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Vertical and Horizontal Deformations Monitoring of FSS Rector's Administrative Block Using Conventional Geodetic Techniques

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Abstract

Many circumstances commonly contribute to changes in the size, shape, or dimensions of large structural objects. Therefore, monitoring the nature of these changes—especially those that may lead to structural collapse—is essential. This study focuses on the monitoring and analysis of vertical and horizontal deformations of the Rector's Administrative Block located within the Federal School of Surveying, Oyo, using ground survey methods. The objectives are: to carry out a preliminary study of the building through a reconnaissance survey; to ascertain the positional status of structural monuments already installed on the building through first-order survey observations; to perform least squares adjustment on the observed data using ADJUST software and MATLAB; and to compute the displacement magnitudes for all structural points and compare them with their respective 95% confidence ellipses for deformation analysis. The methodology adopted involves primary data acquisition using GNSS receivers, Total Station, and a Geodetic Digital Level. A total of eight lawn beacons and thirteen structural target points were observed. Deformation analysis was conducted by comparing the computed displacement magnitudes of each structural point with the USACE (2018) geometric standard to determine whether noticeable alterations or movements had structurally occurred, particularly between the observed epochs and data acquired in 2011. The results indicated that the building was very stable at the time of observation. It is therefore recommended that all large engineering structures be subjected to deformation studies.

Keywords: *Deformation, GNSS, MATLAB, USACE, Ground Survey Method, Epoch.*

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I. INTRODUCTION

Deformation can mean different things to different individuals, but in engineering, structural deformation refers to the change in the size, shape, or dimension of an object. While the death rate from collapsed structures—especially buildings—may not be as high as those from other tragic incidents such as plane crashes or road accidents, building collapses do occur, and the number of victims is often significant. According to [2], the deformation of any large structure is simply the variation in its position, size, and shape with respect to its original or designed state. Measuring the deformations of an engineering structure involves not just calculating the exact positions of the observed object but also analyzing the variation of these positions over time.

The need to monitor large structures is well recognized by both the general public and engineers due to the loss of human lives resulting from structural failures in various countries. According to the Nigerian Building Collapse Prevention Guild (BCPG), as reported by the *Tribune* online newspaper, the incessant collapse of buildings in Nigeria is becoming an alarming issue, with no fewer than sixty-one (61) buildings collapsing across the country in 2022 alone [6]. Out of these, twenty (20) incidents were recorded in Lagos State.

It is also on record that between October 1974 and November 2022, Nigeria experienced five-hundred and forty-one (541) incidents of building collapses with statistical indicator of: 322 cases in Lagos (60%), 20 cases (3.7%) in Anambra, 19 cases in Oyo (3.5%), 18 cases in Abuja (3.3%) 17 cases in Kano (3.1%), 12 cases in Ogun and Delta (2.2%), 11 casesin Ondo, Abia and Rivers (2%), 9 cases in Enugu (1.7%), 7 cases in Kwara, Imo and Plateau (1.3%), 6 cases in Kaduna, Edo and Osun (1.1%), 5 cases in Ebonyi and Jigawa (0.9%), 4 cases in Coss-river (0.7%), 3 cases in Benue, Adamawa and Niger (0.6%), 2 cases in Ekiti, Akwa-Ibom and Nasarawa (0.4%), 1 case in Bayelsa, Bauchi, Borno, Kebbi, Kogi, Kastina, Gombe, Sokoto, Taraba, Yobe and Zamfara (0.2%) respectively.

Deformation monitoring, according to Wieser and Capra is an indispensable contribution of geomatics to society and the economy. It provides quantitative and reliable information for studying processes in both natural and man-made environments, assessing risks, and adopting timely and appropriate measures [8].

There are frequent media reports of collapsed buildings in major cities across Nigeria. Within the first four months of 2023 alone, several cases were recorded—including the collapse of a seven-storey building in the Banana Island area of Lagos State on April 12th, a three-storey building in the Apapa area of Lagos State, and a block of flats at the Sango Police Barracks in Ibadan, Oyo State, on April 23rd. These incidents highlight the growing concern of structural failure in the so-called "Giant of Africa," Nigeria.

Although buildings naturally begin to deteriorate from the moment they are completed—and this gradual deterioration is inevitable—the rate at which it occurs can often be slowed down or even prevented through proper and timely monitoring and maintenance. In light of this, the Rector's Administrative Block at the Federal School of Surveying (FSS) has been equipped with thirteen structural wall target points to facilitate the accurate acquisition of relevant geometric information. This setup is intended to monitor both horizontal and vertical movements of the structure, enabling informed decision-making to help prevent potential future risks to life and property.

A. *Statement of Problem*

The study area, the FSS Rector's Administrative Block, was commissioned on Friday, October 23rd, 2009. The last periodic monitoring observation conducted on this structure was in 2011, approximately twelve years ago. This long interval indicates that the findings from 2011 can no longer be relied upon to represent the current structural status of the building. Therefore, a new deformation monitoring exercise was undertaken to evaluate the present structural condition and strength of the building, with the aim of safeguarding lives and property.

B. *Study Area*

Geographically, the study area is located in the south-west geopolitical zone in Oyo Town, Oyo State approximately between latitude 07^0 50' 29.07''N and 03^0 57'09.69''E and also between longitude 03^0 57'09.69''E. and 03^0 57' 11.18''E; it is bounded in the north by New Administrative complex (Abuja), in the east and south by new CBT Center and in the west by school staff quarters.

II. Literature Review

Deformation monitoring refers to the long-term observation of the deformation phenomenon of deformed objects through special measuring equipment and technology and the analysis and prediction of the deformation form and development trend of deformed objects (Jun Hu, Ensheng Liu, Jiayu Yu 2021). And according to Wan Abdul Aziz Wan MohdAkib and et al 2012) deformation refers to the changes a deformable body undergoes in its shapes, dimension and position and that large engineering structures are subject to deformation due to factors such as changes of ground water level, tidal phenomena, tectonic phenomena, land movements, or any other natural disasters.

Deformation analysis is concerned with determining if a measured displacement is significant enough to warrant a response. Deformation data must be checked for statistical significance, and then checked against specified limits, and reviewed to see if movements below specified limits imply potential risks. Deformation monitoring is one of the requirements to keep track of the designers' assumptions and predictions in order to assess the behavior of the structures for safety reasons [9].

