Densification of Controls and Gravity Stations for Monitoring of Earth Tremor and other Natural Disasters in Nigeria. A case study of Ijebu-Ode.

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Abstract- This study is aimed at densifying gravity stations and generating gravity baseline data for monitoring the Earth Tremor and natural disaster in Ijebu-Ode, Ogun State Nigeria. This was achieved through the densification of controls and gravity Stations within Ijebu-Ode by GNSS/GPS and Gravity observations respectively. The methodology was divided into data acquisition, data processing and results presentation and analysis. The baseline gravity data of the study were collected from field work using gravimeter and GNSS/GPS techniques while the gravity values of the reference gravity station were collected from the office of the Surveyor General of the Federation. Trimble Business centre software with its accessories for the processing of the coordinate data to obtain latitude, longitude and ellipsoidal height of the studied stations, GravSoft software and Notepad were used to process raw gravity data to correct for errors and to also obtain the gravity values of the established stations. Microsoft Excel was used to average the gravity data obtained from field observation before using the GravSoft to process it. At the end of this work, the table showing the adjusted geodetic coordinates of the three reference points and the 61 studied stations including their individual gravity values in Ijebu-Ode were produced also Ijebu-Ode map depicting the location of the 61 gravity Survey stations were produced in accordance to the technical specification that all the receivers was configured to acquire data using logging rate 5secs, elevation mask angle of 15degree, position dilution of precision (PDOP) less than 4 and number of satellite in view during the observation ranged from 10 to 18 satellites. It is recommendation that subsequent observations at a specified time interval to be carried out on these stations for further analysis comparison with baseline data obtained to monitor earth tremor at Ijebu-ode, Ogun State Nigeria.

Index Terms- Tremor, Earthquake, Earth Tremor, Natural Disasters, Global Navigation Satellite System, GNSS, Geoid Model, Ellipsoidal Height, Orthometric Heights.

I. Introduction

An earth tremor is another term for an earthquake, although it is most commonly used to describe earthquakes of low intensity. In earth tremor, there is an involuntary quivering or vibration movement of ground. It can also be called a small earthquake, shock, fore-shock or after-shock (Justice, 2018). The geoid is a surface of the gravity field of the Earth that can be approximated by the mean sea level (MSL). It is defined as "one of the equipotential surfaces of the Earth's gravity potential, of which the (mean) surface of the oceans forms a part" (Hofmann-Wellenhof and Moritz 2006). This means that the geoid surface is perpendicular to the gravity vectors at all points. The geoid, commonly known as the Figure of the Earth, is not a regular surface. This irregularity is highly correlated to the inhomogeneous mass distribution of the Earth. The lack of uniformity of the mass is a result of the surface topography (i.e. mountains, valleys, plains, etc.) and the internal composition of the Earth (i.e. varying in density of the inner crust). Thus, a geoid can be applied to infer the grade of homogeneity (or inhomogeneity) of the mass distribution of the Earth from the measurement of gravitational fluctuations. During the 1990s, precise geoid determination became a focus for international researchers, who started using the geoid models for many scientific applications. In geology, the inversion of geoid was used for mineral exploration, e.g. gas and oil.

In recent times, we all have witnessed series of Natural disasters nationally and internationally; these adverse natural occurrences have ravaged physical developments in many parts of the globe and have cost the international community millions of dollars. However, these disasters have raised concerns internationally about sustainable development. Disaster recovery projects require sustainable and reliable geodetic infrastructure which should be based on accurately determined geodetic surfaces; these are the frameworks that enhance the reliability of geographic data for the spatial information management. Orthometric Height, the height of a point above the Geoid and it is one of the main variables of any spatial information system. This is why it is required for many physical and practical purposes. Orthometric Heights are obtained through the process of Geodetic Leveling; a very tedious, rigorous and expensive method. Global Navigation Satellite System (GNSS) on the other hand, provide an alternative means of determining this quantity (Onwuzuligbo 2011) although what it directly measures is the ellipsoidal height. With the knowledge of the ellipsoidal height of a point from GNSS observations, the Orthometric height of the same point can be determined if the geoidal undulation of the point is known.

