International Journal of Basic Science and Technology ISSN 2488-8648
March, Volume 8, Number 3, Page 70 - 81 http://www.ijbst.fuotuoke.edu.ng/ 70

Index Properties of Road Construction Soils in Southwestern Nigeria

[1,*]Faluyi, S.O., [1]Amu, O.O., and [2]Adetoro A. E.
[1]Department of Civil Engineering, Federal University Oye – Ekiti, Ekiti State, Nigeria
[2]Department of Civil Engineering, the Federal Polytechnic, Ado-Ekiti, Ekiti State, Nigeria

Article Information
Article # 08011
Received: 4th Oct., 2021
Revision: 5th July 2022.
Acceptance: 7th July 2022
Available on line:9th July 2022

Key Words
Index properties,
Soils classification,
Flexible pavement,
Southwestern Nigeria

Abstract

The purpose of this research is to determine the index qualities of soils used for road construction in Southwestern Nigeria. A total of fifty-four samples were collected, three (3) from each senatorial district of each state in the study area (54). The soil samples were tested for natural moisture content (NMC), specific gravity, particle size analysis, and Atterberg limits using conventional techniques. The acquired index attributes were compared to a relevant standard. For all of the soil samples, the NMC and specific gravity values ranged from 3.02 to 17.94 and 2.05 to 2.89, respectively.The particle size distribution demonstrated that the majority of the soil materials did not fall within the 5–20% standard range of sub-base and base course materials. Most soil's plasticity qualities showed that they were unsuitable as underlying soil for flexible pavement. Thirty-two samples received an overall rating of excellent to good, whereas twenty-two samples received a grade of fair to poor. Some soils are only suitable as subgrade materials unless stabilized. To produce a long-lasting road, substantial attention must be paid to quality management of road construction soils in Southwestern Nigeria, as well as stabilization of inappropriate soils.

*Corresponding Author; Faluyi, S.O.,.: fsundayolubunmi@yahoo.com

Introduction

The state of any road layer today and in the future is largely determined by the soil beneath its base. In the construction of foundations in most engineering constructions, having enough information about the engineering features of soil and the subsoil state is critical. This is because the engineering planning, design, and building of such road foundations are based on reliable geotechnical information.The lack of relevant geotechnical data, particularly for primary/preliminary engineering planning and designs, has been the cause of failure of most road construction projects in Nigeria, with failure occurring almost immediately after project commissioning. As a result, the construction material used for engineering road projects is as important as other engineering design factors(Kanyi, 2017; Osinubi *et al*., 2017).

As a result, the soil (subbase and base course) components employed in the pavement construction convey the axle weight to the subgrade in road pavement design. As a result, the ability of a pavement's soil to convey stress created on it to the subsoil without needless distortion is a function of its easiness and rigidity. Lateritic soils are generally good construction materials that are widely employed in construction(Amu and Adetuberu, 2010). In tropical climates around the world, they are employed as road construction materials and form the subgrade of most roadways. According to Lemougna*et al.* (2011), laterite makes a significant contribution to the economies of all places where it is found. This is due to its numerous uses in civil engineering and other fields like as agronomy. For low-cost roads with low to medium traffic, laterite is utilized as a Subbase and base course.According to Jerez et al. (2018), various researchers have highlighted the use of laterite in tropical and sub-tropical nations.

Laterites and lateritic soils, on the other hand, are good quality materials for road construction and can be improved by stabilization treatments for the road subgrade, sub-base, and base course(Osinubi *et al*., 2009; Apampa, 2017). In the Southwestern part of Nigeria, the laterilisation process, which is the formation of laterite, is readily available (Oyelami and Rooy, 2016). Tropical climate weathering, also known as "Laterilisation," is a long-term chemical weathering process that produces soils with a wide range of thickness, grade, chemistry, and ore mineralogy. The first products of this weathering are saprolites, which are kaolinized rocks.Climate (precipitation, leaching, capillary rise, and temperature), terrain (drainage), vegetation, parent rock (iron-rich rocks), and time variables all influence lateritic soil formation. The most important component, though, is the weather (Ojuri and Ogundipe, 2012; Nnochiri and Ogundipe, 2016; Nnochiri, 2018). Many studies have examined the geotechnical properties of lateritic soils from various soil samples, and their findings have proven that changes in the properties of the soils are regulated by a variety of factors, including climatic and environmental ones (Kanyi, 2017). Others who have studied the geotechnical qualities of lateritic soils include Agbede (1992), Ijimdiya (2007), Ugbe (2011), Habeeb *et al.* (2012), and Eberemu *et al.* (2013) etc.

In Southwestern Nigeria, Adeyemi and Wahab (2008) explored the change of geotechnical parameters of residual lateritic soils. The soil samples were gathered from a 39 m^2 restricted area. The soils were found to have medium plasticity and minimal linear shrinkage, as well as high CBR and UCS strength characteristics. It was also discovered that the geotechnical qualities of different soils differ even over short distances.Lateritic soils were obtained from borrowed trenches along the Ogbomosho - Ibadan road in Southwestern Nigeria by Okunlola et al. (2014). The average specific gravity, Liquid Limit (LL), Plastic Limit, Maximum Dry Density (MDD), Optimum Moisture Content (OMC), and California Bearing state. Its capital was Ibadan, which was also the ancient region's capital. In 1976, the Western state was partitioned into three new states: Ogun, Ondo, and Oyo. In 1991 and 1996, the states of Osun and Ekiti were formed from the states of Old Oyo and Ondo, respectively.