Aside from natural disasters, the causes of building collapses include poor structural design, inadequate construction specifications, poor quality control and monitoring, illegal conversions, alterations or additions to existing structures, corruption, poor maintenance, and a lack of genuine geotechnical information about the underlying soil. Similarly, Oloyede attributed the causes of building collapse to human negligence in critical aspects of construction, such as soil investigation, failure to incorporate designs for extra loads, stresses from winds and earthquakes, uneven terrain, the use of substandard building materials, poor monitoring, and overall poor workmanship [4].

Pepe emphasized that photogrammetry can be classified into space, close-range, or microscopic techniques depending on imaging distances. In structural deformation monitoring, close-range photogrammetry shows great potential, as it is a branch of photogrammetry and remote sensing technology capable of acquiring relevant information about the Earth and surrounding objects through non-contact imaging and sensing systems [5]. This method records, measures, analyzes, and represents data within photographic distances of less than 100 meters. It significantly reduces the time required for experimental data collection by utilizing direct linear conversion and collinear condition equations for calculations.

Gethin revealed that laser scanners have the capability to capture millions of points within a relatively short time compared to traditional survey techniques and photogrammetry [3]. Although the accuracy of both methods is generally good, traditional techniques typically gather data only at specific points, which increases the risk of missing localized deformations such as cracks. The advantage of laser scanning technology lies in its ability to capture data from the entire structure without the need for specific deformation targets. Targets are only necessary for registering the structure and can be placed away from it to align various scans, thereby enabling comprehensive structural movement assessment.

III. Material and Methods

Traditional Ground Geodetic Survey Method with the use of Tersus Oscar *GNSS* receivers, Leica *DNA03* geodetic level and *CHCNAV CTS-112R4* Total Station was adopted in this study while the data collection techniques, processing, analysis and various results obtained are discussed as thus:

A. *Network Design for both Angular and Vertical Observation*

In order to aid the principle of Least Squares Adjustment, the network was designed for both angular and lateral observations as shown in Fig 3.1.1 and Fig 3.1.2.

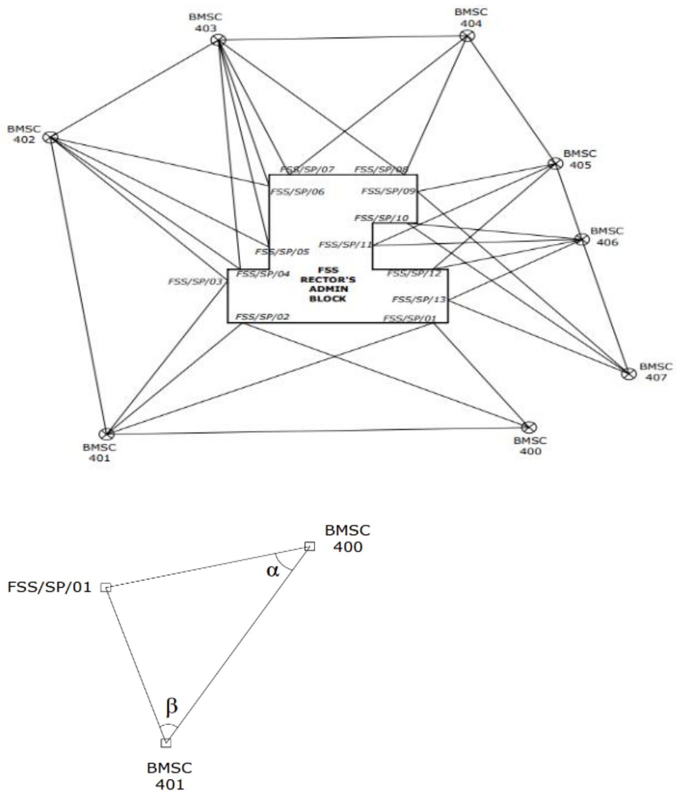

Fig 1: Diagram showing Intersection Observation to Structural Beacons

The formulae used was:

$$E_{SP01} = \frac{(N_B - N_A) + E_A \cdot \cot\beta + E_B \cdot \cot\alpha}{\cot\alpha + \cot\beta}$$

$$N_{SP01} = \frac{(E_B - E_A) + N_A \cdot \cot\beta + N_B \cdot \cot\alpha}{\cot\alpha + \cot\beta}$$

where: E_M = Easting of the wall target

N_M = Northing of the wall target

E_A & E_B = are the Easting of the reference lawn beacons

N_B & N_A = are the Northing of the reference lawn beacons

α and β are the observed angles subtended by lines of sight from the occupied reference lawn beacons to the structural wall target point.

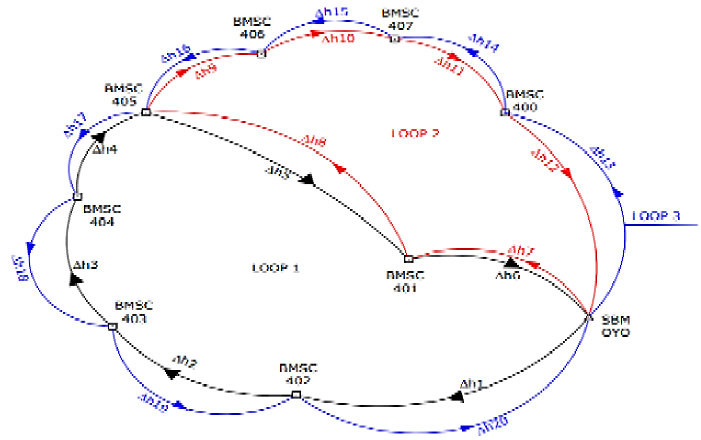

Fig 2: Diagram showing Network Loop Designed for Levelling Observation from Standard Benchmark to the Established Lawn Beacons.

B. *Adjustment Computation*

ADJUST Software was used to adjust the horizontal (X, Y) coordinates of the lawn beacons, while the variation of coordinates technique was applied to adjust the horizontal (X, Y) coordinates of the structural beacons. This was done to derive the final adjusted values of each lawn and structural beacon from their respective provisional coordinates, using the least squares observation method of adjustment.

