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Characterization and Model Prediction of CBR Parameters of Stabilized Ebidang Residual Soils, Akwa Ibom State, Nigeria.

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***Abstract*:** Quarry dust and cement stabilization of Ebidang residual soils were essentially designed to improve the engineering properties and to ascertain structural behaviour on engineering applications. The major goal of treating a residual soil is to increase the shear strength and loading capacity. The laboratory stabilization experiments involved four different soil samples from four distinct borrow pits. Quarry dust content varied from 10% to70% and complemented by residual soil which content varied from 90% to 30% respectively. CBR results obtained ranged from 55% to 107%.Conversely cement content utilized ranged from 2% to 10% and the residual soil content varied from 98% to 90% respectively. The CBR values obtained ranged from 56% to 127%. From the results cement stabilization tends to generate optimal values of CBR as compared to quarry dust stabilization. The contribution of hydrated calcium silicates [$C_2SHx.C_3S_2H_X$] and calcium aluminates [$C_2AH_X.C_4AH_X$] in cement tend to increase the bonding between particulate structures resulting in plasticity reduction hence gaining in strength propagation. Finally multiple non-regressed models were developed to aid prediction and optimization of CBR parameters of Ebidang residual soils at various levels of physical and chemical stabilizations.

Keywords: Quarry Dust, Cement, Residual Soil, Stabilization.

I Introduction

The soil investigation was carried out along Ikot Ebidang, Onna in Akwa Ibom State, Nigeria. The exercise was for the proposed Ebidang-Ebekpo road; a seven kilometres stretch for the purpose of designing appropriate pavement system to aid transportation and economical movement of goods and services. The investigation was aimed at studying the geotechnical properties of the soil in order to provide appropriate data for the design processes and recommend acceptable fill materials during the construction activity. The topography of Ebidang area is basically undulating and covered by granitic residual soils. Residual soils are heterogeneous due to variable weathering of the jointed rock mass [1][Thurairajah, et.al. 1992]. During high peaked rainfall water logs and muddy pools are found along certain portions of the route location. The soils are unique in formation, pleasing in appearance and deceptive in engineering applications. Stabilization is an improvement process designed to achieve a relatively higher shearing resistance, loading capacity, stability and settlement in soils applied for engineering purposes. Quarry dust as a stabilizer will provide sufficient fines to fill the voids thus giving a compact and high load bearing capacity. In all practical cases, the primary ingredient necessary for stabilizing soils is calcium [% of cement]. In addition to plasticity reduction, Portland cement, by its inherent nature of producing strength, developing hydration products, provides improved strength and durability. Therefore the effectiveness of stabilization is based on the number of positions of exchangeable ions – mineralogical composition which is related to liquid limit and the amount of liberated calcium ions from cement [% of cement, % of compaction and curing time] which influences the durability [bonding effect].

II Materials Selected

2.1 Ebidang Residual Soil

Samples of residual soils selected for this research were dug with shovels from four distinct borrow-pits along the proposed road at kilometres 1+500, 2+750, 4+250 and 6+750 respectively. The soil samples were disturbed and at depths varying from 3.0 meters to 5.0 meters of the profile. The samples were excavated bearing in mind the variability of residual soil in its natural composition. Hence the soil samples were excavated both vertically and laterally and thoroughly blended. The samples were conveyed in four, 50kg nylon bags, carefully tagged for identification purpose and transported to the Mothercat Limited, Materials Testing Laboratory at Uyo. The samples and locations are as itemized below:

Sample Identification	Location
1	km 1+500 Ebidang-Ebekpo Road
2	km 2+750 Ebidang-Ebekpo Road
3	km 4+250 Ebidang-Ebekpo Road
4	km 6+750 Ebidang-Ebekpo Road

2.2 Quarry Dust

The quarry dust used in this experiment came from the limestone quarry factory in Akamkpa, Cross River State. This is the by-product or sediments derived from the crushing of limestone. This soil modifying agent has a high percentage of fines, and its application as stabilizer will increase the bonding characteristics of the composite material thereby increasing the shearing resistance of the residual soil.