Nigeria has a tropical climate, which is humid and wet throughout the year. The research region is located in Southwestern Nigeria, which has a tropical monsoon climate (Köppen climatic classification "Am"). It is always drenched in a torrential downpour. This could be because it is so close to the equatorial belt. Annual rainfall averages 2,000 mm (78.7 in) or more. Dry and wet seasons are common in the region. Between March and July is the first rainy season. This is followed by a two- to three-week dry respite in August (also known as August break).The second rainy season, which occurs between September and October, interrupts this hiatus. After the second rainy season ends in October, the dry season begins in November and lasts until March (Adetoro, 2020).

Introduction

The state of any road layer today and in the future is largely determined by the soil beneath its base. In the construction of foundations in most engineering Ratio (CBR) of the soils (soaked and unsoaked) were 2.72, 49 percent, 27 percent, 1570–1870 Kg / m^3, 11.0 – 16.5 percent, 17.0 – 60.0 percent (soaked) and 42.0 – 74.0 percent (unsoaked), respectively.

The state of the roads in southern Nigeria is appalling; the majority of them are impassable owing to pavement failure. On these roads, localized cracks, depression, heaving, and settling are all common failures. The underlying soil utilized as subgrade, subbase, or base material during road building could be blamed for the pavement problems. Traveling a few kilometers of road in Southwestern Nigeria without slowing down due to road failure is difficult. As a result, there is a significant requirement to research and evaluate the appropriateness of the underlying soil courses. In contrast to prior research, this study focused on evaluating the index qualities of road-building soils in Southwestern Nigeria.

Materials and Methods

Study area

The study area is Nigeria's Southwestern region. As indicated in Figure 1, the geopolitical zone of Southwestern Nigeria includes the states of Ekiti, Lagos, Ogun, Ondo, Osun, and Oyo. It is located between the latitudes of 6.214 and 9.000 degrees north; and the longitudes of 2.681 and 9.000 degrees east. It was founded in 1967 when the Western region was separated into the states of Lagos and Western

constructions, having enough information about the engineering features of soil and the subsoil state is critical. This is because the engineering planning, design, and building of such road foundations are based on reliable geotechnical information.The lack of relevant geotechnical data, particularly for primary/preliminary engineering planning and designs, has been the cause of failure of most road construction projects in Nigeria, with failure occurring almost immediately after project commissioning. As a result, the construction material used for engineering road projects is as important as other engineering design factors(Kanyi, 2017; Osinubi *et al*. 2017).

As a result, the soil (subbase and base course) components employed in the pavement construction convey the axle weight to the subgrade in road pavement design. As a result, the ability of a pavement's soil to convey stress created on it to the subsoil without needless distortion is a function of its easiness and rigidity. Lateritic soils are generally good construction materials that are widely employed in construction(Amu & Adetuberu, 2010). In tropical climates around the world, they are employed as road construction materials and form the subgrade of most roadways. According to Lemougna*et al.* (2011), laterite makes a significant contribution to the economies of all places where it is found. This is due to its numerous uses in civil engineering and other fields like as agronomy. For low-cost roads with low to medium traffic, laterite is utilized as a Subbase and base course.According to Jerez et al. (2018), various researchers have highlighted the use of laterite in tropical and sub-tropical nations.

Laterites and lateritic soils, on the other hand, are good quality materials for road construction and can be improved by stabilization treatments for the road subgrade, sub-base, and base course(Osinubi *et al*., 2009; Apampa, 2017). In the Southwestern part of Nigeria, the laterilisation process, which is the formation of laterite, is readily available (Oyelami & Rooy, 2016). Tropical climate weathering, also known as "Laterilisation," is a long-term chemical weathering process that produces soils with a wide range of thickness, grade, chemistry, and ore mineralogy. The first products of this weathering are saprolites, which are kaolinized rocks.Climate (precipitation, leaching, capillary rise, and temperature), terrain (drainage), vegetation, parent rock (iron-rich rocks), and time variables all influence lateritic soil formation. The most important component, though, is the weather (Ojuri and Ogundipe, 2012; Nnochiri and Ogundipe, 2016; Nnochiri, 2018). Many studies have examined the geotechnical properties of lateritic soils from various soil samples, and their findings have proven that changes in the properties of the soils are regulated by a variety of factors, including climatic and environmental ones (Kanyi, 2017). Others who have studied the geotechnical qualities of lateritic soils include Agbede (1992), Ijimdiya (2007), Ugbe (2011), Habeeb *et al.* (2012), and Eberemu *et al.* (2013) etc.

In Southwestern Nigeria, Adeyemi and Wahab (2008) explored the change of geotechnical parameters of residual lateritic soils. The soil samples were gathered from a 39 m^2 restricted area. The soils were found to have medium plasticity and minimal linear shrinkage, as well as high CBR and UCS strength characteristics. It was also discovered that the geotechnical qualities of different soils differ even over short distances.Lateritic soils were obtained from borrowed trenches along the Ogbomosho - Ibadan road in Southwestern Nigeria by Okunlola et al. (2014). The average specific gravity, Liquid Limit (LL), Plastic Limit, Maximum Dry Density (MDD), Optimum Moisture Content (OMC), and California Bearing Ratio (CBR) of the soils (soaked and unsoaked) were 2.72, 49 percent, 27 percent, 1570–1870 Kg / m^3, 11.0 – 16.5 percent, 17.0 – 60.0 percent (soaked) and 42.0 – 74.0 percent (unsoaked), respectively.

The state of the roads in southern Nigeria is appalling; the majority of them are impassable owing to pavement failure. On these roads, localized cracks, depression, heaving, and settling are all common failures. The underlying soil utilized as subgrade, subbase, or base material during road building could be blamed for the pavement problems. Traveling a few kilometers of road in Southwestern Nigeria without slowing down due to road failure is difficult. As a result, there is a significant requirement to research and evaluate the appropriateness of the underlying soil courses. In contrast to prior research, this study focused on evaluating the index qualities of road-building soils in Southwestern Nigeria.

