls were evenly and spatially distributed in order to provide users within the community a sufficient choice for effective usage. Not less than fifteen satellites were acquired by the GNSS receivers for every observation, and a time range of not less than 45 minutes was used for data acquisition at every station, with a Positional Dilution of Precision (PDOP) value that ranged between 1.1 and 1.5, while a CHC-GNSS Dual receiver was used for the data capture in Static mode of observation. In-situ check was carried out for Controls reliability and a total number of nineteen (19) points were established around the boundary of the polytechnic. The size covers an area of 47.159 Hectares and the plan was plotted at a scale of 1:1, 5000.*

Keywords: *third order controls, in-situ check, control point, static mode, GNSS, ArcGIS.*

Introduction

Control Survey covers extensive area where long distances are involved, and provide the standard of accuracy for subsequent and subordinate surveys to attain. All projects, including route surveys, photogrammetric, and Topographical mapping are made up of a series of vertical and horizontal field surveys. These secondary surveys are dependent on control for position and relative accuracy. They are meant to serve as basis of reference for other surveys (Chandra, 2006).

Each control point has a unique set of location values (Coordinates) that define its position within the framework of control points. No two such points have the same values, no matter how close, unless they are defining the same position (Brinker & Wolf, 1997).
Horizontal controls could either be established by plane rectangular coordinates or geodetic longitude and latitude of a station (ASTROFIX). Vertical controls on the other hand establish elevation above a selected datum usually the mean sea level. Three classes of control may be distinguished: First order or Primary control, Second order or Secondary control and Third order or Tertiary controls (Chandra, 2006).

Traditionally there are three common methods of horizontal control survey; they are Triangulation, Traversing and Trilateration. Either of these combinations can be adopted. The terrain, project requirement, available equipment and relative accuracy to be attained govern the choice of method to be adopted (Brinker & Wolf, 1997).

Due to advances in computer and space technologies, surveying and mapping have revolutionized. Conventional methods and instruments in surveying and mapping have being transformed to analytical and digital. The Geo-information Technology tools is now being widely adopted to perform complex tasks in an efficient and effective ways. Examples of these tools are Global Navigation Satellite System (GNSS) Receivers, Total Station, Digital Level, Digital Theodolite, Analytical and Digital Photogrammetric Work Station, Digitizer, Drone, Scanner; Personal Computers and Printers/Plotters (Wolf & Ghilani, 2012).

GPS/GNSS Technology was initially developed for military use is now the game changer in the field of Geospatial technology. It is based on a constellation of twenty-four satellites orbiting the earth over 20,200km above the earth surface. These satellites act as a reference points from which receivers on the ground triangulate their position. (Wolf & Ghilani, 2012).

To measure the distance between the receiver and each satellite, the receiver has to receive a message from each satellite. The distance is then obtained by multiplying the speed of travel by the time interval. The time has to be known very accurately for this method (Micheal, Faith, Thaddeus & Hussaini, 2022).

The GPS positioning can be absolutely or relatively determined whilst the receiver is static or whilst it is moving (Kinematics). Also positions can be determined in real time or by post processing (Army corps, 2007).

Location of Project

The project is located at Ramat polytechnic, Maiduguri, Borno State. The area lies within the coordinates of 296505.528mE, 1308979.660mN, 296413.464mE, 1308960.471mN, 296321.798mE, 1308942.813mN, 296802.517mE, 1309286.805mN.

