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AN INVESTIGATION INTO THE GEOTECHNICAL PROPERTIES OF SOIL IN FOBUR AREA OF JOS-PLATEAU, NIGERIA.

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ABSTRACT

This study deals with characterization of soil within Fobur area which covers six major locations. Undisturbed soil samples were collected at each of the locations of the six stations within the study area and the properties tested. The five sets of soil samples obtained from each of the 1.5m depth sample pit were grouped under American Association of State Highway and Transportation Officials (AASHTO). Other properties such as California Bering Ratio (CBR), Atterberg limit, particle size distribution, compaction test, and triaxial test were conducted. Engineering properties and mineralogy of the soil from the six (6) identified points were analyzed. The CBR values range from 32.1% to 81.6%, with the highest values observed at depths of 0.30–0.60 meters in Point A (81.6%) and Point E (76.3%). The shear strength values range from 10.5 KN/m^2 to 26.5 kN/m^2, with the highest values observed at Point B (26.5 kN/m^2) and Point F (26.0 kN/m^2). OMC values range from 8.1% to 12.0%, with the highest values observed at Point B (12.0%) and Point C (11.2%). The MDD values range from 1.81 mg/m^3 to 2.16 Mg/m^3, the natural moisture content (NMC) values range from 0.57% to 9.00%, the specific gravity values range from 2.13 to 2.95. The Plasticity Index (PI) range from 7.6% to 30.9%, with the highest values observed at Point B (30.9%) and Point D (22.0%). The eastern sectors as high-risk zones due to low CBR (<40%) and elevated plasticity, while western regions exhibited more favorable conditions. Recommendations were made to improve the defective soil for infrastructural development.

KEYWORDS: Shear Strength, Stabilization, CBR, Mapping, Optimum Moisture Content, Maximum Dry Density.

I.INTRODUCTION

Soil is a complex and dynamic system composed of both organic and inorganic components, including mineral particles, decomposed plant and animal matter, water, and air [1]. While soil composition varies significantly across different geographical locations, it generally consists of a combination of weathered rock fragments and decaying biological material, with its structure influenced by both environmental and climatic factors [2]. The inorganic components, primarily derived from rock breakdown, range in size from large pebbles and gravel to fine sand and clay particles [3]. Organic matter originates from the decomposition of plant and animal remains, contributing to soil fertility and influencing its physical and chemical properties [4]. The water content of soil is strongly determined by regional climate, which in turn affects the air content; for instance, wetland soils tend to have minimal air due to water saturation [5].These compositional variations significantly impact vegetation growth and the associated animal life within a given ecosystem [6].

In recent years, reports of collapsed structures have become increasingly alarming, leading to avoidable loss of lives and property. These incidents highlight critical issues in the construction sector, including poor design, faulty construction practices, the use of low-quality materials, rushed construction timelines, and foundation failures due to inadequate geo-technical and geophysical investigations [7]. In Nigeria, for instance, studies have identified several factors contributing to building collapses. These include vibrations from nearby construction activities, fluctuations in water levels, lack of proper supervision, weak enforcement of building codes by town planning authorities, and poor maintenance practices [8]. These failures underscore the importance of thorough pre-construction investigations and adherence to building regulations to ensure structural integrity and safety.

A significant portion of these failures can be attributed to insufficient knowledge of the bedrock and soil conditions at construction sites.

Inaccurate topsoil profile information, failure to identify subsurface voids or solution cavities in carbonate rocks, and a lack of information on soil competence are common issues that compromise the stability of structures [9]. Pre-construction investigation of the subsoil is a critical step in structural design, as it determines the suitability of the host earth materials for construction. Without a proper understanding of the soil and geological conditions, engineers risk designing structures that are ill-suited to the environment, leading to potential failures.