In addition, MATLAB software was employed to adjust the vertical (Z) coordinates of both the lawn and structural beacons, based on the general observation equation mathematical model. According to [2], the functional relationship between the adjusted observations and the adjusted parameters is expressed as:

La = F(Xa)

Where:

- **La** = adjusted vector of observations
- **Xa** = adjusted station coordinates

Equation (1) is a linear function, and the general observation equation model derived from it is:

V = AX - L

Where:

- **V** = vector of residuals
- **A** = design matrix
- **X** = vector of unknown parameters
- **L** = vector of observed values

Estimated parameter

$X = (N)^{-1}(t)$

Where,

$N = (A^T WA)$ = Normal Matrix

$t = (A^T WL)$

$N^{-1} = (A^T WA)^{-1} = Q_{XX}$

$X = (A^T WA)^{-1}(A^T WL)$ = Estimate

W = Weighted Matrix

The models for the computation of the a-posteriori variance, $\sigma_o{}^2$ and a posteriori standard error, σf^2 as given by [2] are:

$$\sigma_o{}^2 = (V^T WV) / (m - n)$$
$$\sigma_o = \sqrt{(V^T WV) / (m - n)}$$

Where:
$(m - n)$ = Degree of freedom

The model for the computation of the standard error of the adjusted parameters is given as [1]:

$$\hat{\sigma} = \hat{\sigma_o} . \sqrt{Q_{nn}} = \sqrt{\sigma_o^2 . Q_{nn}}$$

Where,
Q_{nn} is a diagonal element of the inverse of the normal matrix (N^{-1}).

IV. DEFORMATION ANALYSES

The deformation analysis was conducted to determine whether the measured displacements are significant enough to warrant structural concern or intervention. The approaches adopted are discussed as follows:

A. *Displacement Components Estimation Between Epoch 1 and Epoch 2*

According to the U.S. Army Corps of Engineers [7], geometric modeling standards are commonly employed to analyze spatial displacements and general movement trends using a sufficient number of discrete point displacements. In this study, displacement components (ΔX, ΔY, and ΔZ) were estimated by differencing the most recent adjusted coordinates of the survey observations (Xf, Yf, Zf) from their respective initial adjusted coordinates (Xi, Yi, Zi). This method is expressed as:

- **ΔX = Xf – Xi** → Displacement in the X-direction
- **ΔY = Yf – Yi** → Displacement in the Y-direction
- **ΔZ = Zf – Zi** → Displacement in the Z-direction (vertical)
- **$\theta = \tan^{-1} (\Delta X / \Delta Y)$** → Direction of movement
- **$Dh(n) = \sqrt{(\Delta X^2 + \Delta Y^2)}$** → Magnitude of horizontal displacement
- **$Dv(n) = \sqrt{(\Delta Z^2)}$** → Magnitude of vertical displacement

These displacement components (ΔX, ΔY, and ΔZ), along with the direction (θ), and the magnitudes of horizontal (Dh(n)) and vertical (Dv(n)) displacements for all the installed structural points, are presented in Table 1.

TABLE 1: MAGNITUDE AND DIRECTION OF THE HORIZONTAL AND VERTICAL DISPLACEMENT.

Station ID	ΔX (m)	ΔY (m)	ΔZ (m)	D_h (m)	Direction	D_v (m)
FSS/SP/01	0.001643	0.021363	-0.004	0.021426087	04 23 52.39	0.004
FSS/SP/02	0.0048528	-0.01554	-0.0009	0.01628008	342 39 27.23	0.0009
FSS/SP/03	0.002926	0.0012	-0.0043	0.003162511	67 42 2.42	0.0043
FSS/SP/04	0.0003	0.0015	-0.0039	0.001529706	11 18 35.76	0.0039
FSS/SP/05	0.004168	-0.01012	-0.0043	0.010944708	337 36 55.11	0.0043
FSS/SP/06	0.000293	0.000915	-0.0037	0.000960767	17 45 21.71	0.0037
FSS/SP/07	-0.00742	-0.00068	-0.0078	0.007451094	84 45 49.68	0.0078
FSS/SP/08	-0.003574	0.002905	-0.0084	0.004605703	309 6 16.99	0.0084
FSS/SP/09	0.007145	0.002766	-0.0079	0.007661709	68 50 14.61	0.0079
FSS/SP/10	-0.014755	-0.00816	-0.0019	0.016861068	61 3 21.47	0.0019
FSS/SP/11	-0.0000534	0.001089	-0.0052	0.001090308	357 11 33.73	0.0052
FSS/SP/12	0.000621	0.006248	-0.0081	0.006278785	05 40 33.92	0.0081
FSS/SP/13	0.0000477	-0.00107	-0.0072	0.001071063	357 26 50.91	0.0072

B. *Standard Deviation Evaluation of Structural Points*

According [7], the Max. dimension of combined 95% confidence ellipse (e_n or e_v) for structural points are:

Percentage Confidence in Horizontal Movement (e_n) = $1.96\sqrt{(\sigma i^2 + \sigma f^2)}$

Percentage Confidence in Vertical Movement (e_v) = $1.96\sqrt{(\sigma vi^2 + \sigma vf^2)}$

where:
σi = is the standard error position for the initial survey

σf = is the standard error position for the recent survey

For this study, the standard error in easting and nothing as well as in height of all structural points was estimated using NCSS 2021 Data Analysis (Two Tail T Test Analysis). Standard deviation for both eastings and nothings and heights for Epoch 1 and Epoch 2 were computed as thus:

(i) Easting deviation between 1st and 2nd epoch = 0.00555329 (see Fig 3)
(ii) Nothing deviation between 1st and 2nd epoch = 0.01159894 (see Fig 4)
(iii) Standard deviation of heights for all the structural points was estimated for 1st and 2nd epoch as 0.003301612 (see Fig 5)

