LIQUEFACTION POTENTIAL ASSESMENT OF SOME COASTAL SANDS OF LAGOS, SOUTH-WESTERN NIGERIA, USING GEOPHYSICAL AND GEOTECHNICAL METHODS

Abstract

This paper presents the results of the investigation conducted in some parts of wetland areas of Lagos, Nigeria, using Multi-channel analysis of surface waves (MASW), Cone penetration test (CPT) and Standard penetration test (SPT). The primary aim was to delineate probable areas that were prone to induced seismicity.

The MASW of the seismic method was used to generate the shear wave velocity (V_s) of the near surface soil while the CPT and SPT were employed to infer the penetration resistance and the blow count in the assessment of the stress-based liquefaction potential of these soils respectively. SeisImager and liquefaction assessment software (known as Cliq) were used to process both the MASW and CPT data respectively.

The values of shear wave velocity generated for most sands in the study areas range from 120m/s -200m/s. This value fell within potentially liquefiable sands. From the CPT results, 41.67% of Ikoyi data showed a very high risk to liquefaction while 37% of Badore data indicated severe liquefaction potential. The factors of safety (F.S) against liquefaction potential obtained from the plot of cyclic stress ratio (CSR) against s-wave velocity (Vs) were less than 1. This also corroborated the presence of liquefiable sands within the study areas.

Background of the Study

Liquefaction phenomenon is one of the geological hazards that resulted from sudden ground shaken (Earthquake). It leads to the loss of strength/stiffness of saturated or partially saturated cohesionless soil which makes it to lose their bearing capacity as they behave like liquid. The solid state of soil is been transformed into liquefied state in response to increased pore pressure and reduced effective stress. Loose, partially/saturated soils are then subjected to shearing, which led to re-arrangement in the soil grains to kind of dense packing devoid of much space as a result of forceful ejection of water in the pore spaces [1]. This action led to decrease in effective stress and shear resistance as the stress from the soil skeleton has been transferred to the precipitating pore water.

Coastal Plain Sands is the recent stratigraphic formation of the Dahomey Basin. It is characterized with poorly sorted sands with clay lenses. Nigeria lies on the eastern flank of the Atlantic Ocean, generally believed to be quiet when compare to Pacific Ocean margins which are characterized by subduction tectonics and occurrence of devastating earthquakes. Few Seismic activities have been recorded inform of Earth tremors in Nigeria since 1933 with more than twenty- eight (28) cases (Table 1). These occurrences has been attributed to various factors ranging from the presence of fault zones along Ifewara - Zungeru, uncontrolled mining capable of inducing earth Tremors and others. Dahomey basin is believed to have seated on equatorial fracture zones such as Romanche, Chain and Charcot fracture zones (Figure 1). These fracture zones are reported to have been responsible for shearing and migration process of Earthquakes from South American plate to African plate via Mid-Atlantic Ridge [2,4].

Table 1: Showing Earth Tremors in Nigeria. (Modified after [3])

S/N	**DATE**	**TOWN**
1	1933	WARRI
2	JUNE 1939	**LAGOS**
3	JULY 1948	IBADAN
4	JULY 1961	OHAFIA
5	DECEMBER 1963	IJEBU-ODE
6	APRIL 1981	KUNDUM
7	OCTOBER 1982	JALINGO
8	JULY 1984	IJEBU-ODE/ SAGAMU
9	DECEMBER 1984	YOLA
10	JUNE 1985	KOMBANI YAYA
11	JULY 1986	OBI
12	JANUARY 1987	GEMBU
13	MARCH 1987	AKKO
14	MAY 1987	KURBA
15	MAY 1988	LAGOS
16	JUNE 1990	IBADAN
17	NOVEMBER 1994	IJEBU ODE
18	JUNE 1997	OKITIPUPA
19	MARCH 2000	BENIN
20	MARCH 2000	IBADAN/ABEOKUTA
21	MAY 2001	**LAGOS**
22	AUGUST 2002	**LAGOS**
23	MARCH 2005	YOLA

