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Assessment of Passive Geodetic Control Network in Anambra State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Anambra State is facing a number of environmental challenges that require geodetic infrastructure for effective solutions. Unfortunately, much remains to be done in this area as many control stations have been removed from their original locations, leaving some of their pillars in disrepair. To address this issue, a study was conducted to assess the reliability of the geodetic control network in Anambra for various applications. The study involved identifying the location of control stations within the state, assessing the status of the geodetic control network, and confirming the status of individual control stations. Using a handheld GNSS receiver, the control stations were located and critically assessed for their physical condition. In addition, in situ checks were carried out to determine if they were still maintaining their original positions. The results of the study showed that 36% of the visited and located control stations are still intact in their original positions, while 56% have been removed and 8% require maintenance. There should be continuous sensitization of the public on the importance of geodetic controls and the dangers of their destruction.

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1. INTRODUCTION

A geodetic control network serves as a crucial foundation for consistent and accurate mapping, Geographic Information System (GIS), and surveys. A geodetic control network plays a crucial role in monitoring the deformation and environmental conditions of various structures such as dams, tunnels, high towers, landslides, and bridges [1,2] and in studying crustal movements [3]. The control stations are also essential for cadastral survey purposes. It is certain that any new lower order surveys are connected to the controls to determine the orientation and positions of all the turning points of a landed property [4]. The connection of new surveys to the geodetic network stations requires the measurement of directions and distances from the network stations to the new survey points [5]. This network consists of monument beacons and survey points strategically placed on the earth's surface, with precisely determined horizontal and vertical positions [6]. The geodetic control network comprises active (CORS) and passive (ground controls) stations [7]. The passive control network consists of the zero-order with the highest accuracy, followed by the first or primary order. The next in accuracy is the second or the secondary order, then the third or tertiary order [8]. By providing a means of controlling infrastructure development and laying the groundwork for geospatial data infrastructure, the geodetic control network plays a vital role in any country's development [9]. The establishment of these control infrastructures begins with the geodetic datum, a tool that defines the earth's shape and size, as well as the reference point for various coordinate systems used in earth’s surface mapping.

Over the years, the existing 2-D network has been found inadequate in supporting the basic spatial framework for the sustained management and development of the environment and natural resources in Anambra State. Furthermore, the coverage is sparse, many of the monuments have been destroyed or defaced and the reliability is confirmed to be very low [6].

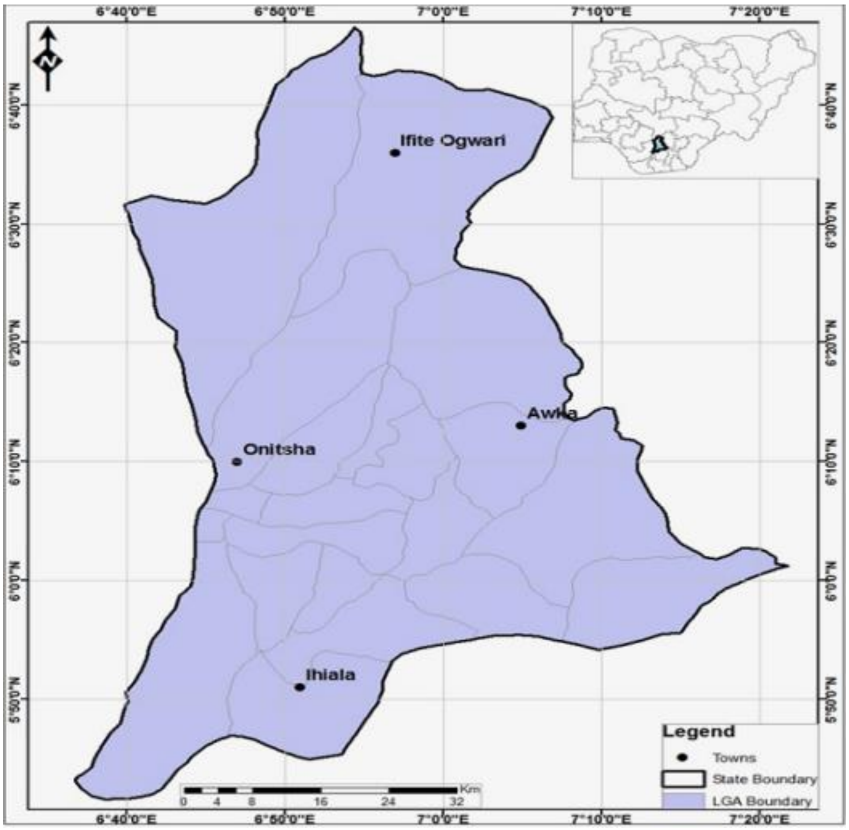

Fig. 1. Map of Anambra State
Source: Ifeka and Akinbobola [12]

