International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

Improvement in Bearing Capacity of Clayey and Sandy Soil Using Geotextile and Terrasil

Okeniyi, A.G.[1], Alli, O. O.[2], Alli, J. O. A.[3], Akolade, A.S.[4]

[1, 2, 4]Department of Civil Engineering, The Polytechnic, Ibadan, Ibadan, Nigeria

[3]BT Struct & Partners, Oyo State, Nigeria

Abstract: ***It is an established fact that weak soils cause damage to structures including road pavement. Stabilization of soil is done to avoid these damages and improve strength, it also helps in improving compaction characteristics of soil. This research examined the basic engineering and geotechnical properties of poor subgrade soil using woven Geotextile and nanochemical (Terrasil) to improve its strength. This is considered to be of great importance in civil engineering works. Subgrade soil on which the load of the pavement rest on is essential to design of pavement structures. Experiments were carried out to investigate the application of Terrasil and inclusion of Geotextile on collected sample A (claysoil) and Sample B (sandy soil) under un-soaked conditions. Geotechnical test was conducted on the samples to determine natural moisture content, grain size analysis, Atterberg limit test, compaction and California bearing ratio test. CBR test were carried out by adding the Terrasil at varying proportion (2%, 4%, 6%,8%) and geotextile placement of 2/5 layer, 3/5layer and 4/5 layer of the compacted soil under the un-soaked conditions to determine the strength of the soil. The result shows that the addition of terrasil with geotextile increases the strength of soil and CBR value from 14% for clay and 26% at control for both clay and sandy soil samples respectively. At 4% terrasil dosage and 2/5 layer of geotextile placement distances from the base recorded the highest number of CBR values which are 22% and 36% of clay and sand respectively. The difference in the behavior of the soil under un-soaked conditions improved on increasing the percentage at 4% dosage of Terrasil with 2/5layer horizontal placement of terrasil.***

Keywords: Geotextile, Terrasil, CBR, Clayey, Sandy, un-soaked conditions, reinforcement, subgrade

1. Introduction

The main usage of unpaved roads is in low volume traffic and accessing roads (Bergado et al., 2002). Basically, in agricultural countries, low volume roads play a very important role in the rural economy. When these types of roads with soft foundation soils are constructed, there is the possibility for large deformations to occur, which increases maintenance cost and lead to interruption of traffic service (Subaida, et al., 2012). The use of geotextile for reinforcement to improve weak soil is currently a popular method. The tensile strength of geotextile and the soil geotextile interaction are the major factors that influence the improvement of soil. Change in fine content within the sand can change the interface behavior between soil and geotextile (Kumar, et al., 2014). Geotextiles have pervaded almost all the branches of geotechnical engineering with almost infinite number of applications (Verma, 2012).

Soil stabilization involves changing the physical structure of the soil. A soil that has not been stabilized tends to have bigger particles. Such a soil can't be used in a road construction project because it will sink due to its inability to bear with the weight of the traffic. Soil stabilization involves changing the physical structure of the soil (Akolade and Olaniyan, 2014). A soil that has not been stabilized tends to have bigger particles. Such a soil can't be used in a road construction project because it will sink due to its inability to bear with the weight of the traffic

Terrasil is an organosilane compound which reacts with soil particles and form hydrophobic (oily) layers on the surface of the soil and clay particles (Prakash and Sridharan,2012). This make soil particles water insensitive and can be compacted to a better particle interlock state by equipment and traffic forces. Terrasil can treat material ranging from clays to silty sand and gravel. It is a nanotechnology that offers a permanent water repellent nano layer on all types of soils, aggregates and other inorganic road construction materials.. However, when it applied on the surface and is bonded to the substrate, the water repellent characteristic of the molecule dominates on the surface and provide water repellency (Sherwood, 1993).

Sandy soils are pale yellowish to yellowish brown in color and are one of the poorest types of soil. Sandy soil is composed of loose coral or rock grain materials and has a dry and gritty touch. Sandy soil is also grouped as one of the soils composed of the largest particles which prevent it from retaining water, as such, sandy soils loose water content very fast which makes it very difficult for plant roots to establish. Clay on the other hand is one of the many unique soil types due to its composition of a very fine-grains and plasticity when moist but hard when fired. The clay soil particles are tightly compressed together with no or very little air space. Because of this feature, clay persists as the heaviest and densest type of soil. Clay soils are normally associated with volumetric changes when subjected to changes in water content because of the seasonal water fluctuations. Furthermore, problems with clays, including low strength and high compressibility, can cause severe damage in construction works. Therefore, these soils must be treated before commencing the construction operation to achieve desired properties (Mitchell, 2009). Also, Clay has plastic property when mixed with water and becomes rigid when it is dried. Because of these properties, clay soil has posed challenges and troubles to the construction activities.