Materials and Methods

Study area

The study area is Nigeria's Southwestern region. As indicated in Figure 1, the geopolitical zone of Southwestern Nigeria includes the states of Ekiti, Lagos, Ogun, Ondo, Osun, and Oyo. It is located between the latitudes of 6.214 and 9.000 degrees north; and the longitudes of 2.681 and 9.000 degrees east. It was founded in 1967 when the Western region was separated into the states of Lagos and Western state. Its capital was Ibadan, which was also the ancient region's capital. In 1976, the Western state was partitioned into three new states: Ogun, Ondo, and Oyo. In 1991 and 1996, the states of Osun and Ekiti were formed from the states of Old Oyo and Ondo, respectively.

Nigeria has a tropical climate, which is humid and wet throughout the year. The research region is located in Southwestern Nigeria, which has a tropical monsoon climate (Köppen climatic classification "Am"). It is always drenched in a torrential downpour. This could be because it is so close to the equatorial belt. Annual rainfall averages 2,000 mm (78.7 in) or more. Dry and wet seasons are common in the region. Between March and July is the first rainy season. This is followed by a two- to three-week dry respite in August (also known as August break).The second rainy season, which occurs between September and October, interrupts this hiatus. After the second rainy season ends in October, the dry season begins in November and lasts until March (Adetoro, 2020).

ISSN 2488-8648

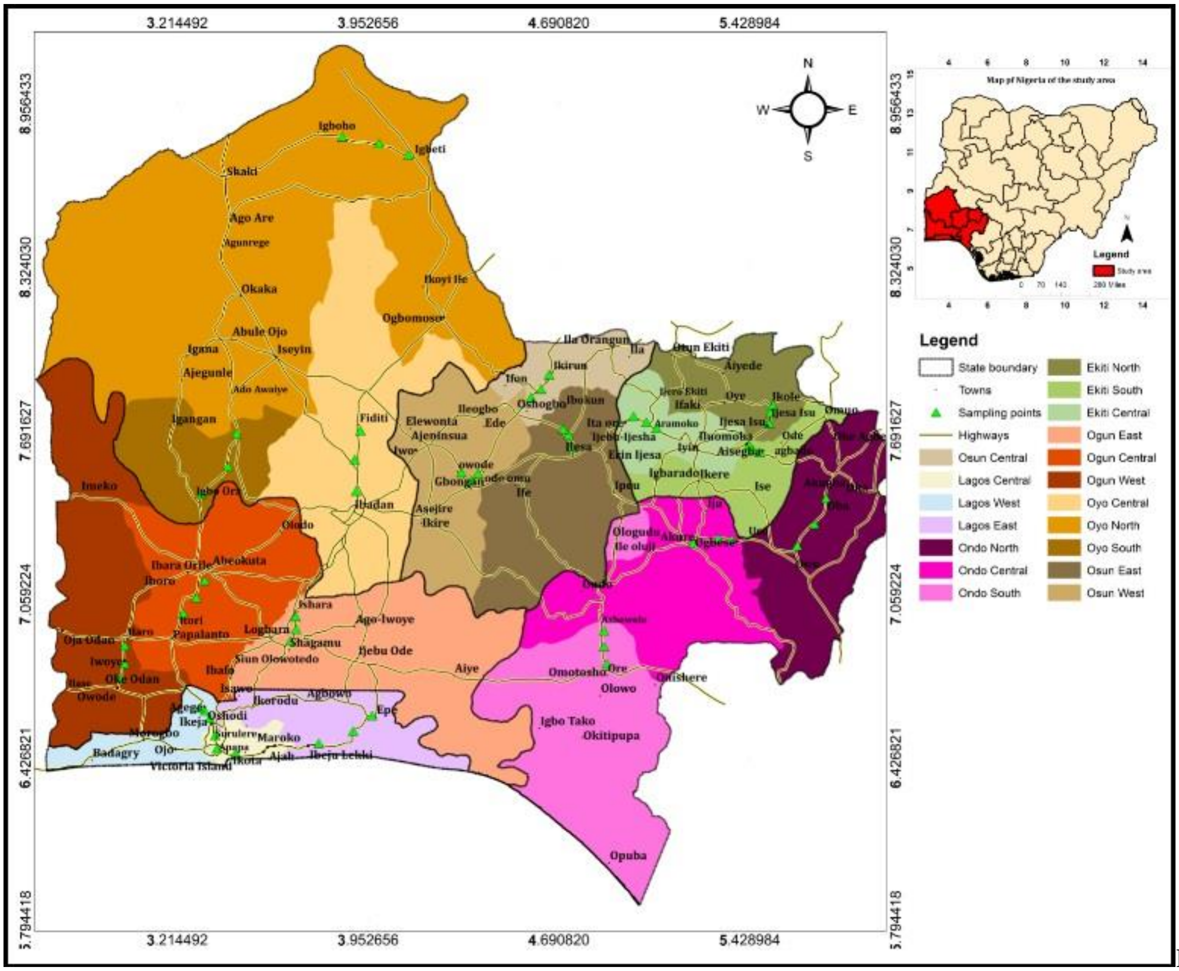

Figure 1: Location of the Study Area – Southwestern Nigeria

As illustrated in Figure 2, the area is geologically positioned in the Southwestern sector of the Nigerian Basement Complex, which comprised the southern half of the neo-proterozoic (750 - 500 Ma) Trans-Saharan mobile belt. Nigeria's geology is characterized by sedimentary and crystalline basement complex formations that are found in about equal amounts across the country. The silt is mostly upper cretaceous to recent in age, whereas the basement complex rocks are Precambrian in age.The existence of migmatite-gneiss complexes, metasediments (supra crustal rocks) comprised of heterogeneous lithology of schistose assemblages known as schist belts, and invading older granite characterize the Precambrian basement complex (Akinyemi *et al*., 2014).

