

## RESEARCH ARTICLE

## EVALUATION OF GEOTECHNICAL PROPERTIES OF SOILS AT BRITISH - AMERICAN AREA, JOS-PLATEAU, NORTHCENTRAL NIGERIA

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## ARTICLE DETAILS

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## ABSTRACT

This research aimed to determine the geotechnical properties of soils along British American area, Jos, Northcentral Nigeria. A total of five (5) soil samples were collected at depth of 1.5 m and were subjected to geotechnical tests: moisture content, Specific gravity, liquid limit, plastic limit, linear shrinkage and plasticity index. The moisture content of the soil ranges from 10.7 to 21.2% while specific gravity of soil ranges from 2.65 to 3.10. The liquid limit ranges from 35.24 to 38.5 %, plastic limit value varies from 15.76 to 24.07% plasticity index value ranges from 11.17 to 20.24% and linear shrinkage value of 6.69 to 7.54%. Cassagrande plasticity chart indicate that all the soil samples plot within CL-Group. The value of specific gravity (2.65 to 3.10) shows that the soil samples in the area can be categorized into sand, silty sand and soil with mica or iron. Based on the value of liquid limit, the degree of expansion was categorized into medium degree of expansion (35-50%) while the danger of severity zone was identified as marginal (35 to 50 %). Based on the plasticity index value, two (2) danger of severity zones were identified as non-critical with plasticity index value of <12% and marginal with plasticity index of 12 to 23%. The degree of expansion was classified as low with plasticity index value of <12% and medium with plasticity index value of 12 to 23%. The value of linear shrinkage indicates non-critical danger of severity zone with value of <15% and the degree of expansion is low. Two (2) plasticity index zones of medium plastic and highly plastic were identified while two (2) swelling potential zones were classified as low with plasticity index value of 0 to 15 % and medium with plasticity index value of 15 to 25%. The soil type in the study area can be classified into two silt clay with plasticity index of 7-17% and clay with plasticity index of > 17%

## KEYWORDS

plastic, index, swelling, soil and expansion

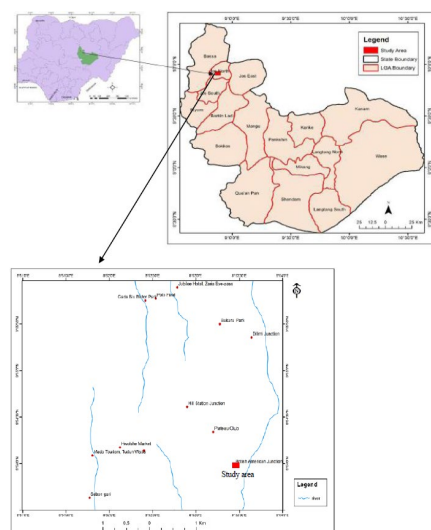
## 1. INTRODUCTION

The nature of soil determines the degree of suitability of soil for building construction. The soils in any environment need to be subjected to laboratory testing to determine their stability for various foundations. The soil capacity and compressibility affect structures directly if they are not taking into consideration (Murthy, 2003). There are reports on the collapse of structures in different part of the world and these can be prevented by a good engineering design and adequate soil testing (Roy and Bhalla, 2017)

Structures of all types - buildings, bridges, highways and dam were designed to be erected on soils (Laskar and Pal, 2012). For these structures, it is important to carry out detailed investigation so as ascertain the soil characteristics (Arora, 2008; Murphy, 2002). Soil conditions vary from one location to another and the values of geotechnical parameters also vary from one environment to another. Hence evaluation of soil is important before any structure is erected at any location (Raj, 2012)

Several studies have reported on appropriate design of engineering buildings to avert construction problems which may be associated with soil settlement, plasticity, shrinkage and compressibility (Oghenero, et al., 2014; Youdeowei and Nwankwoala, 2013; Ngah and Nwankwoala, 2013; Nwankwoala and Amadi, 2013). The need to understand soil behavior in solving engineering problems such as swelling soil will help to prevent

significant damage to civil engineering structures (Abubakar, 2016; Oke and Amadi, 2008).