2.3 Ordinary Portland Cement

Soils most suitable for cement stabilization are mixtures of sand and gravel of good grade, and with less than 10% fines passing 75mm sieve and with coefficient of uniformity of not less than 5. Any type of cement can be used to stabilize soil, but the most commonly used is the ordinary Portland cement. The presence of organic and sulphate materials inside the soil is generally believed to prevent the cement from hardening. The curing time [time of reactions provided by cation exchange and flocculation processes] plays a vital role in the development of efficient cement-stabilization [2][Stavridakis, 2006]. The lower strength and durability of clay soils stabilized by cement, after soaking in water (environmental condition of wetting) are attributed to the higher water absorbing capacity of the active clay fraction. Cement which is mixed with soil is hydrated, turning into the well-known hydrated compounds if water content is enough. The main hydration products are silicates and calcium hydrate aluminates and hydrated lime which deposits form a separate crystal solid phase. When the pore water of the soil encounters with cement, hydration of the cement occurs rapidly and the major hydration (primary cementations) produces hydrated calcium silicate (C_2SHx, C_4AHx) and hydrated lime $Ca(OH)_2$ [3][Bergado, et.al.1996].Therefore the effectiveness of stabilization is based on the time (curing-soaking time) of reactions provided by cat-ion exchange and flocculation processes.

III Preparation and Testing of Samples

3.1 Gradation Test

The samples were air-dried for three weeks. The next step was to sieve through 20mm diameter sieve and any particle retained was broken with rubber hammer or thrown away. With the aid of a riffle box the quantity of material needed or five hundred grams each of the soil samples were extracted and poured into sieve no.200 or 0.075mm diameter sieve and thoroughly washed to remove all clayey materials finer than the 0.075mm diameter. The particles retained were oven-dried, weighed and mechanically sieved in a shaker.

3.2 Liquid Limit Test

The air-dried samples were quantified through a sample divider – the riffle box – and sieved through 425μm test sieve. 50g of material passing through this sieve was used for the liquid limit test. The sample was put in a flat glass plate, moisturized and thoroughly mixed with a spatula to a thick homogeneous paste. The paste was preserved in air-tight polythene sack for 24 hours to allow water permeate the entire sample, devoid of moisture evaporation. It was then put back into the glass plate and properly mixed for 15 minutes. Finally the paste was then put into the Casagrande liquid limit apparatus, grooved to V-shape as per specification, to determine the number of blows that will be required to bring the two parts into contact. The range of blows varied from 10-15, 15-20, 21-30, and 31-40 and for various moisture contents.

3.3 Plastic Limit Test

Sixty grams of samples passing the 425μm test sieve was moisturized and thoroughly mixed in the glass plate until it becomes homogeneous and plastic, enough to be shaped into a ball. The ball was then rolled between the palms of the hand, until the heat of hands dried the sample sufficiently for slight cracks to appear on its surface. It was then rolled continuously forward and backward in between the finger and glass plate until the pressure was sufficient to reduce the diameter of the thread to about 3mm. The procedure was repeated until the thread sheared (crumbled) both longitudinally and transversely. This test determines the lowest moisture content at which the soil is plastic.

3.4 Plain Mechanical Compaction

The Modified Proctor compaction tests were conducted for each of the samples. 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 sixty minutes 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 in the CBR mould and values for the plain mechanical compaction were read for both top and bottom at various depths of penetration. This test was conducted to determine the mass of dry soil per cubic meter and the soil was compacted in a specified manner over a range of moisture contents.

3.5 Quarry Dust Stabilization Tests

Different percentages of quarry dust varying from 10%, 20%, 30%, 40%. 50%, 60% and 70% were added to air-dried samples 1, 2, 3 and 4. Each of the test samples was thoroughly blended with a trowel, divided into five parts with the aid of a riffle box, moisturized and weighed. Thereafter the Modified Proctor compaction test was carried out to determine the OMC and MDD. Liquid limit and plastic limit tests were conducted on each of the samples. Based on the OMC and MDD results, CBR tests were then conducted on each specimen following five equal layers of compaction with 4.5kg rammer at 61 blows each falling over 450mm height to the top of the mould. Equally the quarry dust content was varied from 10% to 70% corresponding to the OMC and MDD derived from the compacted tests.