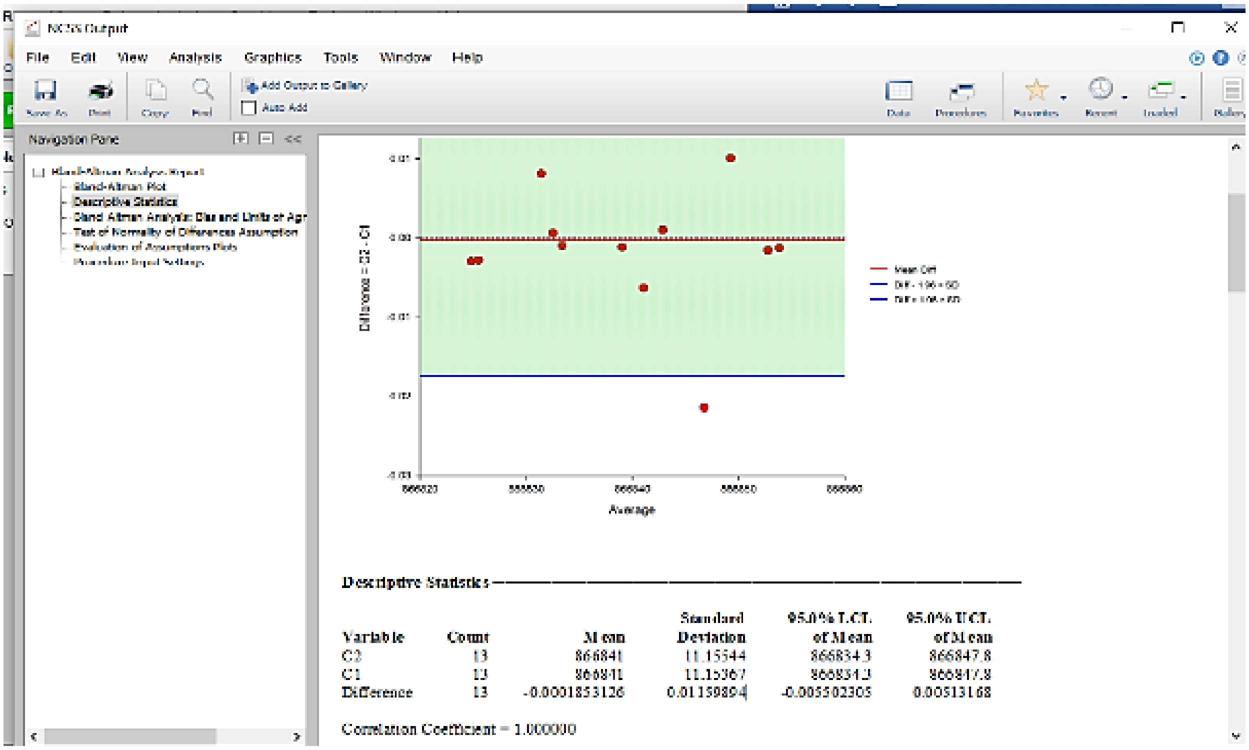

Fig 3: Standard Deviation of Easting Coordinate between 1st and 2nd epoch.

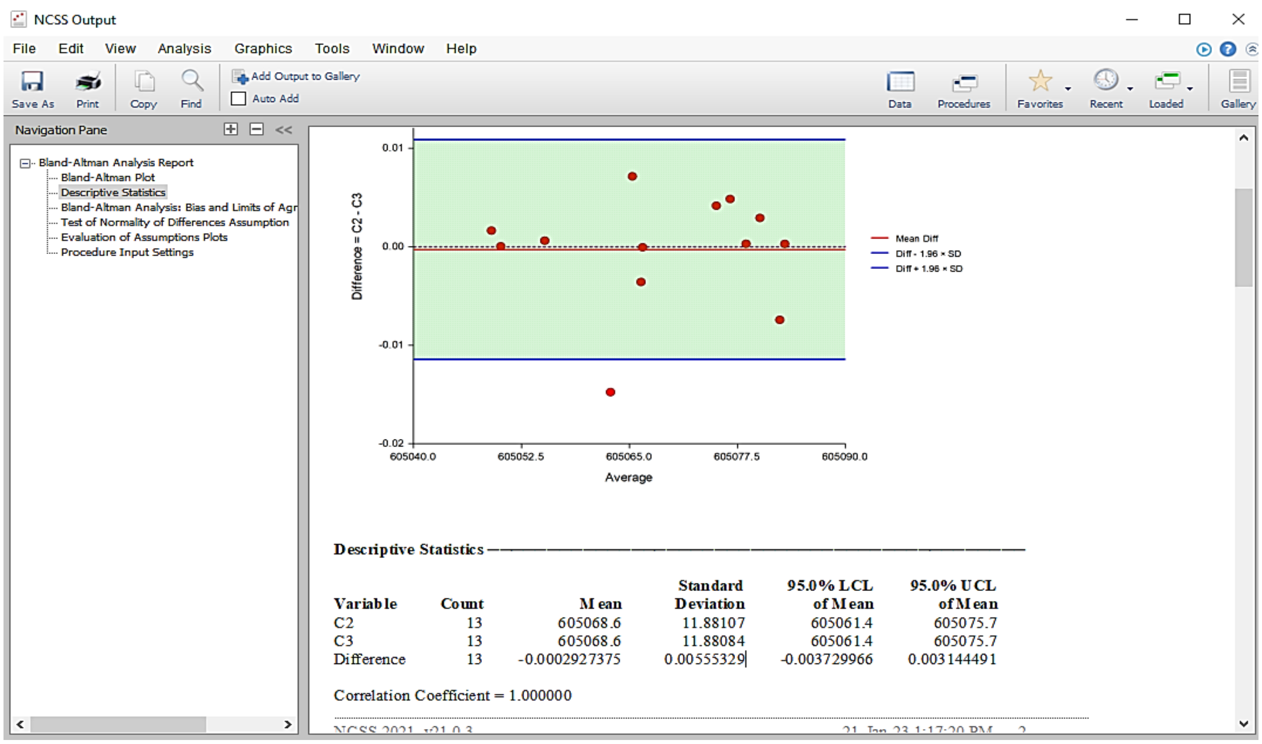

Fig 4: Standard Deviation of Nothing Coordinate between 1st and 2nd epoch.