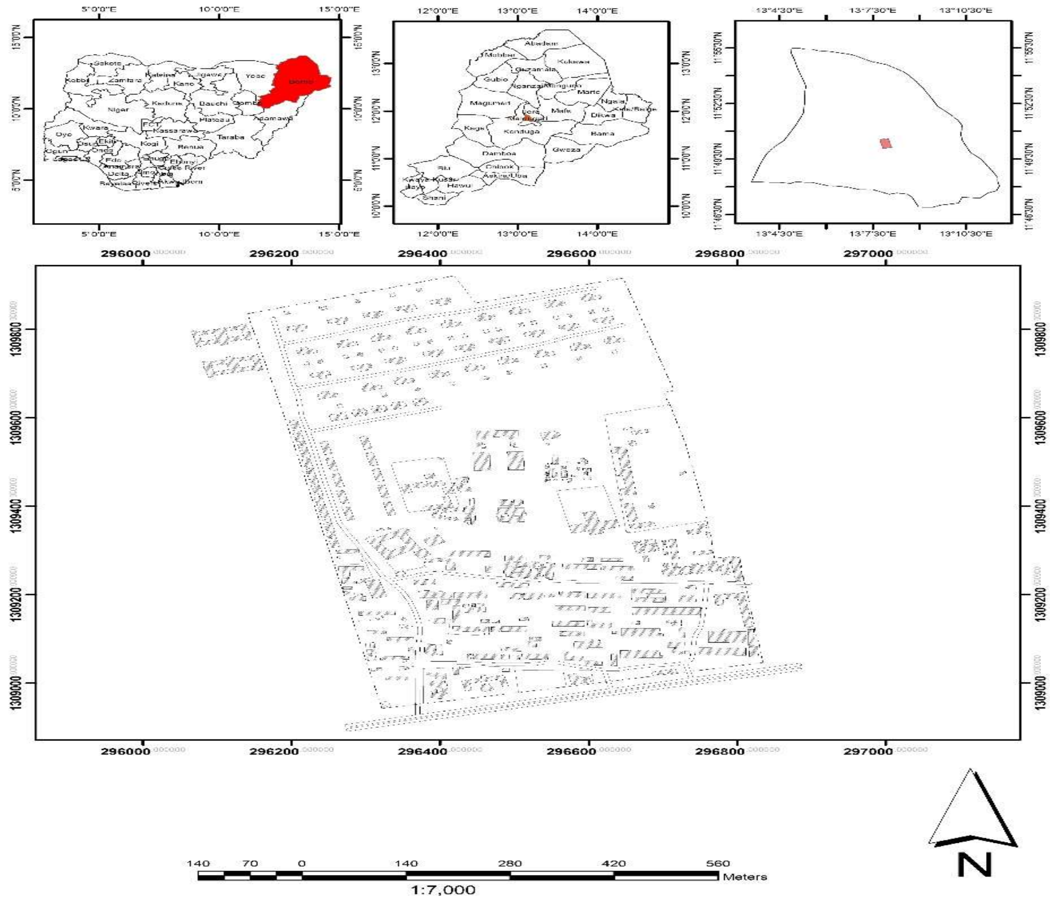


Fig. 1 Source: Modified from On-Street-Map (OSM) Data and Database of Global Boundary Administrative Areas (GADM V2.5). Coordinate system: WGS 1984. UTM Zone 33

Instrument and Material

This study used primary data sets which were obtained through observations from the GPS Receivers and other basic material.

1. Tripods
2. CHC-X20 Dual frequency GNSS Receiver with accessories
3. Writing Materials and Laptop
4. Steel Tape 5. Materials for Survey Pillars 6. Shovel & Digger

Reconnaissance

The field reconnaissance was accomplished through physical visitation to the site. General information on the terrain density and availability of control points were noted. These include but not limited to sketches of details and other utility features. Extent of the area, boundaries between adjoining neighborhoods, location of previously established points and where additional new points are required was noted. New Beacons were established in addition to the existing ones at the point of the field Reconnaissance.

In-Situ Check

To complement the observation, necessary information such as the location of the existing control points used and their coordinates (Northing, Easting, and Height) were obtained. Prior to data acquisition, in-situ checks were carried out to ascertain that the controls are intact and the GNSS Receiver is okay. The property Beacons which form the boundary of the site were equally confirm.

In order to achieve this, the GNSS Receiver was set, centered and levelled over the Base station (RPBM 004), with the Rovers receivers on RPBM 005 and RPBM 002. Data was collected and the difference between the observed and the known values were evaluated.

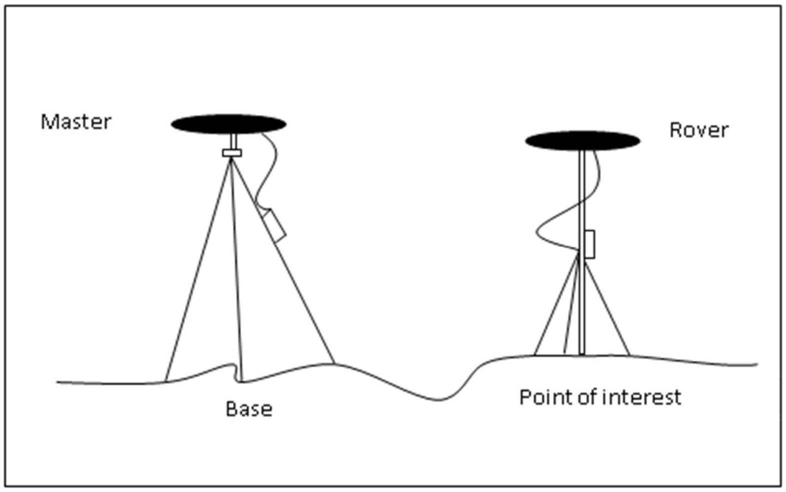


Figure 2: Set up procedure for static GNSS survey and Baseline Test

The result shows that the Beacons were reliable for use. An analytical comparison of the measured data obtained from the in-situ check and the calculated values is as show.