3.6 Ordinary Portland Cement Stabilization Tests.

The cement proportions used varied from 2%, 4%, 6%, 8% to 10% by weight of the air-dried residual soil samples. The four soil samples 1, 2, 3 and 4 were deployed for the experiment. Correspondingly each sample of the residual soil varied from 98%, 96%, 94%, 92% to 90% of the cement proportions. The mixture was thoroughly blended and a 6000g of each was divided into five equal parts and subjected to the Modified Proctor compaction tests. Liquid limit and plastic limit tests were similarly conducted. With the optimum moisture content (OMC) and maximum dry density (MDD) values obtained, three CBR specimens were prepared at each cement content. One specimen was inserted into the CBR machine and penetration reading carried out to establish a base line. The remaining two specimens were wax cured for 6 days. The specimens were then soaked for 24 hours by complete immersion in water and allowed to drain for 15 minutes.

3.7 California Bearing Ratio Tests

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 11 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 six days and thereafter soaked for 24 hours and allowed to drain for 15 minutes. After testing in CBR machine, the average of the two readings was adopted.

V Presentation of Test Results

Table 1. Ebidang Soil Compaction at Plain Condition

Sample No	MDD Kg/m^3	NMC %	unsoaked CBR %	Fines %
1	1970	24.6	18	34.6
2	1960	22.9	17	32.4
3	1830	23.9	17	33.8

4	1820	24.1	16	34.4

Table 2: Ebidang Residual Soil and Quarry Dust Stabilization Sample No. 1

Quarry dust Content	MDD	OMC	CBR	LL	PL	PI	% passing Sieve 200	Classification	
%	Kg/m^3	%	Unsoaked %					AASHTO	USCS
0	1970	16.5	18	34	22	12	34	A- 2 -6	SC
10	1980	22.4	55	31	21	10	26	A- 2 - 5	SM
20	2010	22	61	29	20	9	24	A- 2 -5	SM
30	2020	21	98	29	19	10	25	A- 2 -4	SM
40	2030	25	140	28	19	9	23	A- 2 – 4	SM
50	1910	16	151	21	15	8	30	A- 1 – b	SM
60	1950	15	64	19	NIL	NIL	19	A -1 - b	SM
70	1830	15.3	43	17	NIL	NIL	15	A – 1 - b	SM

Table 3: Ebidang Residual Soil and Quarry Dust Stabilization Sample No. 2

Quarry dust content	MDD	OMC	CBR	LL	PL	PI	% passing Sieve 200	Classification	
%	Kg/m^3	%	Unsoaked %					AASHTO	USCS
0	1960	17.6	17	29	19	10	32	A- 2 -6	SC
10	1920	18.5	58	34	25	9	30	A- 2 – 4	SM
20	1980	18.8	67	30	18	12	27	A- 2 -5	SM
30	2010	17.6	80	28	21	7	24	A- 2 -6	SC
40	2060	18.3	91	27	20	7	21	A- 2 – 7	SC
50	1920	17.1	101	25	21	4	22	A- 1 – b	SM
60	1820	18.7	61	20	NIL	NIL	25	A -1 - b	SM
70	1840	17.0	49	17	NIL	NIL	16		SM

Table 4: Ebidang Residual Soil and Quarry Dust Stabilization Sample No. 3

Quarry dust content	MDD	OMC	CBR	LL	PL	PI	% passing Sieve 200	Classification	
%	g/m^3	%	Unsoaked %					AASHTO	USCS
0	1830	23.9	32	35	24	11	31	A- 2 -6	SC
10	2010	21.6	56	28	18	10	30	A- 2 – 6	SC
20	1940	18.2	65	26	17	9	29	A- 2 -4	SM
30	2050	17.8	81	30	18	12	26	A- 2 -4	SM
40	2110	18.6	98	26	22	4	24	A- 2 – 4	SM
50	1950	16.0	75	28	23	4	22	A- 1 – b	SM
60	1900	9.7	68	19	NIL	NIL	18	A -1 - b	SM
70	1930	11.8	83	17	NIL	NIL	18	A – 1 - b	SM

Table 5: Ebidang Residual Soil and Quarry Dust Stabilization Sample No. 4

Quarry dust content	MDD	OMC	CBR	LL	PL	PI	% passing Sieve 200	Classification	
%	Kg/m^3	%	Unsoaked %					AASHTO	USCS

0	1820	24.8	16	34	20	14	23	A- 2 -6	SC
10	1980	20.6	57	27	15	12	25	A- 2 – 6	SC
20	1930	18.4	68	23	15	8	27	A- 2 -4	SM
30	2050	17.6	80	28	20	8	23	A- 2 -4	SM
40	2120	16.6	95	18	10	8	25	A- 1 – b	SM
50	1950	15.6	107	17	10	7	25	A- 1 – b	SM
60	1880	14.7	88	14	NIL	NIL	16	A -1 - b	SM
70	1910	8.3	72	18	NIL	NIL	16	A – 1 - b	SM