24	MARCH 2006	LUPMA
25	JUNE 2016	KADUNA
26	JUNE 2016	KADUNA
27	JULY 2016	BAYELSA
28	AUGUST 2016	SAKI

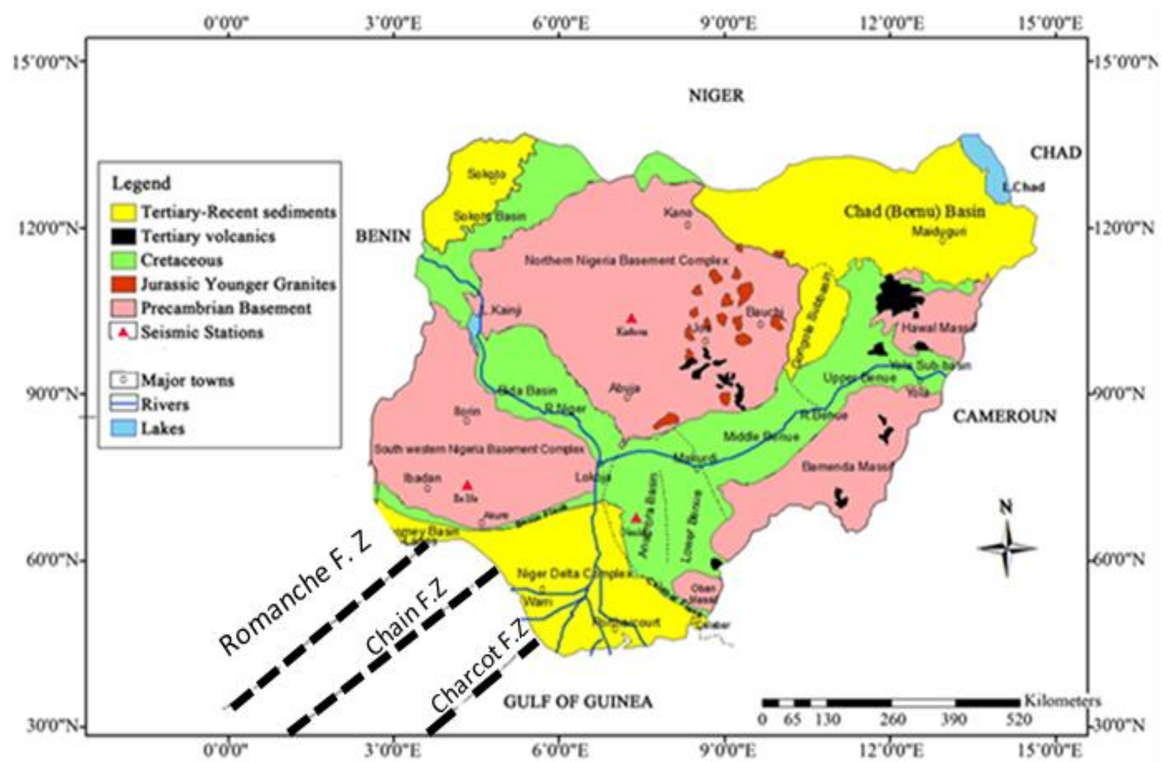

Figure 1: Represents the map of Nigeria showing the fracture Zones which acts on Dahomey Basin [4]

Aims and Objectives

The aim of the study is to assess liquefaction potential of some parts of Lagos wetland areas using geophysical and geotechnical methods.

The objectives are to;

1. generate shear Wave Velocity Model (Vs) for the study area
2. characterize the shear wave velocity model based on their susceptibility to liquefaction
3. obtain the soil behaviour type index value and characterize its liquefiability

4. obtain the factor of safety against Liquefaction from the study area using Vs, CPT and SPT data

MATERIALS AND METHODS

The study was carried out using the integrated approach of Geophysical and geotechnical methods. Multi-Channel Analysis of Surface Wave (MASW) configuration of Seismic refraction was employed for the geophysical method. Cone Penetrating Test (CPT) and Standard Penetrating Test (SPT) were used as geotechnical tools to infer the penetration resistance and the blow count of the study area.

