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Stability Determination of Second (2nd) Order Federal Geodetic Infrastructure in Anambra State, Nigeria

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----------ABSTRACT----------
Geodetic infrastructure is a control framework upon which planning, mapping, security and defence of any nation depended. Sometimes, this geodetic infrastructure is tampered, destroyed, uprooted, removed and became unreliable for tying survey work thus calling for stability determination to know the integrity of the existing monuments within the study area. Stability determination is ability to check if the geodetic monument is fit or not fit for tying surveying work. This stability determination is accomplished through a process called in-situ check. In-situ check is a process employed to determine if the geodetic control monuments are still in their position as it was, when established or shifted with respect to the original position. Therefore the purpose of this study is to carry out stability determination of second order (2nd) federal geodetic control in Anambra State, Nigeria. To accomplish this task, the following objectives were formulated such as knowing the coverage of second order federal geodetic control, physical visitation to second order federal control to know if the geodetic control is still existing physically on ground or not and to confirm the stability of the physically existing controls through in-situ check. The stability determination was achieved by in-situ check. In-situ check employed the use of differential GPS receiver (UniStrong G971 model) under static mode. The findings discovered were as follows; coverage of second order federal geodetic control is linearly along Enugu-Onitsha express way, Anambra State, Nigeria. Again, that out of twenty-two (22) second order federal geodetic controls visited, seventeen (17) do not physically exist on ground while five (5) are physically existing. Among the five (5) physically existing second order federal control, two (2) are defaced, two (2) are in good order while one (1) shifted. Further more in term of control stability, FGPANY 011 is most stable while the most unstable was FGPANY 005. Recommendations were given to carry out re-establishment of geodetic control not physically existing on ground, implementation of penalty as stipulated in constitution of Federal Republic of Nigeria as regards damaging of geodetic control and creation of awareness on importance of geodetic control among people especially construction workers and farmers.
Keywords: *Stability, Geodetic, Infrastructure, In-situ Check*

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I. INTRODUCTION

Geodetic Infrastructure is referred to as control points or station which is described physically on ground with a reference mark such as Monuments, beacons, bench marks (Ono et al, 2011). These geodetic controls are established in many places forming a set of interconnected lines called geodetic network. Thus geodetic infrastructure is made up of Horizontal Control, Vertical Control, Gravity Control, Magnetic Control, Tide-Gauge Control, CORS, that form a framework upon which the national development, security and defense of any nation is hinged (Ono et al, 2013; Mohammed, 2012). In addition to CORS, the geodetic control infrastructure also includes other things such as database archive, the computer and telecommunication equipment and software to make it operate and staff needed to design, operate, maintain, negotiate land use permit renewals with landowners and update the system and physical stations as well as to provide the outreach and instruction that enable professional communities to use it (Matins et al, 2017). A geodetic control infrastructure is the wire-frame or the skeleton on which continuous and consistent mapping, Geographic Information Systems (GIS), and surveys are based. This geodetic infrastructure is a positioning infrastructure which encompasses both the passive ground marks and active CORS to support positioning and mapping within datum (Rizos, 2009).

This geodetic infrastructure has various orders such as zero, first, second, third and fourth order. In term of accuracies and precision required, it ranges from zero order, first order to the fourth order (Ono, 2002), (Surcon, 2003). The zero order control is usually employed in geodynamic studies and seismic activities while

first order is for multipurpose scientific studies, second order for multipurpose control densification and urban control, followed by third order control which is for urban mapping and rest (Ono, 2002).

A geodetic network is important because, it provides means of controlling infrastructure development of any country as well as basic framework for development of any geospatial data infrastructure (Abuto, 2007). Despite the importance of this geodetic infrastructure, sometimes this geodetic infrastructure is tampered, removed, shifted, uprooted, covered by earth due to environmental and human factors such as flood, erosion, earth movement, landslides, construction companies, farming activities, land crappers, miners and individuals thus, some of the controls are not trusted for tying surveying work. This prompted the purpose of this research work for stability determination of second other federal geodetic infrastructure through the use of in-situ check in Anambra State, Nigeria.

