Geotechnical Assessment of the Effect of Road Flooding Durability Depth on Subgrade in Ibeno, South-South Nigeria

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***Abstract*: Globally, flash-flood catastrophe is not a neoteric occurrence as the disastrous proneness breathes periodically enormous, especially in the area of study Ibeno that flood is periodically attributed to coastal flooding. Foundationally, the delineation of road structures is based on the strength of consolidated soil avowed as the subgrade. Subsequently, the subgrade is the in situ material upon which the roadway structure is placed. It is necessary to know the modes of damage to roads caused by flooding before embarking on it rehabilitation. This study assesses the effect of road flooding durability depths on the subgrade stability of soil samples actualized on the Kwa Ibo Upenekang road in Ibeno that was extremely faulty by flash-flood. Wet and dry soil samplings were assessed for California Bearing ratio (CBR), Particle size distributions, Atterberg limit, Group index, and resilient modulus. Resilient Modulus was evaluated for stress to strain relationship for the subgrade. CBR tests for upgrading of plunge, flood limit, durability, and firmness of its fittingness. Atterberg limit determination along with particle size distributions tests set on the bearing of soil as subgrade weighty. For durable flooding, the depth and dimensions of flooded subgrade strength show a lower value. In addition, particle and Atterberg limit resolutions show a fast and soaring existence of deputation for the lengthened durability.**

***Keywords*: Durability, Soil Strength, Atterberg limit, Flooding, Resilient Modulus**

INTRODUCTION

Soil grading influences many properties such as soil stability, density, compatibility, voids content, and permeability. The most hazardous component is soil degradation which lowered the elevation of the soil elevation by creating problems such as flooding, damage to the road, bridges, and so on [9]. Hence, a better understanding of flood impacts can aid in more informed decision-making. However, much research has been dedicated throughout the ages to flood impact assessment. Although flood impacts have been geared for decades, there is a lot of room for innovation [2]. Floods' impacts on road transportation are still not explored in Ibeno and its coastal environment, where flooding impartations are a periodic phenomenon, leaving a massive mark on public and indigenous prudence as shown in Fig. 2. This leads to persistent flooding in the research area and no required depths of road submergence on soil subgrade to describe the involved processes. In facing this perforation, the current research aspires to develop novel approaches to assessing the effect of flooding depths and durability on the soil sub-grade. Flood consequence types were first classified by Penning-Rowell into both uninterrupted and incidental, and, conversely, a combination of both. Uninterrupted destruction significantly increases the display of structure, humans, and domain to deluge reservoirs. Incidental destructions are sheath deluge regions and usually take a long time to become distinguishable [3]. Transportation disturbances as a consequence of flooding are considered incidental impacts because they evaluate the knock-on effect of flood continuously throughout the whole transportation system. Its consequences are impalpable: dally, exasperation, and degeneration owing to carbonic acid gas discharge, but it can also have a monetary dimension [7]. However, exploring an area of science that has not been previously studied is always tempting and challenging. Assessing deluge collisions along roadway carriageways is not an abstract topic of research, and it can affect many road users and motorists on the way to their destinations. Transportation difficulties are everyday experiences for many, and it is not hard to imagine that a flood with a large geographical scope may lead to devastating consequences for transport [6]. Even though this problem is recognized, it is surprising how little we know about it. Flooding is often a result of a complex combination of various causes (coastal, fluvial, and pluvial). Further, transportation systems are susceptible to external disturbances which disrupt many aspects: traffic delays, additional traveled distance, additional greenhouse gas emissions, and frustration. Perpetual flooding of roadways has yielded destruction to the highway foundation. Hence, this destruction distresses the strength and durability of tarry materials on road thicknesses [1]. Recently, Akwa Ibom State Management has allocated bulk money for the overhaul of the embankment of Ibeno roadways that was damaged by flooding as shown in Fig. 4. Moreover, whenever roadways are overloaded for durable period, their bearing strength layer, together with the roadway surface flatter soaked with groundwater void, starts to decrease and its soil subgrade starts to soften with decrease in its load-bearing efficiency.

SUBGRADE

Subgrades are unmoved by matters operating at a certain road construction set up. Within the shipment stage, subsoil acts as the original substance beneath structures [4]. Despite shear failure or severe distortion, the subgrade must have sufficient strength and stiffness to support the road construction and related traffic load. The shear strength of the soil is not typically expected to be a major component in road thickness design due to the nature of pressures produced on-road roadways and their comparatively modest magnitude. The main foundation factors that must be considered are the subgrade's elastic qualities. Nevertheless, because they are highly difficult features to quantify, and given the heterogeneity of soils over short distances, using them directly to evaluate subgrade properties may not be economically practical. In addition, it refers to finding strength that is made up based on the original topsoil, especially antiquated compressed to stability as shown in Fig 3. The subgrade is mainly subject to load-bearing capacity, moisture content, and distortion in the company of concrete roadbed constraint, auxiliary settlement, thickness, and stability with rigidity in subsoil [8]. The attributes of subgrade soil are stability, incompressibility, longevity, void, capability, and adroitness to compression. Its edge sustains effective bearing capacity within its foundation. However, topsoil holding high-rise wetness ensues loosely [5]. Simple test techniques that are linked to structural qualities through experimentation are required whether roads are to be developed empirically based on historical performance and experience records or fundamentally by utilizing the elastic theory analysis, Atterberg limit, compaction, and California Bearing Ratio (CBR) tests are some common basic soil identification and classification tests routinely performed on subgrade soils, as well as some empirical tests specifically developed for subgrade evaluation for road design purposes specified by the Nigerian Federal Ministry of Work Highway specification (FMWHS). The soil sample's coefficient of elasticity can also be determined using the Resilient Modulus (Mr) analysis