**Figure 1:** Location map of the study area at British-American Junction

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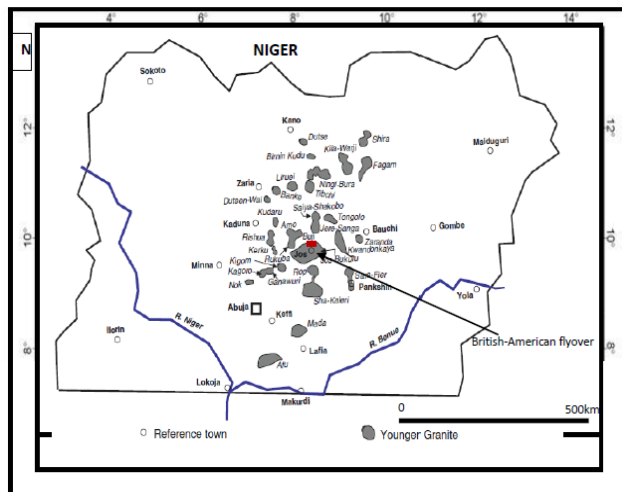
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The assessment of geotechnical parameters of subsoil is necessary for generating relevant input data for design and construction of foundations for any proposed structures (Oke et al., 2009; Nwankwoala and Warmate, 2014). The study was aimed at investigating some of the geotechnical properties of soils at British-American area, Jos - Plateau, Nigeria.

## 2. GEOLOGY OF THE AREA

The study area is underlain by the undifferentiated Older granites of Precambrian in age and the younger granites as shown in fig. 1 (Odewumi 2013; Odewumi and Olarewaju, 2013; Odewumi et al., 2015a; Odewumi, 2020; Turner, 1989). The younger granites occur in N-S zone, 400x150km, centered on the Jos Plateau (Odewumi 2015b; Odewumi et al., 2020a; Macleod et al., 1971; Buchanan et al, 1971; Bowden, 1985; Odewumi et al., 2020b).



**Figure 2:** Location of British-American in Jos within Younger Granites Complexes

## 3. MATERIALS AND METHODS

The study area is located at the British American Flyover in Jos lies within latitude 9.898766 to 9.898988 N to and longitude 8.891060 to 8.891130 E as shown in Figure 1. Five (5) sampling points were selected at an average

depth of 1.5m and a total of five (5) samples were collected from each sampling point. GPS readings were taken at each sampling point and samples were properly labelled. All the laboratory tests were performed according to ASTM standard. The soil samples were subjected to moisture content, specific gravity, Liquid Limit, Plastic Limit, linear shrinkage and Plasticity Index.

Moisture Content test was carried out to determine the existing moisture contained in a given soil sample. It is expressed as a percentage, by comparing with the weight of water to the weight of dry soil (Sidi et al., 2015). The test was carried out with an undisturbed soil sample collected from the field. Three moisture cans was obtained and their identification numbers was known and was weighed using the weighing balance empty with their lids in place. The soil sample was mixed thoroughly and about 45g of the soil was introduced into each of the cans.

The can containing the wet soil was weighed and was put into the electric oven at the regulated temperature of between 105°C-115°C with the lids opened. The can was remained in the oven at the regulated temperature range for 24hours to ensure total dryness. After dryness the container was removed from the oven and the lids was replaced. The can was allowed to cool down in the desiccator for few minutes and the can containing the dried soil was weighed. All the data obtained was recorded to compute the moisture content. The average of the calculated moisture content of the cans give the moisture content of the soil tested (Odewumi, 2019).

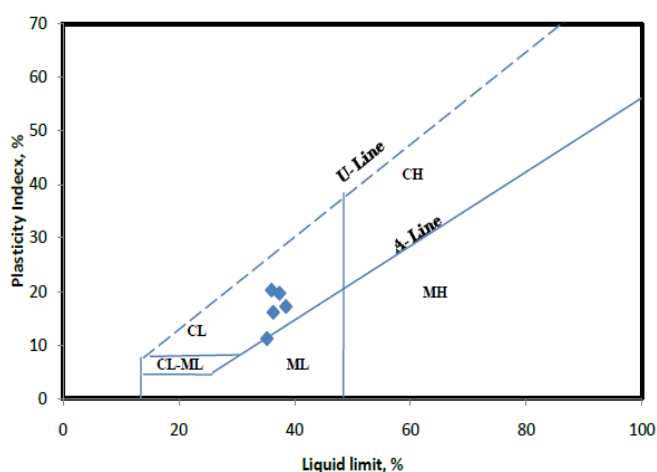
Specific gravity was carried out to determine the ratio of the mass of soil solids to the mass of an equal volume of water for qualitative behaviour of soil (Raj, 2012). Apparatus used: This involves the use of Sample tray, 50ml density bottle, Scoop, weighing balance, funnel, soil sample, distilled water and Aspirator (washed bottle). The liquid Limit was determined according to (Cassagrande, 1952). The linear Shrinkage limit was determined by the use of Mould and Oven.