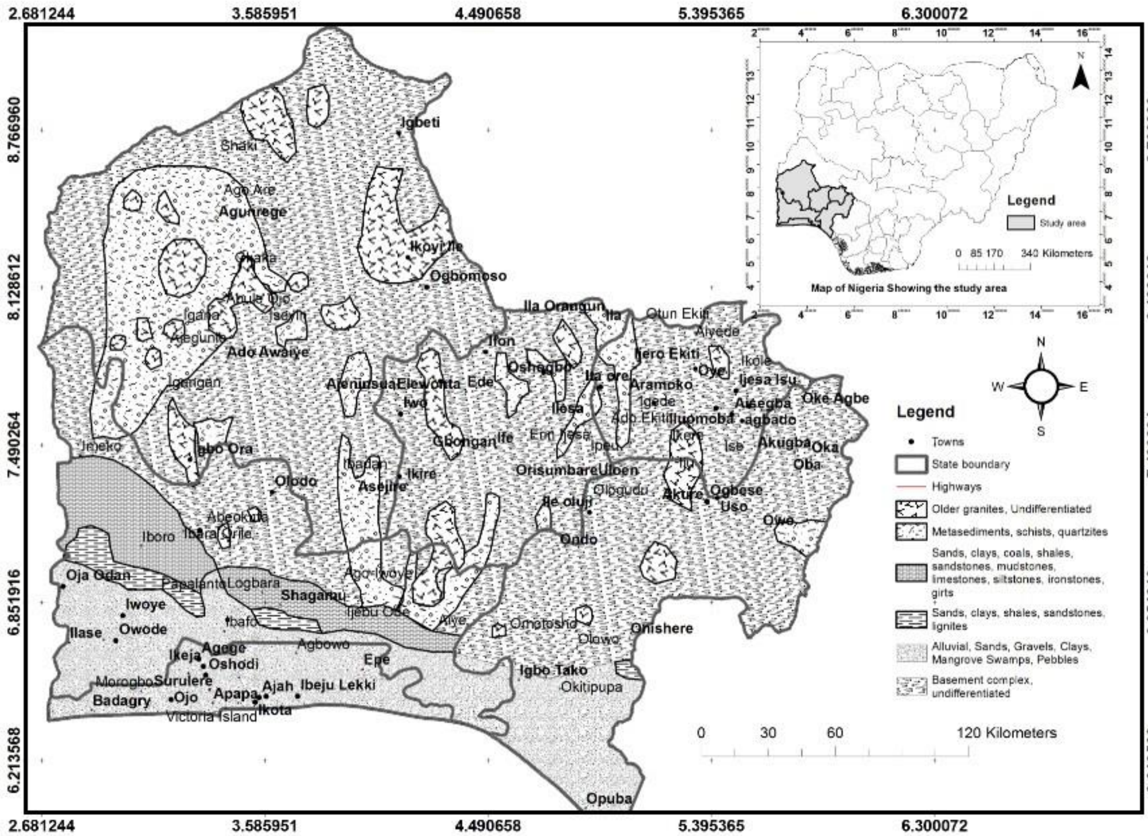

Figure 2: Geology of the Study Area – Southwestern Nigeria

Soil sampling

Three (3) lateritic soil samples were obtained from a major federal road in each senatorial district of each of the six (6) states in Southwestern Nigeria and were given the numbers 1, 2, and 3. Borrow pits material is used on these roads, hence the soil samples are from there. To prevent moisture loss, collected samples were immediately placed in polythene bags before being used. The soils were taken to the Department of Civil Engineering at the Federal Polytechnic in Ado-Ekiti, where they underwent various geotechnical examinations.

Laboratory tests

Natural moisture content, specific gravity, particle size analysis, and Atterberg limits tests were performed on the soil samples in line with BS 1377 (Part 2:1990). The Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI) tests are all part of the Atterberg limits tests, which are also known as consistency tests. They are frequently used to assess the natural reaction of soil samples to moisture (i.e. water). Particle size analysis is the process of analyzing and grouping soil particles or grains into different sizes, such as clay, gravel, and sand amounts. It also aids in determining the proportional proportion of untreated soil samples by bulk.The findings of this test are commonly used to classify soil samples according to AASHTO (1993) and FMWH (1997) guidelines (Adetoro and Adam, 2015; BS 1377, 1990).

Results and Discussion

Natural Moisture Content

Table 1 shows the results of the natural moisture content of the soil samples. The outcomes differ from one state to the next. The Natural Moisture Content (NMC) in Osun State ranged from 3.65 to 8.26, while it was 6.01 to 9.58 in Ondo State. The NMC in Ekiti State ranged from 3.02 to 14.71, making it the state with the lowest NMC. For soil samples from Oyo, Ogun, and Lagos, NMC values varied from 3.4 to 17.94, 3.2 to 9.70, and 12.05 to 15.21, respectively. The amount of moisture contained within soil is a function of its porosity, the availability of water, and the mineralogy of the material, as explained by Bell *et* *al*. (1986). The variation in the NMC values can be attributed to the amount of moisture contained within a soil, which is a function of its porosity, the availability of water, and the mineralogy of the material. The results, on average, show the soil's ability to retain water.