Table 6: Ebidang Residual Soil and Cement Stabilization Sample No. 1

Cement content	MDD	OMC	soaked CBR	LL	PL	PI	% passing Sieve 200	Classification	
%	Kg/m^3	%	%					AASHTO	USCS
0	1970	24.6	18	33	17	16	34	A- 2 - 4	SM
2	1980	22.2	56	28	20	8	39	A- 2 - 4	SM
4	1990	19.2	69	28	21	7	40	A- 2 - 4	SM
6	2030	17.8	81	27	22	5	41	A- 2 - 4	SM
8	2040	13.1	90	23	19	4	43	A- 2 – 4	SM

10	2050	12.1	111	18	NIL	NIL	43	A- 2 - 4	SM

Table 7: Ebidang Residual Soil and Cement Stabilization Sample No.2

Cement content	MDD	OMC	soaked CBR	LL	PL	PI	% passing Sieve 200	Classification	
%	Kg/m^3	%	%					AASHTO	USCS
0	1960	17.6	34	28	24	4	34	A- 2 - 4	SM
2	2030	16.4	61	23	16	9	33	A- 2 - 4	SM
4	2120	15.1	80	22	16	6	33	A- 2 - 4	SM
6	2030	14.8	83	21	15	6	31	A- 2 - 4	SM
8	2060	13.2	91	18	12	6	30	A – 2 - 4	SM
10	2060	11.4	101	16	NIL	NIL	27	A – 2 - 4	SM

Table 8: Ebidang Residual Soil and Cement Stabilization Sample No.3

Cement content	MDD	OMC	soaked CBR	LL	PL	PI	% passing Sieve 200	Classification	
%	Kg/m^3	%	%					AASHTO	USCS
0	1830	23.9	32	30	22	10	24	A- 2 - 4	SM

2	2110	20.2	76	29	20	9	27	A- 2 - 4	SM
4	2050	18.8	78	28	20	8	30	A- 2 - 4	SM
6	2040	16.3	83	27	20	7	32	A- 2 - 4	SM
8	2050	15.7	95	27	22	5	30	A- 2 – 4	SM
10	2050	15.2	113	18	NIL	NIL	32	A- 2 - 4	SM

Table 9: Ebidang Residual Soil and Cement Stabilization Sample No.4

Cement content	MDD	OMC	soaked CBR	LL	PL	PI	% passing Sieve 200	Classification	
%	Kg/m^3	%	%					AASHTO	USCS
0	1820	24.1	18	28	20	8	35	A- 2 - 4	SM
2	2130	14.2	76	30	20	12	26	A- 2 - 4	SM
4	2050	13.9	86	28	20	8	27	A- 2 - 4	SM
6	2060	12.5	116	29	21	8	30	A- 2 - 4	SM
8	2060	14.8	127	26	21	5	30	A- 2 – 4	SM
10	2340	13.2	124	18	NIL	NIL	33	A- 2 - 4	SM

V Discussion of Test Results

Table 1 presents the result of Ebidang residual soil compaction devoid of any modifier. From the results the MDD varies from 1820kg/m^3 to 1970kg/m^3 within the four locations. The NMC fluctuates from 22.9% to 24.6%. The CBR varies from 16% to 18% while the fines content fluctuates between 32.4% and 34.6%.

Tables 2 to 5 present the results of quarry dust stabilized Ebidang residual soils from the four distinct borrow pits. The classification method adopted utilizes both the grading size distribution system as well as the plasticity-limit based systems. The grading or grain-size distribution classification emphasizes the certainty of behaviour. The plasticity index 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. From all the samples and with the deployment of 10% quarry dust and 90% residual soil content, the resultant MDD and CBR values are 1980kg/m^3,1920kg/m^3,2010kg/m^3,1980kg/m^3 and 55%,58%,56%,57% respectively. With an increase in quarry dust content to 30% and residual soil content to 70%, the resultant MDD and CBR values are 2020kg/m^3, 2010kg/m^3, 2050kg/m^3,2050kg/m^3 and 98%, 80%, 81%, 80% respectively.