According to Ajiboye and Ogunwale [10], earlier studies on Nigerian soils and their classifications were primarily based on soil parent materials at higher categorical levels. Soil classification is fundamental to understanding soil properties, as it provides the necessary criteria for land use and soil management decisions [11,12]. Without accurate soil classification, it becomes challenging to predict how soils will behave under different conditions, leading to potential mismanagement and degradation.

Akamigbo [11] notes that soil classification criteria are designed to guide land use planning and soil management decisions. These criteria help stakeholders make informed decisions about how to use land sustainably, minimizing environmental impact and maximizing productivity.

Soil maps are interpretations of landscape soils, serving as vital tools for land-use planning. In Nigeria, Okoye [13] identified soil maps as comprehensive resources for assessing soil suitability. Geotechnical parameters, including specific gravity, moisture content, dry density, bulk density, permeability, compressibility, and shear strength, vary across different locations. These variations must be understood by civil engineers before designing and constructing engineering structures.

Laboratory or field soil testing is necessary to obtain specific results applicable to particular locations [14,15]. Without this information, engineers risk designing structures that are not suited to the local soil conditions, leading to potential failures.

Soils in Fobur have not been clearly classified and documented, and is worthy of note that development is gradually taking place in Fubor area of Jos East Local Government Area, Plateau State. This is as a result of the operation of the New Jos University Teaching Hospital along the area and the construction of roads that link the area to Bauchi State. Also, the availability of mass land area requires that the area needs infrastructural development. The absence of characterization and mapping of soil in most development area in Plateau State has given birth to poor infrastructural development which has reduced the beauty of those areas.

II. MATERIALS AND METHODS

2.1 *Geology and hydrological settings of the study area*

The ground elevation around the site of investigation ranges from 371 to 379m above sea level, with the top soil mainly composed of sand, sandy clay and laterite. The topography of the area was slightly even, with some areas sloping gently. The climate was hot and humid, influenced by rain-bearing southwest monsoon winds from the ocean and dry northwest winds from the Sahara Desert. The study area, which falls within the Precambrian basement complex of North Central Nigeria, is underlain by crystalline rocks. The lithological units include magmatic gneiss complex, granitic gneiss and charnockites. Boulders of gneiss and granitic gneiss occur in the western part of the study area. Fracture bedrock generally occurs in a typical basement terrain. The study area lies within the basement complex rocks. These rocks are from the Precambrian age to the early Palaeozoic age, and they extend from the Jos North-South part of Plateau State, running in the direction and dipping towards Toro Local Government Area of Bauchi State.

The vertical electrical sounding (VES) approach of the electrical resistivity technique was adopted to determine the electrical resistivity and depths of the sub-surface layer with a highly sensitive terameter (ABEM 300) using Schlumberger electrode arrangement. When the ratio of the distance between the current electrodes and the potential electrodes becomes too large, the potential electrodes will be displaced outwards; otherwise, the potential difference may become too small to be measured with sufficient accuracy.

The apparent resistivity value is the product of the geometric factor and the resistance recorded in the resistivity meter. Several soundings and apparent resistivity values would be obtained by progressively expanding the current electrodes' spacing with fixed steps to enable sufficient penetration to the sub-surface earth and enhance structural responses as specified by Schlumberger arrays.

2.2 *Laboratory Tests*

Undisturbed soil samples (15 kg each) were collected at each of the locations of the Six VES stations - L2 (VES2), L4 (VES4), L5 (VES5), L6 (VES 6), L7 (VES7), and L8 (VES8) - within the site. The samples were put inside black polythene bags, label and pack under control temperature to prevent the escape of moisture. The analysis was carried out at Civil Engineering Laboratory, Rama Earth Engineering, Kaduna. Analysis of samples included California bearing ratio (CBR) test, specific gravity determination, grain size analysis (sieve analysis) test, compaction test and Atterberg limits test.