The Second order geodetic infrastructure was established by office of Surveyor General of Federation around 2008, within the study area. The focus on second order federal geodetic control within the study area was due to newly established first order federal geodetic control by Office of Surveyor General of Federation under the formal Surveyor General in the person of Prof. Peter Nwilo around 2014. There is need to use those newly established first order control to check the already existing second order federal geodetic control which was established around 2008 with consideration that those existing second order control might have been affected by environmental and human factor. There is a belief that the factors listed above might have affected those monuments which this research is about to resolve.

II. METHODOLOGY

This ranges from the planning, data acquisition, physical visitation to second (2^{nd}) order federal geodetic controls and confirmation of their stabilities through a process called in-situ check. In using In-situ check, static mode method was adopted for the mode of observation with the use of UniStrong G971 model instrument which is a differential global positioning system (DGPS) receiver to ensure accuracy. The data observed by the instrument was downloaded in the computer, processed with the use of Geo Geomatics Office (GGO) software accompanied with rinex converter; the raw data was converted and also processed.

2.1 Objectives of the Research

To accomplish this task, the following objectives were formulated as knowing the extent of the coverage of second order federal geodetic control, to know if the geodetic controls are physically or not physically existing on ground as well as determining the stability of the physically existing controls to know if they are fit for tying surveying work.

2.2 Sources of Data.

Primary data: Oral interview with staff of the ministry and second (2nd) order federal control point's collection from physically existing control on ground see fig. 1:1, through occupation with instrument and observation taking.

Secondary data: Control records kept by statutory body (these data were assumed to be correct with minimum distortion) which is Office of Surveyor General of Federation.

2.3 Hardware and Software Requirement

Hardware used include: Computer, UniStrong G971 Differential Positioning System (DGPS) receiver, infinix x559c hot 5 series mobile phone with built in camera of 3264 x 2448 pixels, prismatic compass, flash drive, handheld Gps, Calculator, field book and other writing materials while software requirement are Microsoft Excel 2007, GNSS Solution, Microsoft word, ArcGIS 10.5 software, Geo Geomatics Office (GGO), Online Hiper Scientific Calculator and Leica QC software.

2.4 Data Acquisition

After collation of the second order federal geodetic control data, the inspection of the control sheet was executed through oral interview with staff of the ministry. The geodetic control obtained from ministry was plotted on ArcGIS 10.5 to know its coverage within the study area. Physical visitation to control site were embarked upon see fig. 2.1, to confirm if the geodetic control is physically or not physically existing on ground, where physically existing, their Stabilities were obtained through in-situ check.

Fig .2:1 Existing Second Order Federal Control on Ground, with Station id: FGPANY 003 and FGPANY 011 respectively

2.5 Stability Determination through In-situ check

Stability in term of geodetic control is the movement of control in both vertical and horizontal position with respect to initial position as established occasioned by environmental factors like subsidence, landslide, earthquake, flood, earth movement as well as human factors such as activities of farmers, construction companies. Process of determining this movement of geodetic control is referred as stability determination. Method of determining the stability of geodetic control is referred as In-situ check.

In-situ check is a process employed to determine if the geodetic control monuments are still in their position as it was, when established or shifted with respect to the original position. It is comparison of known coordinate with the newly observed one. If the discrepancy/error between the known coordinate and the new one is minimal, the control is stable, if not the controls are not stable.

2.6 **Tests for Stability Determination of Geodetic Infrastructure**

Comparison of coordinate obtained from statutory body and coordinate gotten from the field will be determined, if there is no discrepancy or the discrepancy is minimal, the monument is stable, if not, the monument is not stable, thus not fit for tying surveying work within the study area..

2.7 **Procedures for In-situ check for Stability Determination**

Differential GPS receiver instrument (UniStrong G971 model) under static mode was employed for this in-situ check for stability determination. Master GPS receiver was stationed at first order geodetic control point with station id XVS 911 located within Ukpo town in Dunukofia Local Government Headquarters premises, in Anambra state. The base (XVS 911) is centrally located when compared to the physically existing second order federal control the rover occupied. The base receiver is powered, and then followed by powering rover receiver occupying a station. The base receiver will be on until all the stations are occupied, rover station will be off followed by the base station.

III. DATA PROCESSING

Raw data gotten from differential GPS receiver (UniStrong G971) was downloaded to the computer through the use of cable. The downloaded data was processed with Geo Geomatics Office (GGO) software accompanied with Rinex converter.