Tables 6 to 9 present the results of Ebidang residual soil and cement stabilization. From the results it is observed that with a 2% cement content and 98% residual soil, the MDD and CBR values generated from the four samples are 1980kg/m^3, 2030kg/m^3, 2110kg/m^3, 2130kg/m^3 and 56%, 61%, 76%, 76% respectively. A further increase in cement content to 4% revealed MDD and CBR values as 1990kg/m^3, 2120kg/m^3, 2050kg/m^3, 2050kg/m^3 and 69%, 80%, 78%, 86% respectively. In a nutshell increase in cement content from 2% to 8% appreciates both the MDD and CBR values. However above 8% the samples are observed to be devoid of plasticity hence less useful in engineering applications.

VI Multiple Non-Linear Regressed Models

Utilizing multiple non-linear regressed programs the following models were developed for evaluating CBR parameters of Ebidang residual soils at various levels of stabilization with quarry dust and Portland cement. The models are developed for the purposes of prediction and optimization to determine for what values of the independent variables the dependent variable will be a maximum or minimum.

$CBR_{(Q1)} = 25.269 - .384Q + 1.033D + 1.452M - .O29Q^2 – 5.766D^2 - .086M^2 + .311QD + .251QM + .815DM$……………………………………………1.1

Where Q = quarry dust content (%), D = maximum dry density (Mg/m^3), M = optimum moisture content (%).

$CBR_{(Q2)} = 49.719 – 1.514Q + 8.833D + .927M - .034Q^2 – 4.589D^2 -.027M^2 + .969QD +.194QM - .484DM$……………………………………………1.2

Where Q = quarry dust content (%), D = maximum dry density (Mg/m^3), M = optimum moisture content (%).

$CBR_{(C1)} = 42.534 – 4.171C + 1.557D + 1.211M - .893C^2 - .871D^2 +.199M^2 + .207CD + .442CM + .881DM$……………………………………………1.3

Where C = cement content (%), D = maximum dry density (Mg/m^3), M = optimum moisture content (%).

$CBR_{(C2)}$ = 75.451 – 2.375C + 3.431D + .446M - .181C^2 –1.661D^2 +.011M^2 +.952CD + .271CM + .224DM……………………………………………….1.4

Where C = cement content (%), D = maximum dry density (Mg/m^3), M = optimum moisture content (%).

Table 10: Multiple Regressed Variables for Measured and Computed CBR Values –Ebidang Residual Soil and Quarry Dust Stabilization – Sample no 1 & 2

Sample No.1 & 2				
Quarry Dust Content (%)	MDD (kg/m^3)	OMC (%)	MEASURED CBR (%)	COMPUTED CBR (%)
10	1.98	22.4	55	85.871
20	2.01	22	61	134.072
30	2.02	21	98	170.323
40	2.03	25	140	242.009
50	1.91	16	151	171.130
60	1.95	15	64	166.474
70	1.83	15.3	43	172.433
10	1.92	12.5	58	60.875
20	1.98	12.8	67	87.152
30	2.01	11.6	80	96.805
40	2.06	8.3	91	70.189
50	1.92	11.1	101	106.348
60	1.82	11.7	61	113.343
70	1.84	12	49	112.600