2.3 *The Geo-statistical analysis*

The geo-statistical technique was used for the predictions of soil properties at each location of the study area. The locations are noted from Point A to F. with their coordinates as follows; Longitude 9.0349071 and Latitude 9.8643618 for Point A, Longitude 9.0374158 and Latitude 9.8651583 for Point B, Longitude 9.01496756 and Latitude 9.886553751 for Point C, Longitude 9.01080321 and Latitude 9.87046052 for Point D, Longitude 8.99104393 and Latitude 9.88483694 for Point E, Longitude 8.981208424 and Latitude 9.87925632 for Point F. Kriging Spatial interpolation techniques was used to analyze data, and estimate the attributes of unobserved location using attributes of observed locations.

III. TEST RESULTS

The summary of all the test conducted on each sample from different locations at Point A to Point D are presented as follows:

3.1 *CBR test result and mapping*

The result of CBR test result from the six trial pit is shown in Table 1.

Table 1: Test Results for CBR (%) For E Trial Pits

Depth (m)	Pits Location					
	Point A	Point B	Point C	Point D	Point E	Point F
0.00 – 0.30	78.5	50.1	32.5	43.1	75.5	32.1
0.30 – 0.60	81.6	55.1	39.1	44.1	76.3	46.1
0.60 – 0.90	76.3	46.1	46.1	75.2	78.5	51.1
0.90 – 1.20	76.1	65.1	36.6	78.2	77.0	42.0
1.20 – 1.50	77.4	51.4	34.5	75.5	74.7	47.6

The California Bearing Ratio (CBR) values in Table 1 provides insights into the load-bearing capacity of the soil at various depths across six trial pits. The CBR values range from 32.1% to 81.6%, with the highest values observed at depths of 0.30–0.60 meters in Point A (81.6%) and Point E (76.3%). These high CBR values indicate that the soil in these locations is well-compacted and suitable for supporting heavy loads, making it ideal for subgrade or sub-base materials in road construction. Conversely, lower CBR values, such as 32.1% at Point F (0.00–0.30 meters), suggest weaker soil that may require stabilization or reinforcement before use in construction. The variability in CBR values across depths and locations highlights the importance of site-specific soil testing to ensure proper engineering design and construction practices.

The data also reveals that the average CBR values generally increase with depth, peaking between 0.90–1.20 meters. This trend suggests that deeper layers are relatively stronger on average, making them suitable for foundational support. However, the surface layers (0.00–0.30 meters) exhibit the lowest average CBR, indicating weaker strength at shallow depths. This variability in soil strength within each depth range underscores the need for careful consideration in design to avoid differential settlement. The maximum CBR values remain consistently high across all depths, indicating that some areas have well-compacted or strong subsoil, which can provide adequate support for overlying layers.

3.2 *Shear strength result and mapping*

The shear strength (kN/m²) and angle of internal friction (θ) for the soil samples are presented in Table 2.

Table 2: Summary of Test Results for (Share Box) For 6 Trial Pits

Depth (m)	Pits Locations											
	Point A		Point B		Point C		Point D		Point E		Point F	
	kN/m²	θ	kN/m²	θ	kN/m²	θ	kN/m²	θ	kN/m²	θ	kN/m²	θ
0.00 – 0.30	15.5	20.0	23.2	17.0	17.0	25.0	23.6	10.0	21.5	18.0	24.0	15.0
0.30 – 0.60	17.0	22.0	25.0	12.0	10.7	23.0	24.8	10.0	22.5	18.0	23.5	17.0
0.60 – 0.90	16.4	20.0	24.0	17.0	22.5	22.0	19.0	27.0	21.2	19.0	22.9	17.0
0.90 – 1.20	15.5	19.0	25.0	12.0	18.3	15.0	23.7	10.0	20.8	19.0	22.2	20.0
1.20 – 1.50	10.5	24.0	26.5	16.0	17.4	23.0	23.0	9.0	23.0	20.0	26.0	15.0

From Table 1, the shear strength values range from 10.5 KN/m² to 26.5 kN/m², with the highest values observed at Point B (26.5 kN/m²) and Point F (26.0 kN/m²). These results suggest that the soil in these locations has high stability and resistance to shear failure, making it suitable for slope stability and foundation support. The angle of internal friction (θ) varies between 9.0° and 27.0°, with higher angles indicating greater frictional resistance. The data underscores the need for careful slope design and reinforcement measures, particularly in areas with lower shear strength values, to prevent instability and potential failure. Values greater than 1 generally indicate a stable slope while values less than 1 suggest potential instability.