3.1 Procedures for Processing of Downloaded Data

i) Click on GGO (processing software)
ii) Click on Tools >Rinex Converter
iii) Now create a project (Project Name as Anambra Control and other project parameters are set during this process)
iv) After the conversion and the QC, now click on Projects > Import >ObsFile. This is to import the GNSS data files.
v) Click on Baseline > Process All
vi) Click on Adjustment > Adjustment settings (Fix the known control and Set all other required parameter)

3.2 Result from Processing of Downloaded Raw Data

Baseline report, Map of the Network, Duration of time for Base and Rover Observation as well as Coordinate obtained after processing with Geo Geomatics Software and Leica Quality Control Test for all observed geodetic control.

3.2.1 Baselines Report

XSV911.19O--FGP AN012Y PIC.Report
Reference Station Information
Station Name: XSV911
WGS84 X(m): 6294325.0453
WGS84 Y(m): 770835.9711
WGS84 Z(m): 686789.0705
WGS84 B : 6°13'21.2095"
WGS84 L : 6°58'55.1092"
WGS84 H(m): 149.5161
Receiver Type: UniStrong G971
Antenna Type: UNIG971X003A
Antenna Height(m): 1.2610

Roving Station
Station Name: FGP AN012Y PIC.
WGS84 X(m): 6292346.3519
WGS84 Y(m): 782897.9095
WGS84 Z(m): 687512.7958
WGS84 B : 6°13'44.7450"
WGS84 L : 7°05'33.3390"
WGS84 H(m): 139.4998
Receiver Type: UniStrong G971
Antenna Type: UNIG971X003A
Antenna Height(m): 1.1440
Solving Parameters
Start Time: 2019/04/20 08:25:50
End Time: 2019/04/20 10:25:13
Interval(s): 1
Solve Model: IonoFree
Cutoff: 15
Least Epoches: 60
Limited Ratio: 3
Navigaition Type: BroadCast
Result
Pass !

The result was shown to be successful.

3.2.2 Map of Network

Fig .3:1 Map Showing Connection between the Base Station and Rover Station

The connection between the base station (XVS 911) and rover stations are shown in the fig.3:1 using Geo Geomatics Office (GGO) software.

3.2.3 Duration of Time for Base and Rover Observation

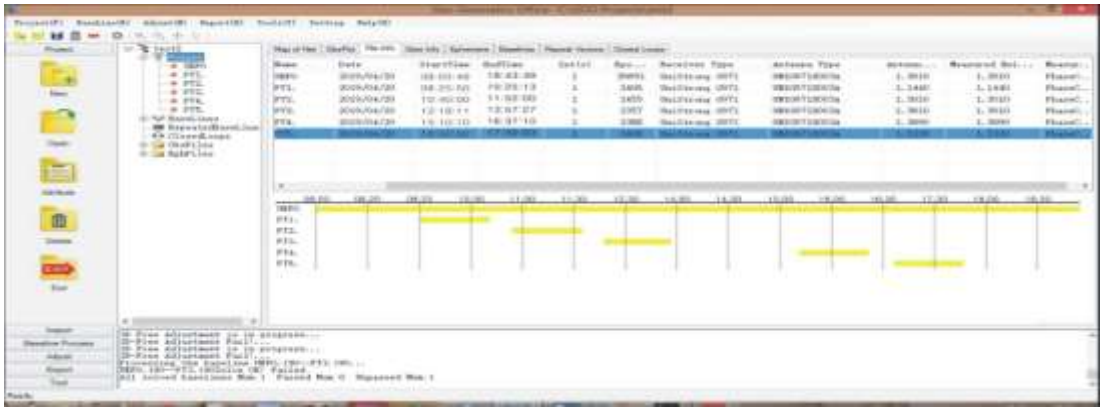

Fig .3:2 Time Intervals for Occupation of Base and Rover Station

The total time spent on base station was 10hrs 38mins 00secs while that of other five rovers' stations were 1hr 59mins 23secs, 1hr 12mins 00secs, 1hr 39mins 16secs, 1hr 27mins 00secs and 1hr 00mins 01secs as shown on fig.3:2. The minimum of 30mins specified for second order Geodetic GPS Survey in Nigeria was maintained (Surcon, 2003).