Station	Northing (m)	Easting (m)	**Observation**	**Result**	**Discrepancies**
RPBM002	1309024.064	296726.565	Obser. Included Angle	78° 21’ 39”	
RPBM004	1309001.134	296615.245	Measr. Dist. RPBM004 to RPBM02	113.656m	
RPBM005	1308954.236	296381.641	Comp. Dist. RPBM004 to RPBM02	113.583m	0.073m
			Measr. Dist. RPBM004 to RPBM05	238.266m	
			Comp. Dist. RPBM004 to RPBM05	238.221m	0.045m
			Comp. Brg.RPBM004 to RPBM02	78° 21’ 57	18″
			Comp. Brg. RPBM004 to RPBM05	78° 38’ 31”	
			Comp. included Angle	78° 38’ 54”	23”

Table 1: IN SITU Check

From the above positional error analyses, it was confirmed that the controls are IN-SITU and the instrument has fraction of centimeters accuracy and suitable to execute a survey project

Monumentation and Pillars Numbering

The pillars were made of pre-cast concrete pillars 76cm long, 18cm square in section, buried in the ground with the upper face projecting 7.5cm above the surface. An iron rod at least 30cm long sunk in the ground with 1cm protruding to the centre of the face forms the station mark. The concrete is mixed in the proportions of five parts of sand and gravel to one part of cement. A total number of nineteen (19) pillars were casted (SURCON, 2007).

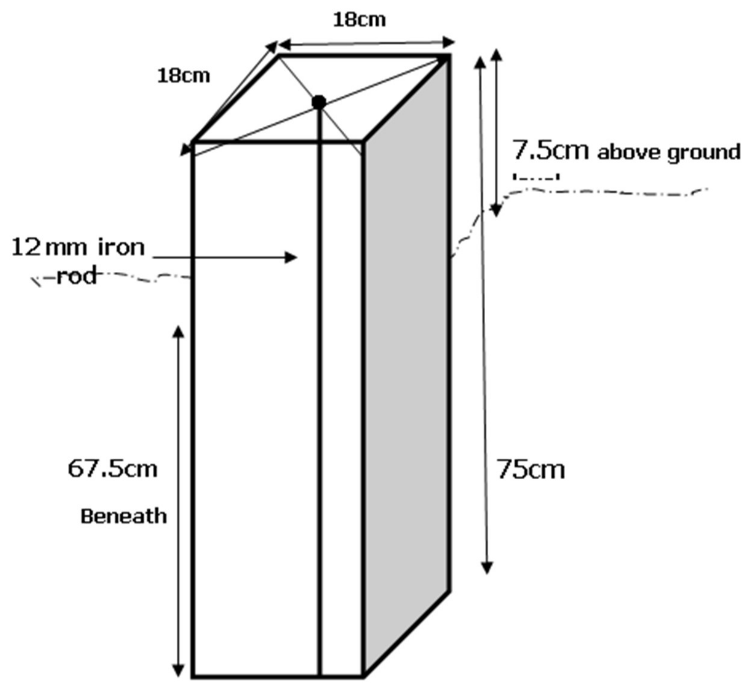


Figure 3: Third order control pillar (**Not drawn to scale)**

Data Acquisition

All GPS receivers required unobstructed sight to the satellites with a minimum of at least four satellites above the observer's horizon. The reference station must be placed in an area without obstruction, with each receiver in contact continuously to those satellites which is indicated by the satellites geometry technically referred to as ***"Position Dilution of Precision*** (PDOP).

The instrument was mounted over the tripod, set and leveled over the Base stations. It was then allowed to initialize in order to harmonize the phase ambiguity before the commencement of the survey work. It was allowed to occupy and generate data over each point for periods of time. The Base Station was used as a reference to determine the position of the newly established ones. The essence of the boundary survey is to provide a framework for the whole operation and at the same time to adhere to the principles of work from whole to part.

