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# Subsoil Geotechnical Investigation of Pacific Paradise Hotel Complex Site at Khana Local Government of Ogoniland in Rivers State - Nigeria

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**ABSTRACT**
Subsoil geotechnical investigation was carried out to determine the underlying geological materials at the proposed building site. The test conducted includes drilling of two number shallow boreholes. In –situ standard penetration tests were performed in cohesion less strata encountered in the boreholes. These tests are standard penetration test (SPT), which were carried out during the boring operations. The other tests are the static cone penetration tests (CPT) using hydraulically 20 tons capacity Dutch cone penetration machine with electric device. The laboratory test relevant to the engineering objective of the investigation were performed which includes soil classification /index property test and soil strength/deformation test. Based on above test, the study recommends the allowing bearing pressure of 188KN/m2 could be adopted for the design of shallow reinforced raft foundation placed at the depth of 3.00 to 6.00 meter below the existing ground level. It was estimated from the analysis that anticipated coefficient of consolidation (CV) ranging between 7.6-8.2m2/year and coefficient of compressibility (MV) ranging from 00.00112-0.1890KN/m2 will occur under allowable bearing pressure of 188KN/m2.

**Keywords**: Geotechnical, Subsoil, Soil strength, Cone penetration, Borehole, Bearing pressure

## I. INTRODUCTION

The major objective of the subsoil investigation works is to ascertain the type and geotechnical properties of the underlying soil, as well as to evaluate the suitability as foundation materials for adequate design of foundation for the proposed development s of the site.

To accomplish these, we carried out studies to access, interpret and analyze results collated from the field in-situ tests as well as laboratory test results with a view to determine the following geological and hydro geological parameters. They include the groundwater conditions of the site, the appropriate foundation depth, the allowable soil bearing pressure that could be adopted for the design of the recommended foundation and precautions to be adopted.

**LOCATION OF THE STUDY AREA**

The proposed pacific paradise hotel complex is located at Khana in Ogoniland of Rivers state, Nigeria. It had latitude and longitudinal co-ordinates in which the latitude is 7.55E to 8.00E longitude 6055N to 60 55N of the meridian respectively, see Figure 1

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Figure 1 Map of the study area

**GEOLOGY OF THE AREA**

Khana in Ogoniland lies entirely within the coastal plain sandstone within the Benin formation which has a thickness of about 800meters. The Benin formation extends from the west across the Niger Delta and southward beyond the present coastline. It is over 90 percent alluvial sandstone with minor shale intercalations in some places. It is coarse grained, gravely; locally fine grained, poorly sorted, sub angular to well rounded, and bears lignite streaks and wood fragments.

Terrain of the area is characterized by two types of landforms, highly undulating ridges and near flat topography. Various structural units such as point bars, channel fills, natural levees, back swamp deposits and oxbow fields are identifiable within the formation indicating the variability of the shallow water depositional medium.

## II. METHODOLOGY

The field works started by locating all the test positions with a bearing compass. The drilling of two number geotechnical boreholes using a shell and auger borehole with a light cable percussion drilling rig to average termination depth of 30.0 meters below the existing ground level at the borehole positions.

During the drilling operation in–situ standard penetration test (SPT) and soil samplings were carried out at appropriate depth interval of between 0.75 and 1.50 meters and at depths changes in subsoil strata as encountered within the drilled hole.

Details of the subsoil strata types encountered in the boreholes and the result of the in situ were produced after hydro physical logging of soil samples retrieved from the borehole and consideration of laboratory tests results.

All the geotechnical site works were carried out in accordance with standard methods of site investigation, according to the British standard institution code of practice C.P 5930(1981). Code of practice for site investigation.

Execution of one number static cone penetration test (CPT) using the 20-ton capacity Dutch cone penetrometer machine. The results of the test indicating the subsoil strength profiles with depths are presented in graphical form. These tests were terminated at depth of between 19 and 20 meters.

