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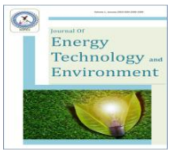

Predicting subgrade soil Modulus of Resilience in Benin City, Nigeria

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Abstract

The quality of subgrade soil is known to significantly affects pavement durability, with the modulus of resilience, measured by tests such as the California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS), being crucial for predicting soil resilience. Accurate estimation ensures cost-effective pavement design tailored to Benin City's conditions. Disturbed soil samples from selected regions in Benin City, were analysed for moisture content, specific gravity, particle size distribution, and Atterberg's Limits, and underwent CBR and UCS tests. Following British Standards, the modulus of resilience was calculated, and a regression model using CBR and UCS predicted resilience, validated with 30% of the data using R-squared, SSE, and RMSE metrics. Specific gravity ranged from 2.592 to 2.865, indicating silty soil with inorganic clay, while particle size distribution and Atterberg limits classified the soil as clay with intermediate plasticity. CBR values ranged from 4.76% to 15.27%, and UCS from 74.13 to 89.41 kN/m², classifying the soil from soft to stiff clay. The model, with a CBR exponent of 1 and UCS exponent of 2, showed an SSE of 0.9288, R-squared of 0.7404, adjusted R-squared of 0.7276, and RMSE of 0.1071, with a validation goodness of fit of 0.6768, indicating a strong predictive relationship.

1. Introduction

Pavements are durable surfaces designed to withstand vehicular loads, consisting of layered structures resting on foundation soils like embankments or cuts [1]. They are classified into flexible and rigid pavements. Recent modifications in pavement design still rely on the strength of subgrade, the compacted soil foundation. Thus, the design and performance of both flexible and rigid pavements depend on the subgrade's strength [2].

The subgrade is the layer from which the vehicular loads from the surface of the pavements are ultimately transmitted through the sub-base. The subgrade is designed such that the stress induced from the vehicular loads does not exceed the elastic limit. Therefore, the suitability and the stability of the material used as subgrade is very vital before the construction of the pavements. Hence, the strength of the soil material forms the basics of which a subgrade is seen [3]. The subgrade soil's characteristics is known to play a critical role in determining the performance and longevity of pavements. The modulus of resilience is a fundamental engineering parameter that measures the subgrade soil's ability to withstand repeated loading and recover its original shape.

The modulus of resilience is the ratio of the repeated deviatory stress to the axial recoverable strain in a cyclic triaxial test [4], and a commonly used stiffness parameter applied in pavement engineering that is used in determining the deformation of the soil under cyclic traffic loads [5]. It also assesses subgrade soil's load-bearing capacity and pavement performance.

Soil compaction aims to increase shear strength, bearing capacity, stiffness, and reduce future settlement and voids between soil particles [6]. Studies by [7], [8], [9], and [10] showed that higher compaction efforts increased dry density, stiffness, and strength. These studies also indicate that for a given compaction effort, optimal water content yields the highest density and best mechanical properties. [11] evaluated on the effect of changes in post compaction moisture content (i.e., wetting or drying) on the resilient moduli of subgrade soils. The effects of wetting and drying were examined by conducting resilient modulus tests on specimens compacted at various initial moisture contents: optimum moisture content (OMC), 4% drier than OMC (OMC – 4%), and 4% wetter than OMC (OMC + 4%). The results showed that modulus of resilience–moisture content (M_R - MC) relationships caused by drying exhibited higher values than the corresponding M_R - MC curves for specimens subject to wetting. The most significant finding was that changes in M_R values depended on the initial compaction moisture contents; the M_R values compacted at OMC exhibited a different drying and wetting trend than the ones compacted at OMC ± 4%.

Some studies highlight density's significant impact, while others note its dependence on aggregate shape and confinement level [12]. Moisture content, especially the degree of saturation, is crucial [13]. Resilient modulus increases with moisture up to the optimum level but decreases beyond it [14]. Additionally, angular and rough-textured aggregates exhibit a higher resilient modulus compared to uncrushed or partially crushed particles, and the modulus increases with bulk stress [15].

Cohesive soils gain strength under compression due to cohesive forces from fine-grained particles and electrical charges. The unconfined compression test, where a cylindrical soil specimen is loaded axially until failure, is commonly used to determine its compressive strength. This test provides insights into the undrained shear strength and compressive behaviour of cohesive soils. High UCS values in soils correlate with increased resilience under repetitive loading, showing greater shear strength and reduced deformation [11]. This positive correlation indicates that soils with higher UCS have higher resilient moduli, better stiffness, and an improved capacity to withstand stresses [16].

[17] explored the utilization of multiple variable regression analysis (MLR) to forecast several soil parameters including California Bearing Ratio (CBR), Coefficient of subgrade reaction K-Value, unconfined compressive strength (UCS), and Field dry density using data collected from Dynamic Cone Penetrometer (DCP) tests, modified liquid limit, and subgrade moisture content. The study, conducted in various locations across Gujarat, India, established empirical correlations through regression analysis. Validation with additional test data indicated the reliability of these correlations, suggesting the potential for efficient determination of subgrade strength parameters using readily available physical properties and DCP measurements. The findings endorse the practicality of employing modified DCP for predicting soaked CBR, UCS, and PBT based on given index properties.