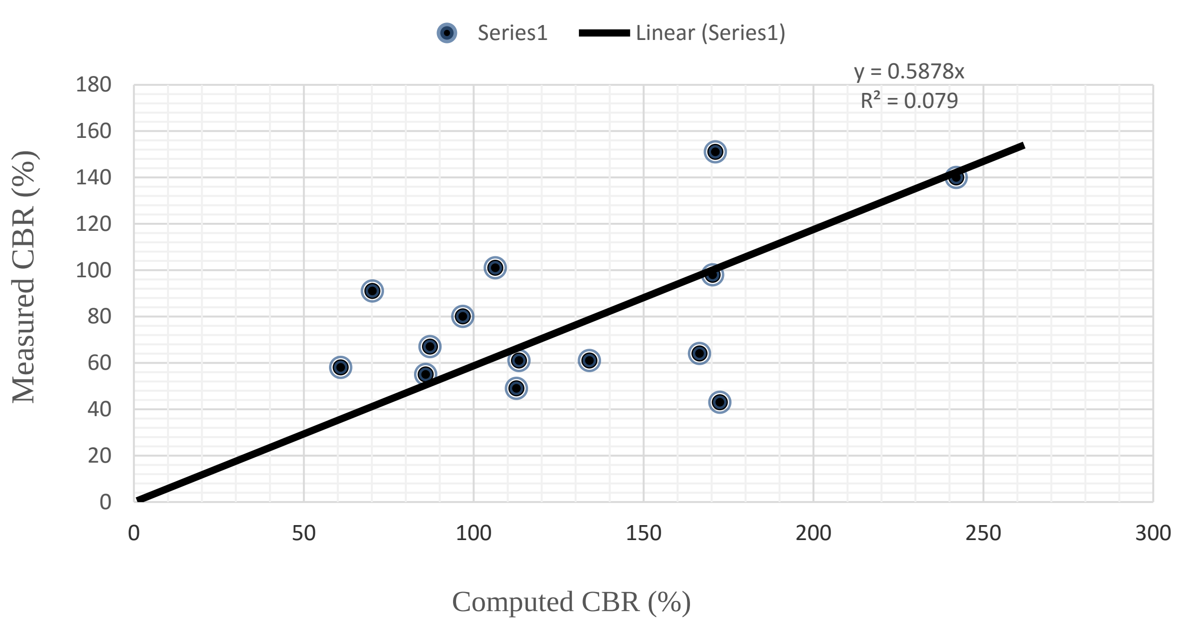

Fig I: Ebidang residual soil and quarry dust stabilization (sample no.1&2)

Table 11: Multiple Regressed Variables for Measured and Computed CBR Values –Ebidang Residual Soil and Quarry Dust Stabilization – Sample no 3 & 4

Sample No. 3 & 4				
Quarry Dust Content (%)	MDD (kg/m^3)	OMC (%)	Measured CBR (%)	Computed CBR (%)
10	2.01	17.6	56	74.844
20	1.94	15.2	65	95.857
30	2.05	14.8	81	111.372
40	2.11	12.6	98	107.052
50	1.95	10	75	77.403
60	1.9	9.7	68	57.601
70	1.93	11.8	83	64.406
10	1.98	20.6	57	77.725
20	1.93	18.4	68	105.316
30	2.05	7.6	80	74.292
40	2.12	9.6	95	86.088
50	1.95	10.6	107	82.879
60	1.88	6.7	88	23.059
70	1.91	8.3	72	17.699

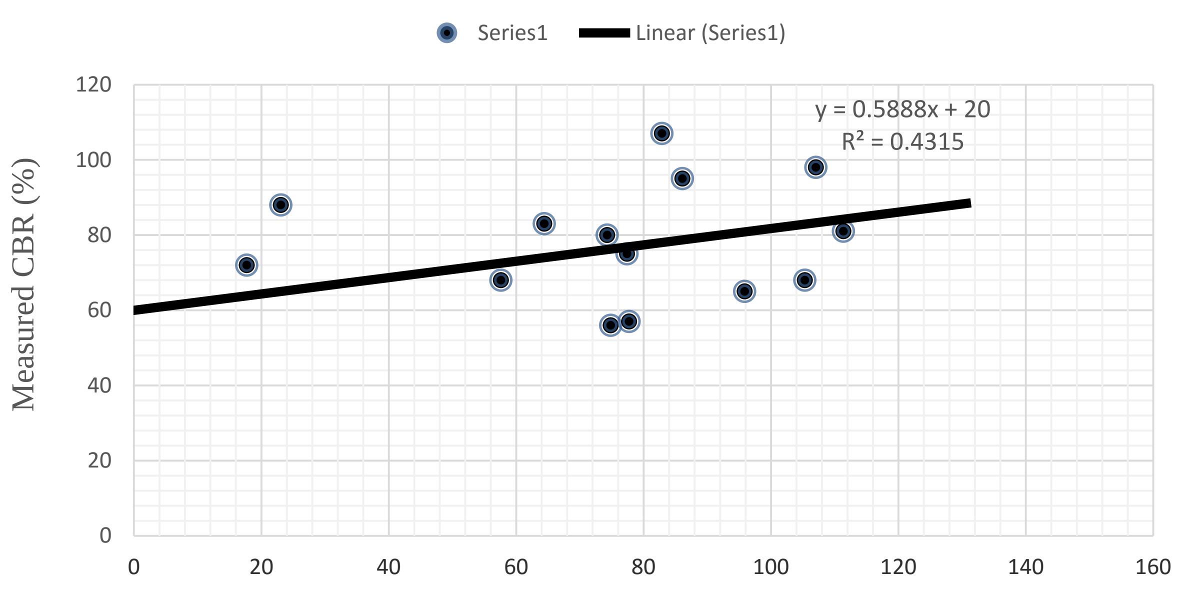

Fig.II: Ebidang residual soil and quarry dust stabilization (sample no.3&4)