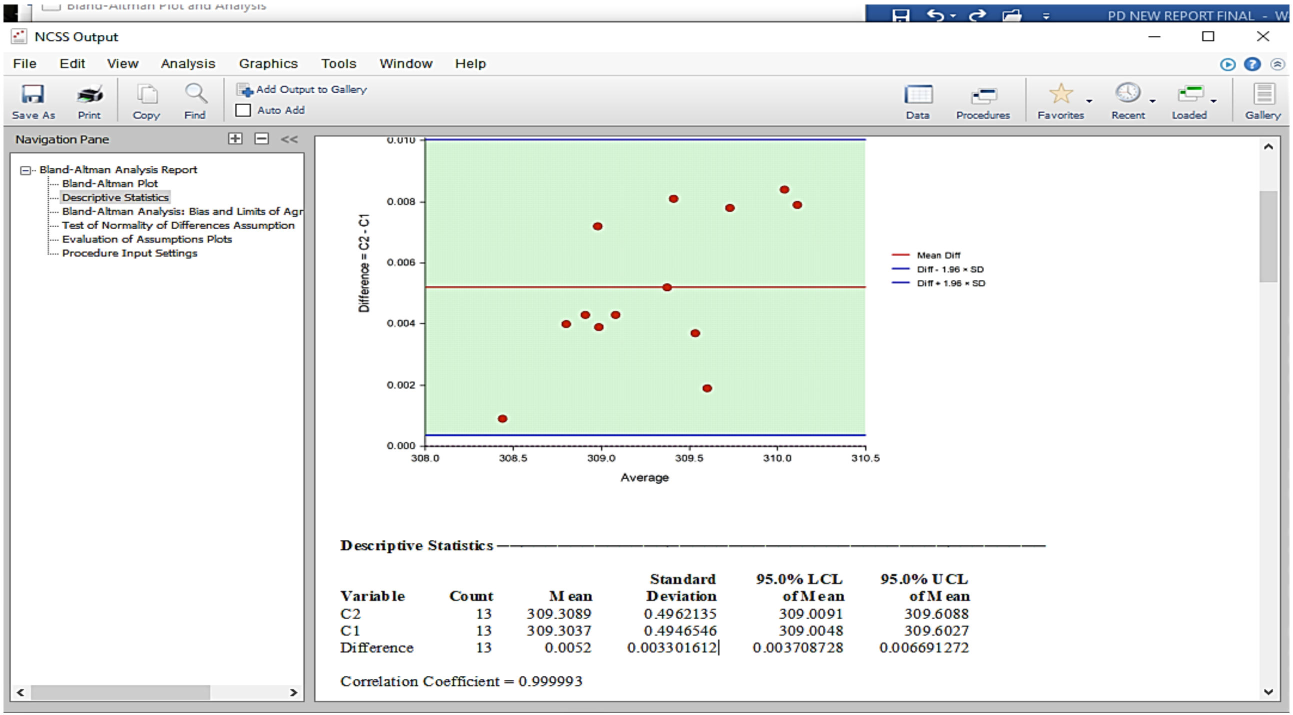

Fig 5: Standard Deviation of Heights Coordinate between 1st and 2nd epoch.

C. *Combined 95% Confidence Ellipse Evaluation of Structural Points*

Average Standard Deviation σ = the mean of Easting & Northing Movement between 1st & 2nd Epoch (Horizontal Movement between 1st & 2nd Epoch) = **0.008576115**

Percentage Confidence in Horizontal Movement = 1.96 x √ (σi ² + σf ²)

= 1.96 x √(0.008576115² + 0.008576115²) = **0.02377177797**

For Vertical Movement Analyses, the Standard Deviation in Heights for all the structural points was estimated using NCSS 2021 Data Analysis (T Tests Analysis).

Standard Deviation σ for the Heights value of Epoch 1 and Epoch 2 as shown in Fig 5 (Heights Movement between 1st & 2nd Epoch) = **0.003301612**

Percentage Confidence in Vertical Movement = (49/25) x √ (σi ² + σf ²)

= 1.96 x √(0.003301612² + 0.003301612²) = **0.00915160156**

The computed percentage confidence in Horizontal and Vertical Movement are shown in table 2

TABLE 2: PERCENTAGE CONFIDENCE IN HORIZONTAL AND VERTICAL MOVEMENT

Station ID	D_h (m)	D_v (m)	% CONFIDENCE IN HORIZONTAL MOVEMENT	% CONFIDENCE IN VERTICAL MOVEMENT	REMARKS
FSS/SP/01	0.021426087	0.004	0.02377177797	0.00915160156	STABLE
FSS/SP/02	0.01628008	0.0009	0.02377177797	0.00915160156	STABLE
FSS/SP/03	0.003162511	0.0043	0.02377177797	0.00915160156	STABLE
FSS/SP/04	0.001529706	0.0039	0.02377177797	0.00915160156	STABLE
FSS/SP/05	0.010944708	0.0043	0.02377177797	0.00915160156	STABLE
FSS/SP/06	0.000960767	0.0037	0.02377177797	0.00915160156	STABLE
FSS/SP/07	0.007451094	0.0078	0.02377177797	0.00915160156	STABLE
FSS/SP/08	0.004605703	0.0084	0.02377177797	0.00915160156	STABLE
FSS/SP/09	0.007661709	0.0079	0.02377177797	0.00915160156	STABLE
FSS/SP/10	0.016861068	0.0019	0.02377177797	0.00915160156	STABLE
FSS/SP/11	0.001090308	0.0052	0.02377177797	0.00915160156	STABLE
FSS/SP/12	0.006278785	0.0081	0.02377177797	0.00915160156	STABLE
FSS/SP/13	0.001071063	0.0072	0.02377177797	0.00915160156	STABLE

V. RESULT ANALYSIS

If any value of Dh(n) (horizontal displacement magnitude) or Dv(n) (vertical displacement magnitude) exceeds the percentage confidence threshold for horizontal or vertical movement, the corresponding point is considered unstable and requires further investigation.

In this study, for all points labeled FSS/SP/01 to FSS/SP/13, the calculated Dh(n) and Dv(n) values were found to be less than the respective confidence thresholds for both horizontal and vertical displacements, as shown in Table 2.

Therefore, all the structural points were considered stable, indicating that the structure as a whole remains structurally sound at the time of observation.

A. Comparison Between 2011 and 2022 Observations

The results of the differences between the previous observations (2011) and the latest observations (2022 and 2023) are presented in Table 3.

TABLE 3: MAGNITUDE OF THE HORIZONTAL AND VERTICAL DISPLACEMENT BETWEEN 2011 & 2022

POINT ID	ΔE	ΔN	ΔZ	Magnitude D_h	D_v	Direction
FSS/SP/01	0.0061	0.1844	-0.0067	0.184501	0.0067	01 53 40.81
FSS/SP/02	0.0279	0.1428	0.00095	0.1455	0.00095	11 03 18.29
FSS/SP/03	0.0413	0.1696	0.00185	0.174556	0.00185	13 41 9.46
FSS/SP/04	-0.113	-0.0548	0.00325	0.125587	0.00325	64 07 43.2
FSS/SP/05	-0.105	0.312	0.00215	0.329194	0.00215	341 23 59.76
FSS/SP/06	-0.1019	0.2593	0.00175	0.278604	0.00175	338 32 46
FSS/SP/07	-0.0637	0.1186	0.0037	0.134624	0.0037	331 45 35.2
FSS/SP/08	-0.0667	0.1971	0.0036	0.20808	0.0036	341 18 13.77
FSS/SP/09	-0.0213	0.186	0.00305	0.187216	0.00305	353 28 01.8
FSS/SP/10	0.0076	0.5917	0.00885	0.591749	0.00885	00 44 9.19
FSS/SP/11	-0.4222	-0.7811	0.0143	0.887902	0.0143	28 23 31.56
FSS/SP/12	0.0854	0.1848	0.00635	0.203578	0.00635	24 48 9.58
FSS/SP/13	-0.0191	0.1828	0.0073	0.183795	0.0073	25 02 27.28

B. Determination of Percentage Confidence

For Horizontal Movement Analyses, the Standard Deviation in Easting and Northing for all the structural points was estimated using NCSS 2021 Data Analysis (T-Tests Analysis). The Standard Deviation (σ) for the Easting coordinates between 2011 and 2022 is shown in Fig 6 (Easting Movement Between 2011 & 2022). The calculated value is 0.3799484 (as shown in Fig 6).