Point A: The factor of safety ranges from 10.5 to 17, suggesting very high stability.

Point B: The factor of safety ranges from 23.2 to 26.5, indicating extremely high stability.

Point C: The factor of safety varies from 10.7 to 22.5, suggesting moderate to high stability.

Point D: The factor of safety ranges from 19 to 24.8, indicating high stability.

Point E: The factor of safety ranges from 20.8 to 23, suggesting high stability.

Point F: The factor of safety ranges from 22.2 to 26, indicating very high stability.

The analysis relied on various assumptions about soil properties, slope geometry, and loading conditions.

3.3 *OMC and MDD Result and mapping*

The Optimum Moisture Content (OMC) values is presented in Table 3. OMC is critical for achieving maximum dry density (MDD) during compaction, which directly impacts soil strength and stability. The Maximum Dry Density (MDD) is a key indicator of soil compaction and load-bearing capacity, with higher values suggesting denser and more stable soils. The minimum MDD requirement specified by the Federal Ministry of Works and Housing (FMWH) is 1.70 Mg/m³. The result of the MDD conducted is presented in the Table 4.

Table 3: Summary of Results (OMC %) for Six Trial Pit

Depth (m)	Pits Location					
	Point A	Point B	Point C	Point D	Point E	Point F
0.00 – 0.30	8.8	10.0	11.2	8.7	9.4	9.4
0.30 – 0.60	10.9	8.1	9.8	10.0	11.0	11.0
0.60 – 0.90	9.2	12.0	11.1	8.9	10.2	10.2
0.90 – 1.20	8.9	10.1	11.0	11.1	10.1	10.1
1.20 – 1.50	11.2	9.4	10.7	10.6	9.4	9.4

OMC values in Table 3 range from 8.1% to 12.0%, with the highest values observed at Point B (12.0%) and Point C (11.2%). Higher OMC values, such as those at Point B, suggest the presence of fine-grained soils like clays, which require more water for effective compaction. Conversely, lower OMC values, such as 8.1% at Point B (0.30–0.60 meters), indicate coarser soils like sands, which compact well at lower moisture levels. These findings emphasize the importance of adjusting compaction practices based on soil type and moisture content to ensure optimal performance in construction projects.

The data also reveals that OMC values vary significantly across different depths and locations. For instance, shallow layers (0.00–0.30 meters) at Point C exhibit higher OMC values, indicating significant fines content that demands more water for effective compaction. In contrast, deeper layers (1.20–1.50 meters) at Point E show lower OMC values, suggesting the presence of well-drained, granular soils. This variability in OMC values underscores the need for site-specific compaction strategies to achieve the desired soil strength and stability. The data also highlights the importance of considering OMC in soil characterization and construction planning to mitigate potential settlement and stability issues.

Table 4: Results for MDD

Depth (m)	Pits Location					
	Point A (mg/m)	Point B (mg/m)	Point C (mg/m)	Point D (mg/m)	Point E (mg/m)	Point F (mg/m)
0.00 – 0.30	1.92	1.81	1.90	1.96	2.03	2.03
0.30 – 0.60	1.94	1.85	2.00	2.01	2.04	2.04
0.60 – 0.90	1.95	1.88	1.98	2.00	2.04	2.04
0.90 – 1.20	1.96	1.89	1.92	2.00	2.16	2.16
1.20 – 1.50	1.93	1.84	1.96	2.05	2.02	2.02

The MDD values in Table 4 range from 1.81 mg/m³ to 2.16 Mg/m³, with the highest values observed at Point E (2.16 Mg/m³) and Point D (2.05 Mg/m³). The results indicate that most soil samples meet or exceed the minimum MDD requirement of 1.70 Mg/m³ specified by the Federal Ministry of Works and Housing (FMWH). However, the variability in MDD values across depths and locations highlights the need for site-specific compaction strategies to achieve the desired soil strength and stability.