Table 12: Multiple Regressed Variables for Measured and Computed CBR Values –Ebidang Residual Soil and cement Stabilization – Sample no 1 & 2

Sample No.1 & 2				
Cement Content (%)	MDD (kg/m^3)	OMC (%)	Measured CBR (%)	Computed CBR (%)
2	1.98	10.2	56	90.974
4	1.99	12.2	69	100.211
6	2.03	12.8	81	92.395
8	2.04	13.1	90	74.824
10	2.05	14.1	111	59.725
2	2.03	13.4	61	118.802
4	2.12	13.1	80	110.346
6	2.03	12.8	83	92.395
8	2.06	11.2	91	53.392
10	2.06	11.4	101	26.044

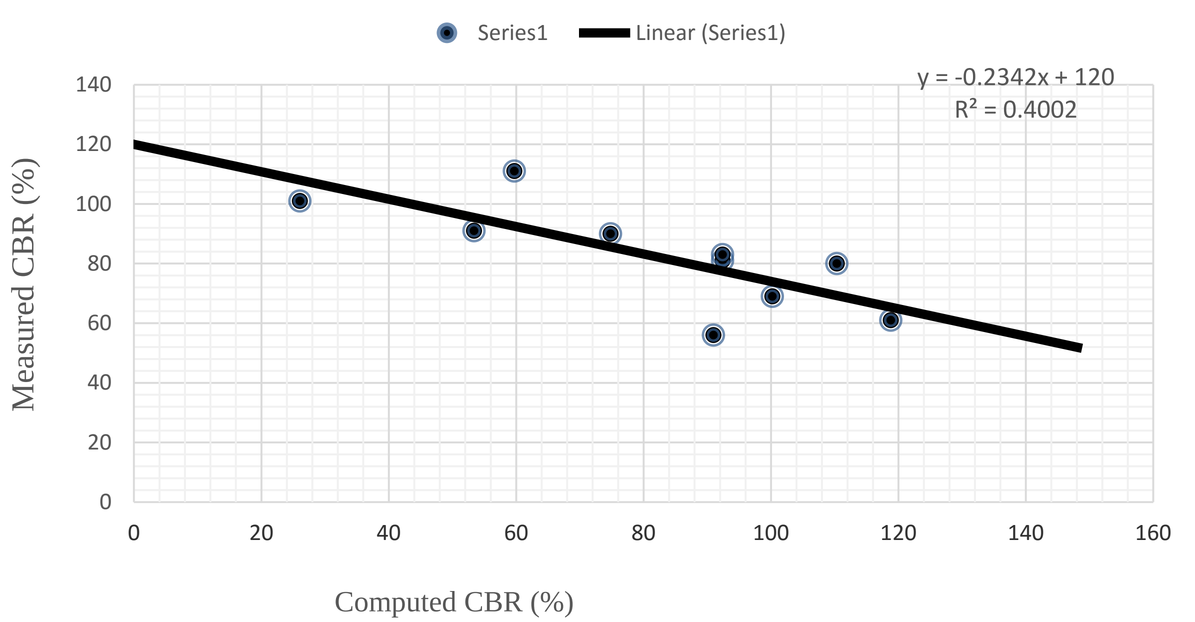

Fig.III: Ebidang residual soil and cement stabilization (sample no.1&2)

Table 13: Multiple Regressed Variables for Measured and Computed CBR Values –Ebidang Residual Soil and Cement Stabilization – Sample no 3 & 4

Sample No.3 & 4				
Cement Content (%)	MDD (kg/m^3)	OMC (%)	Measured CBR (%)	Computed CBR (%)
2	2.11	12.2	76	93.296
4	2.05	14.8	78	102.764
6	2.04	11.3	83	96.406
8	2.05	15.7	95	111.494
10	2.05	15.2	113	110.663
2	2.13	14.2	76	96.828
4	2.05	13.9	86	100.690
6	2.06	12.5	116	99.858
8	2.06	14.8	127	108.501
10	2.34	13.2	124	105.306