Standard Deviation σ for the Northing coordinates of 2011 and 2022 as shown in Fig 7 (Northing Movement between 2011 & 2022) = **0.3590468** (see Fig 7)

Average Standard Deviation σ = the mean of Easting & Northing Movement of 2011 and 2022 (Horizontal Movement between 2011 & 2022) = **0.3694976**

Percentage Confidence in Horizontal Movement = (49/25) x $\sqrt{(\sigma i^2 + \sigma f^2)}$

= 1.96 x $\sqrt{(0.3694976^2 + 0.3694976^2)}$ = **1.024195094**

For Vertical Movement Analyses the Standard Deviation in Heights for all the structural points were estimated using NCSS 2021 Data Analysis (T Tests Analysis).

Standard Deviation σ for the Heights value of 2011 and 2022 as shown in Fig 4.13 (Heights Movement between 2011 & 2022) = **0.004868633** (see Fig 8)

Percentage Confidence in Vertical Movement = (49/25) x $\sqrt{(\sigma i^2 + \sigma f^2)}$

= 1.96 x $\sqrt{(0.004868633^2 + 0.004868633^2)}$ = **0.01349516216** (see Fig 8)

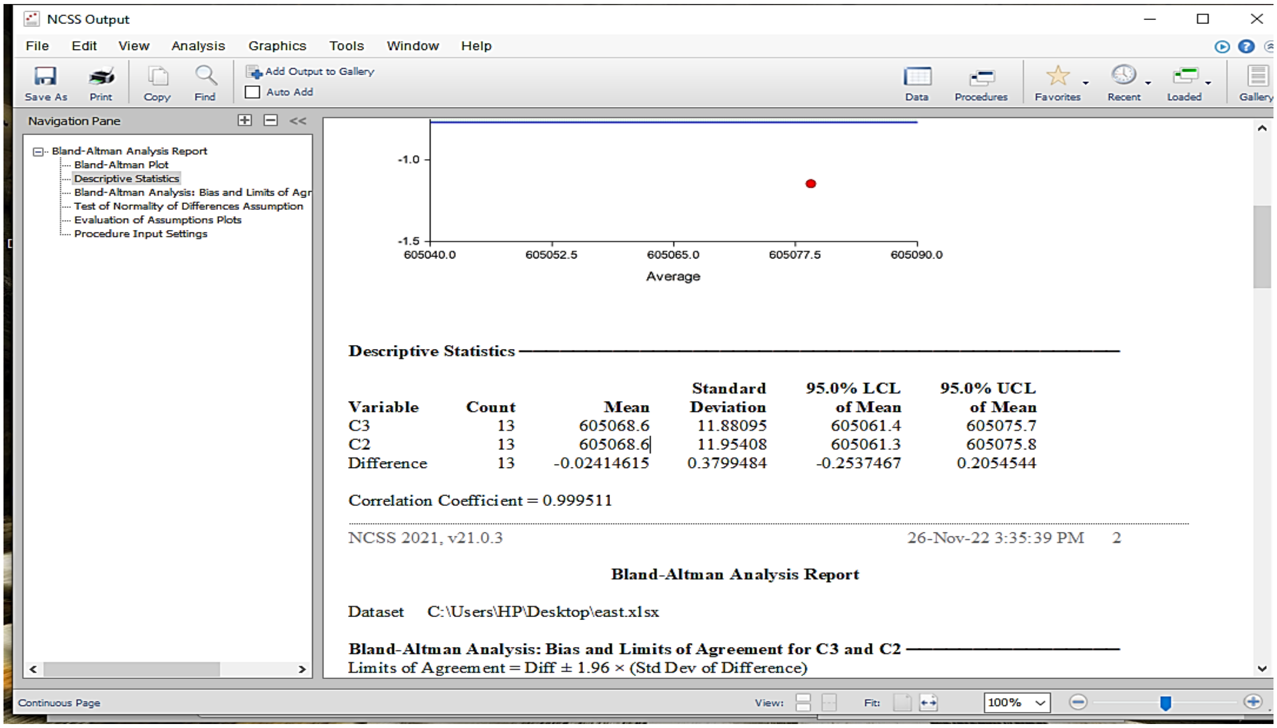

Fig 6: Standard Deviation for the Easting coordinates of 2011 and 2022

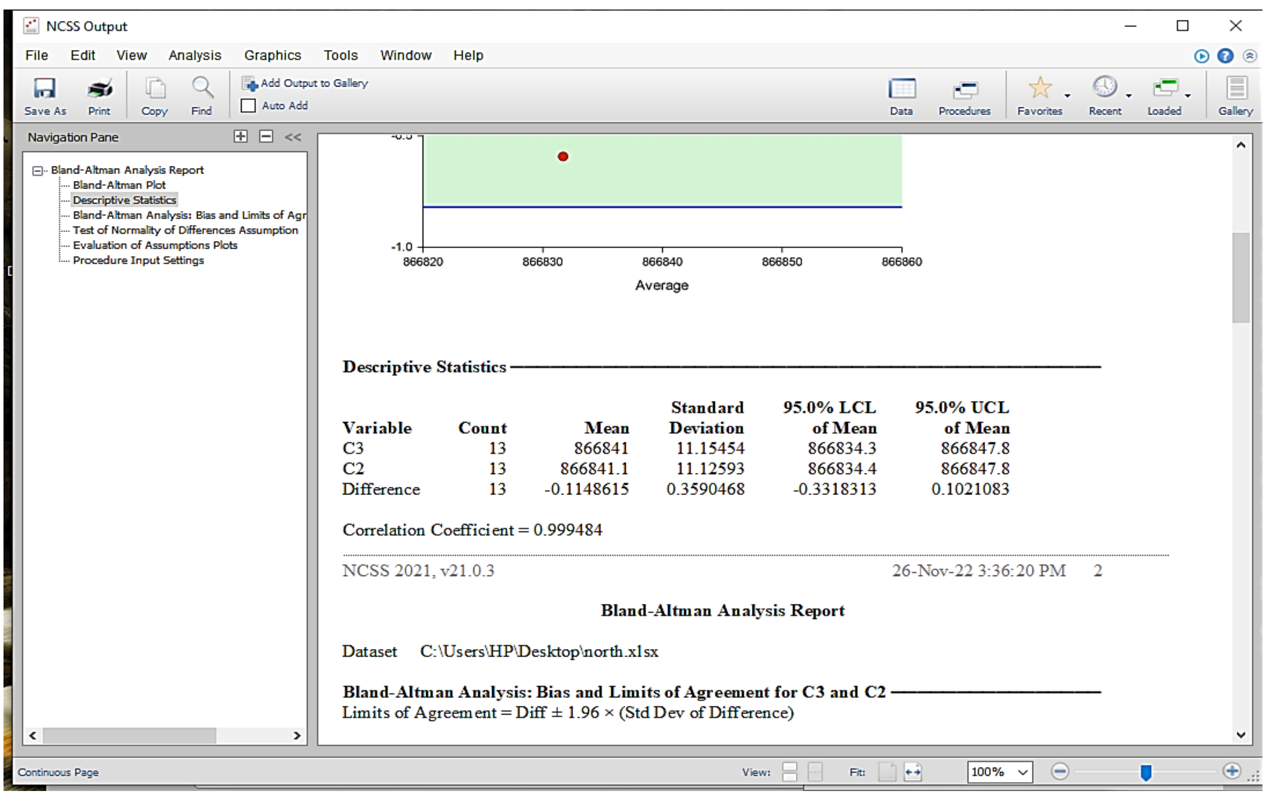

Fig 7: Standard Deviation for the Northing coordinates of 2011 and 2022

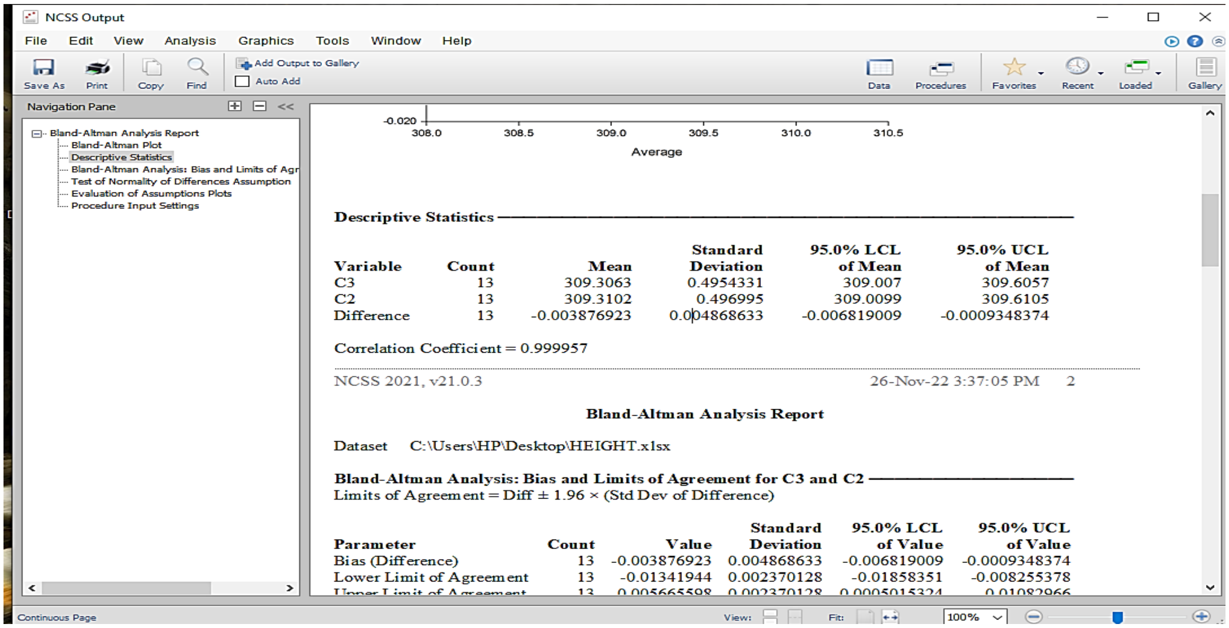

Fig 8: Standard Deviation for the Heights value of 2011 and 2022

TABLE 4: GEOMETRIC STATUS DISPLACEMENT BETWEEN 2011 & 2022

POINT ID	Magnitude D_h	D_v	% CONFIDENCE IN HORIZONTAL MOVEMENT	% CONFIDENCE IN VERTICAL MOVEMENT	REMARKS
FSS/SP/01	0.184501	0.0067	1.024195094	0.01349516216	Stable
FSS/SP/02	0.1455	0.00095	1.024195094	0.01349516216	Stable