Specific Gravity

Table 2 shows the specific gravity data of the soil samples. According to Das (2010), the specific gravity of most genuine soils is between 2.60 and 2.90. The presence of a large amount of clay fraction and alumina reduces specific gravity (Kamtchueng *et al*., 2015). The outcomes differ from one state to the next. Although the majority of the analyzed soil samples do not fall within the range, this could be owing to variability in soil formation mineralogy, which is a key determinant in soil particle density.Ekiti State's specific gravity (Gs) ranged from 2.05 to 2.63, while Ondo State's was between 2.27 and 2.70. The state of Osun fell within the ranges reported by Das (2010), ranging from 2.55 to 2.87. For Oyo, Ogun, and Lagos soil samples, the values ranged from 2.05 to 2.82, 2.17 to 2.39, and 2.28 to 2.89, respectively.

Particle Size Distribution

Table 3 shows the particle size distribution data for the soil samples. According to the AASHTO (1993) Soil Classification System, Ekiti soil samples from the central district are fine-grained (≥ 35 percent passing 0.075mm), while soils from the south district are granular materials (≤ 35 percent passing 0.075mm), and Ekiti North soil samples are predominantly granular except for road 1. The soils in Ondo State's central and north districts (save road 3) are primarily coarse-grained, but the soils of the south region are predominantly fine-grained.In terms of observed gradation variability, Osun, Oyo, Ogun, and Lagos states have similar particle size characteristics. Except for road 3, soil samples from Osun state's center region are generally fine-grained, whereas soil samples from the west district are predominantly granular, except road 2. The Osun east samples are all fine-grained. Except for Oyo south's routes 1 and 3, soil samples in Oyo state are mostly granular. Except for road 2, all of the center soil samples in Ogun state are fine-grained, whereas the west and east soils are largely granular (west).Lagos state soil samples revealed diversity from district to district. All of the soils in the east and west are granular, whereas the soils in the middle district are fine-grained.

Given the results of percentage passing # 200 sieve (0.075mm), Ekiti South (Roads 1 and 3), Ekiti North (Road 3), Ondo North (Road 3), Ondo South (Roads 1 and 3), Oyo North (Road 2), Oyo Central (Roads 2 and 3), Ogun East (Road 2), all samples of Lagos East and Lagos West (Road 1) are the samples fit for subbase material since they are within the range given by FMWH (1997).

Table1: Natural moisture content characteristics of the south western road soils

NMC (%)

Sample No.	EKITI			ONDO			OSUN			OYO			OGUN			LAGOS		
	Central	South	North	Central	South	North	Central	West	East	Central	South	North	Central	West	East	Central	West	East
1	11.92	6.52	3.02	8.03	6.01	7.65	3.65	5.46	6.07	17.94	3.40	7.40	7.42	9.70	8.01	13.89	13.03	13.33
2	12.52	6.26	14.71	8.01	7.55	8.60	8.26	5.49	5.57	3.40	3.60	3.70	7.40	6.20	6.80	14.91	12.05	14.13
3	11.27	4.67	14.00	9.58	8.97	8.94	3.32	6.31	6.89	7.22	3.84	3.78	3.20	6.50	7.40	15.21	13.64	15.11

Table 2: Specific gravity of the Southwestern road soils

SPECIFIC GRAVITY

Sample No.	EKITI			ONDO			OSUN			OYO			OGUN			LAGOS		
	Central	South	North	Central	South	North	Central	West	East	Central	South	North	Central	West	East	Central	West	East
1	2.53	2.42	2.59	2.51	2.37	2.57	2.63	2.60	2.55	2.78	2.05	2.53	2.28	2.25	2.17	2.28	2.60	2.32
2	2.53	2.63	2.38	2.55	2.48	2.56	2.61	2.57	2.55	2.82	2.35	2.62	2.22	2.23	2.22	2.51	2.86	2.52
3	2.60	2.05	2.45	2.41	2.27	2.70	2.55	2.87	2.61	2.63	2.54	2.45	2.22	2.22	2.39	2.47	2.89	2.53

Table 3: Particle size distribution of the Southwestern road soils

Property	Sample No	EKITI			ONDO			OSUN			OYO			OGUN			LAGOS		
		Central	South	North	Central	South	North	Central	West	East	Central	South	North	Central	West	East	Central	West	East
% fines	1	53.36	14.54	47.04	49.70	18.54	58.14	47.94	23.44	56.68	0.74	43.00	22.60	40.02	28.90	33.98	44.66	18.90	8.02
	2	46.14	24.75	20.70	44.64	31.94	42.94	45.23	46.47	56.16	12.48	30.16	10.32	37.46	37.46	18.60	39.38	25.78	2.78
	3	46.92	8.81	19.58	41.72	6.50	17.72	21.48	21.74	38.76	10.80	42.06	25.62	42.18	22.88	31.02	42.33	23.22	5.88
% sand	1	41.44	58.52	52.38	45.58	54.52	40.52	46.38	28.26	26.14	78.98	51.78	59.34	54.08	33.10	50.32	43.68	80.86	91.58
	2	47.20	45.50	74.48	48.70	47.08	56.48	45.51	16.41	33.04	62.34	59.60	51.48	39.30	40.54	43.40	58.50	74.14	95.72
	3	47.92	57.63	53.60	51.48	52.34	77.32	34.36	40.82	44.18	59.48	43.52	57.10	44.54	68.12	19.98	51.83	76.66	90.33

International Journal of Basic Science and Technology
March, Volume 8, Number 3, Page 70 - 81 ISSN 2488-8648
http://www.ijbst.fuotuke.edu.ng/

