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EFFECTS OF LIME AND RIVER SAND ON GEOTECHNICAL PARAMETERS OF MKPOK RESIDUAL SOILS, AKWA IBOM STATE, NIGERIA

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ABSTRACT: Lime and river sand were utilized for this laboratory stabilization experiments. The objective was to evaluate the structural behaviour of Mkpok residual soil at various levels of stabilization and its response to imposed mechanical systems. Four different samples from four distinct borrow pits were deployed for this investigation. The lime content varied from 2% to 10% while the river sand content varied from 10% to 70%. For the purpose of model formulations the lime content was restricted to 6% and the river sand content 50% for CBR and 4% lime content to 40% river sand content for UCS. The results obtained ranged from 72% to 103% and 92% to 157% for measured and computed values respectively on lime stabilization. For the river sand stabilization the results varied from 65% to 113% and 78% to 239% for measured and computed values respectively. The UCS values derived varied from 76KPa to 202KPa for 7 days curing and 134KPa to 274KPa for 28 days curing durations respectively. From engineering and economic considerations river sand stabilization appears plausible compared to lime stabilization. Finally multiple nonlinear regressed models were developed to aid prediction and optimization of CBR and UCS parameters of Mkpok residual soils at various stabilization levels.

Keywords: Lime, Models, River Sand, Residual Soil, Stabilization.

I. INTRODUCTION

Generally application of stabilizers such as lime and river sand on residual soils are designed to increase the bearing resistance to imposed shearing stresses. Mkpok residual soil originated from the concept of decomposition or weathering of a group of igneous and metamorphic rocks of Pre-Cambrian age generally referred to as the Nigerian Basement Complex. The Basement Complex is largely undifferentiated and constitutes about fifty per cent of the bed rock of Nigeria [1]. This soil is pleasing in appearance, unique in formation but quite deceptive in engineering applications. Its application as base course material on the Mkpok – Okat access road project was a failure based on engineering and economic considerations.

II. MATERIALS SELECTED

2.1. Mkpok Residual Soil

Four soil samples were selected for this research. The samples were excavated with shovels at four distinct borrow pits at depths varying from three to six meters below the grade. The samples' extraction reflected both vertical and horizontal components – an indication of disturbance in composition. The samples were conveyed in four fifty kilogram nylon bags, carefully tagged for identification purpose and transported to Materials Testing Laboratory, Civil Engineering Department, and University of Uyo.

2.2. Lime

Addition of lime helps to arrest the shrinkage and swelling behaviour of soil [2]. This is due to the creation of chemical bonds and aggregation [3]. The use of lime to improve the engineering properties of soil had been in practice for long in many parts of the World. The lime used in this work was purchased from Ewet market in Uyo. The primary purpose was to evaluate the behaviour of Mkpok residual soil on application of various percentages of lime and compactive effort on the maximum dry densities and corresponding optimum moisture contents. Lime stabilized soil is an engineered product that must be properly evaluated, proportioned and constructed in order to obtain the good and long-term performance. Generally lime reduces the plasticity of a highly expansive soil, as well as improving the stress-strain behaviour [4].

2.3. River Sand.

River sand provides grains that fill void spaces in soft residual soils. Thus river sand tend to enhance the bond in cementation reactions of soil mixing. This is one of the most abundant stabilizing materials within the coastal plains and tributaries of the Atlantic Ocean. The deleterious and silty substances were thoroughly removed by washing. The material was then air-dried before particle size gradation through sieve analysis. The air-dried sample was separated through the riffle box and 1000g utilized for this experiment. The sample was sieved from 10mm through 0.075mm in a mechanical shaker. It is found that grain size distribution provides a satisfactory skeleton, and the voids are filled with fine sand giving a compact and high load bearing capacity [5]

III. PREPARATION AND TESTING OF SAMPLES

3.1. Plain Mechanical Compaction Tests

As the term implies the tests are devoid of any stabilizer. For each of the samples, the Modified Proctor compaction tests were conducted. The air-dried material was divided into five equal parts through a riffle box and weighed to 6000g each. Each sample was poured into the mixing plate. A particular percentage of distilled water was poured into each plate and thoroughly mixed with a trowel. An interval of about 1hour was allowed for the moisture to fully permeate the soil sample. The sample was thereafter divided into five equal parts, weighed and each was poured into the compaction mould, in five layers and compacted at 61 blows each using a 4.5kg rammer falling over a height of 450mm above the top of the mould. The blows were evenly distributed over the surface of each layer. The collar of the mould was then removed and the compacted sample weighed while the corresponding moisture content was noted. The procedure was repeated with different moisture contents until the weight of compacted sample was noted to be decreasing. With the optimum moisture content obtained from the Modified Proctor test, samples were prepared and inserted into the CBR mould and values for the plain mechanical compaction were read for both top and bottom at various depths of penetration.