The dynamics of the Atlantic fracture zones have been suggested to be responsible for the seismic activities experienced in the area. Today Ijebu-Ode Nigeria lacks the gravity Baseline stations for monitoring these earthquakes, which affects the growth of its economy, the management and Monitoring of its natural resources, environmental disaster and the implementation of integrated urban development strategies(Justice, 2018). Disaster recovery projects require sustainable and reliable geodetic infrastructure which should be based on accurately determined geodetic surfaces and Baseline Gravity Stations; these are the frameworks that enhance the reliability of geographic data for the spatial information management. This has necessitated the adoption of different height systems that are incompatible to one another. Also, geoid heights were required in the past to convert Orthometric heights derived from Spirit leveling and gravity to geodetic height of points but this process is slow, time-consuming and costly; but if there is enough Baseline Gravity stations densify within the states prone to earth Tremor, its monitoring will be made easier for further research.

II. LITERATURE REVIEW

2.1 THEORETICAL FRAMEWORK

2.1.1 Brief Overview of GNSS

GNSS (Global Navigation Satellite System) is a satellite system that is used to pinpoint the geographic location of a user's receiver anywhere in the world. GNSS system is made up of Global Positioning System (GPS) owned by United State government, Russian Federation's Global Orbiting Navigation Satellite System (GLONASS) and the Europe's Galileo. Each of the GNSS systems employs a constellation of orbiting satellites working in conjunction with a network of ground stations. Satellite- based navigation systems use a version of triangulation to locate the user through calculations involving information from a number of satellites. Each satellite transmits coded signals at precise intervals. The receiver converts signal information into position, velocity and time estimates. Using this information, any receiver on or near the earth's surface can calculate the exact position of the transmitting satellite and the distance between it and the receiver. Coordinating current signal data from four or more satellites enables the receiver to determine its position.

Depending on the particular technologies used, GNSS precision varies. Because of the intentional degradation (known as "Selective Availability," or "SA") of GPS signals, GPS accuracy was limited to a 100-meter range for civilian users, although military equipment enabled accuracy within a single meter. Without SA, all GPS receivers are potentially accurate to within 15 meters. When available, Galileo will provide position accuracy to within one meter

2.2 DENSIFICATION OF CONTROL STATIONS

Densification of stations involves the establishment of new stations that are tied to higher order stations with known coordinates (reference stations). It is done by a well-known least-squares Adjustment procedure where the reference control station coordinates are adjusted along with their previously obtained covariance matrix.

2.3 EARTH TREMOR AND GRAVITY

An earth tremor is the shaking of the earth surface, resulting from the sudden release of energy in the earth lithosphere that creates seismic waves. (Https: //en.m.wikipedia.org. April 2019).An earth tremor is another term for an earthquake, although it is most commonly used to describe earthquakes of low intensity. In earth tremor, there is an involuntary quivering or vibration movement of ground. It can also be called a small earthquake, shock, fore-shock or after-shock (Justice, 2018). Earthquakes occur because of abrupt slips on faults due to accumulated stress in the Earth's crust. Because most of these faults and their mechanisms are not readily apparent, deterministic earthquake prediction is difficult. For effective prediction, complex conditions and uncertain elements must be considered, which necessitates stochastic prediction. In particular, a large amount of uncertainty lies in identifying whether abnormal phenomena are precursors to large earthquakes, as well as in assigning urgency to the earthquake. This disaster has raised concerns internationally about sustainable development. Disaster recovery projects require sustainable and reliable geodetic infrastructure which should be based on accurately determined geodetic surfaces; these are the frameworks that enhance the reliability of geographic data for the spatial information management.