**LABORATORY TEST**

The laboratory tests relevant to the engineering objectives of this investigation were scheduled and carried out on selected soil samples retrieved from the drilled geotechnical borehole in accordance with BS 1377; 1990

The tests include:

**Soil classification/index porosity under Standard penetration test (SPT)**

1. Particle size distribution analysis by wet sieving.
2. Atterberg limit
3. Bulk density
4. Natural moisture content

**Soil strength /deformation test**

1. Quick undrained triaxial compression test
2. Permeability test
3. Consolidation test
4. Soil Grading analysis

## III. RESULT AND DISCUSSION

The subsoil types interpreted from the indication of the standard penetration tests and exposed during the geotechnical boreholes are generally consistent with the result of the cone penetration test results. Based on the result of the hydro physical logging of the subsoil types encountered and interpretation of the laboratory test

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results, details of the subsoil strata descriptions and conditions are presented on the borehole logs.

**Table 1: Summary of Standard Penetration Test Results (SPT)**

| Borehole No | Depth (M) | Natural Moisture Content (%) | Bulk Density (M/m") | Angle of Shearing Resistant(Q) | Cohesion (KN/m$^2$) | Bearing Capacity (KN/m$^2$) |
|---|---|---|---|---|---|---|
| 1 | 3.00 | 14.8 | 1.82 | 10 | 50 | **165** |
| | 6.00 | 15.3 | 1.92 | 13 | 58 | **232** |
| 2 | 3.00 | 14.6 | 1.82 | 10 | 51 | **168** |
| | 6.00 | 15.0 | 1.94 | 13 | 56 | **224** |

Average Bearing Capacity @ 3m depth = 167KN/m$^2$
Average Bearing Capacity @ 6m depth = 228(KN/m$^2$)

**Table 2: Undrained Triaxial Test**

| Term | Undrained Shear Strength (KN m$^2$) |
|---|---|
| Very soft | Less than 20 |
| Soft | 20 – 40 |
| Soft – firm | 40 -50 |
| Firm | 40 -75 |
| Firm – stiff | 75 -100 |
| Stiff | 75 -150 |
| Very stiff or hard | Greater than 150 |

Borehole No. : 1
Sample No. : 1
Depth : 3.00M
Description : Loose to Medium Dense Dark Reddish Silt Clayey Soil

Khana L. G. A.
Date: 6$^{TH}$ April, 2011

| TEST NO | CELL PRESSURE KN/M$^2$ | BULK DENSITY MG/M$^2$ | MOISTURE CONTENT % | COMPRESSIVE STRENGTH KN/M$^2$ |
|---|---|---|---|---|
| 1 | 70 | 1.82 | 14.8 | 126 |
| 2 | 140 | 1.82 | 14.8 | 155 |
| 3 | 210 | 1.81 | 14.8 | 185 |

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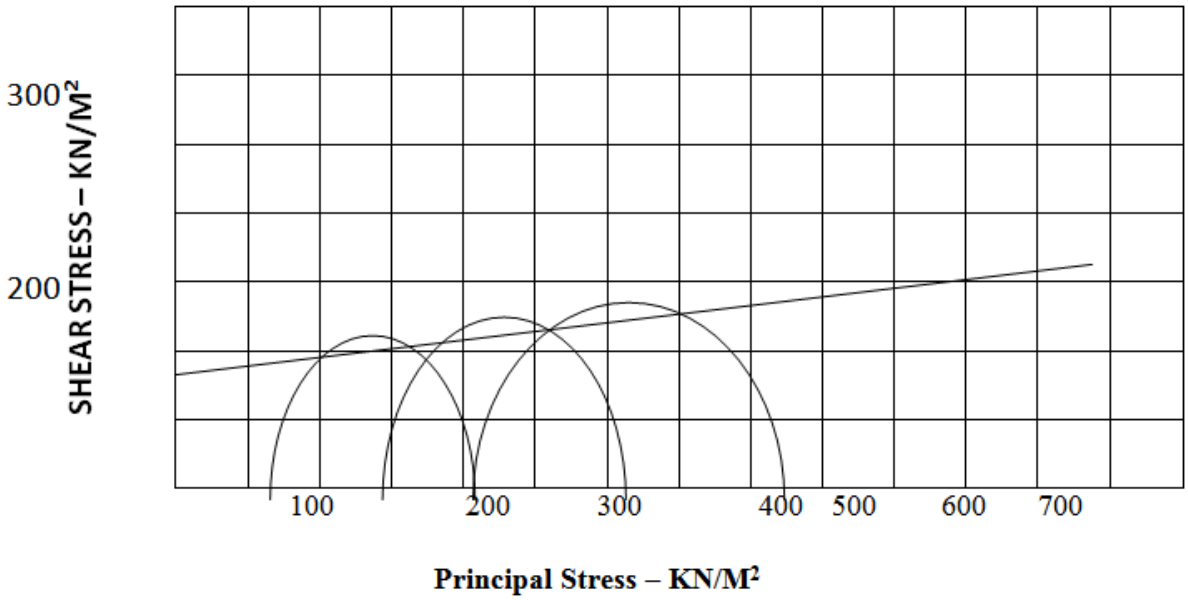
| Cohesion = 50kn/m$^2$ | Q =10$^0$ |
|---|---|
| | |