In today's ever-evolving world, new technologies and methods of data collection are constantly emerging. Unfortunately, in Anambra State, a number of environmental issues require geodetic infrastructure, but not enough action has been taken. One of the main issues is that many geodetic control stations have been displaced from their original locations, with some of their pillars either missing or damaged. This study was conducted to assess the reliability of the geodetic control network in Anambra State for a variety of geodetic applications. It involved identifying control stations within the state, assessing the status of the geodetic control network, and confirming the status of individual control stations.

1.1 The Area of Study

Anambra State is a Nigerian state located in the southeastern region of the country. It was established on August 27th, 1991 and is bordered by Delta State to the west, Imo State and Rivers State to the south, Enugu State to the east, and Kogi State to the north. The state is comprised of 21 Local Government Areas and has Awka as its capital city. Onitsha, which is one of the largest metropolis areas in Africa, is the state's largest city. The majority of the population is made up of Igbos(https://www.britannica.com/place/Anambra)

Anambra State lies between latitudes 6° 00'N and 7° 00'N and longitudes 6° 45'E and 7° 30'E, with a landmass of approximately 4844 km^2. It consists of 21 Local Government Areas with a total of 179 communities [10]. The state has a projected population of 6,149,744 in 2022, according to Opkala *et al*. [11]. Fig. 1 shows the map of Anambra State.

2. METHODOLOGY

The control stations coordinates list and topographic map of the state showing the locations of the control stations were collected from the Department of Survey of Anambra State Ministry of Lands and Surveys. Fig. 2 shows the network of control stations in Awka, the State Capital.

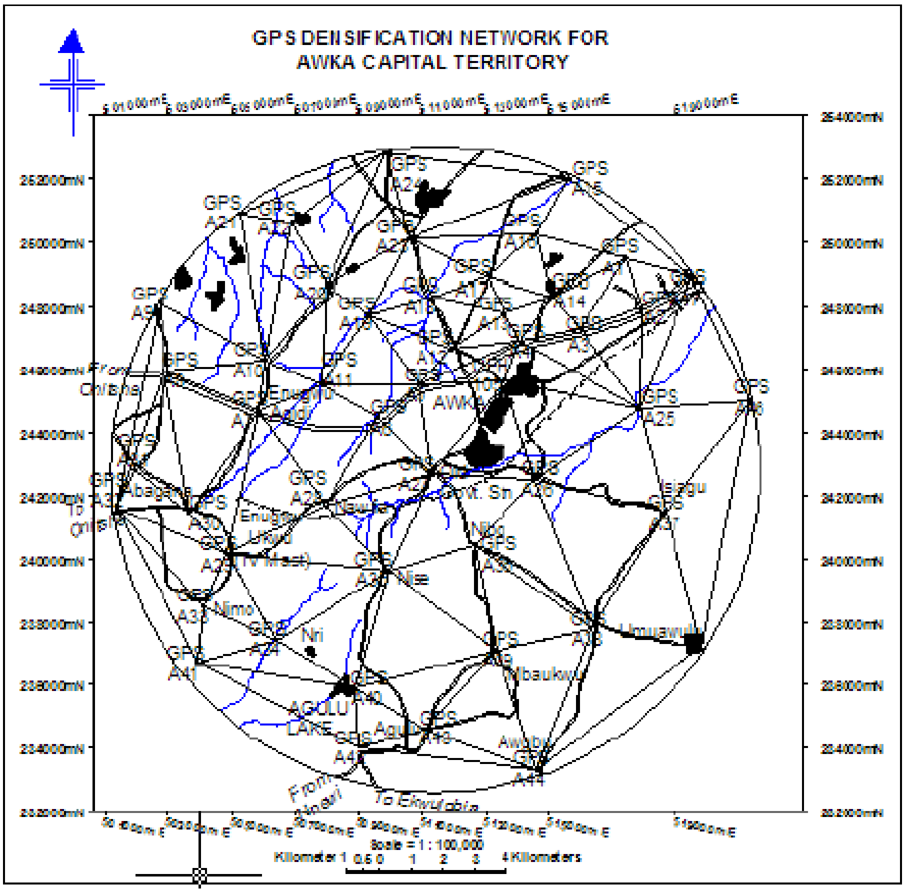

Fig. 2. Network of control stations in Awka

The control stations were located physically on the ground using a handheld Global Navigation Satellite System (GNSS) receiver. Their physical statuses, as well as conditions, were ascertained and noted.