3.2. Lime Stabilization Tests

The percentage of lime used in this study varied from 2%, 4%, 6%, 8% and 10% to the air-dried weight of the residual soil. That decision was informed by the fact that Mkpok residual soil is highly anisotropic. There was need to establish a linear relationship involving lime stabilized residual soil and lime content at optimal level and thereafter determine diminishing properties resulting from excessive lime. The percentage of residual soil on corresponding basis varied from 98%, 96%, 94%, 92% and 90% to the weight of hydrated lime. The mixture was thoroughly blended, moisturised and samples taken for liquid limit tests. Similar compaction procedures were adopted for the four soil samples. The Modified Proctor test was carried out on all the samples uniformly distributed with a 4.5kg rammer and height was 450mm above the soil compacted on five equal layers of 61 blows each. With the OMC and MDD results obtained three samples each of the soil-lime specimen were prepared for CBR test. One sample was tested immediately. The remaining two samples were soaked for 96 hours by complete immersion in water. After the curing duration, the specimen was allowed to drain for 25minutes prior to CBR testing.

3.3. River Sand Stabilization Tests

River sand samples ranging from 10%, 20%, 30%, 40%, 50%, 60% to 70% by weight of the air-dried residual soils were utilized in this stabilization tests. For each of the residual soil samples 1, 2, 3 and 4 different proportions of a 6000g weight ranging from 90%, 80%, 70%, 60%, 50%, 40%, to 30% were correspondingly mixed thoroughly with the river sand to obtain 100% on each sample combination. Liquid limit and plastic limit tests as well as Modified Proctor compaction were carried out on the mixture. With the values of OMC and MDD derived from the Modified Proctor compaction tests, samples were prepared and inserted into the CBR machine and the penetration readings carried out accordingly. It must be noted that on application of 60% to 70% river sand contents the CBR values started falling thus confirming the decreasing to non-plastic nature of the mixture within this range.

3.4. California Bearing Ratio [CBR] Test

The CBR test [as it is commonly known] involves the determination of the load-deformation curve of the soil in the laboratory using the standard CBR testing equipment. It was originally developed by the California Division of Highways prior to World War II and was used in the design of some highway pavements. This test has now been modified and is standardized under the AASHTO designation of T193. With the OMC and MDD results, three specimens each were prepared for the CBR test. One specimen was tested immediately while the remaining two were wax-cured for 6days and thereafter soaked for 24 hours, and allowed to drain for 15minutes. After testing in CBR machine, the average of the two readings was adopted. CBR gives the relative strength of a soil with respect to crushed rock, which is considered an excellent coarse base material. The main criticism of the CBR test is that it does not correctly simulate the shearing forces imposed on sub-base and sub-grade materials as they support highway pavement.

3.5. Unconfined Compression Test

Unconfined Compression Test is a triaxial test in which the axial load is applied to a specimen under zero all round pressure. This test is applicable only for testing intact fully saturated soils i.e. only on saturated samples which can stand without any lateral support. By implication the test is applicable to cohesive soils only. The test is an undrained test and is based on the assumption that there is no moisture loss during the test. The unconfined compression test is one of the tests used for the determination of the undrained shear strength of cohesive soils. In this test no radial stress is applied to the sample and the plunger load is increased rapidly until the soil sample fails. The loading is applied quickly so that pore water cannot drain from the soil; the sample is sheared at constant volume.

IV. PRESENTATION OF TEST RESULTS

Table 1: Mkpok Residual Soil Compaction at Plain Condition

Sample No	MDD Kg/m^3	NMC %	unsoaked CBR %	Fines %
1	1810	8.4	51	31
2	1850	11.4	52	33
3	1920	10.5	57	32
4	1860	10.7	54	29

Table 2: Mkpok Residual Soil and Lime Classification – Sample no. 1

Lime Content (%)	MDD Kg/m^3	OMC (%)	Soaked CBR (%)	LL	PL	PI	% passing Sieve 200	Classification	
								AASHTO	USCS
0	1810	8.4	22	26	21	5	22	A- 2 - 4	SM
2	1940	8.2	72	31	22	9	29	A- 2 - 4	SM
4	2100	8.9	90	28	20	8	29	A- 2 - 4	SM
6	1990	8.5	103	29	23	6	31	A- 2 - 4	SM
8	1980	8.5	96	28	23	5	32	A- 2 – 4	SM
10	1980	8.2	108	19	NIL	NIL	33	A- 2 - 4	SM

Table 3: Mkpok Residual Soil and Lime Classification – Sample no. 2

Lime Content (%)	MDD Kg/m^3	OMC (%)	soaked CBR (%)	LL	PL	PI	% passing Sieve 200	Classification	
								AASHTO	USCS
0	1850	11.4	24	32	23	9	28	A- 2 - 4	SM
2	1820	12.4	78	30	21	9	31	A- 2 - 4	SM
4	1960	11.5	90	25	18	7	32	A- 2 - 4	SM
6	2010	15.0	96	30	21	9	33	A- 2 - 4	SM