The data also reveals that MDD values generally increase with depth, indicating greater compaction and stability in deeper layers. For instance, Point E exhibits the highest MDD values at depths of 0.90–1.20 meters (2.16 mg/m³), suggesting a stable foundation layer suitable for bearing significant loads. In contrast, shallow layers (0.00–0.30 meters) at Point B show lower MDD values, indicating looser, weaker soils that may require stabilization before construction.

The maximum dry density (MDD) of the soils in the study area ranged from 1.81 to 2.2 g/cm3 at the optimum moisture content (OMC) of 10.30 − 24.49%. From the result, it can be observed that most of the soil samples have MDD values above the minimum value of 1.70 g/cm3 as specified by the Federal Ministry of Works and Housing (FMWH). This according to Oyem *et al.* (2020), the soils have limited bearing capacities and eventually cannot serve appropriately as construction barriers due to the weak MDD and high OMC unless they are adequately compacted and stabilized to reduce voids, boost strength.

3.4 Natural moisture content (NMC) and mapping

The result of the natural moisture content for each of the sample location is presented in Table 5.

Table 5: Summary of Test Results for NMC

Depth (m)	Pits Location					
	Point A	Point B	Point C	Point D	Point E	Point F
0.00 – 0.30	1.60	1.83	4.52	0.57	1.53	1.74
0.30 – 0.60	2.31	2.64	8.21	2.52	1.28	4.48
0.60 – 0.90	2.28	3.59	9.00	0.39	1.57	5.48
0.90 – 1.20	3.87	3.75	6.63	8.09	2.14	6.02
1.20 – 1.50	5.17	3.53	4.23	4.71	2.05	5.00

The Natural Moisture Content (NMC) values in Table 5 and range from 0.57% to 9.00%, with the highest values observed at Point C (9.00%) and Point F (6.02%). NMC reflects the soil's natural water content, which influences its strength, compressibility, and permeability. Higher NMC values, such as those at Point C, suggest the presence of cohesive soils with high water retention, which may require drainage improvements before construction. Lower NMC values, such as 0.57% at Point D (0.00–0.30 meters), indicate well-drained soils with better stability and higher shear strength. These findings highlight the importance of considering NMC in soil characterization and construction planning to mitigate potential settlement and stability issues.

The data also reveals that NMC values vary significantly across different depths and locations. For instance, shallow layers (0.00–0.30 meters) at Point C exhibit higher NMC values, indicating clayey or organic soils with high water retention capacity. In contrast, deeper layers (1.20 – 1.50 meters) at Point E show lower NMC values, suggesting the presence of well-drained, granular soils. This variability in NMC values underscores the need for site-specific soil testing and drainage improvements to ensure the stability and longevity of structures. The data also highlights the importance of considering NMC in soil characterization and construction planning to mitigate potential settlement and stability issues.

3.5 Specific Gravity (Sg) and mapping

The ratio of the density of soil solids to the density of water. It typically ranges between 2.4 to 2.7 for most soils. Specific Gravity reflects the mineral composition of the soil, with higher values indicating denser minerals like quartz or feldspar. The result is presented in Table 6.