Shear wave velocity (V_s) models were generated from the study showing the distribution of the shear-wave velocity in the study area. These Vs were used to classify the litho-stratigraphic arrangement of the sand in the study area. The CPT data was processed using computer software called Cliq. Parameters such Soil behaviour Type (SBTn) index, Friction Ratio, Cyclic Stress ratio (CSR), Cyclic Resistant Ratio (CRR) were obtained from the processed CPT and SPT data. These Both data show the sequential arrangement of the sand formation.

RESULTS AND DISCUSSIONS

The MASW data showed various variations of shear wave velocity values ranging from 100m/s – 356m/s. Shear wave velocity within the range of 120m/s -200m/s are delineated as loose saturated sands that can undergo liquefaction with subject to cyclic loading (Figure 2). These low values are as a result of inability of shear wave velocity to pass through liquid medium because of no rigidity involved. The SBTn Index value obtained from the CPT data ranges from 1.4 - 2.5 which is within the range of sand sediments with low degree of fine particles. This also manifested from the friction ratio from the CPT which are mostly less than 1(Figure 3). The liquefaction model curves of the plot of CSR against corrected blow count were also presented (Figure 4). The overall statistics of the liquefaction potential from the CPT were obtained of the study area were obtained. It shows that 41.67% of Ikoyi data showed a very high risk to liquefaction while 37% of Badore data indicated severe liquefaction potential. Factors of safety against liquefaction calculated using the V_s are less than 1 within the depth of 4.50 m – 14.00 m (Table 2).