8	2020	14.8	108	26	21	5	34	A- 2 – 4	SM
10	2030	12.1	116	19	NIL	NIL	35	A- 2 - 4	SM

Table 4: Mkpok Residual Soil and Lime Classification – Sample no. 3

Lime Content (%)		MDD Kg/m^3	OMC (%)	soaked CBR (%)	LL	PL	PI	% passing Sieve 200	Classification	
									AASHTO	USCS
0		1920	10.5	30	29	25	4	35	A- 2 - 4	SM
2		1980	9.3	80	31	21	10	32	A- 2 - 4	SM
4		1950	8.5	84	27	21	6	32	A- 2 - 4	SM
6		1880	11.4	96	28	20	8	34	A- 2 - 4	SM
8		2010	10.3	90	28	21	7	34	A- 2 – 4	SM
10		2110	8.6	156	20	NIL	NIL	38	A- 2 - 4	SM

Table 5: Mkpok Residual Soil and Lime Classification – Sample no. 4

Lime Content (%)	MDD Kg/m^3	OMC (%)	CBR soaked (%)	LL	PL	PI	% passing Sieve 200	Classification	
								AASHTO	USCS
0	1860	10.7	24	37	21	16	33	A-2-4	SM
2	1990	6.1	78	30	20	10	33	A-2-4	SM
4	1920	11.5	83	30	22	8	34	A-2-4	SM
6	1910	10.4	96	30	24	6	35	A-2-4	SM
8	1930	12.4	134	21	NIL	NIL	36	A-2-4	SM
10	1950	8.9	143	18	NIL	NIL	39	A-2-4	SM

Table 6: Mkpok Residual Soil and River Sand Classification – Sample no 1

River sand content	MDD	OMC	CBR	LL	PL	PI	% passing Sieve 200	Classification	
%	Kg/m^3	%	Unsoaked %					AASHTO	USCS
0	1900	12.5	51	35	24	9	31	A- 2 -6	SC
10	1880	14.8	54	36	25	11	33	A- 2 – 4	SM
20	1800	14.0	72	34	23	11	31	A- 2 -5	SM

30	1820	13.5	79	24	15	9	29	A- 2 -4	SM
40	1930	12.2	88	24	19	5	21	A- 1 – b	SM
50	2050	10.4	80	23	20	3	20	A- 1 – b	SM
60	2010	8.0	68	20	NIL	NIL	18	A -1 - b	SM
70	1850	13.1	57	17	NIL	NIL	15	A – 1 - b	SM

Table 7: Mkpok Residual Soil and River Sand Classification – Sample no 2

River sand content	MDD	OMC	CBR	LL	PL	PI	% passing Sieve 200	Classification	
%	Kg/m^3	%	Unsoaked %					AASHTO	USCS
0	1820	14.6	52	29	19	10	33	A- 2 -6	SC
10	1880	12.5	70	34	25	9	30	A- 2 – 4	SM
20	1970	12.8	72	30	18	12	27	A- 2 -5	SM
30	1910	11.6	81	28	21	7	24	A- 2 -6	SC
40	1960	8.3	92	27	20	7	21	A- 2 – 7	SC
50	1900	11.1	78	25	21	4	19	A- 1 – b	SM
60	1830	11.7	62	20	NIL	NIL	20	A -1 - b	SM
70	1850	12.0	55	17	NIL	NIL	14		SM

Table 8: Mkpok Residual Soil and River Sand Classification – Sample no 3

River sand content	MDD	MC	CBR	LL	PL	PI	% passing Sieve 200	Classification

%	g/m^3	%	Unsoaked %					AASHTO	USCS
0	1910	10.5	57	29	20	9	32	A- 2 -6	SC
10	1900	10.6	63	33	23	10	30	A- 2 – 6	SC
20	1920	11.2	73	2	23	9	29	A- 2 -4	SM
30	2040	10.8	84	30	18	12	26	A- 2 -4	SM
40	2110	10.8	108	6	22	4	24	A- 2 – 4	SM
50	1860	10.0	69	18	NIL	NIL	22	A- 1 – b	SM
60	1810	9.7	65	19	NIL	NIL	18	A -1 - b	SM
70	1920	11.8	81	17	NIL	NIL	18	A – 1 - b	SM

Table 9: Mkpok Residual Soil and River Sand Classification – Sample no 4

River sand content	MDD	OMC	CBR	LL	PL	PI	% passing Sieve 200	Classification	
%	Kg/m^3	%	Unsoaked %					AASHTO	USCS
0	1820	14.8	54	32	20	12	29	A- 2 -6	SC
10	1900	10.6	65	37	25	12	29	A- 2 – 6	SC
20	1840	10.4	75	23	15	8	28	A- 2 -4	SM
30	2040	7.6	88	28	20	8	22	A- 2 -4	SM
40	2030	9.6	113	18	NIL	NIL	25	A- 1 – b	SM
50	1960	10.6	80	20	NIL	NIL	25	A- 1 – b	SM

