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Evaluation of Geotechnical Properties of Lateritic Soils in Federal Polytechnic, Ado-Ekiti South Western, Nigeria

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Abstract: This research work evaluates the Geotechnical properties of lateritic soil found within the Federal Polytechnic Ado Ekiti, Ekiti state Nigeria. The lateritic soil samples used for the analysis were obtained from ten (10) different locations within ear marked five zones identified at the campus of the Federal polytechnic Ado Ekiti, Ekiti State Nigeria, obtained with handheld digital GPS. The ten (10) samples were designated as Z1A1-Z1A2, to Z5E1-Z5E2 respectively. Disturbed method of sampling was employed in obtaining the samples. Laboratory tests such as Natural Moisture content (NMC), Specific Gravity (Gs), Sieve Analysis, Consistency Limits, Compaction test and California Bearing Ratio (CBR) in compliance with British standard 1377 (1990) were performed. The results showed that NMC ranges between 9.0 to 23 %, the Gs ranges between 2.05 to 2.9, liquid limit ranges between 42 to 75 %; plastic limit ranges between 18 to 48 % and plasticity index ranges between 18 to 34 9%.The percentage passing 75-micron sieve for most of the pits were greater than 35 % which classified the soils in the study area as Sandy Silty clayey Soils. The strength testMDD kg/m^3 and OMC % of all the samples ranges between 1508 to 1993 kg/m^3 and 11.6 to 18.7 % respectively; The soaked CBR value ranges between 1.8 to 13.3 %. The above analysis showed that the borrow pits materials investigated are not suitable for base and sub base material for road work since most of the Zones fell within the allowable limits for sub grade and earth fills materials except for Zone 3. It's recommended that materials found within the study area should be stabilized to improve its engineering properties if it to be used for base and sub base materials.

Keywords: Lateritic soils, Index properties, Geotechnical properties, California Bearing Ratio, Federal Polytechnic

1.0. Introduction

The Federal Polytechnic Ado-Ekiti is one of the oldest tertiary Institutions in the South Western Region of Nigeria with a very rapid infrastructural development in recent time. The construction of the foundation of most engineering structures requires that adequate information about the engineering properties of the soil and sub soil conditions of the area is established (Tijani *etal* ,2017). This is necessary for the engineering planning, design and construction of such foundations to be based on sound geotechnical parameters. The geotechnical parameters of soil play an important role in civil engineering infrastructural works particularly in road constructions, foundations, embankments and dams to mention a few. This made imperative, the testing of soil, on which a foundation or superstructure is to be laid. This would determine its geotechnical suitability as a construction material (Belayhun Yilma, 2013). The relative abundance and ease of acquisition of lateritic soil in Nigeria has made its uses as foundation soil common in engineering construction works especially in highways. Therefore, understanding its engineering indexes will prevent engineers, designers and contractors from selecting unsuitable laterite materials for pavement construction. Lateritic soils are commonly formed in tropical regions within 30^{o}N and 30^{o}S of the equator. Its properties depend on numerous factors which include climate, parent rock,

topography, vegetation and time (Gillot, 1969; Gidigasu, 1976). Ola (1983) defined laterite as products of tropical weathering with red, reddish brown or dark brown colour. It may contain nodules or concreting and are generally foundbelow hardened ferruginous crust or hard pan. Furthermore, laterite is described as a highly weathered material, rich in secondary oxides of iron, aluminum, or both. It is void or nearly void of bases primary silicates, but it may contain large amounts of quartz and kaolinite (Alexandra and Cady, 1962). Many authors have worked on geotechnical properties of lateritic soil in Nigeria. Jackson (1980) stated that lateritic soils have been used successfully as base and sub-base materials in road construction. Nwankwoala *et al*. (2014) identified wrong application of laterite as base and sub base materials in road construction as a major cause of road failure. According to Jegede (2000), highway failure can be attributed to undesirable fine fraction content of laterite used as sub base Soils. Addition of lime to lateritic soil increases its geotechnical properties (Balogun, 1984). Ogunsanwo (1989) assessed CBR and shear strength of some compacted lateritic soils from southwestern part of Nigeria. Others authors include Bello, 2007, Agbede and Osuolale, 2005, Tijani et al, 2017, Osuji and Akinwamide 2018, Adewoye et al., 2004, Adeyemi, 2002, Oladeji and Raheem 2002. However, there exist few published documents on the strength properties of laterites in the study area. Hence, the need for this research arises. This paper presents the result of geotechnical properties of lateritic soils obtained from ten different borrow pits available in poly Ado- Ekiti, Southwestern Nigeria.

1.1. Study Area

The study areas are as shown in figure1 lies on latitude 8° 00′North of the Equator and on longitude 5° 59′east of the Greenwich Meridian. It stands on the altitude between 360 and 387 meters approximately above the sea level. The samples were taken at a depth of about 1m from the ground surface.