Gravity is the force of attraction between masses. In geophysical terms it is the force due to the integrated mass of the whole Earth, which acts on the mechanism of a measuring instrument. Measurements are usually made at the surface of the Earth, in aircraft or on ships. They may also be made in mines or on man-made structures. The gravity field in space may be inferred from the orbit of a satellite. The measuring instrument may be a very precise spring balance, a pendulum or a small body falling in a vacuum. If the Earth were a perfect homogeneous sphere the gravity field would only depend on the distance from the center of the Earth. In fact the Earth is a slightly irregular oblate ellipsoid which means that the gravity field at its surface is stronger at the poles than at the equator. The mass (density) distribution is also uneven, particularly in the rigid crust, which causes gravity to vary from the expected value as the measurement position changes. These variations are expressed as gravity anomalies, the mapping of which gives us an insight into the structure of the Earth (Alice S Murray & Ray M. Tracey 2001).Gravity varies as the inverse square of the distance of the observer from a mass so that nearby mass variations will have a more pronounced (higher frequency) effect than more distant masses whose effect will be integrated over a larger area (lower frequency). The force is proportional to the mass so that, per unit volume, higher density bodies will cause a more positive gravity anomaly than lower density bodies. Gravity surveyors originally used quartz spring meters with a scale range of as little Measurements could only be made over larger intervals by resetting the scale range with a coarse reset screw or dial that required precise manual dexterity to achieve any repeatability of readings. Resetting the scale range also causes stresses in the mechanism, which relax slowly (over hours or days); this is manifested by irregular meter drift. The precision of these quartz meters was about or more if a reset had been made. The new electronic quartz meters, such as the Centrex CG-3, have a worldwide range and incorporate software to compensate for meter tilt and to La Coste and Romberg (LC&R) steel spring gravimeters have a worldwide range the scale factor varies with dial reading and is tabulated by the manufacturer. The drift rate of

LC&R meters decreases as they age and is generally less than the drift of quartz meters.

2.3.1 Orthometric Height, Geoid Undulation and Ellipsoidal Height

Orthometric height (H) is the height of a point above the Geoid; Ellipsoidal height (h) is the height of a point above its Reference ellipsoid and Geoid undulation (N) is the difference between ellipsoidal height and Orthometric height of a point on the earth surface. The determination of Orthometric height is one of the main variables of any spatial information system. This is why it is required for many physical and practical purposes. Orthometric Heights are obtained through the process of Geodetic Leveling; a very tedious, rigorous and expensive method. Global Navigation Satellite System (GNSS) on the other hand, provide an alternative means of determining this quantity (Onwuzuligbo 2011) although what it directly measures is the ellipsoidal height. With the knowledge of the ellipsoidal height of a point from GNSS observations, the Orthometric height of the same point can be determined if the geoidal undulation of the point is known.