GEOLOGICAL SETTING

The site attributed to the research study is Ibeno, South-South Nigeria. It lies allying latitudes 4°52'N and latitudes 4°56'N and longitudes 7°81 'E and 8°07'E, 16 m elevation above the coastal level with about 1200 km^2 covering an area as illustrated using and ArcGIS software program in Fig.1. It has the watercourse flowing through the area, bounded by Estern Obolo, Onna, Esit–Eket and Eket and Altantic Ocean. Geographically, the actual ease of the region breathes primarily smooth in the company of swampy inlet scrub throughout its edge above the rivulet. It gravitates in an equatorial bed in which other fallow flora greenish verdure undergrowth along with Elaeis Guineensis shrub zone. The region possesses duo timeliness: rainy and dried. The rainy timeliness amounts to warm and clouded while dried timeliness amounts to hot and mostly overclouded as well as brutal age globular. The region experiences extreme periodic variance within regular precipitation. The month with the most rain is August, with an average rainfall of 358.14 mm. The month with the least rain is January, with an average rainfall of 17.78 mm. The resources of the region are: natural and forest resources. A natural resource is the abundant deposit of crude oil and clay, and the oil mining activities of local and multinational oil companies contribute immensely to the economic development of the area. It is the hub of Mobil Producing Nigeria operations with more than 250 companies providing support services such as catering, flights, and exports. Forest resources include timber, and palm products to boot nourishment management. Traditionally, Ibeno people are fishermen, hunters, farmers, and weavers. Geologically, the parent rock materials within the area are mainly sedimentary rocks which have resulted in the prevalence of sandy, clayey-silt soils.

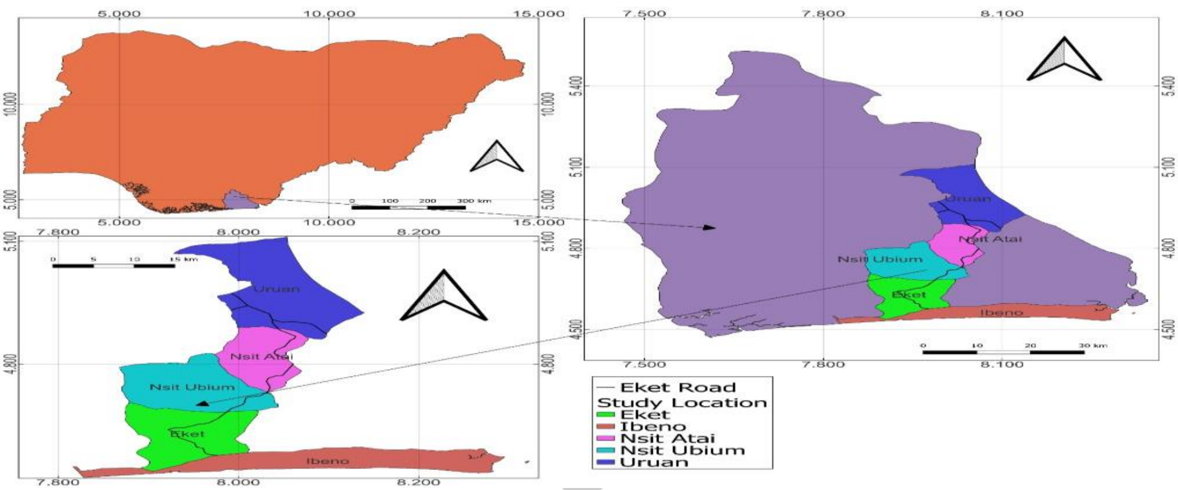

Figure 1: Map of Ibeno, showing Kwa Ibo Upenekang road and its terrain

Figure 2: Recent Flooding on Kwa Ibo Upenekang road

Figure.3. Flooding effects on topsoil foundation in Ibeno

Figure. 4: Kwa Ibo Upenekang road construction damaged by flooding

MATERIALS AND METHODS

MATERIALS

Fields assessments along with laboratory analysis prevail adopted in this research. The field tools used were hand Auger, auger stems, shovel, hand gloves, sample bags, measuring tape and first aid kits. The laboratory tools were: non-corrodible container, drying oven container handling apparatus, standard sieves, sample splitter, mechanical sieve shaker, and pans, cylindrical compaction mold equipped proctor rammer, steel straightedge, metallic tray, and a scoop, liquid limit machine and casagrande grooving tool, plastic limit test apparatus, is sieves, penetration plunger, and loading machine spatula and weighing balance.

METHODS

The British Standard Code for Site Investigation was adopted to acquire the soil samples, with the depth ranging from (1- 3) m was drilled, and samples was collected at 1 m intervals, stamped and stored in sample bags with in-situ interpretation of soil tincture, texture and moisture to the laboratory for further analysis. Sample locations, depths, GPS coordinates and elevations were measured as shown in Table 1.