3.2.4 Coordinate obtained after Processing with Geo Geomatics Software

:

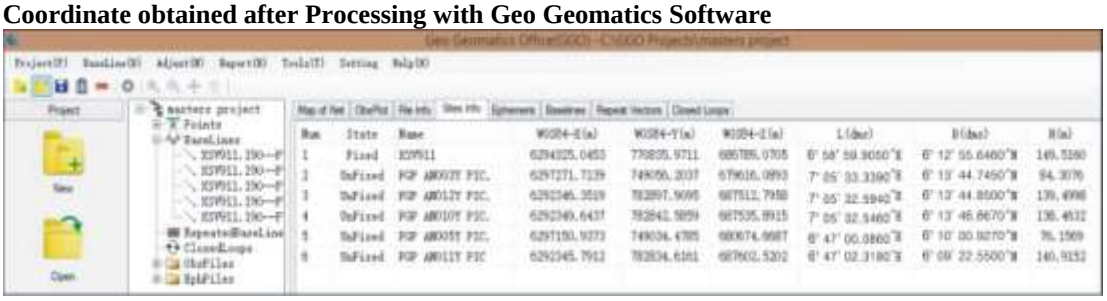

Fig .3:3 Coordinate obtained after Processing

Figure.3:3 show the final coordinates obtained after processing of downloaded raw data. The coordinates are in both geodetic form and Cartesian format.

3.2.5 Leica GNSS QC v2.2 - Quality Report

Program Run:2019/4/25 16:22:00.38

File Details:
Observation File:FGP AN012Y PIC.19O
GPS Navigation File:FGP AN012Y PIC .19n
GLONASS Navigation File:FGP AN012Y PIC.19g
Quality Testing:Pass
Quality Testing:

Pass/FailDetails
General Tests
Epochs With Data:Pass Value 100.0 %, Threshold 99.0 % File Format: Pass
RX Clock:Pass
Other:Pass

GPS Specific Tests
Cycle Slips:Pass Value 0 slips, Threshold 0 slips
Multipath:PassValue 0.00m MP1 / 0.00m MP2 / 0.00m MP5, Threshold 0.5 m Data Completeness: PassValue 100 %, Threshold 95.0 %
Navigation Data:Pass

GLONASS Specific Tests
Cycle Slips:Pass Value 3 slips, Threshold 88 slips
Multipath:PassValue 0.10m MP1 / 0.18m MP2, Threshold 0.5 m Data Completeness:PassValue 98.3 %, Threshold 90.0 %

The Quality Check tests carried out for each station were: General Test, GPS Specific Test and GLONASS Specific Test. GPS Specific Tests were sub – divided into Cyclic Slips, Multipath, Data Completeness and Navigational Data. All these tests were passed by all the stations between the values of minimum 98.3% to minimum threshold of 90.0%. Thus the processing of downloaded raw geodetic data gotten from field was successful and ready for comparison with the coordinate obtained from statutory body (Office of Surveyor General of Federation, Abuja, Nigeria).

IV. RESULT ANALYSIS

4.1 Coverage of Second Order Federal Geodetic Control

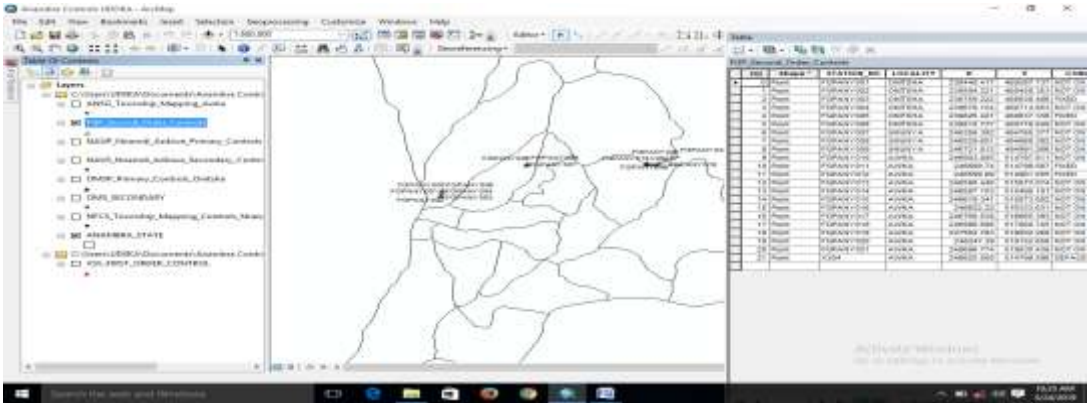

Fig .4:1 Second order federal Geodetic Control Plotted in ArcGIS 10.5 Showing its Coverage