FSS/SP/03	0.174556	0.00185	1.024195094	0.01349516216	Stable
FSS/SP/04	0.125587	0.00325	1.024195094	0.01349516216	Stable
FSS/SP/05	0.329194	0.00215	1.024195094	0.01349516216	Stable
FSS/SP/06	0.278604	0.00175	1.024195094	0.01349516216	Stable
FSS/SP/07	0.134624	0.0037	1.024195094	0.01349516216	Stable
FSS/SP/08	0.20808	0.0036	1.024195094	0.01349516216	Stable
FSS/SP/09	0.187216	0.00305	1.024195094	0.01349516216	Stable
FSS/SP/10	0.591749	0.00885	1.024195094	0.01349516216	Stable
FSS/SP/11	0.887902	0.0143	1.024195094	0.01349516216	Stable
FSS/SP/12	0.203578	0.00635	1.024195094	0.01349516216	Stable
FSS/SP/13	0.183795	0.0073	1.024195094	0.01349516216	Stable

If any value of Dh(n) exceeds the Percentage Confidence in horizontal movement, the corresponding point must be considered unstable and require further investigation.

Similarly, if any value of Dv(n) exceeds the Percentage Confidence in vertical movement, the point must be assumed unstable (indicating that differential settlement is likely to have occurred) and requires further investigation to confirm this. If confirmed, construction engineers must be contacted for further action.

Since no part of the structure has been identified as unstable, the structure is deemed safe for continuous use by its occupants.

C. *Graphical Analysis*

The graphical analysis was performed using Microsoft Excel, which includes charts and graphs to visually represent the results of the geometric analysis. The Fig below shows the horizontal graphical representation of the structure for the two epochs.