[18] established an empirical relationship between resilient modulus (M_R) and soaked California Bearing Ratio (CBR) for subgrade soil, which is significant for pavement design, notably in software like IIT PAVE. They gathered disturbed soil samples from various locations in and around Chennai, conducting laboratory tests to classify soil based on index properties. Specimens for soaked CBR and triaxial tests were prepared according to the Optimum Moisture Content and Maximum Dry Density from Modified Proctor Compaction Test results. Through repetitive triaxial testing, an

empirical correlation was derived between soaked CBR and M_R, tailored to Indian design conditions. [19] derived the resilient modulus (M_R) model parameters from both the bulk stress model and the generalized constitutive resilient modulus model. They utilized statistical analysis to create M_R estimation models based on soil index properties. Additionally, a correlation was established between laboratory-measured M_R and the modulus from Falling Weight Deflectometer tests. Their study also investigated the impact of M_R on subgrade rutting using MEPDG. Results indicated that these models offer improved accuracy over the universal Long-Term Pavement Performance models for estimating M_R of undisturbed soils and predicting subgrade rutting in South Carolina.

Benin City faces increasing traffic and environmental stresses, leading to subgrade soil deformation and road failures. Laboratory investigation of the strength of subgrade parameter such as the California Bearing Ratio (CBR) and the compression strength are very important in the design of pavements by empirical methods such as the AASHTO method of pavement design. Hence, this study considers the use of multiple variable regression analysis in predicting the modulus of resilience of soils in Benin-City, when the CBR and the unconfined compressive strength are known. Reliable prediction of the modulus of resilience using commonly conducted tests such as the California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS) is essential for cost-effective and efficient pavement design and construction in the specific geological and climatic conditions of Benin City. CBR and UCS tests evaluate subgrade mechanical properties, but their correlation and effectiveness in predicting resilience for Benin City's soil are uncertain, challenging the design of durable pavement.

2. Methodology

2.1.Description of the Study Area

Benin City is the capital of Edo State in southern Nigeria, located in the Niger Delta region. It is situated between latitude 6.3167° N and longitude 5.6167° E, approximately 40 kilometres north of the Gulf of Guinea. In recent times, Benin City has experienced significant urban growth and development, leading to increased infrastructural demands, including the construction and maintenance of road networks [20].

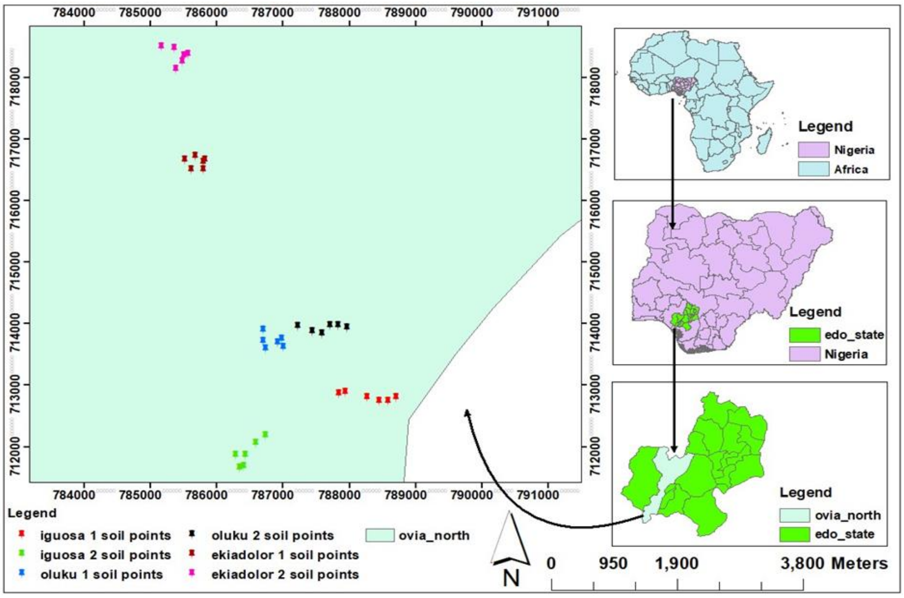

Figure 1 Map Showing the study Area

Benin City, situated in the Niger Delta basin, is part of Nigeria's vast and productive sedimentary basins. The region's geological history, shaped by sedimentary processes, tectonics, and sea-level changes over millions of years, is complex and dynamic. Geological formations predominantly comprise sediments like clays, sands, and shales, deposited by rivers and the sea. The southern part of the city lies within the coastal plain, characterized by coastal plain sands composed of fine to medium-grained quartz sands and interbedded clay layers. While these sands are valuable for construction and groundwater storage, their vulnerability to erosion and sea-level rise presents challenges for coastal infrastructure development. The soil types in Benin City reflect the diversity influenced by regional geology and environmental conditions.

Unconfirmed Compressive Strength (UCS) is the maximum axial compressive stress that a soil specimen can resist under zero confining stress. Since the stress is applied along the longitudinal axis, Unconfined Compression Test is also known as Uniaxial Compression Test. Test results of unconfined compression strength (q_u) with respect to the consistency of clay soil as presented in Table 1.