The samples before the subsoil lay hold of pair contrasting burrows that give the soil to some - extent commonly employed being ridge topsoil during roadway projects. The soil selected breathes graded as saturated and unsaturated matter by Nigeria FMWHS. The characteristics of the soil are laid out in Tables 1 – 4.

Sample Preparation

Primarily, natural moisture content investigation was carried out to differentiate between the wet and dry weights soil. This was accompanied by subsequent tests such as: mechanical analysis to determine the percentage distribution of sand, silt, and clay in immersed and drained samples. Compaction test for soil density and extracting air enhance the stability and rigidity of subsoil. Atterberg limit test to evaluate the plastic, liquid state, and plastic indexes, and CBR test to evaluate the subsoil stability, depth, and overburden capacity of roadway concrete. Ultimately, calculate the resilient modulus (Mr) to determine the elastic modulus for the soil subgrade.

Particle Size Analysis.

Mechanical analysis otherwise called particle size distribution calculates the proportions of extents accompanied with sand, silt, and clay revealed being the hundredth overall dried mass. The apparatus set up were: Drying oven maintained at 110 ± 5°C, Standard sieves, Sample splitter, Mechanical sieve shaker, and Pans. The procedure consists of the following: Drying the soil sample in an oven for 24 hours to get rid of moisture, measuring 500 g of the dry sample, and soaking in water for 24 hours. Proceedings the mass of the stain container, and compute the soil mass preserved on an individual besides deducting the mass of an unfilled griddle following the analysis. However, aggregate mass sampling preserves were added on comparatively with a primary mass of the soil sampling. The portion of the sample preserved on individual stains was split up primarily and calculates the entire portion flowing along with its cumulative percentage reserved and the ones above it from the totality. On the other hand, the grain size allocation reflects how the medium-fine sand was plotted to calculate its deviation measure (Cu) expresses the variety in particle sizes of soil ratio of D60 to D10 as shown in Eqn.1.

$$C_u = \frac{D_{60}}{D_{10}} \quad 1$$

Conversely C_u is exceeding four, the soil is grouped being competent grading; whereas a C_u values underneath four, the soil is grouped simultaneously imperfectly graded and uniformly graded respectively

Compaction Test

This is a conventional compression process that uses a set amount of compactive effort to obtain a soil density that can be compared to site density readings. On building sites, this is the most prevalent form of quality control. The initial test consisted of compacting the earth in three about equal layers in a calibre framework with a 2.5kg hammer dropping from 305mm above the high point. Greater densities were now possible on the ground, thanks to the introduction of heavier compaction machinery. A modified version of the analytical breathe was developed to allow for increased compaction effort in five about equal layers utilising a 4.5kg hammer dropping through a 457mm height (modified or heavy compaction test). The soil sample is air-dried, sieved (typically with a 4.75-mm (No. 4) or 19-mm sieve), thoroughly mixed with water, and then compacted in layers. A concretion of compacted test breathes (W) is computed, along with a small sample obtained to determine the moisture content (w). After then, more water is applied to the soil, and the process is continued until the dry density achieved lowers. Finally, as illustrated in Eqn.2, the dry unit weight (d) was computed.

$$\gamma_d = \frac{W - W_m}{(1 + w) \times V} \quad 2$$

Where: W = the weight of the mold and the soil mass (kg), W_m = the weight of the mold (kg)
w = the water content of the soil (%) and V = the volume of the mold (m^3)

The procedure was repeated four 4 times, for a given selected water content from lower to higher than the optimum. Hence, the calculated dry unit weights were plotted against their corresponding water contents to determine OMC and MDD along the Zero Air Voids at a 100% saturation line. On the other hand, the Zero-Voids curve is calculated as shown in Eqn. 3

$$\gamma_d = \frac{G_S \times \gamma_W}{1 + w \times G_S} \quad 3$$

Where: G_S = the specific gravity of soil particles, γ_W = the saturated unit weight of the soil (kN/m^3) w = the water content of the soil

Atterberg Limit

The Atterberg limits specify the moisture content of the soil as it transitions from one condition to the next. The liquid limit (LL), the plastic limit (PL), and the shrinkage limit are some of them (SL). They are determined by tests performed at the 75m (No. 200) sieve using fine topsoil fragments. The liquid limit may be defined as the bottom reservoir cheery as regards topsoil determination drift undergoing a standard shearing force. Plastic limits estimate the firmness of wet at ease. The plasticity index (PI) is algebraic contrast linking fluid and plastic limits. Thus, it indicates the range of moisture content over which the soil remains deformable. Liquid index (LI) treats the throwback attributes regards the natural soil and is calculated as shown in Eqn. 4

$$LI \quad \frac{W_n - PL}{PI} \quad 4$$

The procedure involved: 150 g air-dry soil samples passing sieve No.40 were used. The Moisture was adjusted by adding 20% of water to sampling and mixing thoroughly. The samples were allowed to condition for at least 16 hours. For a LL Test, a little proportion sampling was spread in the brass LL apparatus case grinder. A groove was cut to at least a 2 mm base with a grooving tool, turns the device and notes the number of blows (N), and stops when the channel inside the soil closes. Finally, a sample and oven-dry were taken to determine its moisture content. The tests were repeated three times and plotted the moisture content against the number of blows to determine LL, PL, and SL respectively

California Bearing Ratio (CBR)