2. Materials Used

Clay soil sample was collected from a borrow pit at Moborode, Oke-ola with latitude and longitude of 7.00917 N

Licensed Under Creative Commons Attribution CC BY

7^0 0'33.006 and 3.68118 E $3^0$40'52.26 while sandy soil from a stock pile 602186.085 E, 832800.586 N and was used for the experiment while the geotextile and terrasil was purchased locally. Conventional tests were carried out for the evaluation of soil suitability for engineering purposes. Laboratory procedures were followed and thereafter, several of the required geotechnical analyses were carried out. These include particle size analysis, liquid limit, plastic limit, plasticity index, standard compaction test and the California Bearing Ratio (CBR) test. These tests were performed according to AASHTO (1993), BS 1377 PT4 (2000). The compaction tests were conducted according to the West African Standard (WAS) The samples were tested under soaked conditions with the geotextile introduced at different depths within the sample height in the mould, in single layers. The CBR Tests were carried out on the compacted soils in un-soaked conditions without reinforcement and then with reinforcement at different levels with terrasil variation. The un-soaked CBR values were obtained in this study after the soil samples has been cured for 24hours (a day).

3. Result and Discussion

The summary of the result of the laboratory test (grain size analysis, atterbergs limit and compaction) shown below. Also the engineering property test California bearing ratio (CBR) value is presented in the tables and figures below.

3.1 Sieve analysis of soil sample A (sand) and B (clayey)

Samples A are fine clayey material, the percentage passing sieve size number 200 was 36.1 which are less than 50%. and Sample B are fine sand material, the percentage passing sieve size number 200 was 4.9 which are less than 50%. (which are both less than 50%, this indicates that soil Sample A and B are suitable for subgrade construction because it has high quality of soil strength as their percentage weight passing through sieve No. 200 is lesser than 35%, while sample B has percentage weight greater than 35%.according to the Unified Soil Classification System (USCS) (Olaniyan & Akolade, 2014).

The percentage passing through the sieves for soil sample A and B respectively are shown in the tables below

Table 1: Sample A (Clayey Soil)

Sieve Size (mm)	Weight Retained (g)	% Cummulative Retained	% Passing	% Passing (Average)
9.50	0.0	0.0	100	100
4.75	1.0	0.2	99.8	99.8
2.30	5.5	1.1	98.9	99.1
1.18	47.0	9.4	90.6	91.3
0.60	126.0	25.2	74.8	75
0.425	177.5	35.5	64.5	64.75
0.300	229.5	45.9	54.1	54.5
0.150	299.5	59	40.1	39.8
0.075	320.0	64.0	36.0	36.1

Table 2: Sieve analysis of soil sample B (Sandy Soil)

Sieve Size (mm)	Weight Retained (g)	% Cummulative Retained	% Passing	% Passing (Average)
9.50	0.0	0.0	100	99.9
4.75	7.0	1.4	98.6	98.5
2.30	19.0	3.8	96.2	96.4
1.18	51.5	10.3	89.7	90.0
0.60	128.5	25.7	74.3	74.7
0.425	187.5	37.5	62.5	63.2
0.300	271.0	54.2	45.8	46.6
0.150	426.5	85.3	14.7	15.1
0.075	476.0	95.2	4.8	4.9

3.2 Atterberg's test result for soil sample A and Sample A+4% terrasil.

According to whitlow (1995), liquid limit less than 35% indicates low plasticity, between 35% and 50% indicates intermediate plasticity, between 50% and 70% high plasticity and between 70% and 90% very high plasticity and greater than 90% extremely high plasticity. Samples A indicates intermediate plasticity while sample B indicates non-plastic material and also Sample A+ 4% terrasil shows indicates low plasticity