Table 1 Correlation of the Unconfined Compression Strength with Consistency

Consistency	$q_u (kN/m^2)$
Hard Clay	>400
Very Stiff Clay	200 – 400
Stiff Clay	100 – 200
Medium Clay	50 – 100
Soft Clay	25 – 50
Very Soft Clay	< 25

In pavement engineering, soil strength is often expressed using the California Bearing Ratio (CBR). The CBR test measures soil's resistance to deformation under applied force, like a wheel load. It compares a material's bearing capacity to a well-graded crushed stone with a reference CBR of 100%. The test applies load to a small piston at 1.3 mm per minute, recording loads at penetrations from 0.64 mm to 7.62 mm. Maximum resistance typically occurs at 2.54 mm, but sometimes at 5.08 mm, where the CBR is then calculated. This is calculated by equation 1

$$CBR = 100\left(\frac{Material\ load\ resistance\ at\ either\ 2.5mm\ or\ 5.00mm}{Standard\ pressure\ for\ the\ well\ graded\ crushed\ stone}\right) \tag{1}$$

According to [21] soils can be classified based on its use as subgrade with respect to the CBR value of the type of soil. The CBR value of subgrade is as represented in Table 2

Table 2 CBR value of Subgrade (Source: Directorate General of Highways 1976)

CBR Value	CBR of Subgrade
> 24 %	Very Good
8 – 24 %	Good
5 – 8 %	Medium
3 – 5 %	Poor
2 – 3 %	Very Poor

The Resilient Modulus (M_R) is a measure of the stiffness of the subgrade material. A material's resilient modulus is actually an estimate of its modulus of elasticity (E). While the modulus of elasticity is stress divided by strain for a slowly applied load, resilient modulus is stress divided by strain for rapidly applied loads like those experienced by pavements. The modulus of resilience is also called the stiffness modulus [22]. The resilient or elastic properties of unbound layers are determined by the use repeated load triaxial tests. Considering a cylindrical specimen that is subjected to a confined triaxial stress state under a constant confinement and a dynamic axial compressive load. In this case, the confining stress in the radial direction represents the minor and intermediate principal stresses, while the vertical stress is the major principal stress. The measured modulus is defined as the ratio of the applied deviatory stress (axial stress minus the radial stress) divided by the resilient strain. The modulus of resilience is given by the equation 2

$$M_R = \frac{\Delta(\sigma_1 - \sigma_3)}{\varepsilon_{1,R}} \tag{2}$$

where, σ_1 is the major principal stress, σ_3 is the minor principal stress, $\varepsilon_{1,R}$ is the major principal resilient strain. The resilient modulus is influenced by density, gradation, fine content, and moisture content.

2.2.Materials and Methods

Disturbed soil samples were manually collected by means of a hand auger, from 6 locations in Ovia North East Local Government Area in Benin - City. Of which a total of 80 samples were collected from these areas at depths of 0.50m, 0.75m, 1.00m and 1.50m. The locations where the samples were collected include Iguosa 1 and 2, Oluku 1 and 2, and Ekhidolor 1 and 2.

The British Standard BS 5930:2015 "Code of Practice for Ground Investigations" which provide guidelines for conducting disturbed soil sampling to ensure accurate representation and characterization of the soil for various engineering purposes was also applied. The samples collected were disturbed, collected by means of a hand auger. About 30kg of the samples were collected from each sampling location, bagged and transported to the laboratory. Each sample was labelled accurately, indicating the location, depth, and any other relevant information. Detailed documentation of the sampling process, including soil conditions and weather conditions, which are essential for interpreting the results are recorded. These samples collected in the polythene sheets were used to determine the natural moisture content of the soil samples. The larger soil samples were air dried and the larger lumps pulverized to smaller particles. After air drying the samples, they were then tested for the necessary tests that were to be conducted.

The tests conducted on the soil samples were classification tests which include specific gravity, sieve analysis and Atterbergs' limits test. Strength tests were conducted on the soil samples which include the CBR test that was conducted by means of the CBR machine and the UCS test which was conducted by means of the triaxial machine. The necessary tests that were conducted were the classification tests which include; specific gravity, sieve analysis, Atterberg's limits, Standard Proctor compaction tests, CBR and UCS in accordance to BS EN 1997 – 2: 2007. The modulus of resilience of each sample was determined by the expression given in equation 3 [22]

$$M_R = \frac{\sigma}{\varepsilon_r} \tag{3}$$

where σ is the applied stress, and ε_r is the recoverable axial strain

From the data gotten, the CBR and UCS serve as the independent variables while M_R is the dependent variable, were used in the prediction model formulation

3. Results and Discussions

The classification results of the samples from Iguosa 1, revealed that the specific gravity of the borehole samples ranged from 2.608 to 2.724, which indicated that they had some amount of organic matter or porous matter in them, while according to [23] the samples organic clay group as their specific gravity is below 2.65. Also, the particle size distribution shows that the soil samples have a high percentage of particles passing through the 0.075mm sieve, ranging from 31.65% to 43.75%, the soil samples are said to be fine grained soil [23]. The consistency limit results showed that with the LL ranging from 38.00% to 45.00%, PL ranging from 13.57% to 24.75%, and PI ranging from 17.00% to 29.85%. With reference to the plasticity chart as proposed by BS 5390:1999, the soil samples from this location were found to be Clay of Medium plasticity.

The results of the samples from Iguosa 2, showed that the soil samples are fine-grained soils with specific gravity ranging from 2.597 to 2.752. The liquid limit (LL) values range from 38.00 to 49.31, while the plastic limit (PL) values range from 11.69 to 30.70. The plasticity index (PI) values range from 17.00 to 40.40. Based on the plasticity chart as seen in BS 5930:1999, the soils from this location are said to be clay soils of intermediate plasticity. Also, the soil samples collected from Oluku 1 are fine-grained soils with specific gravity ranging from 2.605 to 2.865. The liquid limit (LL) values range from 37.50 to 44.00, while the plastic limit (PL) values range from 16.33 to 25.94. The plasticity index (PI) values range from 17.04 to 22.67. Based on the classification test results, the soil samples can be classified as clayey soils with varying plasticity.

The soil samples collected from Oluku 2 are fine-grained soils with specific gravity ranging from 2.62 to 2.75 and they are within the range of sandy soils to clayey soils as proposed by [24]. Also, the liquid limit (LL) values range from 37.25 to 43.97, while the plastic limit (PL) values range from 12.55 to 21.55. The plasticity index (PI) values range from 18.61 to 27.50.