The California Division of Highways developed the CBR test in the 1930s as part of a study of pavement failures. It was created with the goal of determining the relative stability of fine crushed rock foundation materials. The test is currently extensively used across the world for evaluating the stability, sub-gradient, and other flexible paving materials for road design. Soil, density, and moisture content all play a role in sub-gradient soil stability. As a result, it is clear that the density-moisture content-strength connection unique to the subgrade soils encountered along the project road must be determined. As a result, the CBR design of the subgrade soil should be assessed at the wet at ease density, which is typical of the subgrade state during construction. Procedure: Soil samples were measured at about 6kg, added water to the sample, and mixed thoroughly. Using a 2.5 kg rammer, Weight of empty mold, compact the mixed sample into three (3) layers with 61 blows per layer. After compaction, the collar was removed, and taken a sample to determine moisture content. Record the weight of mold plus compressed sample respectively. Mold was placed on the drenching panzer quadruplet for soaked and ignored for unsoaked. The process was repeated for another set of samples after quadruplet, measuring as regards inflate finding the percentage swell, after, the mold was removed via panzer and allowed fluid drainage. Then the soil sample was placed under the penetration piston and placed a surcharge load of 2.5 kg, applied the load, and noted the penetration load values were. Finally, the graph of piston load against penetration was plotted to determine the California bearing ratio desirability, along with Dry Density to obtain its concretion strength.

Resilient Modulus (M_R.)

The resilient modulus (MR.) is an expandable module derived from a repeated load test that mimics actual pavement loading. The percentage applied to recurrent deviator strain to an unlikely axial strain is determined. The most representative test for soils and aggregates under highway loading conditions has just been recognised as MR. Because repeated moving wheel loads cause stress in pavements, this test replicates the soil under a succession of load applications. Consequently, the sample preparation, conditioning, and testing are conducted to simulate field conditions as prescribed by AASHTO T-274 standard method. Consequently, the stress to strain relationship for the subgrade breathes a vital factor contributing to surface deflection. Also, a subgrade elastic coefficient is considered a crucial factor in flexible pavement performance. There are two major types of load to induce flexible pavement failure: fatigue cracking and rutting. The concrete strain decreases as the elastic coefficient of the subgrade increases. Strains decrease as the load applications are before cracking for the concrete surfacing. The test is creditable to the perfect category unbounded related to road data varying along with coherent compatibility via the sustained medium. However, asphalt institute recommendations tests correlation of CBR with the resilient modulus is shown in Eqn. 5.

$$M_R = 10.35 \text{ x CBR Value} \quad (5)$$

Table 1. Sample locations with their Coordinates

Locations	Sample ID	Depth(m)	Latitude (^{0})	Longitude(^{0})	Elevations (m)
1	Ibeno 1	1-3	4.565	8.0725	16.0
2	Ibeno 2	1- 3	4.5258	7.8140	13.00
3	Ibeno 3	1 -3	4.8541	8.2949	12.00
4	Ibeno 4	1 -3	4.8801	7.76728	34.00
5	Ibeno 5	1-3	4.5650	8.0725	16.00
6	Ibeno 6	1-3	4.5258	7.8140	13.00
7	Ibeno 7	1-3	4.5293	7.6728	27.00
8	Ibeno 8	1-3	4.5339	7.7669	12.00
9	Ibeno 9	1-3	4.7756	8.1907	15.00
10	Ibeno 10	1-3	4.5541	7.8791	18.00

Table 2: The summary of the Mechanical, Atterbery Limit and Natural Moisture Content characteristics

Soil	Mechanical analysis (% passing sieve 200)	Atterbery limit (%)			NMC (%)
		LL	PL	PI	
Soil 1: Sand +clayey gravel	24.2	33	18	15	9.93
Soil 2: Silty + Clayey gravel	39.3	48	34	14	17.40

Table 3: The summary of the Compaction, California Bearing Ratio and Resilient Modulus characteristics

Soils	Compaction		(CBR) (%)				M_R (Mpa)	G1 (%)
	MDD (%)	OMC (g/cm^3)		Unsoaked69	Soaked			
Soil 1: Sand +clayey gravel	13.6	1.5	1 2 3	.3	52.4 49.3 45.0		542.34 510.26 465.75	11.8
Soil 2 Silty +Clayey gravel	8.4	1.96	1 2 3	51.2	26.7 23.1 12.4		276.35 239.09 128.34	5.4