60	1900	6.7	66	14	NIL	NIL	16	A -1 - b	SM
70	1930	8.3	72	18	NIL	NIL	16	A – 1 - b	SM

Table 10: Unconfined Compressive Strength – Mk[pok Residual Soil and Lime-Sand Stabilization at 7- Days Curing Duration

Lime (%)	River Sand Content (%)	Age (days)	Compressive Strength (KPa)
Sample Location 1			
2	10	7	70
	20	7	76
	30	7	105
	40	7	110
	50	7	95
	60	7	98
4	10	7	101
	20	7	115
	30	7	142
	40	7	155
	50	7	165
	60	7	167
6	10	7	161
	20	7	190
	30	7	202
	40	7	210
	50	7	233
	60	7	245
8	10	7	257
	20	7	270
	30	7	281
	40	7	289

	50	7	300
	60	7	311

Table 11: Unconfined Compressive Strength - Mkpok Residual Soil and Lime-Sand Stabilization at 7-Days Curing Duration.

Lime Content (%)	River Sand Content (%)	Age (days)	Compressive Strength (KPa)
Sample Location 4			
2	10	7	70
	20	7	78
	30	7	107
	40	7	114
	50	7	120
	60	7	126
4	10	7	107
	20	7	127
	30	7	144
	40	7	155
	50	7	159
	60	7	169
6	10	7	117
	20	7	154
	30	7	159
	40	7	168
	50	7	200
	60	7	226
8	10	7	252
	20	7	273
	30	7	289
	40	7	309
	50	7	328

	60	7	345

Table 12: Unconfined Compressive Strength – Mkpok Residual Soil and Lime-Sand Stabilization at 28- Days Curing Duration.

Lime Content (%)	River Sand Content (%)	Age (days)	Compressive Strength (KPa)
Sample Location 1			
2	10	28	134
	20	28	148
	30	28	168
	40	28	176
	50	28	173
	60	28	153
4	10	28	170
	20	28	194
	30	28	199
	40	28	220
	50	28	251
	60	28	275
6	10	28	211
	20	28	228
	30	28	274
	40	28	298
	50	28	311
	60	28	329
8	10	28	350
	20	28	362
	30	28	376
	40	28	386
	50	28	396
	60	28	400

Table 13: Unconfined Compressive Strength – Mkpok Residual Soil and Lime-Sand Stabilization at 28- Days Curing Duration

Cement Content (%)	River Sand Content (%)	Age (days)	Compressive Strength (KPa)
Sample location 4			
2	10	28	142
	20	28	153
	30	28	167
	40	28	160
	50	28	136
	60	28	185
4	10	28	198
	20	28	201
	30	28	212
	40	28	222
	50	28	234
	60	28	223
6	10	28	252
	20	28	260
	30	28	268
	40	28	281
	50	28	323
	60	28	340
8	10	28	349
	20	28	356
	30	28	368
	40	28	386
	50	28	393
	60	28	408

V. DISCUSSION OF TEST RESULT

Table 1 presents the results of Mkpok residual soil at plain or unmodified condition. The CBR values obtained are relatively low, hence unsuitable for base course applications. Tables 2 to 5 show the results of Mkpok residual soil stabilized with lime. Significant appreciation in CBR values is observed ranging from a minimum of 72% to a maximum of 143%. The presentation incorporates both the plasticity limit as well as the grain-size distribution systems. The plasticity index (PI) classification provides a soil profile over depth with the probability of belonging to different soil types, which more realistically and continuously reflect the in-situ soil characterization which involves the variability of soil type. The grain-size distribution classification emphasizes certainty of behaviour.

Tables 6 to 9 show the results of Mkpok residual soil stabilized with river sand. The CBR values varied from a minimum of 54% to a maximum of 113%. On comparative basis the values of CBR obtained from lime stabilization appear higher than those derived from river sand stabilization. This could be attributed to pozzolanic contribution from lime which enhances particulate bonding hence increasing the shearing resistance to imposed stresses.

Tables 10 to 11 show the results of unconfined compressive strength tests of the lime-river sand composite for 7-days curing duration. The values obtained varied from 70KPa to 345KPa. Tables 12 to 13 show similar results for 28-days curing duration. The values obtained varied from 134KPa to 408KPa. A direct inference from the result is that the curing duration influences durability, hence strength propagation.