The Base receiver was set and centered over RPBM 04 (i.e. serving as the reference station) and the antenna arrow was now pointed in the direction of the north using a magnetic compass. After the initialization process between the Base station and the Rover Stations, the receiver was then turned on and with the help of the navigation key the satellite status screen was selected to check the number of satellites received. The Station ID (RPBM 004), survey mode (static), antenna height (in metres), height type and recording interval (30 seconds) were entered. The “Occupy” key was tapped again to start data collection and this opened the static survey screen. The static survey screen displayed such information as observation range; time elapsed since data collection started, number of satellites received and the current GDOP value. The saving mode was set to auto save so that the instrument can store the observed data and stop observation after the set time. When 45 minutes has elapsed the receiver automatically stop and store the observed data and give a beep sound signifying the data has been stored

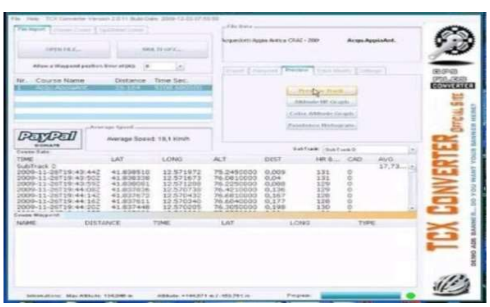
At the end of the observation, a time lag of 5 minutes was allowed before notifying the crew members at the base station to stop, store and shutdown the base receiver.

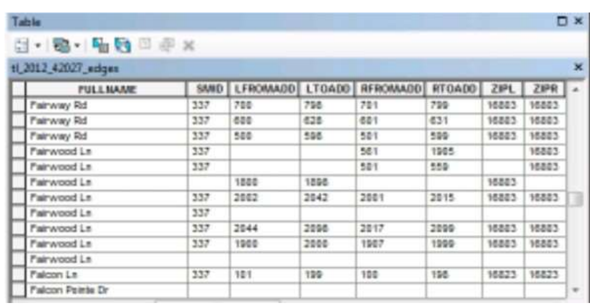
Data Downloading and Processing

The data was downloaded into the computer using Geomatics post-processing software. The geographic coordinates are post processed and transformed into rectangular coordinate and the adjusted coordinates of each point was obtained via the CHC Loader software. The data was further manipulated with the aid of the software in order to obtain the final adjusted UTM Coordinates of all points.

The principle behind DGPS is to use the reference location of the Base receiver to correct for the error position of the unknown Rover position. Since the base station is fixed, we can use the difference between the measurement of the base and the rover receivers to create an error correction vector. The precise location of the rover can then be calculated if we apply the error correction over all the satellite data. DGPS can be achieved through real-time or through post-processing the data. Post-processing differential techniques only require the use of two GPS receivers with storage capacity. The user will post-process the data on a computer after the GPS data have been collected (Agor, 2012).

Post processing and Corrections of field data was done by using RINEX (Receiver Independent Exchange Format) software, a standard data interchangeable format that allows the management and disposal of measures raw satellite navigation system data generated by a receiver and their off-line processing. It allows the user to post-process the received data to produce more accurate result.





Table

tl_2012_42027_edges

FULLNAME	SMID	LFROMADD	LTOADD	RFROMADD	RTOADD	ZIPL	ZIPR
Fairway Rd	337	700	798	701	799	16803	16803
Fairway Rd	337	600	628	601	631	16803	16803
Fairway Rd	337	500	598	501	599	16803	16803
Fairwood Ln	337			501	1905		16803
Fairwood Ln	337			501	559		16803
Fairwood Ln		1800	1898			16803	
Fairwood Ln	337	2002	2042	2001	2015	16803	16803
Fairwood Ln	337						
Fairwood Ln	337	2044	2098	2017	2099	16803	16803
Fairwood Ln	337	1900	2000	1907	1999	16803	16803
Fairwood Ln							
Falcon Ln	337	101	199	100	198	16823	16823
Falcon Pointe Dr							

Figure 4.TCX converter screenshot

Network Adjustment Report

Adjustment Settings

Set-Up Errors

GNSS

Error in Height of Antenna:	0.000 m
Centering Error:	0.000 m

Covariance Display

Horizontal:

Propagated Linear Error [E]:	U.S.
Constant Term [C]:	0.000 m
Scale on Linear Error [S]:	1.960

Three-Dimensional

Propagated Linear Error [E]:	U.S.
Constant Term [C]:	0.000 m
Scale on Linear Error [S]:	1.960

Adjustment Statistics

Number of Iterations for Successful Adjustment:	2
Network Reference Factor:	0.57
Chi Square Test (95%):	passed
Precision Confidence Level:	95%
Degrees of Freedom:	9