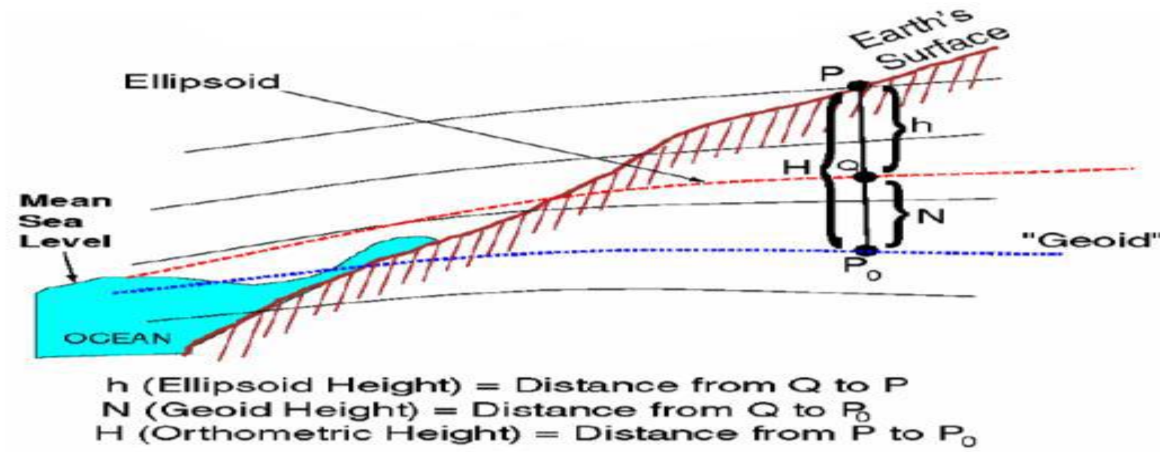

Figure 1: Relationship between the Geoid height, N, the ellipsoidal height, h and the Orthometric height, H. N = h – H. (Source: Ono, (2009))

This method of obtaining Orthometric height has been adopted by many nations around the world. This is because the approach is fast, less tedious in difficult terrain and relatively cheap when compared to the geodetic leveling technique. Depending on data availability and accuracy requirements, there are many principle approaches for determining Geoid models; some of the approaches are gravimetric method, geometric method and the astrogeodetic method (Ono, 2009). The gravimetric method is achieved by making gravity measurements and applying the remove-restore (RR) procedure in the determination of a local and regional gravimetric Geoid. Experts have warned that impending earthquakes is looming in the South-South and some other States (Abuja, Lagos, Port-Harcourt, Warri, Bayelsa, Oyo, and Cross-River) in Nigeria before 2020. (Https: //en.m.wikipedia.org. April 2019).

2.3.2 Factors Affecting Gravity and Its Measurement

Gravitational acceleration measured at any point depends on five factors, all related to either *M* or *r* or both. The affects are as follows, and corrections for these effects must be applied to data sets. The section on data reduction explains further.

a. **Latitude**: From equator to pole, gravity varies by roughly 5000 mGal (greater at poles). The gradient (i.e. rate of change with respect to latitude) is maximum at 45° latitude, where it is about 0.8 mGal/km.
b. **Elevation**: The effect of changing the elevation of a measurement is quite significant. For modern instruments, a change of only a few centimetres can be detected, and between sea level and the top of Mt. Everest, the difference is roughly 2000 mGal.
c. **Slab effect:** Going up in elevation rarely means up into air (except for airborne surveys). If we are "up," there are rocks and soils between us and where we were. The attraction of these materials counteracts the effect of going up in elevation. Therefore, the elevation correction is counteracted by subtracting a factor of $0.0419 \times h \times d$ mGal, where h is elevation in metres, d is density of intervening materials in g/cc. This is called the **Bouguer correction**.
d. **Topography**: Effects due to nearby topographic relief (hills or valleys) may be significant, but are rarely more than 1.0 mGal. These effects are rather tedious to apply, but are important when there is steep topography near the measurement locations.
e. **Earth tides**: Tidal effects are as much as 0.3 mGal, and these are usually accounted for by recording several measurements at a single station (a base station) throughout the course of a survey.
f. **Effects of a moving platform**: If the instrument is in motion while a measurement is made, the acceleration caused by motion on a rotating sphere must be accounted for. These contributions to measured acceleration can be very large, especially in aircraft. Even the slight rotational motion of a ship resting on a sea with mild swells will have significant effects on measurements (Jones, 2007).

III. METHODOLOGY

The methodology was divided into data acquisition, data processing and results presentation and analysis. Figure 2 shows the flow chart of the adopted methodology.