## 4. RESULT

The results of the geotechnical analyses of five (5) soil samples are presented in Table 1. The moisture content of the soil in the study area ranges from 10.7 to 21.2% while specific gravity of soil ranges from 2.65 to 3.10. The liquid limit ranges from 35.24 to 38.5 %, plastic limit value varies from 15.76 to 24.07% plasticity index value ranges from 11.17 to 20.24% and linear shrinkage value of 6.69 to 7.54% (Table 1). The Cassagrande plasticity chart is shown in Figure 3 and most of the soil samples from the study area fall within CL-Group

**Table 1:** Moisture content, specific gravity and Consistency limits

| Sample | Moisture content | Specific gravity | Liquid limit % | Plastic limit % | Plasticity index % | Linear shrinkage % |
|--------|------------------|------------------|----------------|-----------------|--------------------|--------------------|
| A      | 21.2             | 2.65             | 36.00          | 15.76           | 20.24              | 6.69               |
| B      | 20.6             | 2.69             | 37.40          | 17.73           | 19.67              | 6.94               |
| C      | 19.4             | 2.66             | 38.50          | 21.31           | 17.19              | 7.11               |
| D      | 15.5             | 2.97             | 36.30          | 20.19           | 16.11              | 7.23               |
| E      | 10.7             | 3.10             | 35.24          | 24.07           | 11.17              | 7.54               |



**Figure 3:** Casagrande chart classification of the studied soils

C-clay, M-silt:

Level of plasticity:

L-low

H-high

A line- is the boundary between two types of soil

U line- upper limit of the relationship between PL and LL

## 5. DISCUSSION

The specific gravity of soil samples in the study area ranges from 2.65 to 3.10 (Table 1). According to a study, as shown in Table 2, the soil in the study area can be categorized into sand, silty sand and soil with mica or iron (Bowles, 2012; Jain, et al., 2015; Roy and Dass, 2014; Roy, 2016).

**Table 2:** Typical values of specific gravity (Bowles, 2012)

| Type of soil           | Specific gravity | Samples |
|------------------------|------------------|---------|
| Sand                   | 2.65-2.67        | A, C    |
| Silty sand             | 2.67-2.70        | B       |
| Inorganic clay         | 2.70-2.80        |         |
| Soil with mica or iron | 2.75-3.00        | D, E    |
| Organic soil           | 1.00-2.60        |         |

The classification for degree of expansion and danger of severity is presented in (Table 3) according to International standard of 1498. The degree of expansion in the study area was categorized into one (1) namely based on the value of liquid limit of 35.24 to 38.5 % (Table 1) which falls in medium degree of expansion (35-50%).

The danger of severity in the area was classified based on the liquid limit values obtained from the study area. The value of liquid limit from the study area varies from 35.24 to 38.5 % (Table 1) and one (1) danger of severity zone was identified in the area as the marginal with liquid limit of 35 to 50 %. When the soil absorbed so much water above the liquid limit, the soil will flow like water and this also cause structures such as undulation and crack to the structure placed on such area (Momoh et al., 2017).

The plasticity index from the study area varies from 11.17 to 20.24%. (Table 1) and two (2) danger of severity zones were identified in the area which include: non-critical with plasticity index value of <12% and marginal with plasticity index of 12 to 23%. Degree of expansion can be classified into two (2) namely: low with plasticity index value of <12% and medium with plasticity index value of 12 to 23% (Table 3). The linear shrinkage from the study area varies from 6.69 to 7.54% (Table 1) and one (1) danger of severity zone was identified in the area as non-critical with linear shrinkage value of <15% and the degree of expansion is low (Table 3).

**Table 3: International Standard Classification System [IS: 1498-1970 (Revised 2002)]**

| Liquid limit (LL) % | Plasticity Index (PI) % | Linear Shrinkage (LS) % | Degree of expansion | Danger of severity |
|---------------------|-------------------------|-------------------------|---------------------|--------------------|
| 12-35               | <12                     | <15                     | Low                 | Non-critical       |
| 35-50               | 12-23                   | 15-30                   | Medium              | Marginal           |
| 50-70               | 23-32                   | 30-60                   | High                | Critical           |
| 70-90               | >32                     | >60                     | Very high           | Severe             |

The Classification of soil according to plasticity index is presented Table 4. The Plasticity index of the study area varies from 11.17 to 20.24% (Table 1) and two (2) plasticity index zones were identified in the area which include: medium plastic with plasticity index value of 7 to 17 % while highly plastic with plasticity index value >17.

**Table 4: Classification of soil according to plasticity index (Prakash and Jain, 2002)**

| Plasticity | Index Plasticity |
|------------|------------------|
| 0          | Non-Plastic      |
| <7         | Low - Plastic    |
| 7 - 17     | Medium - Plastic |
| >17        | Highly Plastic   |

Relationship between the plasticity index and the swelling potential is shown in (Table 5). The Plasticity index of the study area varies from 11.17 to 20.24% (Table 1) and two (2) swelling potential zones were identified in the area which includes: low with plasticity index value of 0 to 15 % and medium with plasticity index value of 15 to 25%.