Figure 1: Samples' location within the Federal Polytechnic Ado Ekiti

2.0. Material and Method

2.1. Sample Collection

The study involves collection of soil samples from borrow pits within The Federal Polytechnic Ado Ekiti, using the method of disturbed sampling. For the purpose of the project work, the lateritic soil samples used for the analysis were obtained from ten (10) different locations within earmarked five zones identified at the campus of the Federal Polytechnic Ado Ekiti, Ekiti State Nigeria, obtained with handheld digital GPS. The ten (10) samples were designated as Z1A1-Z1A2, to Z5E1-Z5E2 respectively. A disturbed method of sampling was employed in obtaining the samples. Care was taken when collecting the samples to ensure that the samples were true representatives of the in-situ materials. The samples were packaged in polyethylene bags (to avoid natural moisture lost), clearly labeled with half of each sample spread in a tray to air-dried and labeled accordingly by keeping in a conducive environment before further analysis were carried out in the Soil Mechanics Laboratory of the Federal Polytechnic Ado-Ekiti, to evaluate the Geotechnical properties of the lateritic soil.

2.2. Methods

Laboratory tests were conducted in accordance with BS 1377: 1990 where test such as Natural Moisture Content (NMC), Specific gravity Sieve analysis, Compaction test, California Bearing Ratio (CBR) were performed to evaluate the index and geotechnical indices.

3.0. Result and Discussion

3.1. Natural Moisture Content result

The Natural Moisture Content (NMC %) of all samples as shown in summary Table1 ranges between 9.0 and 22.72%. Soil samples in Zone 3, Zone 4 and Zone 1 showed a higher water content than samples from Zone 2 and Zone 5. This indicates a property of fine grains soils considering the period of the investigation. The engineering implication this is that the material will be susceptible to swelling and shrinkage during rain and dry season respectively.

3.2. Sieve Size Analysis results

The grain size distribution analysis shows the range of particle sizes presents in the soil. According to AASHTOrequirement, for a sample to be used for road construction, the percentage by weight passing the No. 200 sieves (75μm sieve) shall not be less than but not greater than 35%. Sequel to the above, Z1A2, Z2B1, Z2B2, Z5E1, Z5E2 fell within the specified range except for Z1A1, Z3C1, Z3C2, Z4D1, Z4D2 which were greater than35% as shown in Table 1 and Figure 2.

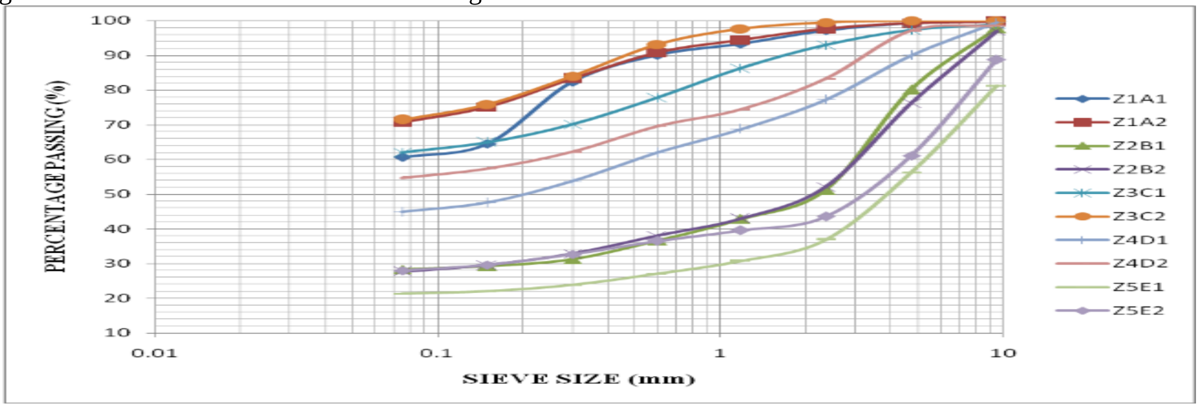

Figure 2: Graph of Grain size analysis

3.3. Specific Gravity Results

The specific gravity of the soil depends on the amount of sand, mineral constituents and mode of formation of the soil. The specific gravity for the studied soil samples ranged from 2.045 to 2.896 as shown in Table 1. According to specification, a good lateritic material should have specific gravity ranging from 2.5-2.80 (Wright, 1986 According to De Graff-Johnson, (1972), "The higher the specific gravity, the higher the degree of laterization. Thus, Z2B2 (2.896) samples appear to be the most evolved samples in term of laterization (ferruginization), while other zones range from (2.045-2.485) which shows a less dense materials and is an indication of presence of organic matter in the soil samples.