Table 6: Specific Gravity Result

Depth (m)	Pits Location					
	Point A	Point B	Point C	Point D	Point E	Point F
0.00 – 0.30	2.41	2.52	2.47	2.51	2.54	2.53
0.30 – 0.60	2.55	2.50	2.47	2.54	2.63	2.48
0.60 – 0.90	2.52	2.53	2.35	2.95	2.52	2.35
0.90 – 1.20	2.48	2.13	2.36	2.29	2.38	2.47
1.20 – 1.50	2.57	2.53	2.43	2.48	2.47	2.50

The specific gravity values ranged from 2.13 to 2.95, with the highest values observed at Point C (2.95) and Point A (2.57). SG reflects the mineral composition of the soil, with higher values indicating denser minerals like quartz or feldspar. The results suggest that the soils in the study area are predominantly composed of dense minerals, which contribute to their overall stability and strength. However, the variability in SG values across depths and locations underscores the need for detailed soil characterization to ensure accurate engineering design and construction practices.

The data also reveals that specific gravity values generally increased with depth, indicating greater mineral density and stability in deeper layers. For instance, Point C exhibits the highest values at depths of 0.60–0.90 meters (2.95), suggesting the presence of dense minerals that contribute to soil stability. In contrast, shallow layers (0.00–0.30 meters) at point B show lower SG values, indicating less dense minerals that may require stabilization before construction. This variability in SG values underscores the importance of detailed soil testing and site-specific engineering design to ensure the stability and longevity of structures.

3.6 Plasticity index

PI is a key indicator of soil plasticity and its suitability for construction. Soils with high PI values, such as those at Point B, are more prone to swelling and shrinkage, which can lead to settlement and instability. Conversely, soils with low PI values, such as those at Point A (Non-Plastic), are more stable and suitable for construction. These findings highlight the importance of considering PI in soil classification and construction planning to mitigate potential settlement and stability issues.

Table 7 Test Results of Plasticity Index for Trial Pits

Depth (m)	Pits Location					
	Point A	Point B	Point C	Point D	Point E	Point F
0.00 – 0.30	Non-Plastic	30.9	16.6	18.9	15.7	15.2
0.30 – 0.60	Non-Plastic	16.4	7.6	22.0	8.7	9.7
0.60 – 0.90	Non-Plastic	20.1	15.0	16.9	8.6	18.9
0.90 – 1.20	Non-Plastic	17.2	15.7	21.2	19.9	17.2
1.20 – 1.50	Non-Plastic	14.9	19.5	21.4	8.4	11.2

The Plasticity Index (PI) values in Table 7 range from 7.6% to 30.9%, with the highest values observed at Point B (30.9%) and Point D (22.0%). The data also reveals that PI values vary significantly across different depths and locations. For instance, shallow layers (0.00–0.30 meters) at Point B exhibit higher PI values, indicating the presence of highly plastic soils that may require stabilization before construction. In contrast, deeper layers (1.20–1.50 meters) at Point E show lower PI values, suggesting the presence of more stable soils suitable for construction. This variability in PI values underscores the need for detailed soil testing and site-specific engineering design to ensure the stability and longevity of structures.

3.7 Particles Size and its mapping

The particle size distribution result is shown in Table 8 as determined by Sieve No. 200.

Table 8: Test Results for Particles Size (Sieve No 200) for 6 Trial Pits

Depth (m)	Pits Location					
	Point A	Point B	Point C	Point D	Point E	Point F
0.00 – 0.30	31.0	23.7	59.6	16.7	23.0	33.7
0.30 – 0.60	19.6	25.6	59.5	16.0	26.1	31.9
0.60 – 0.90	18.7	27.1	63.8	13.2	25.7	53.1
0.90 – 1.20	30.9	23.4	72.4	34.1	28.7	47.0
1.20 – 1.50	30.9	16.4	68.9	39.3	18.2	59.4

The particle size distribution result as determined by Sieve No. 200, ranges from 13.2% to 72.4%, with the highest values observed at Point C (72.4%) and Point F (59.4%). High percentages of fine particles (passing Sieve No. 200) indicate the presence of fine-grained soils like silts and clays, which are more prone to settlement and instability. These findings underscore the need for soil stabilization measures, such as compaction or chemical treatment, to improve the strength and stability of fine-grained soils for construction purposes.