Several researchers have also reported on geochemical properties of soils and clays on the Jos Plateau (Odewumi et al., 2023; Odewumi, 2024; Odewumi and Omoniwa, 2024; Odewumi et al., 2024). This is similar to the current findings where swelling potential clays and soils were identified in British-American area

**Table 5: Relationship between the plasticity index and swelling potential (Prakash and Jain, 2002)**

| Plasticity Index (%) | Swelling Potential |
|----------------------|--------------------|
| 0 - 15               | Low                |
| 15 - 25              | Medium             |
| 25 - 35              | High               |
| >35                  | Very high          |

Classification of soil according to linear shrinkage is shown in (Table 6). The linear shrinkage of the study area varies from 6.69 to 7.54% (Table 1) and two (2) quality of soil zones were identified in the area which includes: medium good quality of soil with linear shrinkage value of 5 to 10%.

**Table 6: Classification of soil according to linear shrinkage (Prakash and Jain, 2002)**

| Linear Shrinkage (%) | Quality of Soil |
|----------------------|-----------------|
| <5                   | Good            |
| 5 - 10               | Medium good     |
| 10 - 15              | Poor            |
| >15s                 | Very poor       |

Engineering classification using plasticity index (P1) showing index classification and cassagrande classification index (Table 7). The Plasticity index of the study area varies from 11.17 to 20.24% (Table 1) and two (2) zones was identified which includes: Medium plasticity/medium compressibility/moderate competence with plasticity index ranging from (10-20%) and High plasticity/high compressibility/low competence with plasticity index of >20 (Cassagrande classification index).

**Table 7: Engineering classification using plasticity index (PI)**

| Plasticity Index Range % | Index Classification | Cassagrande Plasticity Classification                         |
|--------------------------|----------------------|---------------------------------------------------------------|
| <10                      | Low                  | Low plasticity/ low compressibility/high competence           |
| 10-20                    | Medium               | Medium plasticity/medium compressibility/ moderate competence |
| >20                      | High                 | High plasticity/high compressibility/low competence           |

The plasticity index of the study area ranges from 11.17 to 20.24% and soil type in the area can be classified into two namely: silt clay with plasticity index of 7-17% and clay with plasticity index of > 17% (Table 8). Based on the plasticity index of 11.17 to 20.24%, the degree of cohesiveness of the soil can be classified into cohesive soils with plasticity index value of 7-17% and >17% (Table 8).

**Table 8: Types of soils based on plasticity index (Prakash and Jain, 2002)**

| Plasticity index (%) | Soil type | Degree of Plasticity | Degree of Cohesiveness |
|----------------------|-----------|----------------------|------------------------|
| 0                    | Sand      | Non-plastic          | Non-cohesiveness       |
| <7                   | Silt      | Low plastic          | Partly cohesiveness    |
| 7-17                 | Silt clay | Medium plastic       | Cohesive               |
| >17                  | Clay      | High plastic         | Cohesive               |

The plasticity chart classification as shown in Figure 2, all the samples plotted above the A line, indicates clayey content. All the samples plotted on the left side of the vertical line which have liquid limit (LL) values ranging from 35.24 to 38.5 % signifying medium compressibility. Casagrande plasticity chart which depicts that soils with liquid limit of less than 10% are cohesionless soils, liquid limit of less than 30% are of low plasticity, liquid limit ranging between 35-50% are of intermediate plasticity and liquid limit above 50% are not plastic. The liquid limit of the soils in the study area ranged from 35.24 to 38.5 % indicating intermediate plasticity of the soils.

The Casagrande plasticity chart (Figure 3) showed that most of the soil samples fall within CL-Group which implies that they would exhibit intermediate/moderate swelling potential. Federal Ministry of Works and Housing, (2010), states that material to be used as sub-base and base course, for building and road construction should have liquid limit less than 30% and all the soils have liquid limit above 30%

## 6. CONCLUSION

The degree of expansion in the area was categorized into medium degree of expansion and the danger of severity zone was identified as marginal based on liquid limit value. The danger of severity zones of non-critical and marginal were identified from plasticity index values while Low and medium degree of expansion were also obtained from plasticity index values. The value of linear shrinkage indicates non-critical danger of severity zone and the degree of expansion is low. Two (2) plasticity index zones of medium plastic and highly plastic were identified while two (2) swelling potential zones of low and medium were also identified in the study area. The soil type in the study area can be classified into silt clay and clay as suggested by the plasticity index value and was attested to Cassagrande plasticity chart as all the soil samples fall within CL-Group.

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