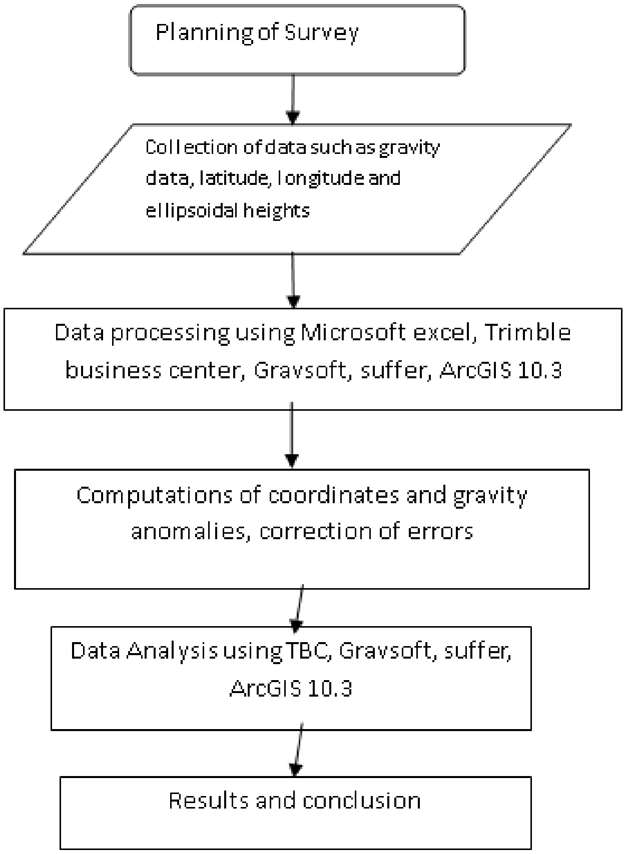

Fig 2: Flow Chart of the Adopted Methodology

3.1 Data Acquisition

During the field reconnaissance, the coordinate of some selected control points were picked using Hand held GPS Garmin 60CSX and 62S and the total of 61 points were selected for Monumentation and observation within Ijebu-Ode. Monumentation is the process of emplacing or erecting permanent marks on the ground for the purpose of survey activities. The pillars used as control for the execution of this project were casted in strict compliance with specification for Geodetic surveys in Nigeria published by the Surveyors Council of Nigeria for monumentation of beacons.

Plate 1a, b & c the constructed monitoring pillars.

Two control pillars were used in the execution of this project:

i. Gravity Station point in Ondo state and first order control XSO 166A located at Ondo West LGA, Ondo state were used to coordinate and transfer the Gravity base point to Ogun state.
ii. While XST 382 located at Ikoto, Odogbolu LGA in Ogun was used to coordinate monitoring control pillars within the project areas.

3.2 Data Processing

The RENIX data were downloaded from the data collector into a computer system with installed TBC software and processing were carried out using the Trimble Business Center (TBC) software version 2.5 on the RENIX data to obtain the geodetic coordinates o all the observed station and their corresponding ellipsoidal heights.

Here at each station, the Lacoste gravimeter was used to observe and obtain the gravity values three times at different time intervals of 2 to 5 mins, so for each station point we have three different gravity readings at different voltage of the gravimeter, these reading are typed into the Microsoft excel where the average for each stations are calculated for to produce one gravity reading for each station, as shown below for point IJ 04, IJ 05 and IJ06

station s	date	time	Grav. reading	voltag e	Average grav. Readings
IJ 04	17/12/201 9	8.01 8.04 8.06	1713.24 1713.22 1 1713.22 8	0.03 0.02 0	1713.229. 6
IJ05	17/12/201 9	10.2 1 10.2 3 10.2 5	1713.85 1713.85 1 1713.85 6	0.02 0.05 0.02	1713.852 3
IJ 06	17/12/201 9	12.5 9 13.0 1 13.0 3	1712.92 2 1712.91 8 1712.90 6	0.04 0.05 0.02	1712.915 3

The averaged gravity readings for each station were later imported into the gravisoft software with its corresponding geodetic coordinate and ellipsoidal height which were converted into a notepad environments from excel environment , this is necessary because the Gravsoft software only understands the word of programming. The Gravsoft software involves three stages which includes: *The requirements:* this is where the observed gravity data has been converted to notepad document after taking the average using Microsoft excel and feed it into the Gravisoft software. *The preprocessGrav:* this is where all the corrections were done automatically by the gravisoft software. *The AnalyseGrav:* when the corrections have been done using preprocessGrav then this extension is the final stage to derive the residual, normal gravity and gravity anomaly. These three stages are extensions of the Gravsoft software and they use FORTRAN programming languages. When the Gravsoft finished its own execution the end results were then used together with the coordinates derived from the analyses done using Trimble business center in the ArcGIS environment to plot the locations of the studied points in order to present the results in form of a map to aid decision making.