% gravel	1	5.20	26.94	0.58	4.72	26.94	1.34	5.68	48.30	17.18	20.28	5.22	18.06	5.90	38.00	15.70	11.66	0.24	0.40
	2	6.66	29.76	4.82	6.66	20.98	0.58	9.26	37.12	10.80	25.18	10.24	38.20	23.23	22.00	38.00	2.12	0.08	1.50
	3	5.16	33.56	26.82	6.80	41.16	4.96	44.16	37.44	17.06	29.72	14.42	17.28	13.28	9.00	49.00	5.84	0.12	3.79

Table 4: Atterberg limit behaviour of the Southwestern road soils

Property	Sample No	EKITI			ONDO			OSUN			OYO			OGUN			LAGOS		
		Central	South	North	Central	South	North	Central	West	East	Central	South	North	Central	West	East	Central	West	East
LL (%)	1	55.10	32.60	51.60	31.00	52.40	49.20	75.00	45.00	43.06	30.70	26.25	29.25	40.50	42.20	33.00	42.25	39.00	22.50
	2	58.20	51.00	31.30	41.30	45.80	57.20	47.10	43.40	26.50	40.80	28.00	26.35	50.60	34.20	32.00	31.50	33.40	37.00
	3	51.80	37.30	34.30	43.80	37.90	33.80	41.00	45.50	41.20	32.60	36.50	33.50	51.75	34.50	30.40	51.40	38.80	39.70
PL (%)	1	32.47	18.80	34.01	18.72	32.50	37.88	41.31	15.98	13.26	12.12	8.24	18.67	20.11	28.00	19.53	22.53	22.37	NP
	2	31.72	21.71	18.64	27.59	34.44	35.41	33.14	32.33	12.38	11.48	9.87	10.41	33.01	21.89	17.58	NP	15.75	19.18
	3	31.63	14.93	22.46	33.05	29.49	19.85	28.30	27.56	31.10	11.59	22.67	17.32	36.33	22.89	18.09	24.67	17.98	18.13
PI (%)	1	22.63	13.80	17.59	12.28	19.90	11.32	33.69	29.02	29.80	18.58	18.01	10.58	20.39	14.20	13.47	19.72	16.63	NP
	2	26.48	29.29	12.66	13.71	11.36	21.79	13.96	11.07	14.12	29.32	18.13	15.94	17.59	12.31	14.42	NP	17.65	17.82
	3	20.17	22.37	11.84	10.75	8.41	13.95	12.70	17.94	10.10	21.01	13.83	16.18	15.42	11.61	12.31	26.73	20.82	21.57

ISSN 2488-8648

Atterberg Limit

Table 4 shows the results of the soil samples' Atterberg limits behaviour. The Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI), which is the difference between the two, are all displayed. For materials acceptable for subbase and base courses, FMWH (1997) indicated that LL and PI should not exceed 35 percent and 12 percent, respectively. Few soil samples met this condition, according to the results of the soil tests. For Ekiti, Ondo, Osun, and Lagos, the sample soils that met the LL level are South (Road 1) and North (Roads 2 and 3); Central (Road 1) and North (Road 3); East (Road 2); Central (Road 2), East (Road 2), and West (Road 1). The criteria were also met by Oyo Central (Roads 1 and 3), Oyo South (Roads 1 and 2), all Oyo North roads, Ogun West (Roads 2 and 3), and all Ogun East roads.

However, only nine (9) soil samples satisfied the criterion for the maximum PI of 12 percent: Ekiti North (Road 3), Ondo Central (Road 3), Ondo North (Road 1), Ondo South (Roads 2 and 3), Osun East (Road 3), Osun West (Road 2), Oyo North (Road 1), and Ogun West (Road 3).

Engineering Soil Classification

AASHTO (1993) was used to classify the soil samples. This approach, which incorporates both particle size distribution and the Atterberg limits, assigns a rating to soil based on its suitability for supporting roadway pavement. Only A-1 and A-3, which are granular materials, are excellent to acceptable materials, while A-4 to A-7 are fair and bad materials, and A-8 are unsuitable materials, according to AASHTO (1993).Tables 5 and 6 show that the particle size characteristics and Atterberg behavior of the samples soil indicate that Ekiti Central roads, Ekiti North (Road 1), Ondo Central roads, Ondo North (Roads 1 and 2), Osun Central (Roads 1 and 2), Osun West (Road 2), Osun East roads, Oyo Central (Roads 1 and 3), Ogun Central roads, Ogun West (Road 2), Lagos Central (Roads 1 and 3) are not good but fair to poor materials for flexible pavement construction.

Table5: Engineering classification of Ekiti, Ondo, and Osun road soils

State	Senatorial District	Road	Sample No.	% Passing No. 200 Sieve	Atterberg limit			Classification
					LL	PL	PI	AASHTO
Ekiti (A)	Central	Ado-Itawure	1	53.36	55.10	32.47	22.63	A-7-5
			2	46.14	58.20	31.72	26.48	A-7-5
			3	46.92	51.80	31.63	20.17	A-7-5
	South	Aisegba-Ilumoba	1	14.54	32.60	18.80	13.80	A-2-6
			2	24.75	51.00	21.71	29.29	A-2-7
			3	8.81	37.30	14.93	22.37	A-2-6
	North	Ikole- Ijesa-Isu	1	47.04	51.60	34.01	17.59	A-7-5
			2	20.70	31.30	18.64	12.66	A-2-6
			3	19.58	34.30	22.46	11.84	A-2-6
Ondo (B)	Central	Akure-Ogbese	1	49.70	31.00	18.72	12.28	A-6
			2	44.64	41.30	27.59	13.71	A-7-6
			3	41.72	43.80	33.05	10.75	A-7-5
	South	Ondo- Ore	1	18.54	52.40	32.50	19.90	A-2-7
			2	31.94	45.80	34.44	11.36	A-2-7
			3	6.50	37.90	29.49	8.41	A-2-4
	North	Owo-Akoko	1	58.14	49.20	37.88	11.32	A-7-5
			2	42.94	57.20	35.41	21.79	A-7-5
			3	17.72	33.80	19.85	13.95	A-2-6
Osun (C)	Central	Osogbo-Ikirun	1	47.94	75.00	41.31	33.69	A-7-5
			2	45.23	47.10	33.14	13.96	A-7-5
			3	21.48	41.00	28.30	12.70	A-2-7