Fig. 4.1 is ArcGIS 10.5 plotting of the second order federal geodetic control obtained from the statutory body which showed that coverage of the control is linearly along Enugu-Onitsha express way, Anambra State, Nigeria.

4.2 Result Analysis from Physical Visitation to Geodetic Control Site.

Table-4.1 Result from Physical Visitation of Second Order Federal Geodetic Infrastructure

S/N	CONTROL STATION	LOCATION	CONDITION
1	FGPANY 001	Onitsha	Not physically existing on ground
2	FGPANYOO2	Onitsha	Not physically existing on ground
3	FGPANY003	Onitsha	Physically existing on ground
4	FGPANY004	Onitsha	Not physically existing on ground
5	FGPANY005	Onitsha	Physically existing on ground but defaced
6	FGPANY006	Onitsha	Not physically existing on ground
7	FGPANY007	Umunya	Not physically existing on ground
8	FGPANY008	Umunya	Not physically existing on ground
9	FGPANY009	Umunya	Not physically existing on ground
10	FGPANY010	Awka	Not physically existing on ground
11	FGPANY011	Awka	Physically existing on ground
12	FGPANY012	Awka	Physically existing on ground but shifted
13	FGPANY013	Awka	Not physically existing on ground
14	FGPANY014	Awka	Not physically existing on ground
15	FGPANY015	Awka	Not physically existing on ground
16	FGPANY016	Awka	Not physically existing on ground
17	FGPANY017	Awka	Not physically existing on ground
18	FGPANY018	Awka	Not physically existing on ground
19	FGPANY019	Awka	Not physically existing on ground
20	FGPANY020	Awka	Not physically existing on ground
21	FGPANY021	Awka	Not physically existing on ground
22	X304	Awka	Physically existing on ground but defaced

In term of physical visitation to the control site as seen in table-4.1, out of twenty-two (22) second order federal geodetic controls visited, seventeen (17) do not physically exist on ground while five (5) are physically existing. Among the five (5) physically existing second order federal control, two (2) are defaced,

two (2) are in good order while one (1) shifted. Further more in term of control stability, FGPANY 011 is most stable while the most unstable was FGPANY 005.

4.3 Stability Determination through in-situ check

Table-4.2 Result of Stability Determination by In-situ check

Station id	Book Value		Obtained Direct From Field		Differences	
	Northing	Easting	Northing	Easting	**ΔN**	**ΔE**
FGP 012Y	688823.236	2888995.309	688847.869	288956.098	-24.583	39.211
X304	688848.465	288933.846	688850.904	288933.210	-2.439	0.636
FGP 011Y	688913.205	288932.881	688912.892	288931.978	0.313	0.903
FGP 005Y	682080.262	254760.937	682104.262	254696.399	-24.000	64.538
FGP 003Y	681013.899	254761.090	681016.989	254760.514	-3.09	0.576

Change in Northing and Easting is more on FGPANY 005 and least in FGPANY 011 as indicated in table-4.2, signifying that geodetic control point FGPANY 011 is the most stable, followed by X304, then by FGPANY 003, again by FGPANY 012 and finally by FGPANY 005.

V. CONCLUSION

The aim of this project has been achieved by determining the stability of second order federal geodetic control in Anambra State. In likely manner, the objectives formulated were achieved. The task embarked which involved physical visitation and determination of the conditions and stability of geodetic control was accomplished. Recommendation was also given such as re-establishment of geodetic controls not physically existing on ground, implementation of penalty as stipulated by constitution of Federal Republic of Nigeria incase of damaging of geodetic controls, creation of awareness on importance of geodetic infrastructure.

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