IV. Results Analysis

4.1 Analysis of the adjusted geodetic coordinate of the three base stations and the gravity base station

The Fig 4.4 explained that the adjusted geodetic coordinate of the three base stations are: MCP5 has latitude of N6d 49’ 09.75966’’, longitude of E3d 56’ 50.55748’’, ellipsoidal height of 92.386m and height error of 0.020 when compared with the height obtained from OSGoF,MCP6 has latitude of N6d 49’ 44.72299’’, longitude of E3d 56’ 32.64554’’, ellipsoidal height of 112.447m and height error of 0.016 when compared with the height obtained from OSGoF, MCP7 has latitude of N6d 47’ 55.51916’’, longitude of E3d 56’ 37.28247’’, ellipsoidal height of 61.274m and height error of 0.018 when compared with the height obtained from OSGoF. While the geodetic coordinate of the gravity base station at Ondo XST 382 are latitude of N6d 47’ 17.499930’’, longitude of E3d 56’ 50.80566’’, ellipsoidal height of 83.547m

4.2 The result on the adjusted ECEF coordinates of the three base stations and the gravity base station

Fig 4.4 also explained that the adjusted ECEF coordinate of the three base stations are:

MCP5 has X= 6318620.145m and X=0.020m, Y=432500.947m and Y = 0.003, Z=752315.189m and Z = 0.004m. MCP6 has X= 6318310.528m and X = 0.016m, Y= 432437.012m and Y = 0.003m, Z=753384.034m and Z = 0.003m. MCP7 has X= 6318773.570m and X = 0.017m, Y= 433764.891m and Y = 0.003m, Z=750046.934m and Z = 0.004m. While the ECEF coordinate of the gravity base station at Ondo XST 382 has
X= 6318778.449m, Y= 436028.227mand Z=748889.809m

Adjusted Geodetic Coordinates

Point ID	Latitude	Longitude	Height (Meter)	Height Error (Meter)	Constraint
XST 382	N6°47'17.49930"	E3°56'50.80566"	83.547	?	LLh
YST07/MCP7	N6°47'55.51916"	E3°55'37.28247"	61.274	0.018	
YST5/MCP5	N6°49'09.75966"	E3°54'56.55748"	92.386	0.020	
YST6/MCP6	N6°49'44.72299"	E3°56'32.64554"	112.447	0.016	

Adjusted ECEF Coordinates

Point ID	X (Meter)	X Error (Meter)	Y (Meter)	Y Error (Meter)	Z (Meter)	Z Error (Meter)	3D Error (Meter)	Constraint
XST 382	6318778.449	?	436028.227	?	748889.809	?	?	LLh
YST07/MCP7	6318773.570	0.017	433764.891	0.003	750046.934	0.004	0.018	
YST5/MCP5	6318620.145	0.020	432500.947	0.003	752315.189	0.004	0.021	
YST6 MCP6	6318310.528	0.016	435437.012	0.003	753384.034	0.003	0.016	

Error Ellipse Components

Point ID	Semi-major axis (Meter)	Semi-minor axis (Meter)	Azimuth
YST07/MCP7	0.004	0.003	69°
YST5/MCP5	0.004	0.004	27°
YST6 MCP6	0.003	0.003	94°

Fig 4.4 Adjusted

4.3 The DTM of Ijebu-Ode with gravity station

Fig 4.8 shows the superimposition of the plan of Ijebu-ode showing the gravity survey stations represented with into the Digital Terrain Model of Ijebu-Ode, to see how undulated the gravity stations area is, I found out that gravity station IJ31 fell within the areas with deep blue color with height of 113.976m, also gravity station IJ29 fell within the areas with light blue color with height of 104.5m, also gravity station IJ42 fell within the areas with yellow color with height of 91.1m and gravity station IJ61 fell within the areas with red color with height of 58.8m.