Post Processed Vector Statistics

Reference Factor:	0.57
Redundancy Number:	3.00
A Priori Scalar:	1.00

APPENDIX 1 COORDINATES, BEARING AND DISTANCES FIELD DATA

point	Northing	Easting	Course	Length	Bearing_angle	N_S	D	M	S	E_W
AMA001	1309046.292	296834.478	1-2	110.1783	78.36080151	S	78	21	38.88545	W
RPBM002	1309024.064	296726.565	2-3	113.6564	78.3608012	S	78	21	38.88433	W
RPBM004	1309001.134	296615.245	3-4	238.2661	78.64844567	S	78	38	54.40442	W
RPBM005	1308954.236	296381.64	4-5	60.40875	79.48750796	S	79	29	15.02867	W
AMA002	1308943.215	296322.245	5-6	164.5382	11.43186466	S	11	25	54.71277	E
AMA003	1309104.489	296289.634	6-7	208.5202	11.25157772	S	11	15	5.679794	E
AMA004	1309309.001	296248.948	7-8	140.141	11.25157802	S	11	15	5.680874	E
AMA005	1309446.449	296221.604	8-9	147.1112	11.25157825	S	11	15	5.681708	E
AMA006	1309590.732	296192.9	9-10	249.0334	12.23351297	S	12	14	0.64668	E
AMA007	1309834.111	296140.131	10-11	150.5795	72.64295642	N	72	38	34.64311	E
AMA008	1309879.033	296283.853	11-12	140.4011	72.89195298	N	72	53	31.03073	E
AMA009	1309920.335	296418.042	12-13	67.48854	25.8721413	N	25	52	19.70869	W
AMA010	1309859.611	296447.491	13-14	206.6789	74.20439059	N	74	12	15.80612	E
AMA011	1309915.87	296646.366	14-15	133.6806	15.04538275	N	15	2	43.37789	W
AMA012	1309786.772	296681.067	15-16	129.8565	15.1321895	N	15	7	55.88221	W
AMA013	1309661.418	296714.966	16-17	14.07651	74.63154618	S	74	37	53.56625	W
AMA014	1309657.688	296701.393	17-18	122.3229	13.94605092	N	13	56	45.78333	W
AMA015	1309538.97	296730.874	18-19	149.4678	9.731065512	N	9	43	51.83584	W
AMA016	1309391.653	296756.137	19-20	188.2939	17.415211	N	17	24	54.75961	W
AMA017	1309211.99	296812.492	20-21	82.71704	31.42431084	S	31	25	27.51901	E
AMA018	1309282.575	296769.366	21-22	33.41935	82.72868668	N	82	43	43.27204	E
AMA019	1309286.805	296802.517	22-1	242.6272	7.569471081	S	7	34	10.09589	W

Analysis of Result

It is desirable that at the end of survey operation, a comprehensive analysis of results should be drawn against the specification to determine its acceptability. The quality of the GPS position solution is largely dependent on the number of availability of satellites and their geometry with respect to the user. If enough satellites are visible on all sides of the receiver, good position accuracy can be expected. The Linear Accuracy was computed using linear misclosure formulae:-

$$\text{Linear Accuracy} = \frac{1}{\left(\frac{\sqrt{(\Delta E^2 + \Delta N^2)}}{total\ distance}\right)}$$

$1(-0.023)^2+(0.021)^2 \quad = 1:36,000$

To compute the linear accuracy, the parameters below were used:
Change in Northing = 0.075m
Change in Easting = 0.045m
Total distance covered = 3093.460m

$$\text{Closing error} = \sqrt{(-0.023)^2 + (0.021)^2}$$

Linear Accuracy = 1/ (√ ($\Delta N^2 + \Delta E^2$) / Total Distance.
This Misclosure has occurred over a distance of 3093.460m

Therefore, linear Accuracy = 1: 36,000

Table 4: Summary Analysis of the Accuracy of the tertiary traverse survey

Aspect	Obtained Accuracy	Required Accuracy
Linear Accuracy	ΔN(– 0.023; ΔE = +0.021)	Linear Accuracy = $\sqrt{(\Delta N)^2+(\Delta E)^2}$ /Total distance
Linear Accuracy	1:36,000	1:5,000 (minimum)
Total distance for perimeter survey = 3208.363m		**(Table 5)**

Conclusion

Establishment of Third Order Control Points along controls within the Polytechnic was successfully completed. The results obtained indicated a great achievement of the set objectives in accordance with the specifications. Consequently, the newly established control points are appropriate for use in subsequent survey projects in the area.

The high relative precision obtained in establishing each control point can be attributed to the right choice of methodology and instrumentation, especially the use of network processing with a minimum of two GNSS receivers.

The theoretical and practical background to control survey based on GNSS observation has also been established. The control points established will invariably provide consistent and accurate horizontal and vertical control for all subsequent surveys projects; photogrammetric, mapping, planning, design, construction, development of contract plans, right of way, as well as improvement projects and facilities. In addition, both Horizontal and Vertical controls values (coordinates) are now provided as a result of this project.

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