VI. MULTIPLE NONLINEAR REGRESSED MODELS

The essence of this feature is to develop optimization models for this stabilization experiments. Based on analysis and utilizing multiple nonlinear regressed programs some models were developed for Mkpok residual soil with lime and river sand at various levels of stabilization. The models aid in prediction and optimization of what values of independent variables will generate the maximum or minimum dependent variable.

$$CBR_{[1]} = 77.756 - .356L + .687D + .379M - .407L^2 - .271D^2 + .031M^2 + 1.699LD + .157LM + .134DM \qquad 1.1$$

Where L =lime content [%], D = Maximum dry density [kg/m^3], M = Optimum moisture content [%]

$$CBR_{[2]} = 27.502 - .226L + .695D + .409M + .115L^2 - .366D^2 + .302M^2 + .894LD + .392LM + .238DM \qquad 1.2$$

Where L =lime content [%], D = Maximum dry density [kg/m^3], M = Optimum moisture content [%]

$$CBR_{[3]} = 13.662 + .417S - .414D + .484M - .054S^2 - .197D^2 + .308M^2 + .195SD + .044SM - .211DM \qquad 1.3$$

Where S =river sand content [%], D = Maximum dry density [kg/m^3], M = Optimum moisture content [%]

$$CBR_{[4]} = 47.991 - .705S + .851D + .141M + .045S^2 - .373D^2 + .186M^2 + .302SD + .136SM - .498DM \qquad 1.4$$

Where S =river sand content [%], D = Maximum dry density [kg/m^3], M = Optimum moisture content [%]

$$UCS_{[7]} = 9.449 + .524L + .231S + .936T + .825L^2 + .317S^2 - .179T^2 - .067LS - .311LT + .046ST \qquad 1.5$$

Where L =lime content [%], S= river sand content [%], T = Curing duration [days]

$$UCS_{[28]} = 28.488 + .869L + .403S + .411T + .185L^2 + .131S^2 - .179T^2 - .067LS - .311LT + .046ST \qquad 1.6$$

Table 14: Multiple Regressed Variables for Measured and Computed CBR Values - Residual Soil and Lime Stabilization – Sample Location 1

Sample no.1				
Lime Content (%)	MDD (kg/m^3)	OMC (%)	Measured CBR (%)	Computed CBR (%)
2	1.94	8.2	72	92.220
4	2.1	8.9	90	98.261
6	0.199	8.5	103	76.817
8	1.98	8.5	96	94.462
10	1.98	8.2	108	87.676

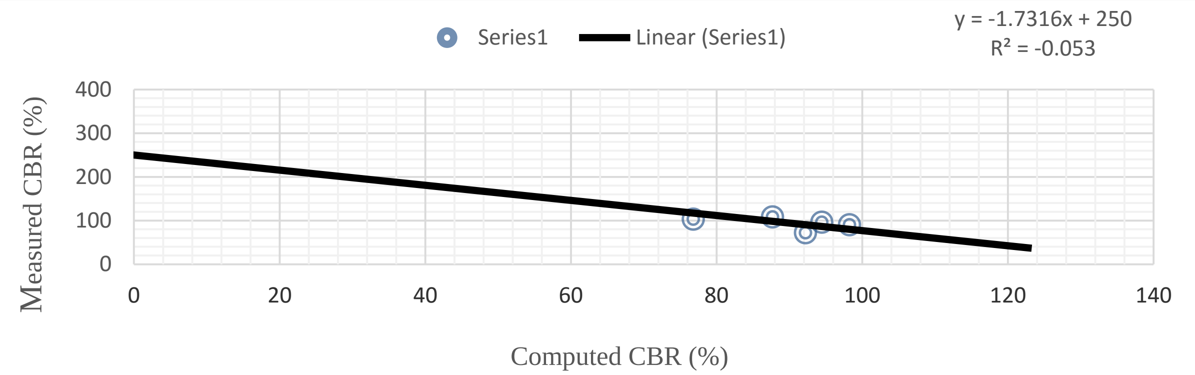

Fig1: Cross Plot of Measured Vs Computed CBR Values Using Equation 1.1

Table 15: Multiple Regressed Variables for Measured and Computed CBR Values - Residual Soil and Lime Stabilization - Sample Location 2

Sample no.2				
Lime Content (%)	MDD (kg/m^3)	OMC (%)	Measured CBR (%)	Computed CBR (%)
2	1.82	12.4	78	97.417
4	1.96	11.5	90	103.443
6	2.01	15	96	157.527
8	2.02	14.8	108	173.143
10	2.03	12.1	116	157.236