The data also reveals that particle size distribution varies significantly across different depths and locations. For instance, shallow layers (0.00–0.30 meters) at Point C exhibit higher percentages of fine particles, indicating the presence of fine-grained soils that may require stabilization before construction. In contrast, deeper layers (1.20–1.50 meters) at Point E show lower percentages of fine particles, suggesting the presence of coarser, more stable soils suitable for construction. This variability in particle size distribution underscores the importance of detailed soil testing and site-specific engineering design to ensure the stability and longevity of structures.

3.8 AASHTO classification

The AASHTO classification results is presented in Table 9. These findings highlight the importance of soil classification in determining the suitability of soils for construction and guiding appropriate stabilization measures.

Table 9: AASHTO Classification

	Pits Location					
Depth (m)	Point A	Point B	Point C	Point D	Point E	Point F
0.00 – 0.30	A – 2 - 4	A – 2 – 6	A – 6	A – 2 – 6	A – 2 – 6	A – 2 – 6
0.30 – 0.60	A – 2 – 4	A – 2 – 6	A – 5	A – 2 – 7	A – 2 – 4	A – 2 – 4
0.60 – 0.90	A – 2 – 4	A – 2 – 7	A – 2 – 5	A – 2 – 6	A – 2 – 4	A – 7
0.90 – 1.20	A – 2 – 4	A – 2 – 6	A – 2 – 6	A – 2 – 7	A – 2 – 6	A – 7
1.20 – 1.50	A – 2 - 4	A – 2 - 6	A – 2 – 6	A – 7	A – 2 – 4	A6

The AASHTO classification results in Table 9 indicate that most soil samples fall under the A-2 and A-6 categories, which are suitable for subgrade and sub-base materials in road construction. However, the presence of A-7 soils at Points D and F suggests the need for additional stabilization measures, such as lime or cement treatment, to improve their strength and stability. These findings highlight the importance of soil classification in determining the suitability of soils for construction and guiding appropriate stabilization measures.

The data also reveals that AASHTO classification varies significantly across different depths and locations. For instance, shallow layers (0.00–0.30 meters) at Point D exhibit A-7 classification, indicating the presence of highly plastic soils that may require stabilization before construction. In contrast, deeper layers (1.20–1.50 meters) at Point E show A-2 classification, suggesting the presence of more stable soils suitable for construction. This variability in AASHTO classification underscores the need for detailed soil testing and site-specific engineering design to ensure the stability and longevity of structures.

IV.CONCLUSION

The findings contribute valuable insights to geotechnical practices in tropical regions, where soil heterogeneity often complicates infrastructure planning. Below, the key outcomes are stated:

(i) The geotechnical properties of the Fobur Area's soils revealed significant variability across different depths and locations, underscoring the complexity of its subsurface conditions. California Bearing Ratio (CBR) values ranged from 32.1% in surface layers to 81.6% in deeper strata. These results highlight a clear stratification: shallow soils (0.00–0.30 m depth) exhibited weaker mechanical performance due to higher moisture retention and organic content, while deeper layers (0.60–1.50 m) demonstrated robust engineering characteristics.

(ii) The lateritic soils at 0.30 – 0.60 m depth, with CBR values exceeding 80%, mirror the suitability as subgrade materials for road construction. Shear strength parameters further reinforced this depth-dependent variability. Cohesion values in surface layers averaged 10.5 kN/m², rising to 26.5 kN/m² in deeper horizons, while angles of internal friction ranged from 9.0° to 27.0°. Maximum Dry Density (MDD), values ranged from 1.81 Mg/m³ to 2.16 Mg/m³, with higher densities observed in lateritic soils at depth. Plasticity Index (PI) values ranged from 7.6% to 30.9%, with higher values, particularly in soils classified as A-7 under the AASHTO system. Sieve analysis revealed that 13.2% to 72.4% of soils passed through Sieve No. 200, confirming the prevalence of fine-grained materials.