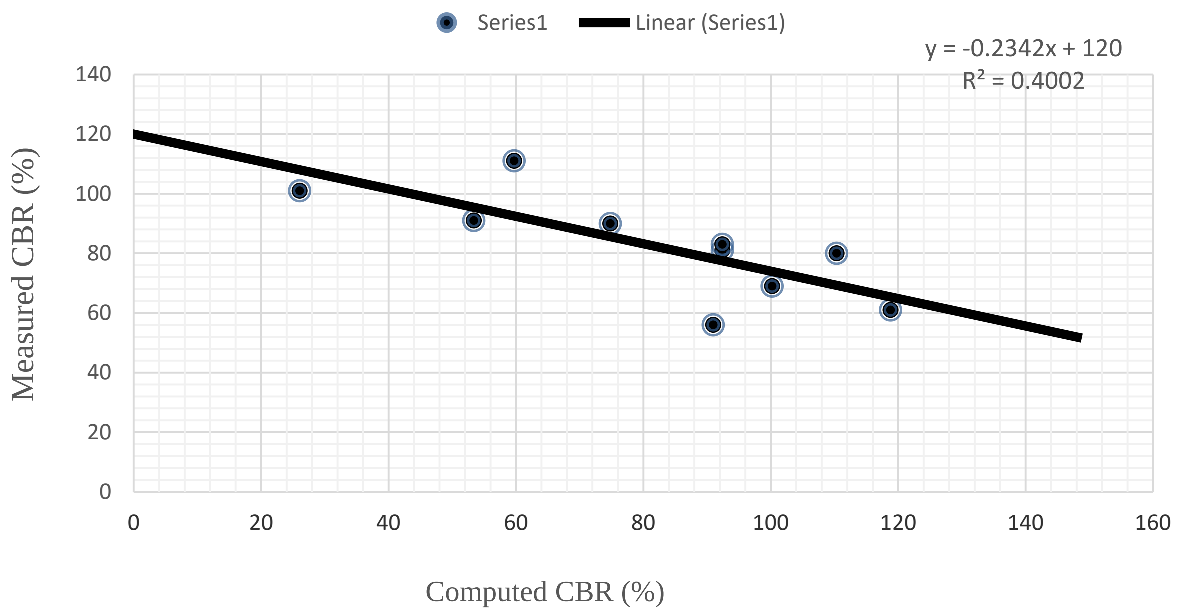

Fig.IV: Ebidang residual soil and cement stabilization (sample no.3&4)

VII Conclusions

Data derived from the multiple non-linear regressed models are presented on Tables 10 to 13 showing the input variables and the resulting measured and computed CBR values. Specifically Tables 10 and 11 present the measured and computed CBR values resulting from residual soil and quarry dust stabilization. Tables 12 and 13 present the measured and computed CBR values resulting from residual soil and cement stabilization. The measured and computed values varied from 55% to 151% and 85% to 171% respectively for sample from location 1. Sample from location 2 varied from 56% to 107% and 74% to 82% respectively. Sample from locations 3 revealed measured and computed CBR values ranging from 56% to 91% and 90% to 118% and sample from location 4 revealed measured and computed CBR values as 76% to 127% and 93% to 108% respectively.

Generally it is observed that when quarry dust content exceeds 50% the CBR value decreases. Similarly when cement content exceeds 8% the sample is devoid of plasticity hence less useful in engineering applications..

The model 1.1 revealed that a quarry dust content of 30% and 70% residual soil stabilization will generate measured and computed CBR values of 98% and 170% respectively. These values are above the recommended minimum of 80% specified by the code [4][FMW&H 1997] for both sub base and base course applications. Model 1.2 with similar quarry dust and residual soil contents generates measured and computed CBR values of 81% and 111% a bit lower values compared to model 1.1. Model 1.3 values though acceptable could further be optimized by subjecting the input variables to some basic iteration. Model 1.4 generates measured and computed CBR values of 83% and 96% respectively. The models 1.1, 1.2, 1.3 and 1.4 are considered satisfactory for this research.

The accuracy and reliability of the models 1.1 to 1.4 were checked by comparing the measured and computed CBR values and computing the correlation coefficients. Figures I to IV present cross plots of these measured and computed values. The correlation coefficients at 95% confidence interval are .079, .4315, .4002 and .4002. These values are statistically significant and suggest compatibility of both measured and computed values.

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