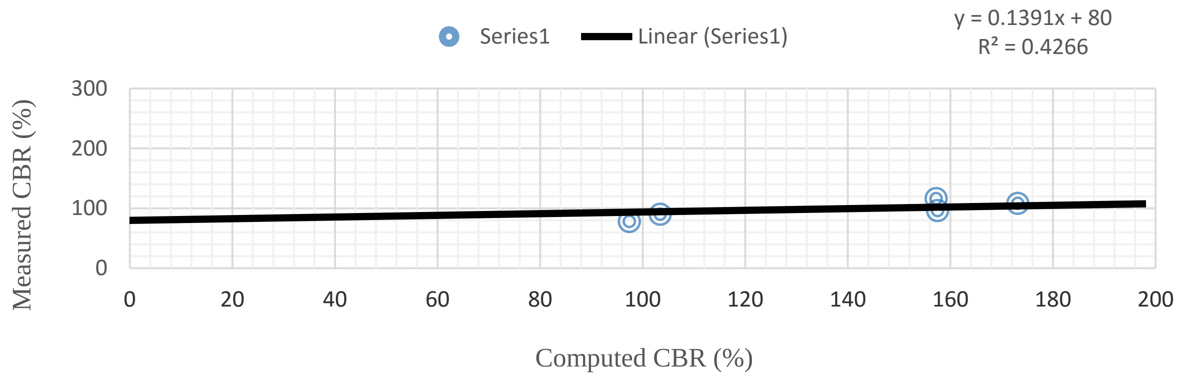

Fig 2: Cross Plot of Measured Vs Computed CBR Values Using Equation 1.2

Table 16: Multiple Regressed Variables for Measured and Computed CBR Values - Residual Soil and River Sand Stabilization - Sample Location 3

Sample no.3				
River sand Content (%)	MDD (kg/m^3)	OMC (%)	Measured CBR (%)	Computed CBR (%)
10	1.9	10.6	63	54.791
20	1.92	11.2	73	55.744
30	2.04	10.8	84	38.601
40	2.11	10.8	108	14.001
50	1.86	10	69	-30.089
60	1.81	9.7	65	-80.358
70	1.92	11.8	81	-116.900

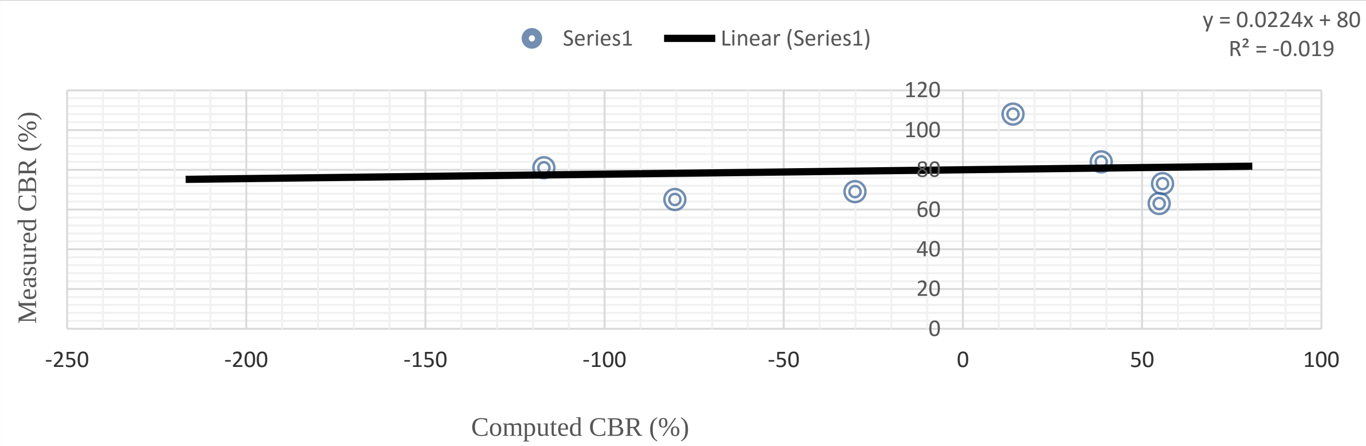

Fig.3: Cross Plot of Measured Vs Computed CBR Values Using Equation 1.3

Table 17: Multiple Regressed Variables for Measured and Computed CBR Values - Residual Soil and River Sand Stabilization - Sample Location 4

Sample no.4

River sand Content (%)	MDD (kg/m^3)	OMC (%)	Measured CBR (%)	Computed CBR (%)
10	1.9	10.6	65	78.229
20	1.84	10.4	75	103.650
30	2.04	7.6	88	121.109
40	2.03	9.6	113	177.518
50	1.96	10.6	80	239.199
60	1.9	6.7	66	260.016
70	1.93	8.3	72	345.217