**MOHR'S CIRCLES**




**Summary of Consolidation Test Results**
Initial void ratios at 3m = 0.4238
Initial void ratios at 6m = 0.3982

| Borehole No | Depth Meters (m) | Specific Gravity | Pressure Range (KN/m$^2$) | Void Ratio ($\epsilon_0$) | MV in (KN/m$^2$) | CV in Capacity (m$^2$/years |
|---|---|---|---|---|---|---|
| 1 | 3.00 | 12.73 | 0-50<br>50-100<br>100-200<br>200-400 | 0.4144<br>0.4092<br>0.4045<br>0.3975 | 0.1329<br>0.0739<br>0.0334<br>0.0250 | 5.5<br>5.4<br>5.2<br>5.0 |
| | 6.00 | 2.60 | 0-50<br>50-100<br>100-200<br>200-400 | | 0.3912<br>0.3870<br>0.3818<br>0.3764 | 9.0<br>6.8<br>5.0<br>4.9 |

MV = Coefficient of Compressibility

$$= \frac{\epsilon\lambda - \epsilon_0}{1+\epsilon_0} \times \frac{1}{\Delta p} \times \frac{100}{1}$$

Where Δp = Change in pressure
$\epsilon_0$ = Void Ratio at the start of test
$\epsilon_0$ = Void Ratio at the end of load increment
CV = Coefficient of Consolidation

$$= \frac{0.111}{t_{90}} \times \hat{H}2$$

Where 0.11 factor of Oedometer machine

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$\hat{H}$ = Average height of the specimen over the load increment.
$t_{90}$ or $t_{50}$ can be compatible from the log time or square root of time

**Table 3: Summary of Standard Penetration Test Results (SPT)**

| Borehole No | Depth (M) | Number of Below per 300mm (N) | Average N | N | Bearing Capacity for Sq Footing of 1.5m width Q All (KN/m$^2$) |
|---|---|---|---|---|---|
| 1 | 1.50<br>4.50<br>7.50<br>9.00<br>10.50<br>12.00<br>13.50<br>15.00<br>16.50<br>18.00<br>19.50<br>21.00<br>22.50<br>24.00<br>27.00<br>28.50<br>30.00 | 4<br>6<br>9<br>12<br>14<br>18<br>14<br>18<br>22<br>24<br>22<br>27<br>26<br>30<br>32<br>32<br>38 | 20 | 18 | 200 |

| N Value Below/300mm of Penetration | Relative density |
|---|---|
| Below 4 | Very loose |
| 4-10 | Loose |
| 10-30 | Medium-dense |
| 30-50 | Dense |
| Over 50 | Very dense |

The grading analyses carried out on selected samples of the geotechnical borehole 2 Nos indicate that the silts and clay composition ranges from 0.3- 15%.

The shear strengths of the cohesion soils were determined by means of quick drained triaxial compression tests on some undisturbed samples. The undrained cohesion ranges from 50kn/m2 and 58kn/m2 with angles of internal friction range of 10 degree and 13 degree. The bulk density of the undisturbed samples was in the range of 1.82 mg/m3 1/94mg/m3.

The groundwater was encountered at depths varying between 20.5 and 22 m below the existing ground level.

## IV. CONCLUSION AND RECOMMENDATION

The adoption of both shallow and deep foundation type has been considered for the proposed development, provided it satisfies design loading requirements.

The study recommended that the shallow reinforced raft foundation type can terminate within the range of 3-6 meters while deep pile foundation can terminate within the medium to dense strata generally encountered below 13 meter depth.

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