In situ checks were also carried out on the existing control stations. An in situ check is carried out on control stations to determine whether they still maintain their original positions on the ground. The process requires computing the angle formed by any three controls and measuring the distances between any two stations with a total station (Fig. 3). The angle (Ø) subtends at one of the stations (A) and the distances between the other two stations and the middle station (AB and AC) are computed with the existing coordinates of the stations and compared with the observed angle (Ø) and measured distances (AB and AC) (Fig. 3).

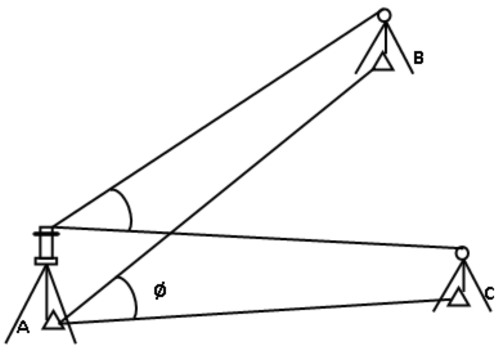

Fig. 3. *In situ* check with a total station

An in situ check is also carried out with GNSS receivers by observing the control stations relative to other existing reliable controls and comparing the newly determined coordinates with the known coordinates of the control stations in question.

In this study, both methods were used. For the control stations that were intervisible the total station method was used while the relative stations that were far from each other were checked using the GNSS method. The models for the computation of the bearings of the two survey lines and the distances between the controls are given respectively by Eteje and Okpeahior [13] as:

$$\text{Bearings } (\alpha_{AB}) = \tan^{-1}\left(\frac{\Delta E_{AB}}{\Delta N_{AB}}\right) = \tan^{-1}\left(\frac{\text{Departure}}{\text{Latitude}}\right) \quad (1)$$

$$\text{Distance } (\text{D}_{\text{AB}}) = \sqrt{(\Delta N_{AB})^2 + (\Delta E_{AB})^2} \quad (2)$$

Where,

$\Delta N_{AB} = (N_B - N_A)$ = Change in northing between points A and B

$\Delta E_{AB} = (E_B - E_A)$ = Change in easting between points A and B

The angle (θ) subtend at one of the control stations is computed using

$$\theta = \alpha_{AC} - \alpha_{AB} \quad (3)$$

Where α_{AC} is bearing of line AC and α_{AB} bearing of line AB

3. RESULTS AND DISCUSSION

3.1 Presentation of Results

Tables 1 to 3 show the current status of the first, second and third-order controls in various parts of Anambra State. The control stations are in Awka South and North, Nnewi South and North, Onitsha South and North, Anambra East and West, Idemili North and South, Anaocha, Oyi, Njikoka, Dunukofia, Ihiala, Aguata, Orumba North and Orumba South.

3.2 Discussion of Results

It can be seen in Table 1 that there are 15 primary controls in the state, 10 (XVS 982, XVS 983z, XVS 994, XVS 995, XVS 091, XVS 912, XVS 913, XVS 914, XVS 855 and XVS 855) are visible on the ground, 3 (XVS 992, XVS 993 and XVS 856) have been removed while 2 (XVS 779 and XVS 911) are on the ground but defaced. It implies that 10 of the 15 primary controls in Anambra are in good physical condition, 3 need to be re-established, and 2 need physical maintenance. It also indicates that 77% of the visited primary controls are physically intact on the ground, 8% of them have been removed while 15% that exist on the ground require maintenance.

It can also be seen in Table 2 that 1 (FGPANY 003) of the 9 second order controls is physically intact on the ground, 7 (FGPANY 001, FGPANY 002, FGPANY 004, FGPANY 006, FGPANY 007, FGPANY 008 and FGPANY 009) have been removed and 1 (FGPANY 005) is visible on the ground, but defaced. It shows that 1 of the 9 secondary control stations located in the state is still intact in its position, 7 need to be reestablished while 1 is visible on the ground but requires maintenance. It also implies that 15% of the visited and located secondary controls are physically intact on the ground, 35% have been removed while 50% of them that exist on the ground need maintenance.