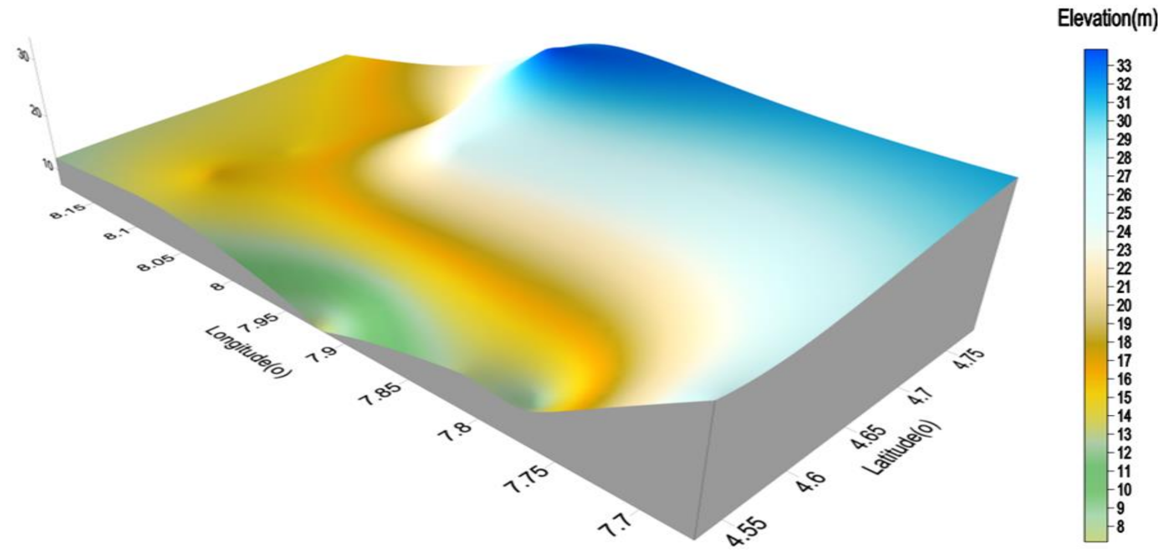

Figure5. 3D Topography Outline showing the study locations

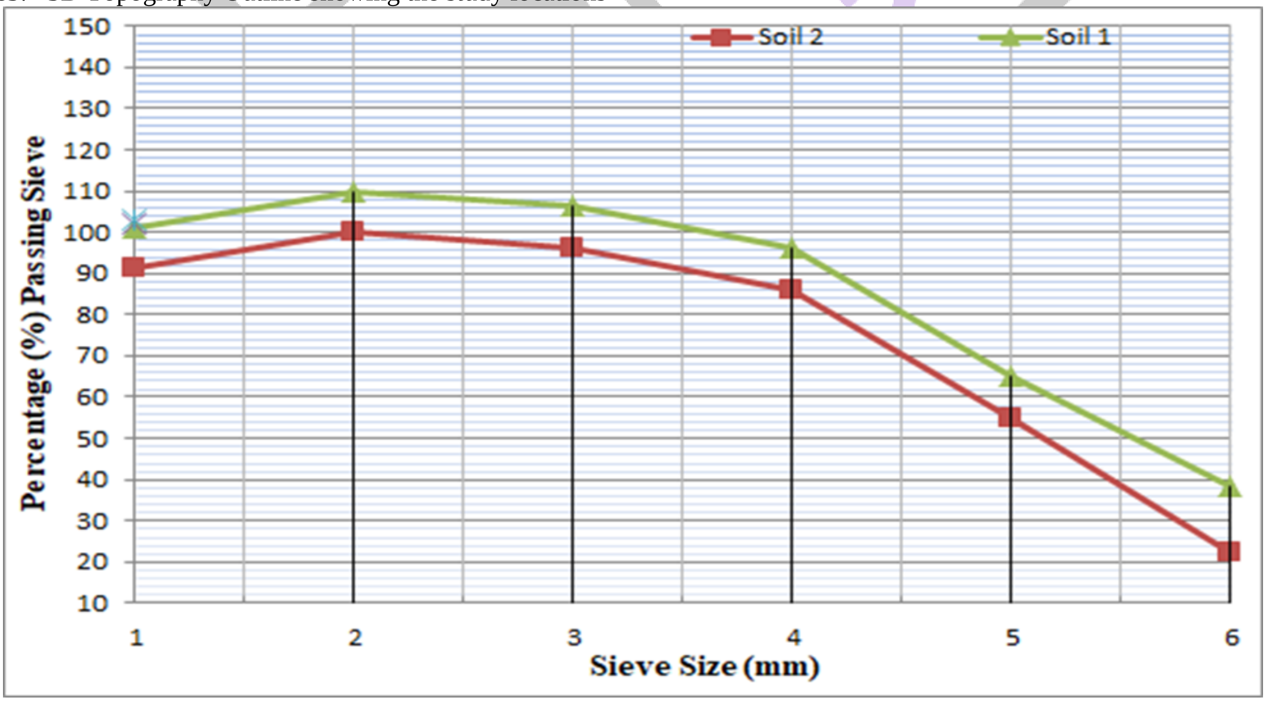

Figure 6: A graph of Percentage (%) passing sieve against sieve size (mm)