Table 3: Result Showing Atterberg Limit for Sample A and B

		Atterberg's Limit (%)			Sieve Analysis	Soil Classification		
Sample	*NMC*	*LL*	*PL*	*PI*	*Percent passing through No 200*	*Typical name*	*AASHTO*	*USCS*
Sample A	12.09	35	22	13	36.1	Clayey	A-4	CL
Sample B	4.35	Non-cohesive soil (non-plastic)			4.9	Fine sand	A-3	SW
Sample A+4%terrasil	-	30	23	7	36.1	Clay	A-4	CL

3.3 Compaction test for soil sample A and B

The OMC values obtained from the moisture-density curve were used to prepare soil samples used for CBR. The MDD for the soil samples A was 1.80g/cc while sample B was 1.66g/cc and OMC for the soil samples A and B are 12.2% and 4.2% respectively without the application of terrasil, the results are shown in the tables and figures below..

Table 4 (a): Result of Compaction Test for Clay Sample Control

MOLD NO	NM 21		NM 14		NM 13		NM 19		NM 15	
WI. WET SAMPLE + MOLD	7160		7894		8156.5		8291.5		8103	
WT. OF MOLD	3484		3697		3761		3853.8		3738	
WT. OF WET SAMPLE	3676		4197		4395.5		4437.7		4365	
VOLUME OF SAMPLE	2103		2190		2187		2185		2187	
WET DENSITY	1.75		1.92		2.01		2.03		2	
CONT. NO.	BK	AZ	AO	AS	AK	BL	BE	BU	BO	BD
WT. WET SAMPLE + CONT.	97.53	98.47	98.69	99.49	99.49	95.1	90.65	91.23	94.13	94.91
WT. DRY SAMPLE + CONT.	92.93	93.68	92.86	93.59	93.59	88.81	83.84	84.4	86.07	86.7

Licensed Under Creative Commons Attribution CC BY

WT. WATER	4.6	4.79	5.83	5.9	5.9	6.29	6.81	6.83	8.06	8.21
WT. CONT.	35.58	35.52	35.77	35.97	35.97	35.76	36.06	35.9	35.86	35.8
WT. DRY SAMPLE	57.35	58.16	57.09	57.09	57.62	53.05	47.78	48.5	50.21	50.9
MOISTURE CONTENT %	8.0	8.2	10.2	10.2	10.2	11.9	14.3	14.1	16.1	16.1
AVERAGE MOISTURE CONTENT %	8.1		10.2		11.7		14.2		16.1	
DENSITY DRY	1.62		1.74		1.80		1.78		1.72	
C.B.R.			1		13		10		3	

Table 4 (b): Result of Compaction Test for Sand Sample Control

MOLD NO	NM 15		NM 20		NM 21		NM 13		NM 20	
WI. WET SAMPLE + MOLD	8151		7952		8010.5		8275.5		7151	
WT. OF MOLD	3735		3470		3484		3762.5		3470	
WT. OF WET SAMPLE	4416		4482		4526.5		4513		3681	
VOLUME OF SAMPLE	2187		2105		2103		2187		2105	
WET DENSITY	2.02		2.13		2.15		2.06		1.75	
CONT. NO.	BO	BB	AD	AO	AJ	AH	BD	BR	AX	AT
WT. WET SAMPLE + CONT.	89.98	90.35	89.83	91.18	91.81	91.65	93.98	93.98	84.66	84.97
AVERAGE MOISTURE CONTENT %	12.2		8.1		5.8		8		10.1	
DRY DENSITY	1.8		1.97		2.03		1.91		1.59	
C.B.R.	23		26		24		20		11	
WT. DRY SAMPLE + CONT.	83.68	84.03	83.94	89.14	88.67	88.65	89.62	89.67	80.21	80.41
WT. WATER	6.3	6.32	5.89	2.04	3.14	3	4.36	4.31	4.45	4.56
WT. CONT.	32.08	32.43	36	35.97	35.79	35.9	35.91	35.61	35.92	35.81
WT. DRY SAMPLE	51.6	51.6	47.94	53.17	52.88	52.75	53.71	54.06	44.29	44.6
MOISTURE CONTENT %	12.2	12.2	12.3	3.8	5.9	5.7	8.1	**8**	**10**	10.2