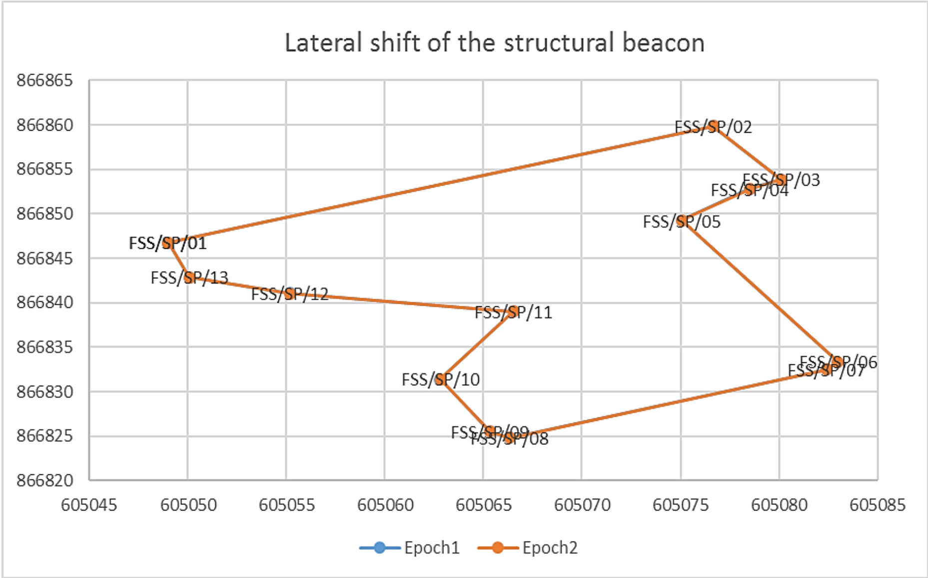

Fig 9: Horizontal Comparison of structural beacons (Epoch 1 and Epoch 2)

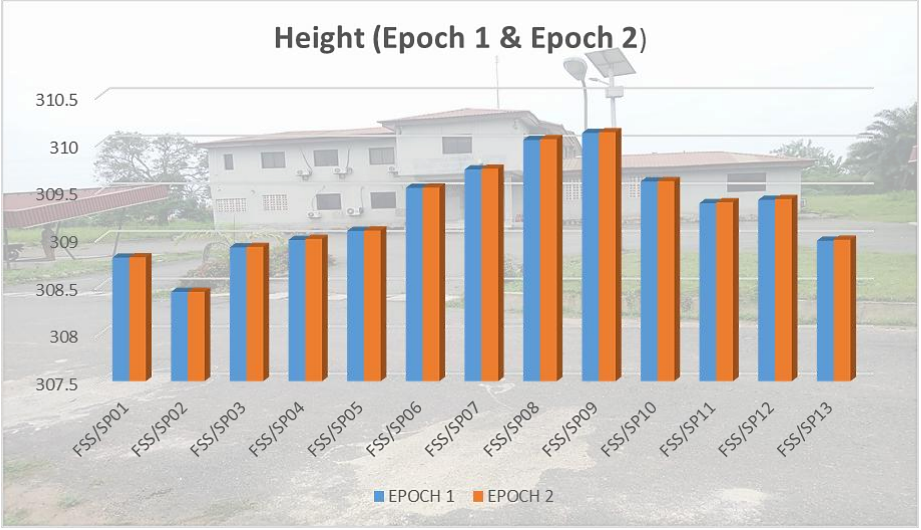

Fig 10: Height Comparison of structural beacons (Epoch 1 & Epoch 2)

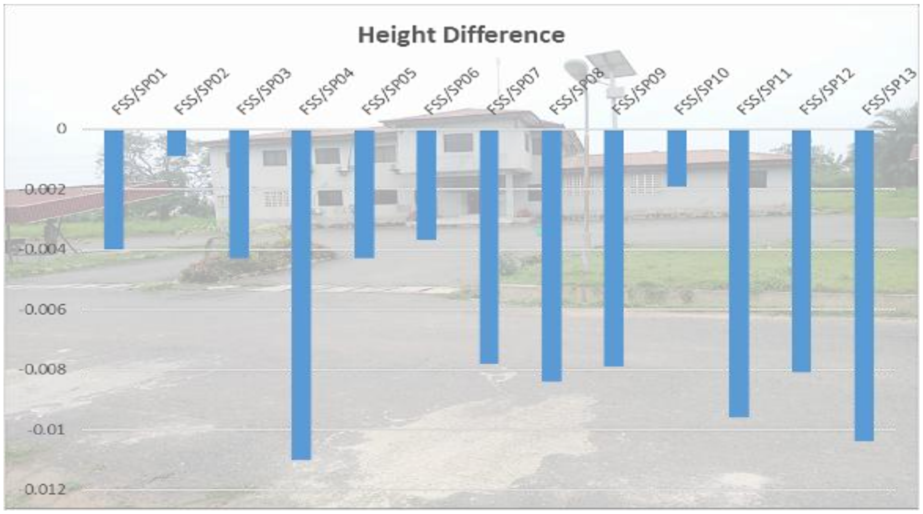

Fig 11: Height Difference of structural beacons (Epoch 1 and Epoch 2)

VI. Conclusion

FSS Rector's Administrative Block was monitored using ground geodetic survey techniques. The established eight (8) lawn beacons and thirteen (13) structural monitoring points were used to determined the stability of the building, using Tersus Oscar GNSS dual-frequency receivers, Total Station, and Digital Level. This project successfully conducted a comprehensive deformation survey of the Centenary Administrative Building at the Federal School of Surveying, Oyo. By employing advanced geodetic techniques such as GNSS observations, precise leveling, and total station angular measurements, the study accurately assessed the current structural integrity of the building. Data from multiple epochs were processed and analyzed using least squares adjustment methods, revealing minimal displacement within acceptable tolerance limits. Both horizontal and vertical movements observed were within the percentage confidence thresholds, confirming the stability of the structure. The findings validate the reliability of the building's structural components over the observed period and emphasize the importance of regular monitoring for early detection of potential deformations. This survey serves as a critical reference for maintenance planning, ensuring safety, and extending the structure's service life.

VII. Recommendations

To reduce the rate of building collapses in Nigeria as a whole, the following recommendations are proposed:

1. Soil investigation, material tests, and Environmental Impact Assessments (E.I.A.) should be made mandatory for all institutional, industrial, and commercial buildings. An excellently designed and constructed structure will not stand on a faulty foundation.
2. Illegal conversion, alteration, or addition to existing structures for uses other than the original design purpose should be discouraged, with strict penalties enforced at all tiers of government for any attempts to do so.
3. Proper planning, supervision, and monitoring of construction activities should be institutionalized by policymakers to ensure that all buildings are constructed according to design specifications and planning regulations.
4. There should be a review of existing building laws to accommodate post-construction monitoring, ensuring continuous structural safety.

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