Table 1. Status of First (Primary) Order Federal Controls in Anambra State

S/N	Control points	Location	District	Status/condition
1	XVS 982	Awka	UNIZIK Postgraduate Office	Visible on Ground
2	XVS 983z	Awka	UNIZIK Gate	Visible on Ground
3	XVS 992	Oko	FED Poly Oko	Uprooted
4	XVS 993	Onitsha	Oyiglueze	Uprooted
5	XVS 994	Ogboji	Central School Ogboji	Visible on Ground
6	XVS 995	Adazinnuku	Union Primary School, Adazinnukwu	Visible on Ground
7	XVS 091	Achalla	Awka North Secretariat Achalla	Visible on Ground
8	XVS 779	Nzam	Anambra West Secretariat Nzam	Visible on Ground But Defaced
9	XVS 911	Ukpo	Dunukofia Secretariat Ukpo	Visible on Ground But Defaced
10	XVS 91 2	Nnewi	Nnewi North Secretariat Nnewi	Visible on Ground
11	XVS 913	Ajali	Orumba North Secretariat Ajali	Visible on Ground
12	XVS 914	Ihiala	Ihiala Local Govt. Headquarters Ihiala	Visible on Ground
13	XVS 855	Abagana	Njikoka Secretariat Abagana	Visible on Ground
14	XVS 856	Neni	Aniocha Secretariat Neni	Uprooted
15	XVS 857	Ekwulobia	Aguata Secretariat Headquarter	Visible on Ground

Table 2. Status of second (Secondary) order federal controls in Anambra State

S/n	Control station	Location	District	Status/condition
1	FGPANY001	Onitsha	Old Hospital Road, Onitsha	Physically Not on Ground
2	FGPANY002	Onitsha	Onitsha Recreation Centre, Court Road	Physically not on Ground
3	FGPANY003	Onitsha	Court Road by Enugu Road	Visible on Ground
4	FGPANY004	Onitsha	Chinese Restaurant, Trans Nkisi	Physically not on Ground
5	FGPANY005	Onitsha	Magazine Junction, Onitsha	Visible on Ground But Defaced
6	FGPANY006	Onitsha	Garden of Light and Power Church	Physically not on Ground
7	FGPANY007	Umunya	Odumodu Junction, Along Enugu - Onitsha Express Way, Umunya	Uprooted by RCC Company
8	FGPANY008	Umunya	NYSC Camp Along Enugu - Onitsha Express Way, Umunya	Uprooted by RCC Company
9	FGPANY009	Umunya	NYSC Camp, Along Enugu -Onitsha Express Way, Umunya	Uprooted by RCC Company

Table 3. Status of third (tertiary) order federal controls in Anambra State

S/n	Control point	Location	District	Condition
01	ANSG GPS A1	AWKA	Amansea JXN, Old Enugu-Onitsha Express Way	Physically not on Ground
02	ANSG GPS A2	AWKA	UNIZIK Gate, B/W Two Arms of Road, Express Way	Physically not on Ground
03	ANSG GPS A3	AWKA	Ikenga Hotel JXN, Awka	Physically not on Ground
04	ANSG GPS A4	AWKA	Queen Anglican Convent, Ifite Awka Road	Physically not on Ground
05	ANSG GPS A5	AWKA	Before Amawbia JXN By Express Road, Ascending Hill to Osha	Physically not on Ground
06	ANSG GPS A6	AWKA	Amawbia Junction By Express Road	Physically not on Ground
07	ANSG GPS A7	AWKA	Enugu Agidi Junction	Physically not on Ground
08	ANSG GPS AS	AWKA	Ukpo Junction	Physically not on Ground
09	ANSG GPS A9	AWKA	Road to Nawgu, 2km From Ukpo Junction	Visible on Ground
10	ANSG GPS A10	AWKA	Community Council Hall, Enugu Agidi	Visible on Ground
11	ANSG GPS All	AWKA	Girls Secondary Amawbia	Physically not on Ground
12	ANSG GPS A12	AWKA	JXN B/W Achalla And Regina Celli, Awka	Physically not on Ground

It can again be seen in Table 3 that 2 (ANSG GPS A9 and ANSG GPS A10) of the 12 third order controls located are physically on the ground while 10 (ANSG GPS A1, ANSG GPS A2, ANSG GPS A3, ANSG GPS A4, ANSG GPS A5, ANSG GPS A6, ANSG GPS A7, ANSG GPS A8, ANSG GPS 11 and ANSG GPS A12) have been removed. It shows that 2 of the 12 visited tertiary order control stations exist physically on the ground while 10 are no longer in existence. It also implies that 17% of the visited and located third order control stations are physically intact on the ground while 83% of them have been removed.