	West	Owode-Ode-Omu	1	23.44	45.00	15.98	29.02	A-2-7
			2	46.47	43.40	32.33	11.07	A-7-5
			3	21.74	45.50	27.56	17.94	A-2-7
	East	Ilesha-IjebuIjesha	1	56.68	43.06	13.26	29.80	A-7-6
			2	56.16	26.50	12.38	14.12	A-6
			3	38.76	41.20	31.10	10.10	A-5

Table 6: Engineering classification of Oyo, Ogun and Lagos road soils

State	Senatorial District	Road	Sample No.	% Passing No. 200 Sieve	Atterberg limit			Classification
					LL	PL	PI	AASHTO
Oyo (D)	Central	Ogbomoso-Oko	1	0.74	30.70	12.12	18.58	A-2-6
			2	12.48	40.80	11.48	29.32	A-2-7
			3	10.80	32.60	11.59	21.01	A-2-6
	South	Ibadan-Fiditi	1	43.00	26.25	8.24	18.01	A-6
			2	30.16	28.00	9.87	18.13	A-2-6
			3	42.06	36.50	22.67	13.83	A-6
	North	Igbeti-Igboho	1	22.60	29.25	18.67	10.58	A-2-6
			2	10.32	26.35	10.41	15.94	A-2-6
			3	25.62	33.50	17.32	16.18	A-2-6
Ogun (E)	Central	Abeokuta-Itori	1	40.02	40.50	20.11	20.39	A-7-6
			2	37.46	50.60	33.01	17.59	A-7-5
			3	42.18	51.75	36.33	15.42	A-7-5
	West	Ilaro-Papanlanto	1	28.90	42.20	28.00	14.20	A-2-7
			2	37.46	34.20	21.89	12.31	A-6
			3	22.88	34.50	22.89	11.61	A-2-6
	East	Shagamu-Ishara	1	33.98	33.00	19.53	13.47	A-2-6
			2	18.60	32.00	17.58	14.42	A-2-6
			3	31.02	30.40	18.09	12.31	A-2-6
Lagos (F)	Central	Lekki-Ajah	1	44.66	42.25	22.53	19.72	A-7-6
			2	39.38	31.50	NP	NP	A-3
			3	42.33	51.40	24.67	26.73	A-7-6
	West	Oshodi-Agege	1	18.90	39.00	22.37	16.63	A-2-6
			2	25.78	33.40	15.75	17.65	A-2-6
			3	23.22	38.80	17.98	20.82	A-2-6
	East	Apapa west-Apapa East	1	8.02	22.50	NP	NP	A-3
			2	2.78	37.00	19.18	17.82	A-2-6
			3	5.88	39.70	18.13	21.57	A-2-6

Conclusions

This study looked at the index qualities of a variety of southern road soils. The results revealed that most soil samples have a high level of plasticity, as well as a significant percentage of particles. These variables had a significant impact on the AASHTO classification groups of the soil samples. According to the findings, some of the soil utilized for road construction in the

Southwest is of fair to bad quality, which has invariably contributed to the failure of most highways in the region.These findings support the necessity of quality control in the specification of road materials and the requirement for soil stabilization in mostly fair to bad soils. For a long-lasting flexible pavement in Southwestern Nigeria, government agencies and other interested authorities should ensure that real laboratory investigations of soil are carried out and remedial solutions are offered where appropriate.

References

Adetoro, A. E., and Adam, J. O. (2015a). Analysis of Influences of Locally Available Additives on Geotechnical Properties of Ekiti State Soil, Southwestern, Nigeria, *International Journal of Innovative Research in Science, Engineering and Technology*, 4(8), 7093 - 7099.

Adetoro, A. E. (2020). *Adsorption of Selected Heavy Metal Ions from Mining Wastewater using Carica Papaya Stem Activated Carbon*. Nigeria: Ogbomoso, Ladoke Akintola University of Technology, Department of Civil Engineering: Unpublished Ph.D. Dissertation.

Adeyemi, G.O., and Wahab, K.A. (2008).Variability in the Geotechnical Properties of a Lateritic Soil from Southwestern Nigeria. *Bull. Eng. Geol. Environ*. doi:10.1007/ s10064-008- 01372.

Agbede, O. A. (1992). Characteristics of Tropical Red soils as Foundation Materials, *Nigerian Journal of Science*, 26, 237-242.

American Association of State Highway and Transportation Officials, AASHTO (1993). *Recommended Practice for the Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes: AASHTO Designation M 145-91, Standard Specifications for Transportation Materials and Methods of Sampling and Testing.* Washington DC, USA.

Akinyemi, S. A., Ogunniyia, S. O., Ojo, A. O., Gitari, W. M., Momoh, A., Akinola, O. O., … Ayodele, O. S. (2014). Mineralogy, Physicochemical Characteristics and Industrial Potential of Some Residual Clay Deposits within Ekiti State, Southwestern Nigeria. *Journal of Environmental and Earth Science*, *4*(17), 70–89.