For the soil samples collected from Ekhiadolor 1, the specific gravity was within the range of 2.627 to 2.725 and also is within the range of sandy soils to clayey soils as proposed by [24]. Also, the liquid limit (LL) values range from 32.50 to 46.00, while the plastic limit (PL) values range from 12.65 to 20.03. The plasticity index (PI) values range from 14.97 to 31.38. The results of the soil samples collected from Ekhiadolor 2, showed that the specific gravity were within the range of 2.614 to 2.715 and also is within the range of sandy soils to clayey soils as proposed by [24]. Also, the liquid limit (LL) values range from 33.00 to 47.00, while the plastic limit (PL) values range from 10.88 to 17.07. The plasticity index (PI) values range from 17.43 to 31.81.

In summary the soil samples from locations based on the Plasticity Chart as proposed by BS 5930:2015. Majority of the soils are clayey soils with intermediate plasticity as seen in Figure 2.

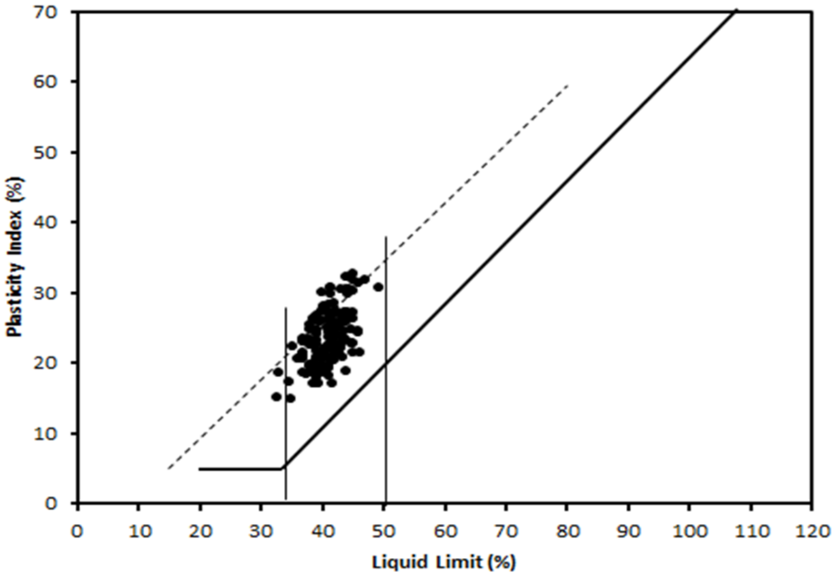

Figure 2 Plasticity Chart of Samples according to BS 5930:2015

The compaction results from the sample locations indicated that the maximum dry density (MDD) values range from 1.544 g/cm^3 to 1.934 g/cm3, while the OMC values range from 9.9% to 15.6% and the study conducted by [25] showed the ranges of values that may be anticipated when using the standard Proctor test methods for different soil types. For clay soils, maximum dry density (MDD) may fall before 1.44g/cm^3 and 1.685g/ cm^3 and optimum moisture content (OMC) may fall between 20-30%; while for silty clay soils, MDD is usually between 1.6 and 1.845g/cm^3 and OMC ranged between 15-25%, and for sandy clay soils MDD usually ranged between 1.76 and 2.165g/cm^3 and OMC between 8 and 15% These soils from the study area could be classified as silty clay and sandy clay soils.

The descriptive statistics of the results from the CBR, UCS and M$_R$ is as summarized in Table 3 below

Table 3 Descriptive statistics of the Combined Results

	M_R (kN/m^2)	CBR (%)	UCS (kN/m^2)
Count	144	144	144
Range	2396.92	10.51	15.28
Minimum	1200.16	4.76	74.13
Maximum	3597.08	15.27	89.41
Mean	1950.36	8.26	80.57
Standard Error	39.66	0.16	0.29
Median	1939.18	7.84	80.49
Standard Deviation	475.91	1.97	3.54
Sample Variance	226491.62	3.87	12.51
Kurtosis	-0.20	0.27	-0.60
Skewness	0.47	0.81	0.08
Shapiro-Wilk test	0.000	0.000	0.013
Kolmogorov-Smirnov test:	0.036	0.000	0.020

It was observed that the total numbers of samples were 144. The minimum and maximum CBR values were 4.76% and 15.47% respectively which showed that the soil samples have a poor to fair level and can be used as subgrade material as specified in FMWH (2013). The minimum and maximum M$_R$ of the soil samples are 1200.16kN/m^2 and 3597.08kN/m^2 which according to [26] classified the soil to be within the soft clay and stiff clay category. And the minimum and maximum

UCS values were 74.13kN/m^2 and 89.41kN/m^2. Based on the test of normality as conducted by the Kolmogorov-Smirnov and Shapiro-Wilk tests, it was observed that the level of significance is less than 0.05 for all the tests conducted; hence the samples are not normally distributed. Therefore, the data need to the transformed.

The scattered plot of the relationship between the modulus of resilience of the soil and the CBR values of the soils are as seen in Figure 3, while Figure 4 shows the scattered plot of the resilience and the UCS of the soils.