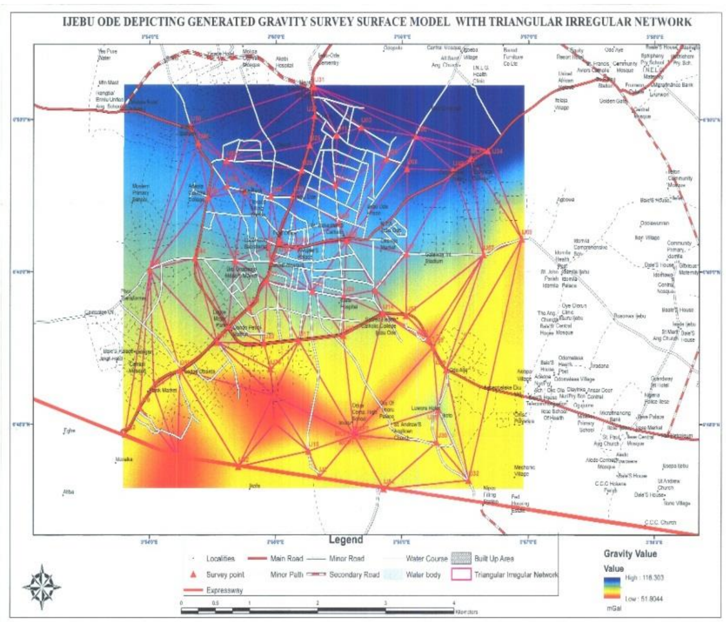

Fig. 4.8 the DTM of Ijebu-Ode with Gravity Stations.

4.4 Baseline gravity data of Ijebu-ode

Table 5.4 shows the gravity stations' baseline data in terms of the stations identification numbers, the station latitude and longitude, the stations ellipsoidal heights and the stations' Delta g (g), and these can be consulted any time for relevant geodetic information concerning Ijebu-ode.

STN ID	**Longitude**	**Latitude**	**Ellipsoidal height (m)**	**g (mGal)** **g**
J1	3.91548	6.81567	87.775	6.101
J2	3.91175	6.79532	69.743	2.358
J3	3.92791	6.83248	108.371	10.294
J4	3.90772	6.82485	98.785	9.17
J5	3.93133	6.82904	101.041	8.461
J6	3.93515	6.8315	106.298	9.384
J7	3.93393	6.81859	93.24	6.812
J8	3.93399	6.82794	106.876	9.82
J9	3.9491	6.82022	65.29	0.095
J10	3.8987	6.8019	73.456	3.537
J11	3.91634	6.80313	50.847	2.148
J12	3.92247	6.79423	77.124	3.779
J13	3.9298	6.81466	91.143	6.604
J14	3.93084	6.81208	83.929	4.723
J15	3.90058	6.80389	74.92	3.838
J16	3.9245	6.82614	102.064	9.199
J17	3.91972	6.80909	79.967	4.665
J18	3.921	6.79702	73.222	2.89
J19	3.91126	6.81786	90.601	7.217
J20	3.92563	6.81401	88.861	6.233
J21	3.9037	6.79647	52.412	1.337
J22	3.89679	6.79893	73.087	3.403
J23	3.91511	6.80885	76.119	3.769
J24	3.91604	6.81771	90.133	6.399
J25	3.92113	6.83055	109.013	10.734
J26	3.92011	6.82783	110.2	10.946
J27	3.92177	6.83371	111.428	11.18
J28	3.91602	6.82495	99.897	8.63
J29	3.91898	6.82501	104.074	9.634
J30	3.93793	6.798	70.27	1.105
J31	3.92169	6.83692	114.971	12.112
J32	3.94213	6.79383	72.773	1.573
J33	3.91022	6.82608	100.405	9.169
J34	3.94465	6.82989	116.303	11.566
J35	3.93809	6.80159	87.608	5.202
J36	3.91598	6.80602	70.862	2.731
J37	3.91035	6.81071	86.196	6.319
J38	3.92557	6.8097	80.806	4.446
J39	3.93917	6.80596	78.471	2.891
J40	3.94004	6.82778	106.845	9.232
J41	3.92469	6.83161	109.771	10.913
J42	3.92599	6.82001	92.668	6.836