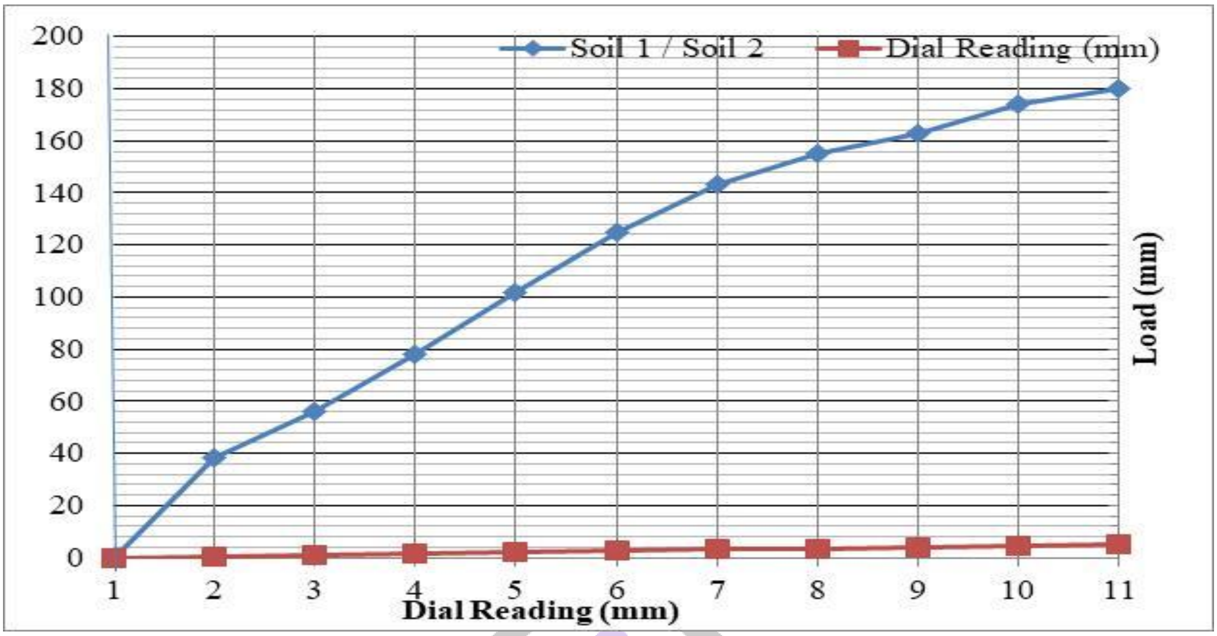

Figure 7: A graph of load (mm) against penetration (mm)

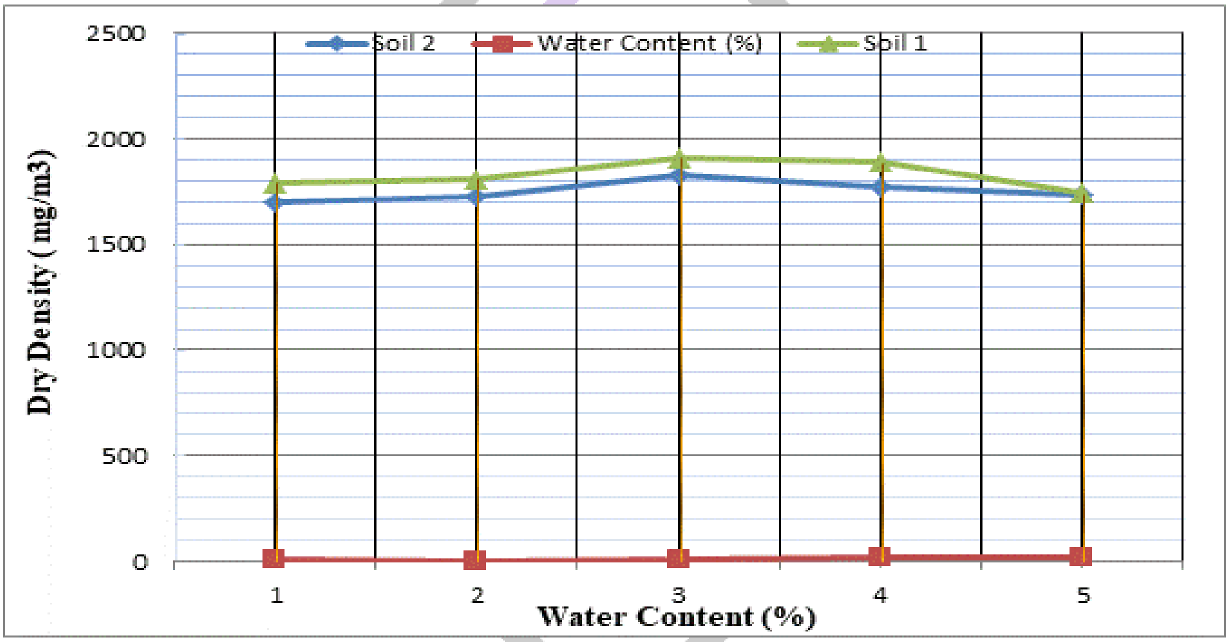

Figure 8: A graph of dry density (mg/m^3) against water content (%)