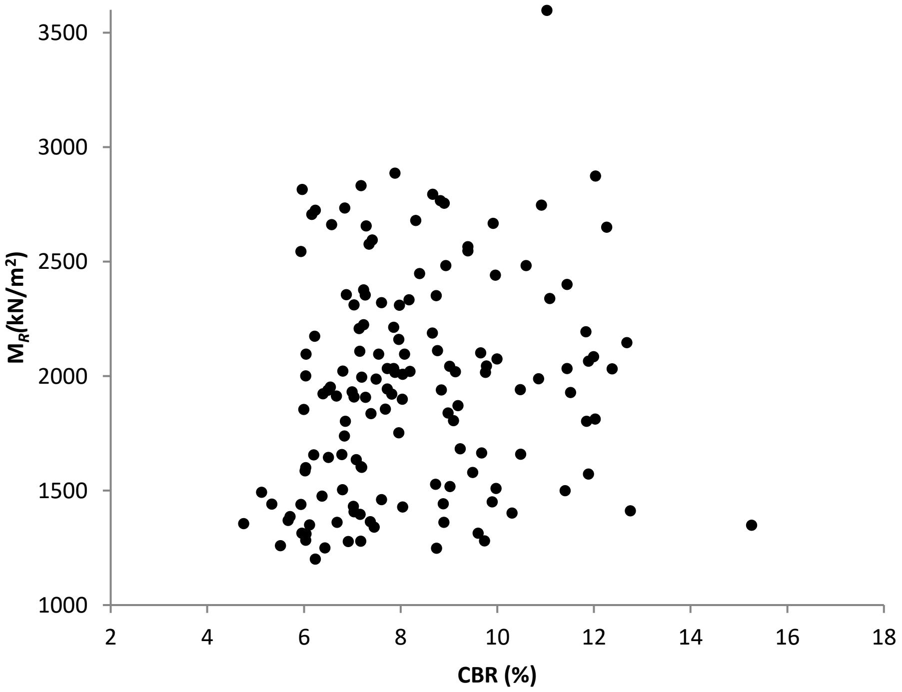

Figure 3. Scattered Plot of CBR and Modulus of Resilience

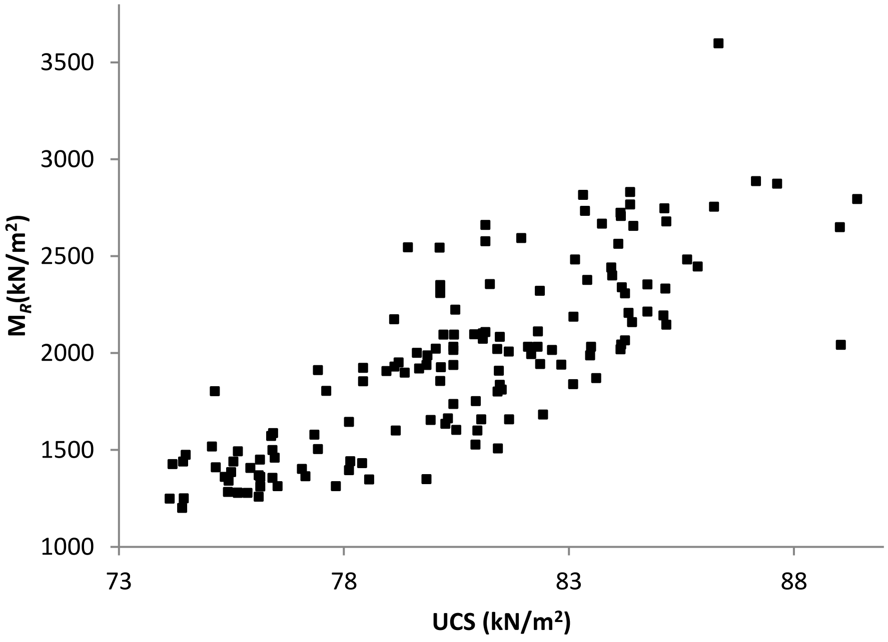

Figure 4. Scattered Plot of UCS and Modulus of Resilience

Analysis of Strength Parameters

By rescaling the data set so that they are within the range of 0 and 1, the Min–Max Scaling was applied and is as summarized in the descriptive statistics shown in Table 4, and the scattered plot of the relationship between the rescaled modulus of resilience of the soil and the rescaled CBR and UCS values of the soils are as combined in Figure 5.

Table 4 Summary Statistics of Rescaled M_R, CBR and UCS.

	M_R Norm	*CBR Norm*	*UCS Norm*
Count	144.0000	144.0000	144.0000
Range	1.0000	1.0000	1.0000
Minimum	0.0000	0.0000	0.0000
Maximum	1.0000	1.0000	1.0000
Mean	0.3130	0.3334	0.4215
Standard Error	0.0165	0.0156	0.0193
Median	0.3083	0.2931	0.4162
Standard Deviation	0.1986	0.1871	0.2315
Sample Variance	0.0394	0.0350	0.0536
Kurtosis	-0.2047	0.2687	-0.5950
Skewness	0.4740	0.8140	0.0794