Most of the control stations that are no longer in existence were removed from their respective location by construction companies moving equipment, and others were removed by individuals because of their landed property development.

In situ checks were carried out on the physically existing geodetic controls and were found to be intact in their original positions.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The study has evaluated the status of the geodetic control network in Anambra State by identifying the locations of some control stations to assess their physical conditions and confirm the stability of the controls. The study shows that 36% of the visited and located control stations are intact in their original positions, 56% have been removed, and 8% require maintenance.

4.2 Recommendations

The following recommendations are to prevent unnecessary destruction and removal of geodetic control stations:

1. There should be continuous sensitization of the public on the importance of geodetic controls and the dangers of their destruction.
2. Control stations should be established within government organization premises such as local government headquarters, government hospitals, state government secretariat, secondary and primary schools, etc., where they will be protected.
3. The establishment of control stations along highways should be done with considerable offset from the edges of the road to prevent their destruction during the future expansion of the road.
4. Construction companies are to report to the appropriate authority whenever they are to or mistakenly remove or destroy any geodetic control stations when working.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bagherbandi M, Shirazian M. Geodetic control networks: Challenges and solutions. GIM International; 2022. https://www.gim-international.com/content/article/geodetic-control-networks-challenges-and-solutions. Accessed 24th February, 2024.
2. Bagherbandi M, Shirazian M, Ågren J, Horemuz M. Physical and geometric effects on the classical geodeticobservations in small-scale control networks. Journal of Surveying Engineering. 2023;149(1).
3. AbdAllah AAG, Wang Z. Optimizing the geodetic networks based on the distances between the net points and the project border. Scientific Reports. 2022;12:647.
4. Ono MN, Onwuzuligbo CU, Ogonobo T. Evalvaluating geodetic control network of Awka Capital territory of Anambra State for sustainable development. FIG Working Week, Abuja, Nigeria; 2013.
5. Matsuoka MT, Rofatto VR, Klein I, Veronez MR, Silveira LG, Neto JB, Alves AC. Control points selection based on maximum external reliability for designing geodetic networks. Applied Sciences. 2020;10:687.
6. Ono MN, Onwuziligbo CU, Ijioma DI. Status of geodetic control network in Anambra State. Nigerian Journal of Surveying and Geoinformatics. 2011;3(2):45-55.
7. Emenari US. Management of first order dgps geodetic infrastructure in Anambra State. International Journal of Advances in Engineering and Management (IJAEM). 2021;3(11):157-165.
8. Aleem KF, Abubakar AF. The review and development of the Nigerian geodetic control network. Journal of Geospatial Surveying. 2022;2(2):22-29.
9. Abuto W. The use of gis technology in the development of an interactive geodetic

network information system with application in Kenya. Published MSc. Published Thesis of the Department of Surveying, University of Nairobi, Kenya; 2007.
10. Ayadiuno RU, Ndulue DC, Ndichie CC, Mozie AT, Phil-Eze PO, Onyekwelu AC. Geospatial Analysis of Soil Erosion Susceptibility and Causative Factors in Anambra State, South East, Nigeria. Scientific Review. 2022;8(1):5-32.
11. Okpala OV, Dim CC, Ugwu CI, Onyemaechi S, Uchebo O, Chukwulobelu U et al. Population Seroprevalence of SARS-CoV-2 Antibodies in Anambra State, South-East, Nigeria. International Journal of Infectious Diseases. 2021;110:171–178.
12. Ifeka AC, Akinbobola A. Land use/land cover change detection in some selected stations in Anambra State. Journal of Geography and Regional Planning. 2015;8(1):1-11.
13. Eteje SO, Okpeahior AC. Determination of the Topography and Draining of the Site for the Benin City Bus Rapid Transit (BRT) Station. Asian Journal of Advanced Research and Reports. 2021;15(8):48-63.

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