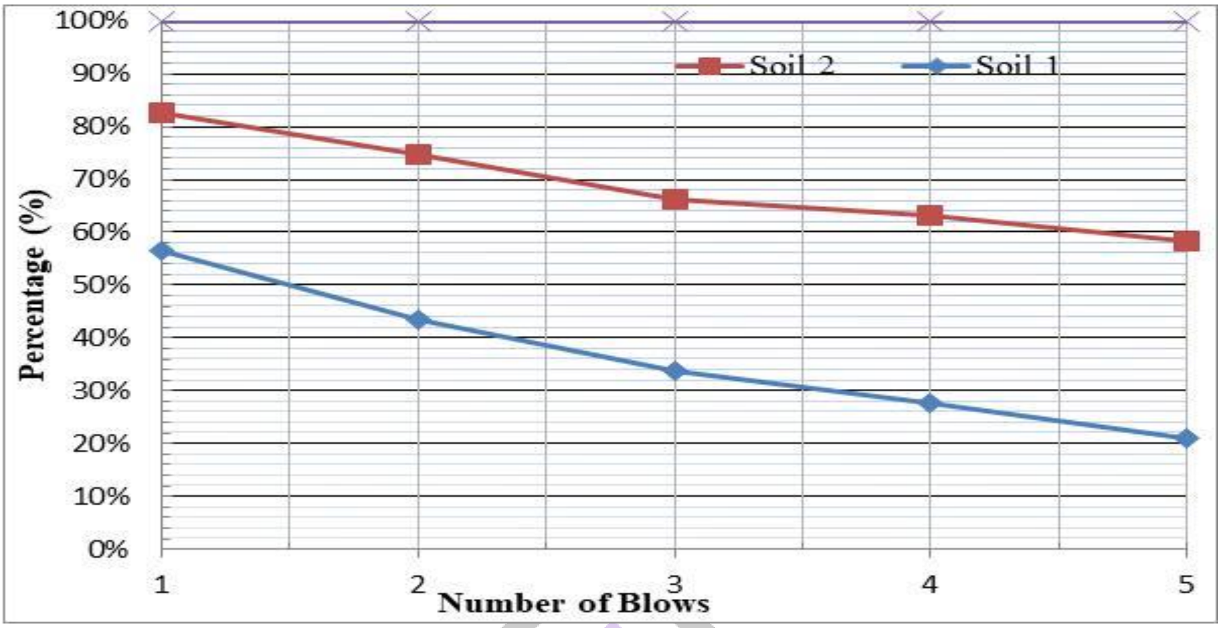

Figure 9: A graph of percentage (%) moisture content against number of blows

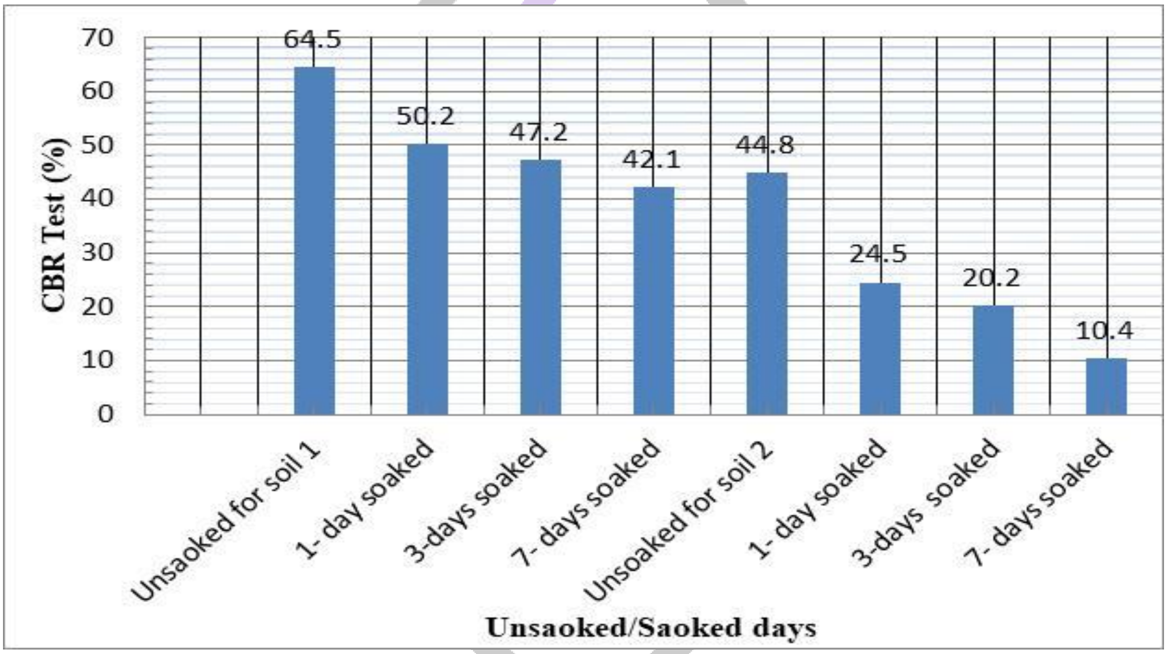

Figure 10: Comparison of CBR test (%) values of unsoaked and soaked soils (1&2) samples