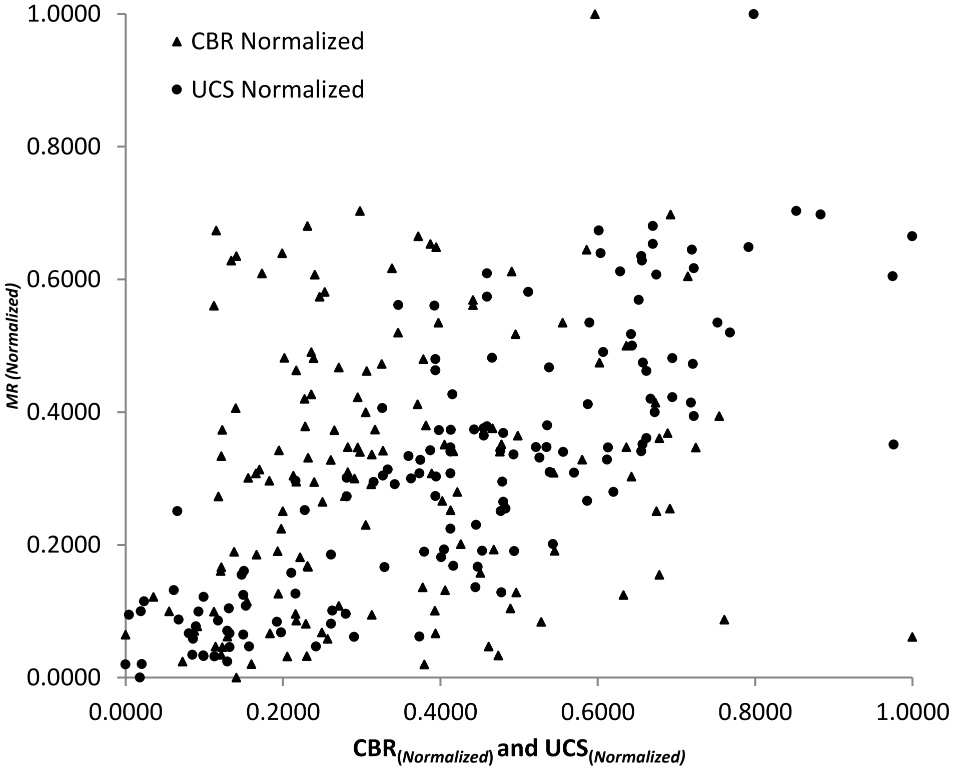

Figure 5 Scattered Plot of the Rescaled CBR, UCS and Modulus of Resilience

3.1 Model Selection

Regression model was used in the prediction of the best relationship that works effectively in the determination of the modulus of resilience (M_R) as the dependent variables and with the other two variables the California Bearing Ratio (CBR) and the Unconfined Compressive Strength (UCS) being the independent variables. This was performed by the use of the Curve Fitting tool App in MatLAB software. The polynomial fit type was used in this study to predict the best model that describes the most suitable model for this study. The data set was divided into three sections with 60% of the data being used for training the model, 30% used for testing the model and 10% of the dataset were used for validation of the data set. Trial and error method was used to get the best model in which the degrees of independent variables were changing. The model that best suit the study involved that in which the degree of the CBR is 1 while that of the UCS were increasing from 1 to 3.

Equation 4, shows the relationship in which the powers of the independent variables were both 1 and also the sum of squares error, R squares, adjusted R squared and the root mean squared errors of the training data set is as shown

$$M_R = 0.02437 - 0.0659CBR + 0.6836UCS \qquad (4)$$

The Sum of Square Error (SSE) is 0.9971; R-squared is 0.7213; the adjusted R- squared is 0.7146 and the Root Mean Squared Error (RMSE) was 0.1096. The main plot of the normalized variables, the residual plots are as seen in Figure 6a and 6b respectively.

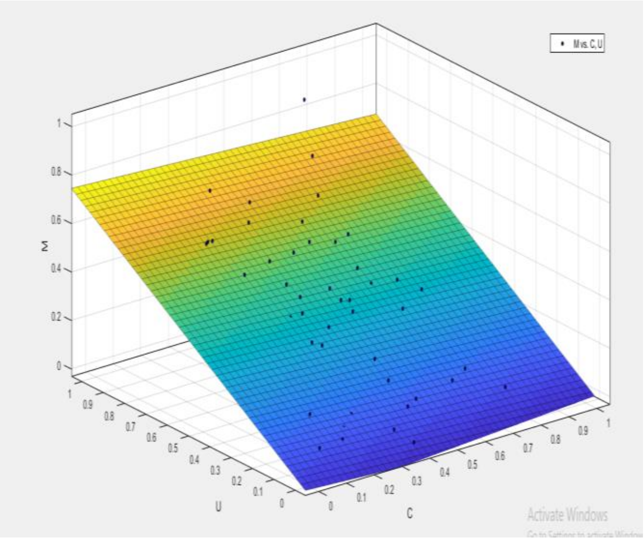

Figure 6a Main Plot of Modulus of Resilience in relation to 4.

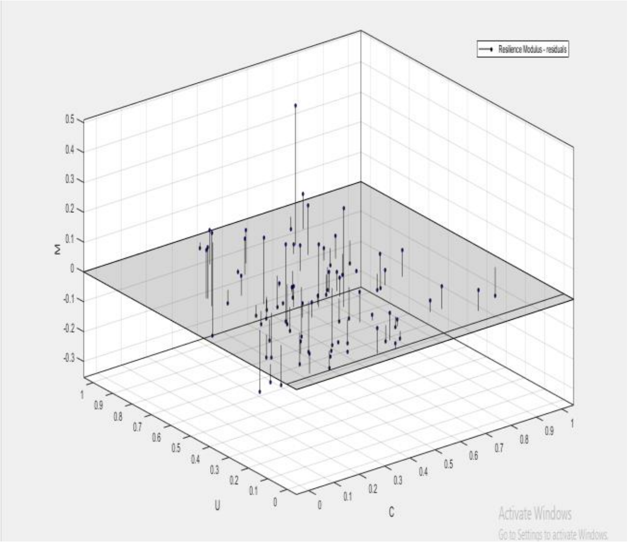

Figure 6b Residual Plot of Modulus of Resilience in relation to 4

Equation 5, shows the relationship in which the maximum exponent of the CBR variable was 1 and that of the UCS variable was 2 and also the sum of squares error, R squares, adjusted R squared and the root mean squared errors of the training data set is as seen

$$M_R = 0.02922 - 0.01996CBR + 0.1761UCS - 0.02274CBR.UCS + 0.02344UCS^2 \qquad (5)$$

The Sum of Square Error (SSE) is 0.9288; R-squared is 0.7404; the adjusted R- squared is 0.7276 and the Root Mean Squared Error (RMSE) was 0.1071. The main plot of the normalized variables, the residual plots are as seen in Figure 7a and 7b respectively.