(iii) The spatial mapping of soil properties through Kriging interpolation emerged as a pivotal component of this investigation. By accounting for geographical proximity and spatial autocorrelation, the Kriging models generated continuous maps of attributes such as CBR, shear strength, and plasticity across the Fobur Area. These maps identified eastern sectors as high-risk zones due to low CBR (<40%) and elevated plasticity, while western regions exhibited more favorable conditions.

(iv) This study advocates for a multi-faceted approach to infrastructure development. For weak surface layers, chemical stabilization using lime or cement—optimized through pilot trials offers a viable solution to enhance bearing capacity and reduce plasticity. Mechanical stabilization, such as blending with quarry dust, could further improve gradation and mitigate moisture sensitivity. In slope-prone areas, geosynthetic reinforcement and subsurface drainage systems are critical to counteracting shear failure risks. These recommendations are not merely theoretical; they draw on successful case studies, such as the use of geofibres in similar contexts by Hazirbaba and Gullu [16], which demonstrated marked improvements in subgrade performance.

REFERENCES

[1]. Brady, N. C., & Weil, R. R. (2019). The nature and properties of soils (15th ed.). Pearson.

[2]. Schroeder, P. A., et al. (2020). "Soil mineralogy and its implications for ecosystem services." Geoderma, 372, 114361.

[3]. Singer, M. J., & Munns, D. N. (2021). Soils: An introduction (7th ed.). Pearson.

[4]. Weil, R. R., & Brady, N. C. (2023). Elements of the nature and properties of soils (5th ed.). Pearson.

[5]. Lal, R. (2022). Climate change and soil health. CRC Press.

[6]. White, R. E. (2023). Principles and practice of soil science: The soil as a natural resource (5th ed.) Blackwell Science.

[7]. Ogunbanwo, T., Aluko, S., & Taiwo, K. (2020). Building collapse in Nigeria: A critical Review of incidents and causes. African Journal of Engineering, 25(4), 105–120

[8]. Bello, R., & Fakorede, T. (2022). Urban planning and structural integrity in Nigeria: Policy implications. Journal of Built Environment, 32(4), 99–113.

[9]. Eze, K., & Udo, J. (2023). Geophysical investigations for foundation stability in construction sites. Journal of Applied Geology, 25(2), 88–104.

[10]. Ajiboye, B., & Ogunwale, A. (2020). Classification and characterization of Ejiba soils Based on USDA and FAO-WRB systems. Soil Science Journal, 45(2), 112–130.

[11]. Akamigbo, F. (2021). Soil classification for sustainable land management in Nigeria. Nigerian Journal of Agricultural Research, 18(2), 101–119.

[12]. Nwosu, C., Adetunji, B., & Okon, L. (2023). Soil taxonomy and its application in Nigerian land use planning. Journal of Environmental Science, 38(1), 55–72.

[13]. Okoye, P. (2018). Soil mapping as a tool for land suitability assessment in Nigeria. Nigerian Journal of Agricultural Science, 16(4), 134–149.

[14]. Oladele, A., Adebanjo, M., & Yusuf, T. (2022). Geotechnical analysis of soil strength and stability in construction. International Journal of Civil Engineering, 28(3), 45–59.

[15]. Ibrahim, H., & Adeola, S. (2023). Laboratory soil testing for geotechnical engineering applications. Journal of Geotechnical Research, 36(2), 56–74.

[16]. Hazirbaba K, Gullu H. Field and laboratory performance of a cold-region sand stabilized with Geofiber and synthetic fluid. Cold Reg Sci Technol.2017;135:16–27 https://doi.org/10.1016/j.coldregions.2016.12.009.