3.4. Atterberg Limits Results

The Atterberg limits test on the samples shows the Liquid limit, Plastic limit, Linear shrinkage, and the Plasticity index as shown on Table 1 and figure 3. The Liquid limit (LL %) ranges between 34 and 79 %, plastic limit (PL %) ranges between 18 and 48% and plasticity index (PI %) ranges between 18 and 34%. (FMW, 1997) recommendsLiquid limits not greater than 80% for sub- grade and not greater than 35 for sub base and base course materials. Also, PlasticityIndex not greater than 55% for sub-grade and not greater than 12% for both sub-base and base course.This result indicates that the soils samples are only suitable for Sub grade and earth fill materials.

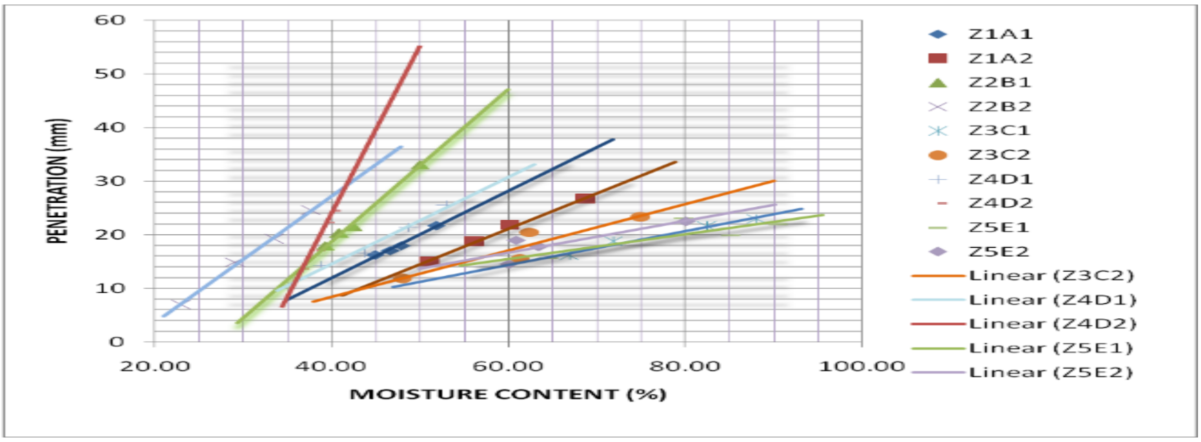

Figure 3: Graph of Atterberg limits

3.5. Compaction Test Results

This test is used to establish a dry density/moisture content relationship of a soil under controlled condition which can form a standard for comparison with field specifications. The Optimum Moisture Content (OMC %) as shown inFigure 4 and Table 1 ranges between 11.60 and 27.96 % for all the zones while Maximum Dry Density (MDD Kg/m^3) of the samples varied between 1508-1993 Kg/m^3. TheMDD values fallsbelowspecification for subbase and base materials according to (FMW, 1997), hence, soils samples within the study area are suitable for sub grade and earth fill material only.

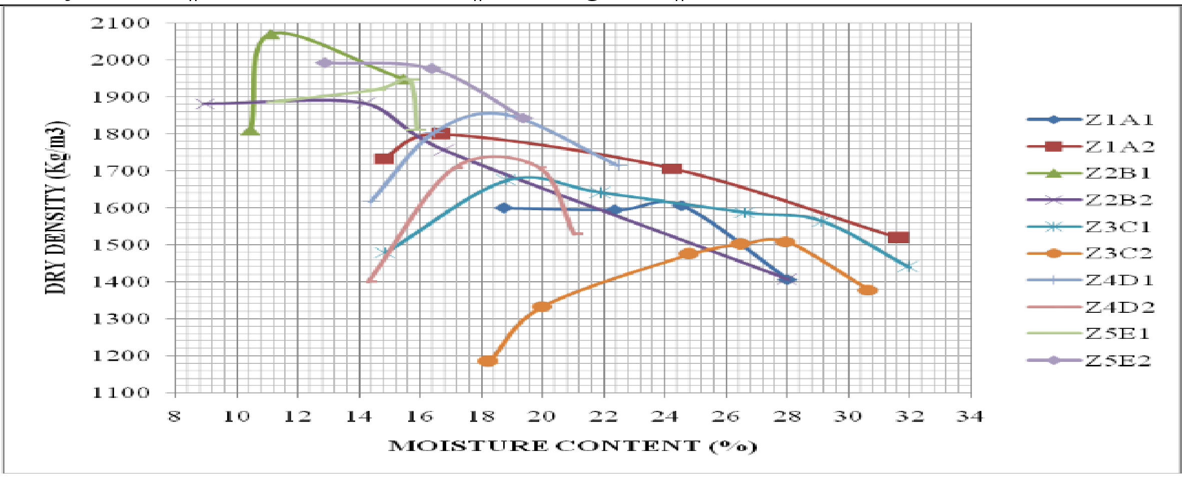

Figure 4: Graph of Compaction

3.6. California Bearing Ratio (CBR)

The CBR is a semi empirical test that is often employed in the estimation of the bearing capacity of sub-grade, sub-base and base materials (Simon et al. 1973 and Gidigasu, 1980. The test results for the samples ranges between 1.8 % and 13.3 % for all the soils sample as shown in Table 1 and figure 5 respectively. Federal Ministry of Works and Housing (1997) recommendation for soils for use as: sub-grade, sub-base and base materials should not be less than 5%, 30% and 80% respectively for soakedCBR. This result implies that materials are only suitable for sub grade material since the CBR only fell within specification for sub grade materials only.