J43	3.91312	6.81274	85.63	5.849
J44	3.90598	6.81815	87.459	7.162
J45	3.92148	6.81455	93.164	7.329
J46	3.90641	6.83077	102.165	9.606
J47	3.90894	6.80896	82.386	5.393
J48	3.91709	6.81993	93.487	7.089
J49	3.92499	6.82201	96.608	7.721
J50	3.9054	6.8327	104.12	10.048
J51	3.93388	6.81188	74.553	2.61
J52	3.91254	6.82552	101.325	9.492
J53	3.91012	6.82889	103.112	9.748
J54	3.93097	6.7929	81.91	4.295
J55	3.93744	6.80844	63.13	0.488
J56	3.90403	6.80594	71.602	3.003
J57	3.94407	6.81849	82.928	4.191
J58	3.9194	6.81938	95.012	7.336
J59	3.91652	6.8001	55.409	0.757
J60	3.90004	6.81695	87.812	7.675
J61	3.93689	6.80933	58.8	1.797
MCP 5	3.91571	6.81938	92.386	7.17
MCP6	3.9424	6.82909	112.447	10.575
MCP 7	3.92702	6.79876	61.274	0

V. CONCLUSION

The research concludes that the quality of the densification adjustment methods used, as it depends on the quality of the reference station coordinates, the quality of the baseline vector observations, and, more importantly, on how good the a prior information about these parameters is, The gravity method responds directly to a mass excess or deficit, the method requires a relatively small amount of instrumentation and is an unobtrusive method able to be conducted in environmentally sensitive areas, It is also a straightforward geophysical technique that can be applied to a variety of engineering and environmental problems as well as exploration for geothermal energy including the location of heat sources and faults, the costs are much lower than other geophysical methods especially if performed by the client himself. The Densification of Gravity Station's' Baseline Data for Monitoring Earth Tremor in Ijebu-Ode, Ogun state was successfully carried out with the required accuracy and falls within the limit of the technical specifications using R8 Trimble GNSS equipment on static mode for minimum of 30 minutes and Lacoste and Romberg (G664) Gravimeter. Also detailed information and plan of the locations of the reference stations and new stations can be found in the report made for this study as appendixes, Monumentation of the new station were done by cementing a brass disc on the ground. Each brass disc has a code identification in the IJ series on top (e.g.IJ56) to provide extra identification of the new station

VI. RECOMMENDATIONS

The following recommendations are hereby made for further research: The data acquired during this project are to serve as baseline data for subsequent Geo-hazard survey in Ijebu-ode, Ogun State, Nigeria, therefore subsequent GNSS and Gravity Observations can be repeated on these Gravity Stations at a chosen time interval for monitoring of earth tremor occurrences and its prediction at Ijebu-Ode, Ogun State Nigeria to save life and properties.

Control establishment is expensive therefore both SURCON and State chapters of NIS Nationwide should ensure that the pillars are protected by the relevant bodies that are charged with the responsibility by law.

Even though to acquire GNSS receivers is costly, it should still be encouraged for use among Surveyors in order to broaden their knowledge on the various equipment for data acquisition

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