Amu, O. O., & Adetuberu, A. A. (2010). Characteristics of Bamboo Leaf Ash Stabilization on Lateritic Soil in Highway Construction. *International Journal of Engineering and Technology*, *2*(4), 212–219.

Apampa, O. A. (2017). Environmental Benefits of Corn Cob Ash in Lateritic Soil Cement Stabilization for Road Works. *African Journal of Science, Technology, Innovation and Development*, (1–5), 427–431. https://doi.org/10.1080/20421338.2017.1399533

Bell, F. G., Cripps, J. C., & Culshaw, M. G. (1986). A Review of the Engineering Behaviour of Soils and Rocks with respect to Groundwater. *Geological Society Engineering Geology Special Publication*, *3*(3), 1–23. https://doi.org/10.1144/GSL.ENG.1986.003.01.01

British Standard 1377 (BS 1377) (1990). *British Standard Methods of Test for Soils for Civil Engineering Purposes.* UK: London, British Standards Institution.

Das, B. M. (2010). *Principles of Geotechnical Engineering* (7th ed.). Stamford,USA: Cengage Learning.

Eberemu, A.O., Edeh, J.E. and Gbolokun, A. O. (2013). The Geotechnical Properties of Lateritic Soil Treated with Crushed Glass Cullet. *Advanced Materials Research*, 824, 21-28.

Federal Ministry of Works and Housing (FMWH) (1997). *General Specification (Roads and Bridges) – Revised Edition (Volume II).* Nigeria: Abuja, Federal Ministry of Works.

Habeeb, A. O.,Olabambe, A. A., Oladipupo, S. O. (2012). Investigation of the Geotechnical Engineering Properties of Laterite as Sub-grade and Base Material for Road Construction in Nigeria. *Civil and Environmental Research*, 2(8), 23 – 31.

Ijimdiya, T.S. (2007). Effect of Oil Contamination on Soil Properties. Book of Abstracts of 5th Nigerian Material Congress (NIMACON), 14 – 17 November, Ile-Ife, Osun State, Nigeria.

Jerez, L. D., Gómez, O. E., & Murillo, C. A. (2018). Stabilization of Colombian Lateritic Soil with a Hydrophobic Compound (Organosilane). *International Journal of Pavement Research and Technology*, *11*(6), 639–646. https://doi.org/10.1016/j.ijprt.2018.06.001

Kamtchueng, B. T., Onana, V. L., Fantong, W. Y., Ueda, A., Ntouala, R. F., Wongolo, M. H., … Ondoa, J. M. (2015). Geotechnical, Chemical and Mineralogical Evaluation of Lateritic Soils in Humid Tropical Area (Mfou, Central-Cameroon): Implications for Road Construction. *International Journal of Geo-Engineering*, *6*(1), 1–21. https://doi.org/10.1186/s40703-014-0001-0.

Kanyi, M. I. (2017). *Soil Stabilization Using Lime: Cement Stabilization of Lateritic Soil using Iron Ore Tailing as Admixture*. Nigeria: Zaria, Ahmadu Bello University, Department of Civil Engineering: Unpublished MSc Dissertation.

Lemougna, P. N., Melo, U. F. C., Kamseu, E., & Tchamba, A. B. (2011). Laterite based Stabilized

ISSN 2488-8648

Products for Sustainable Building Applications in Tropical Countries: Review and Prospects for the case of Cameroon. *Sustainability*, *3*(1), 293–305. https://doi.org/10.3390/su3010293

Nnochiri, E. S. (2018). Effects of Corn Cob Ash on Lime Stabilized Lateritic Soil, *Journal of Civil Engineering*, Special Issue, 66 - 76.

Nnochiri, E. S., and Ogundipe, O. M. (2016). Geotechnical Properties of Lateritic Soil Stabilized with Groundnut Husk Ash, *Civil Engineering Journal*, 2(11), 568 - 575.

Ojuri, O. O., and Ogundipe, O. O. (2012). Modeling used Engine Oil Impact on the Compaction and Strength Characteristics of a Lateritic Soil. *Electronic Journal of Geotechnical Engineering*, 17, 3491–3501.

Okunlola, I. A., Idris-Nda, A., Dindey, A. O. and Kolawole L. L. (2014). Geotechnical and Geochemical Properties of Lateritic Profile on Migmatite Gneiss along Ogbomosho – Ilorin Highway, Southwestern Nigeria, *African Journal of Geographical Science*,1(1), 01 – 06.

Osinubi, K. J., Bafyau, V., & Eberemu, A. O. (2009). Bagasse Ash Stabilization of Lateritic Soil. In E. K. Yanful (Ed.), *Appropriate Technologies for Environmental Protection in the Developing World* (pp. 271–280). Springer,Dordrecht. https://doi.org/10.1007/978-1-4020-9139-1_26

Osinubi, K. J., Oluremi, J. R., Eberemu, A. O., & Ijimdiya, S. T. (2017). Interaction of Landfill Leachate with Compacted Lateritic Soil-waste Wood Ash Mixture. *Waste and Resource Management*, *170*(3+4), 128–138. https://doi.org/10.1680/jwarm.17.00012

Oyelami, C., & Rooy, J. L. Van. (2016). A Review of the Use of Lateritic Soils in the Construction / Development of Sustainable Housing in Africa : A Geological Perspective. *Journal of African Earth Sciences*, *119*, 1–12. https://doi.org/10.1016/j.jafrearsci.2016.03.018.

Ugbe, F.C. (2011). Basic Engineering Geological Properties of Lateritic Soils from Western Niger Delta, *Research Journal of Environmental and Earth Sciences*,3(5), 571-577.