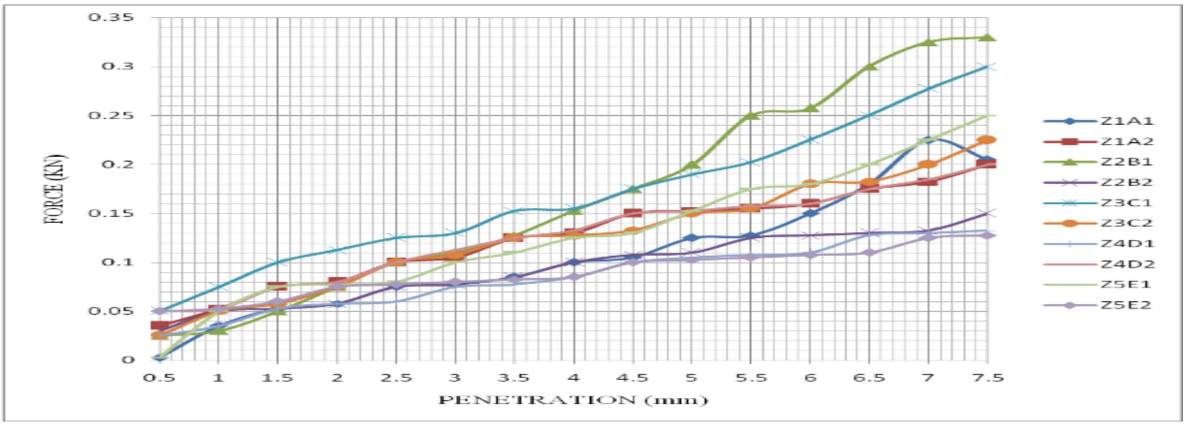

Figure 5: Graph of California Bearing Ratio

Table 1: Summary of the Geotechnical Property of Lateritic Soil

Location	**Main gate**		**Engineering**		**Abuja Hostel**		**EED Centre**		**Rector's village**	
Zone	**Z_1A_1**	**Z_1A_2**	**Z_2B_1**	**Z_2B_2**	**Z_3C_1**	**Z_3C_2**	**Z_4D_1**	**Z_4D_2**	**Z_5E_1**	**Z_5E_2**
NMC%	22.7	21.4	11.9	9.0	20	22	17	16	12	14
GS	2.09	2.05	2.39	2.9	2.05	2.06	2.2	2.2	2.34	2.36
LL	50	55	42	44	68	68	45	49	75	72
PL	26	33	24	18	34	36	25	25	48	43
LS	8.6	9.4	9.3	11	9.3	5.4	7.5	5.5	6.2	12
PI	24	22	18	26	34	32	21	24	27	29
%Passing 0.075mm	61	45	28	28	62	71	45	55	21	28
%Passing 0.06mm	90	31	37	38	78	93	62	70	27	37
%Passing 2mm	97	98	51	52	92	99	77	83	37	44

AASHO class.	A-7-6	A-2-7	A-2-7	A-2-4	A-7-5	A-7-5	A-7-5	A-4	A-2-7	A-2-7
USCS class.	CL	CH	CL	CL	CH	CH	CL	CL	CH	CH
OMC	24.1	16.7	12.9	11.6	11.5	27.9	18.6	18.7	15.6	12.9
MDD	1610	1810	1877	1900	1684	1508	1880	1727	1946	1993
CBR	2.5	5.3	10.3	11.4	2.6	1.8	11.2	7.4	12.8	13.3

4.0. Conclusion

The Natural Moisture Content of all the samples values are higher values, which implies that the material has high water retention property which inhibits behavior of a clay soil. The grain size analysis showed that the soil samples are dominantly of clay. The specific gravity result show that only one sample shows lateritic characteristics other are predominantly clay.The Atterberg limit result shows that the samples meet specification for only subgrade and earth fill materials and at that are not suitable for sub-base or base materials except the materials are stabilized. The Maximum Dry Density result also indicate suitability for sub grade and earth fill material only since MDD is within the specification for sub grade and earth fill materialsaccording to (FMW,1997).The California Bearing Ratio results only meet specification for subgrade and earth fill material only.

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