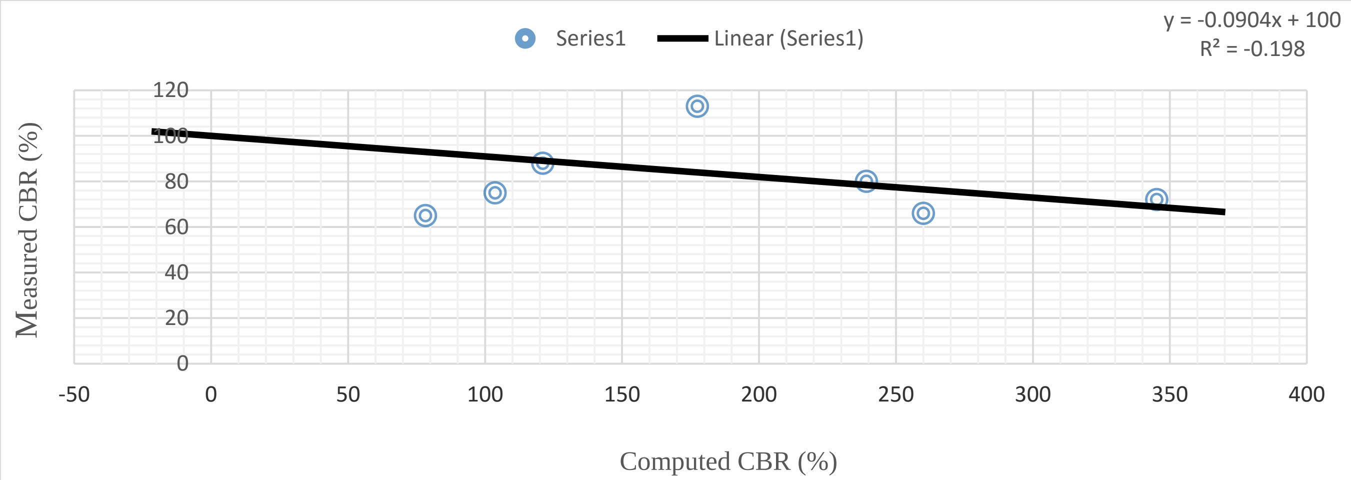

Fig 4: Cross Plot of Measured Vs Computed CBR Values Using Equation 1.4

Table 18: Multiple Regressed Variables for Measured and Computed UCS Values - Lime and River Sand Stabilization - 7 days Curing – Sample Location 1

Sample location 1				
Lime Content (%)	River sand Content (%)	Duration (days)	Measured UCS (KPa)	Computed UCS (KPa)
2	10	7	70	43.114
2	20	7	76	142.404
2	30	7	105	305.094
2	40	7	110	531.184
4	10	7	101	48.368
4	20	7	115	146.318
4	30	7	142	307.668
4	40	7	155	532.418
6	10	7	161	60.222
6	20	7	190	156.832
6	30	7	202	316.842

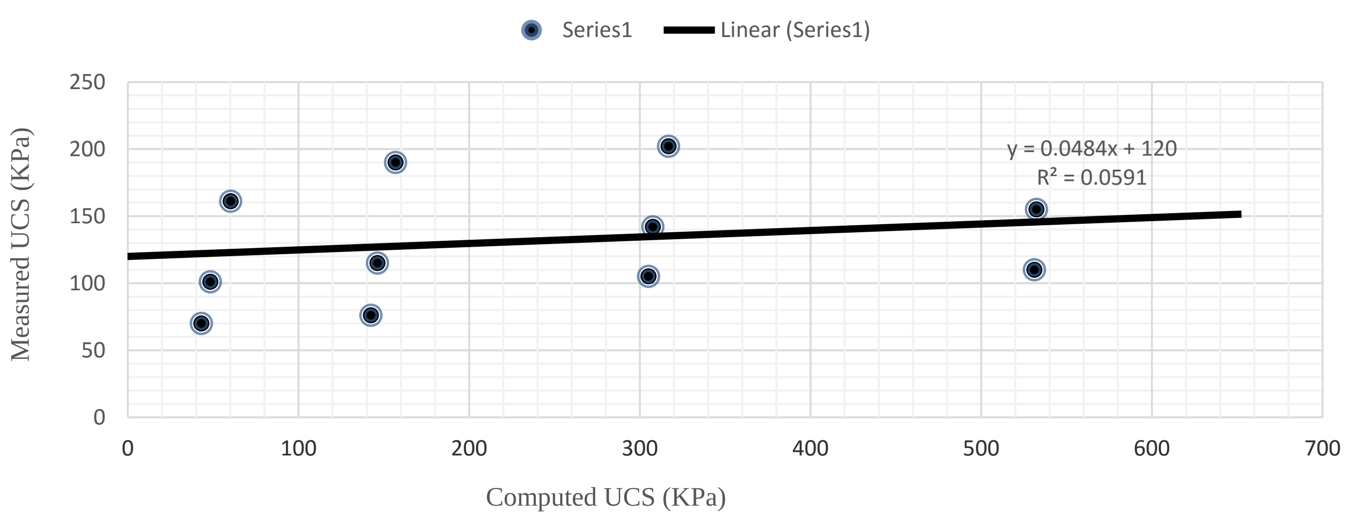

Fig. 5: Cross Plot of Measured Vs Computed UCS Values Using Equation 1.5

Table 18: Multiple Regressed Variables for Measured and Computed CBR Values- Lime and River Sand Stabilization - 28 days Curing – Sample Location 1