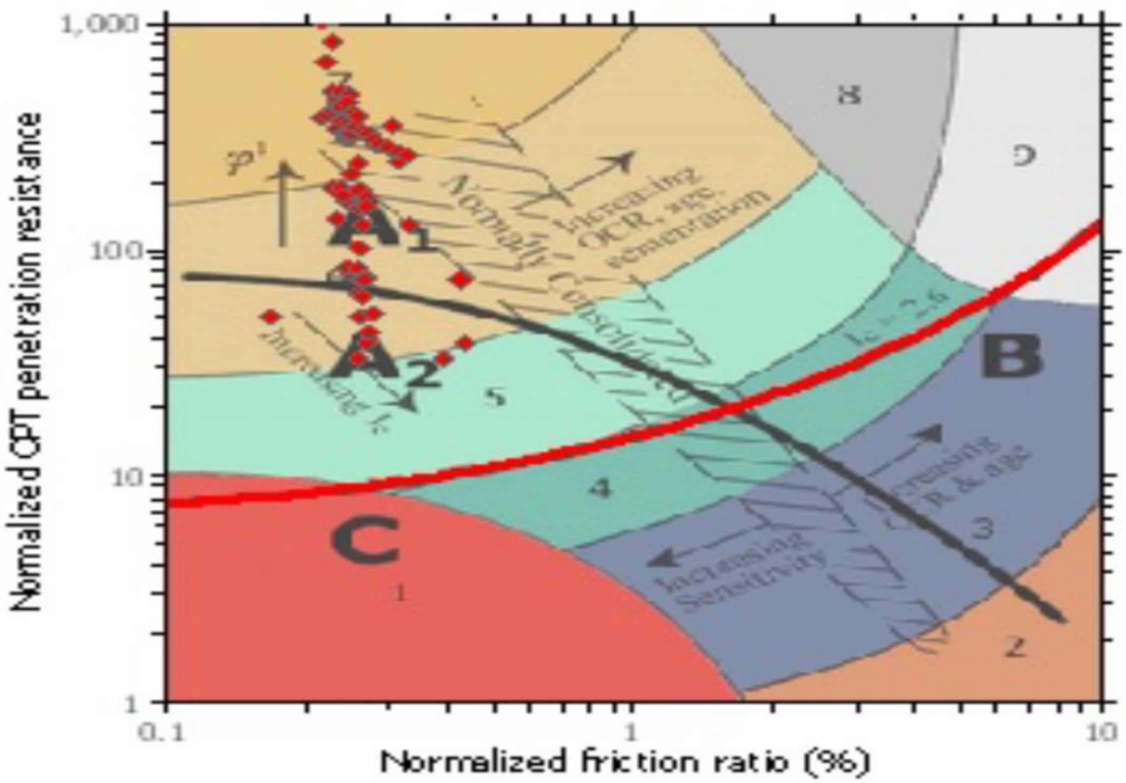

Figure 3: Typified SBTn Chart of CPT Data from the study Area

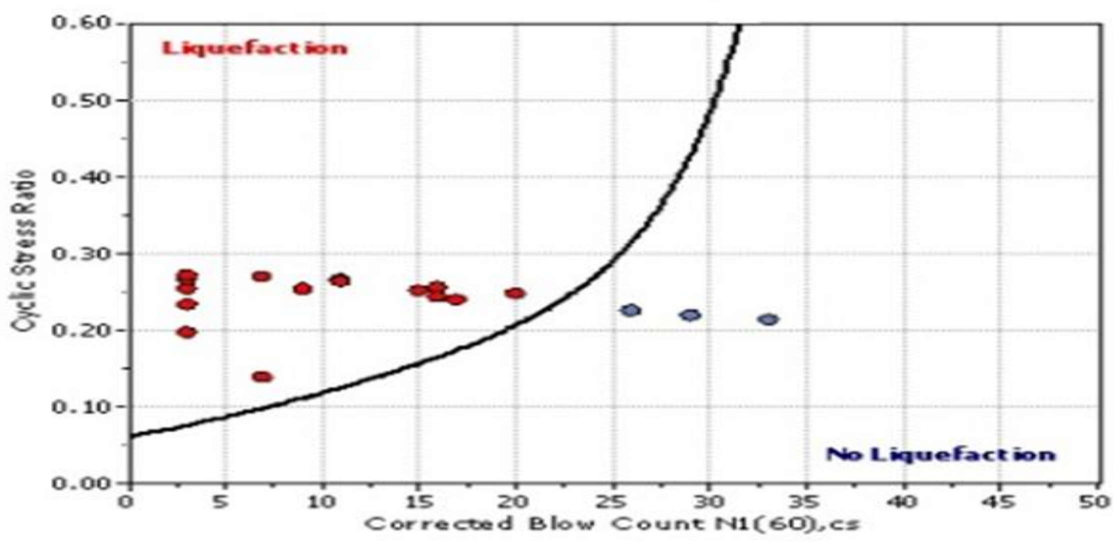

Figure 4: Typified Liquefaction model curve of CSR against Corrected Blow count of the study Area

Table 2: The Liquefaction Assessment Table Obtained from Shear Wave Velocity.

S/N	Depth(m)	Vs(m/s)	Fines %	n	Vs1(m/s)	CRR	F.S	Can Liquefy
1	2.00	150.00	5.00	0.25	215.04	4.000	2.00	No
2	4.50	100.00	5.00	0.25	128.43	0.056	0.23	Yes
3	7.00	152.00	4.28	0.25	176.51	0.128	0.50	Yes
4	10.50	165.00	0.00	0.25	170.20	0.113	0.47	Yes
5	14.00	160.00	0.04	0.25	152.36	0.083	0.37	Yes
6	18.00	284.00	0.00	0.25	249.42	0.500	2.51	No

CITED REFERENCES

1. **Salden J.A., D'Hollander, R.D. and Krahn J.A. (1985):** The Liquefaction of Sands, a Collapse Surface Approach. Canadian Geotechnical Journal, Vol. 22 pp 564-578
2. **Akpan, U. O and Yakubu, T.A (2010):** A review of Earthquake Occurrences and Observation in Nigeria. Earthquake Sciences 23, 289-294, Doi 10.1007/s11589-010-0725-7
3. **Mohammed, S.T, Lar, U.A, Yakubu T.A, Kadiri, U. A (2015):** The Review of the Historical and Recent Seismic Activity in Nigeria. Journal of applied Geology and Geophysics 3(1) 48-56
4. **Samaila, N.K and Likkason O.K (2013):** Role of equatorial Fracture zones on Fluid Migration across the South Atlantic Margins. Journal of Earth Science and Climate Change. Doi: 10.4172/2157-7617-004