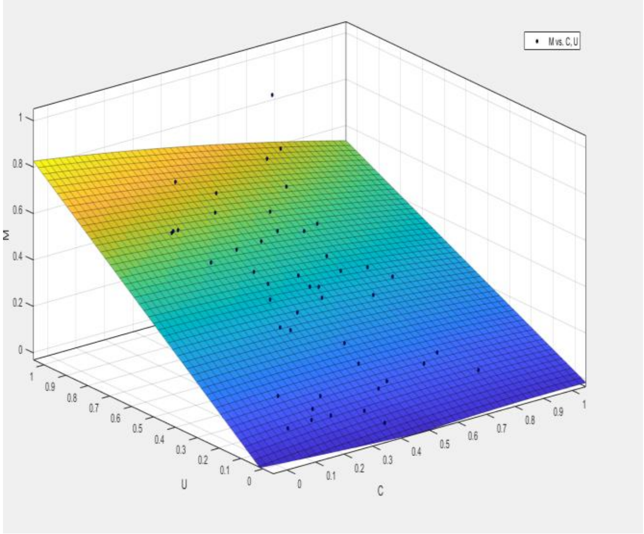

Figure 7a Main Plot of Modulus of Resilience in relation to 5

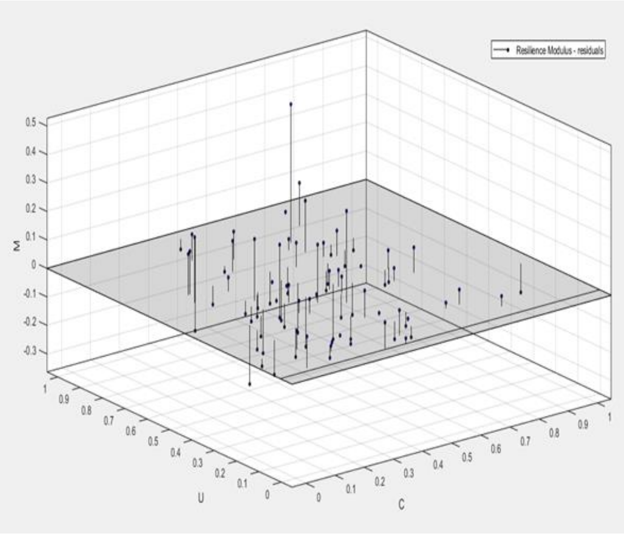

Figure 7b Residual Plot of Modulus of Resilience in relation to 5

Equation 6, showed the relationship in which the maximum exponent of the CBR variable was 1 and that of the UCS variable was 3 and also the sum of squares error, R squares, adjusted R squared and the root mean squared errors of the training data set is as seen

$$M_R = 0.02872 - 0.0172CBR + 0.2114UCS - 0.02215CBR.UCS + 0.0273UCS^2 - 0.1327CBR.UCS^2 - 1.092UCS^3 \qquad (6)$$

The Sum of Square Error (SSE) is 0.9307; R-squared is 0.7399; the adjusted R- squared is 0.7201and the Root Mean Squared Error (RMSE) was 0.1085. The main plot of the normalized variables, the residual plots are as seen in Figure 8a and 8b respectively.

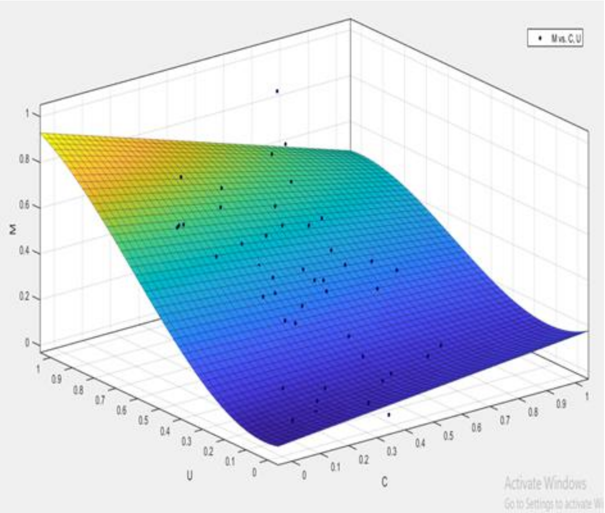

Figure 8a Main Plot of Modulus of Resilience in relation to 6

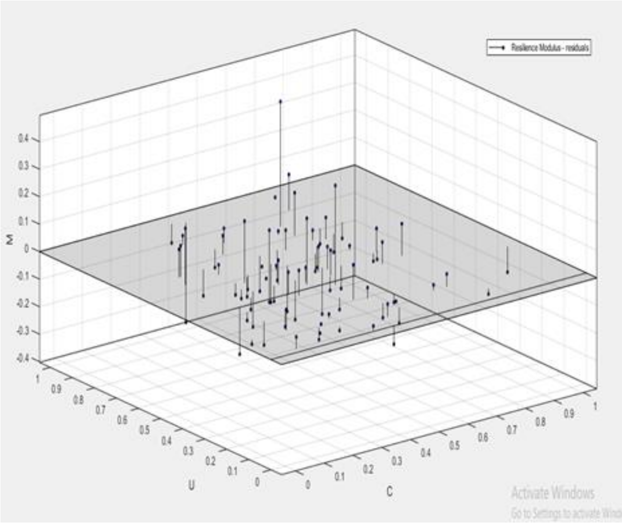

Figure 8b Residual Plot of Modulus of Resilience in relation to 6

The best model that predicts the modulus of resilience using CBR and UCS as the predictors is Equation 5. It implies that with an R-squared value of 0.7404 approximately 74.04% of the variability in the modulus of resilience can be explained by the variation in CBR and UCS as independent variables in the regression model. Hence, equation 5 fit the model well. The RMSE value of 0.1071 indicates that the average difference between the observed values of the modulus of resilience and the values predicted by the regression model. The lower the RMSE value the closer of the prediction model to the actual observed values, indicating higher prediction accuracy (Chai and Draxler, 2014).