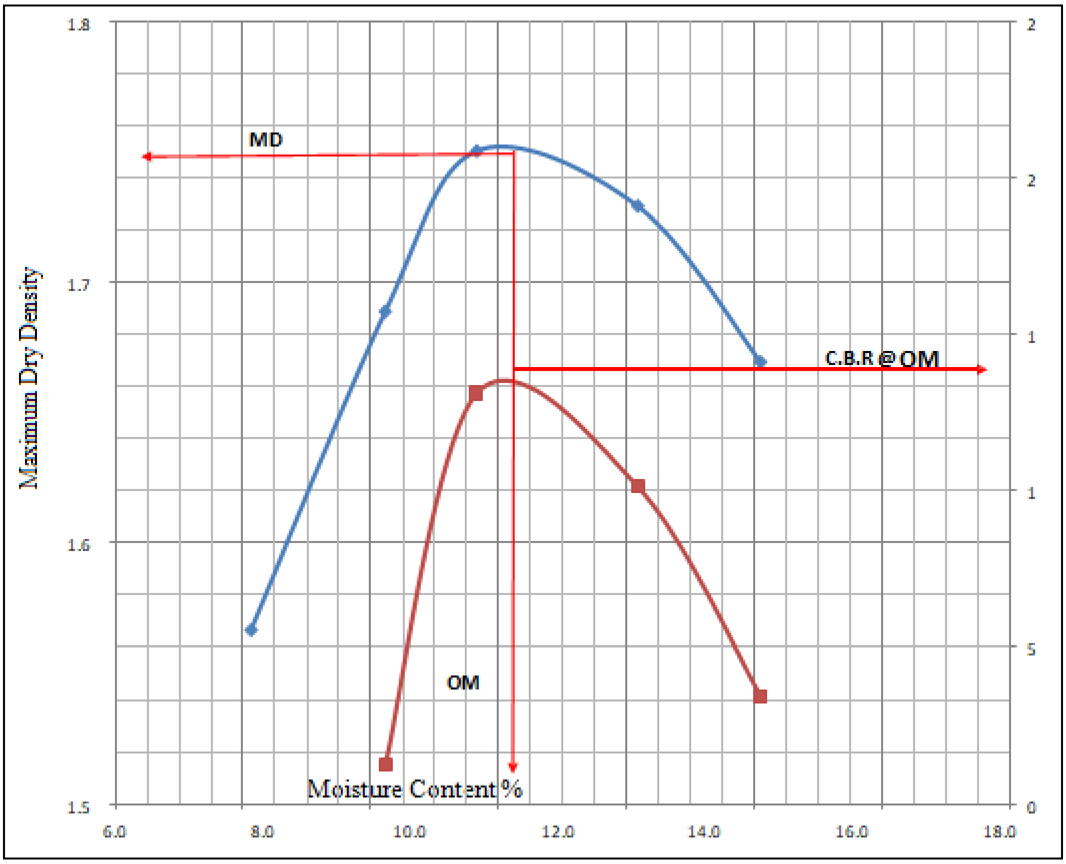

Figure 1: Compaction Curve showing OMC, MDD AND CBR for Clay Sample Control

Licensed Under Creative Commons Attribution CC BY

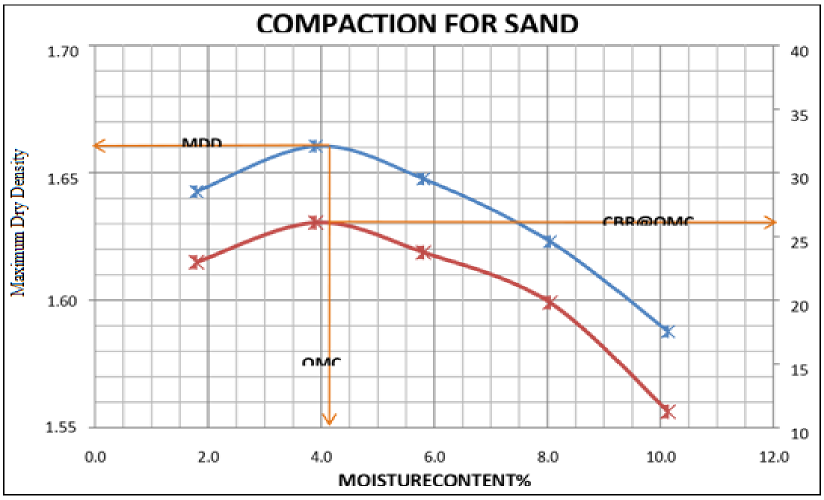

Figure 2: Compaction Curve showing OMC, MDD AND CBR for Sand Sample Control

3.5 CBR readings for soil sample A(clayey) + 0%, 2%, 4%, 6% and 8% of terrasil dossage with geotextile at 0/5, 2/5, 3/5 and 4/5 of the compaction mould