Sample location 1				
Lime Content (%)	River sand Content (%)	Duration (days)	Measured UCS (KPa)	Computed UCS (KPa)
2	10	28	134	-86.608
2	20	28	148	-31.738
2	30	28	168	49.332
2	40	28	176	156.602
4	10	28	170	-101.406
4	20	28	194	-47.876
4	30	28	199	31.854
4	40	28	220	137.784
6	10	28	211	-114.724
6	20	28	228	-62.534
6	30	28	274	15.856

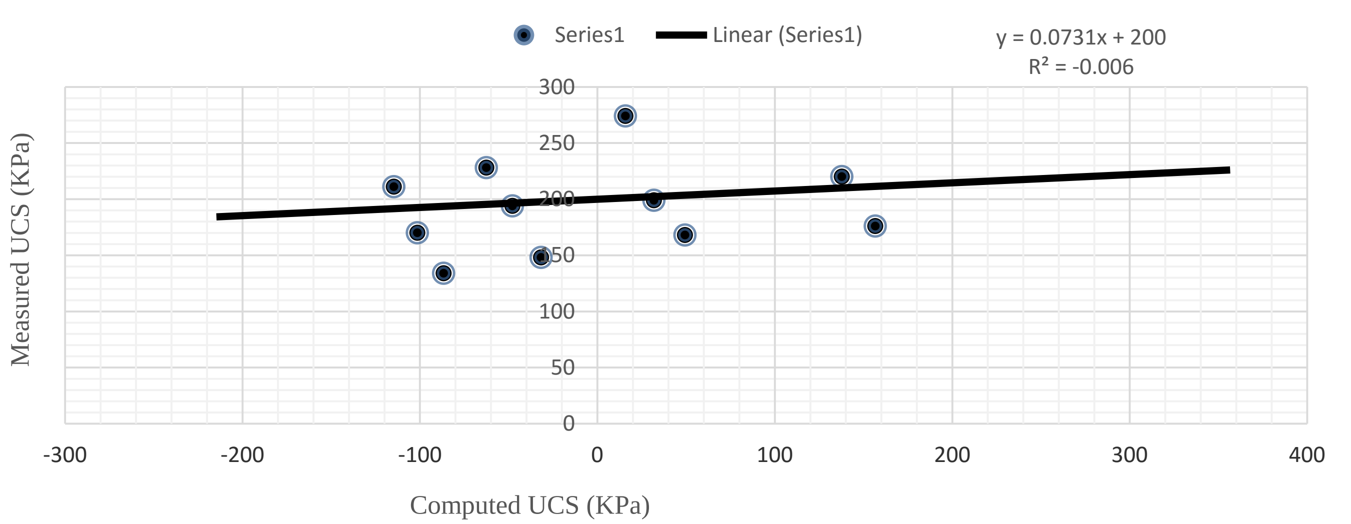

Fig. 6: Cross Plot of Measured Vs Computed UCS Values Using Equation 1.6

VII. CONCLUSION

Tables 14 and 15 present the multiple regressed variables for measured and computed CBR values using equations 1.1 and 1.2 utilizing lime stabilization. The values derived varied from 78% to 116% and 97% to 157% respectively. Tables 16 and 17 show the multiple regressed variables for measured and computed CBR values using equations 1.3 and 1.4 with river sand stabilization. The values varied from 65% to 113% and 78% to 117% at 40% river sand stabilization.

Tables 18 and 19 present the multiple regressed variables for measured and computed UCS values using equations 1.5 and 1.6 with a combination of lime-river sand stabilization. The values derived varied from 70KPa to 202KPa and 43KPa to 316KPa for 7 days curing duration. For the 28 days curing duration the values varied from 134KPa to 274KPa and 86KPa to 156KPa for measured and computed values respectively.

The models 1.2, 1.4, and 1.5 are considered adequate for this research. The models 1.1, 1.3 and 1.6 tend to generate lower and negative variables and therefore could be ignored.

From the stabilization experiments, it appears plausible to recommend 40% river sand stabilization with CBR values ranging from 78% to 117% compared to 10% lime stabilization with CBR values ranging from 78% to 116%. The recommendation is predicated on technical adequacy and economic consideration.

The reliability and accuracy of the models were checked by comparing the measured and computed CBR and UCS values and computing the correlation coefficients. Figures I to VI illustrate these values based on nonlinear regressed models. The straight line in the figure represents the line of perfect equality where the measured and computed values are exactly equal. The R^2 at 95% confidence intervals are shown on the plots. These values are statistically significant and suggest compatibility of the measured and computed values of both CBR and UCS for Mkpok residual soil stabilization.

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