3.2 Model Validation

30% of the dataset was then validated by inserting them into the equation from which the predicted modulus od resilience were then determined. The plot of the actual modulus of resilience against the predicted modulus of resilience is as seen in Figure 9

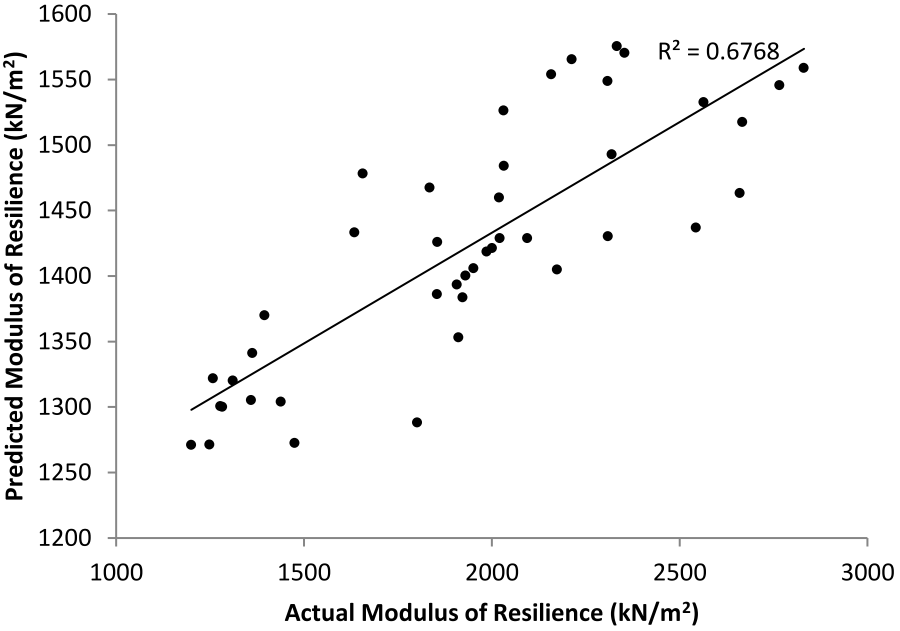

Figure 9 Plot of Actual Modulus of Resilience against Predicted Modulus of Resilience

Figure 9 showed that the goodness of fit between the actual modulus of resilience and the predicted modulus of resilience was 0.6768, which implies that 67.68% of the actual modulus of resilience can predict the predicted modulus of resilience using equation 4.2. This also implies that the correlation of both parameters is a very strong relationship. The root mean square error base on this is 630.07kN/m^2

4. Conclusion

The classification tests which include specific gravity, particle size distribution and Atterbergs' limits test; showed that the range of the samples specific gravity was within the ranges of 2.592 to 2.865, which implies that the soils were silty soil with inorganic clay. The liquid limits were within the range of 33.00% to 49.31%, which shows that they have a tendency to absorb water, and the plasticity index within the ranges of 14.93% to 31.81%. Therefore, based on the above the soil samples from the locations indicate the soil to be clay of intermediate plasticity.

The compaction results indicated that the maximum dry density (MDD) values range from 1.544 g/cm^3 to 1.934 g/cm^3, while the OMC values range from 9.9% to 16.30%, the soils from the study area were classified as silty clay and sandy clay soils in relation to the standard proctor compaction test on the soil samples.

Also, the CBR values of the soil samples were within the ranges of 4.76% to 15.27%, which indicate that they are subgrade materials that are poor to fair and are suitable for subgrade construction. Also, the unconfined compressive strength of the soils showed that strength was within 74.13kN/m^2 and 89.41kN/m^2, and the modulus of resilience of the soils were within the ranges of 1200.16kN/m^2 and 3597.08kN/m^2. Hence, the soil samples as classified based on strength were of soft clay and stiff clay.The most suitable model chosen involve that in which the maximum exponent of the CBR variable was 1 and that of the UCS variable was 2 and also the sum of squares error was 0.9288, R squares is 0.7404, adjusted R squared was 0.7276 and the root mean squared errors was 0.1071 and an empirical relationship that predicts the soil modulus of resistance was developed.

The validation of the above model showed that there was a goodness of fit of 0.6768 between the actual modulus of resilience and the predicted modulus of resilience, thus indicating a good relationship between the resulting prediction with a root mean square error of 630.07kN/m^2.

The following recommendations are proposed that future studies could explore the inclusion of additional soil properties or characteristics that might contribute to a more accurate prediction. Also, the accuracy and reliability of the predictive model could be further enhanced by expanding the dataset and this can be done by collecting data from more locations with varying soil compositions and subgrade conditions and this would help to validate the robustness and applicability of the predictive model across diverse settings. And integrating advanced machine learning techniques into prediction modelling can enhance the accuracy and reliability of compaction predictions.

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