Results and Discussion

The soil essential quality outcomes for the wet and dry soils 1 and 2 for ten samples collected are shown in Tables 1, 2, and 3. In Fig. 5, the 3D topography outlines of the area is located in troughs which act as a rally spike for flooding water and waters draining from surrounding highland areas. The coordinates of the area averages are 4.565 ^{0}N and 8.073^{0}E with corresponding elevations of 16 m above the coastal level. The tiniest elevation among the study locations has its bottom areas receiving flooding waters after rainfall, thereby making it more prone to flooding menace. The NMC value for soils 1 and 2 reached was 9.93 % and 17.40 %. This content reveals that the rate of moist content on soil 1 is slighter as a result of its bottom hydrology potential grading that fixes its catastrophe vulnerability. In Soil 2, the high moist content rating is depicted on road structure quality as a result of moisture variation in sub-grade soils. Figs. 6 – 10 present and interrelationship of various soil attributes. In Fig. 6, the percentage of soils 1 and 2 passing no. 200 sieves were 24.2% and 39.3% respectively. Comparatively, AASHTO resoluteness for soils sub-grade classified the soils as A-1 by a sub-group of A-1-b having no.200 sieve values of 24.2 %. This revealed a stone fragment with weighty earth at a coarse particle size distribution with, LL, PL, and PI values of 33 %, 18%, and 15% for soil 1, whereas 48%, 34.0%, and 14.0% were apprehended for soil 2. However, soil 2 silty to clayey formations show fair to poor significant constituent materials, the liquid limit and plastic limit depend on the type and amount of clay in the soils. The stiffness of soil1 stone fragment sand soils depends on their moisture content which varies with variations in the amount of moisture present. As a result, soils with the same liquid limit but differing plasticity index vary their rate of volume change, dry strength rises, and permeability reduces as the plasticity index increases. In soils with the same plasticity index but differing liquid limits, compressibility and permeability improve, while dry strength falls as the liquid limit increases. According to Nigeria (F.M.W. & H), requirements for liquid limit and plastic index of soils are not more than 35 % and 12 %, as determined by the American Society for Testing Materials Method (ASTM). Hence, the subgrade of soil 1 is suitable to be used in road construction since liquid limit and plastic index values do not exceed the standard limits of 35 % and 12 % whereas soil 2 shows fair to poor suitability. Nevertheless, soil assessment is accomplished by engaging the experimental method regarding finding a group index (GI) of the selection. The graded evaluation conveys roughly 11.8% and 5.4% for soils 1 and 2. This reveals that the GI of soil arises as the subgrade materials lessen. This shows that indexed soil 1 gives a faulty intimation of sub-grade significance due to a long submerging of sampling, whereas soil 2 displays fair sub-grade drift. Fig. 7 shows the CBR relationship linking topsoil strength and overflow soil environs. The sample selected was immersed for 1, 3, and 7 days as a result of a numerical timeline for submerged ambiance. The delineated histogram shown in Fig. 10 compared CBR test results of wet and dry soils 1 and 2 pick-outs. In contrast, the histogram displayed fairly CBR values of dry sampling excelling those in a wet site as a result of the soaking age of the topsoil sampling test. This reveals that the CBR values of dry environs breathe 69.3 % as well as a wet sampling of 1, 3, and 7 days breast 52.4 %, 49.3%, and 45.0 % for soil1. Successively, for soil 2, the dry value breathed 51.2 % as regards wet sampling of 1, 3, and 7 days, breast 26.7 %, 23.1 %, and 12.4 % depicting that flooding of soil for long durations reduces the soil stability. Nevertheless, topsoil is hard, losing its durability periodically from the first day of flooding, in contrast to its dry environs. Moreover, CBR values for the wet environment lessen as regards its durability based on the flooding age for individual sampling. Further soaking of soil for days, lowers its CBR values continuously, which leads to a weighty drop in soil stability, thickness, and bearing capacity. In Table 3, the compaction test for soils 1 and 2 indicates the OMC and MDD values of 13.6 % with 1.5 g/cm^3 and 8.4% with 1.96 g/cm^3. Soil 1 with stone fragment sand soil has proportional intensified predominant densities at lower optimal moist degrees, but soil 2 with clayey soils has low densities and noble OMC occurrences. On the other hand, when soil 1 is compacted, the recesses linking sizable particles are filled with smaller particles, resulting in a higher density than when a poorly graded soil 2 is compressed. In general, increasing soil density improves soil durability while decreasing leads to deformability. When loose topsoil is squeezed by a constant amount of energy, the dry thickness achieved is proportional to the wetness gratification. In Fig.8, the dry density of the soil will vary with its water content for a particular compacting effort. It was observed that as more water is injected, a bigger film of water forms over the particles, causing lubricating effects and making relative motions between particles easier, allowing the particles to form a denser structure. Thus, as the moisture content rises and reaches the maximum practicable degree of saturation, the density rises and the air content falls. As such, any more water will cause the voids to overfill with water, producing particle separation and a fall in density. The dry density, on the other hand, falls when the total voids grow at higher moisture contents than the optimal moisture values. The M_R and soaked CBR values for soils 1 and 2 with a caliber rectification factor vouched by asphalt institute recommendations were presented in Table 3. From the study, it was observed that the M_R averages ranged from (506.12) MPa to (214.6) MPa for soils 1 and 2 via 1, 3, and 7 days of soaking, regarding M_R for soil 1 with 2.4 stress, greater than soil 2. However, the M_R value increases with an increased constraint and is slighter with anomalous strain showing a high-value attribution to the dry sample with corresponding low values of the wet sample.

CONCLUSION

The assessments were carried out to regulate the effect of road flooding durability depth on the Subgrade. The most content percentages show lesser values in soil 1 due to its lower hydrology ductility with a corresponding higher value in soil 2 resulting in the road structure quality as a result of a wet shift in sub-grade soils. The particle size distribution of samples 1 and 2 were graded based on AASHTO standards, as A-1 by A-1-b sub-group having stone fragment sand and soil 2 having silty-clay earth. The OMC and MDD test analog depicted that Soil 1 shows fairly elevated topmost densities at lower optimum moisture contents, while soil 2 shows lower densities and higher OMC. The liquid limit and plastic index for soil1 shows lower values than soil 2, which has a good moisture restraint and subgrades materials. Similarly, the resilient modulus increases with increasing density and decreases with increased water content. However, the dry sample shows a higher resilient modulus rating, which is linked with the corresponding low values of wet sampling. CBR values for soils 1 and 2 wet environs are bounded on their durability hinging on the flooding age for soil sampling. Durable soaking of sampling days reduces its CBR values periodically, which leads to a massive relinquish in soil stability and stratum.

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