The CBR penetration was taken at each percentage i.e. 0%, 2%, 4%, 6% and 8% for soil A and B with the variation of geotextile placement. The CBR result shows that terrasil stabilization is most suitable at 4% with the geotextile placed at 2/5 of the layer for both soil sample.

Table 5a: CBR readings for soil sample A(clayey) + 0%, 2%, 4%, 6% and 8% of terrasil dossage with geotextile at 0/5, 2/5, 3/5 and 4/5 of the compaction mould

CBR Value for Clayey Soil with Terrasil and Geotextile Comparison

Geotextile / Terrasil	Without	Layer 2	Layer 3	Layer 4
0.0%TERRASIL	14	17	12	10
2.0%TERRASIL	17	21	15	12
4.0%TERRASIL	20	22	18	16
6.0%TERRASIL	13	18	11	9
8.0%TERRASIL	12	15	10	9

Table 5b: CBR readings for soil sample B (sandy) + 0%, 2%, 4%, 6% and 8% of terrasil dossage with geotextile at 0/5, 2/5, 3/5 and 4/5 of the compaction mould

CBR Value for Terrasil and Geotextile Comparision

Geotextile / Terrasil	Without	Layer 2	Layer 3	Layer 4
0.0%TERRASIL	25	28	24	21
2.0%TERRASIL	28	32	27	25
4.0%TERRASIL	32	36	30	27
6.0%TERRASIL	24	27	20	16
8.0%TERRASIL	17	21	14	10

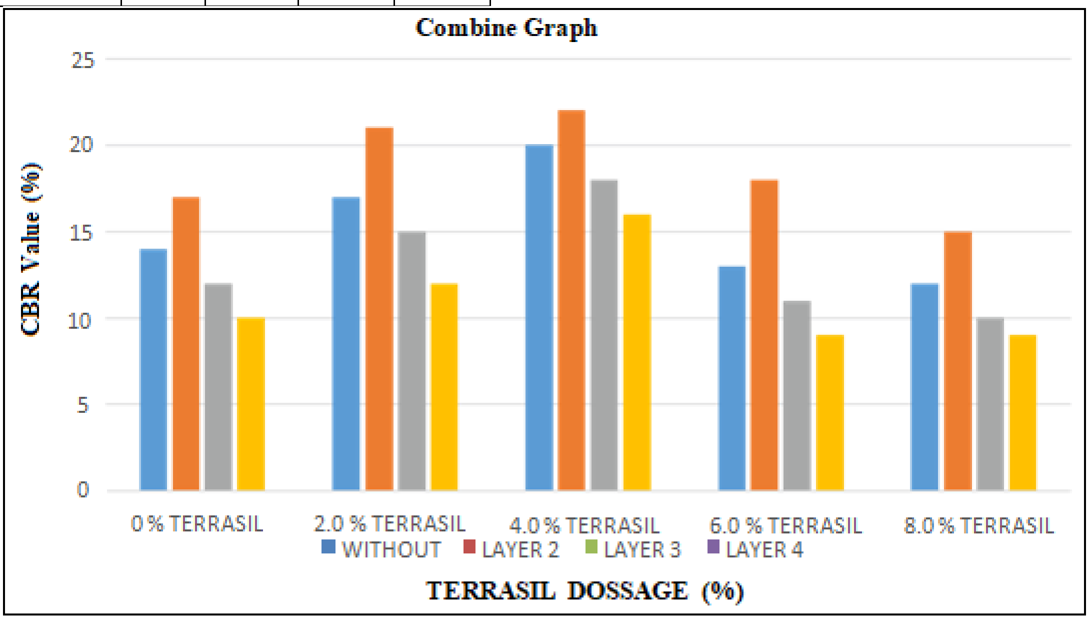

Figure 3: Graph of CBR against % dosage of terasil with geotextile for sample A (Clayey soil) before and after the application of terrasil

Licensed Under Creative Commons Attribution CC BY

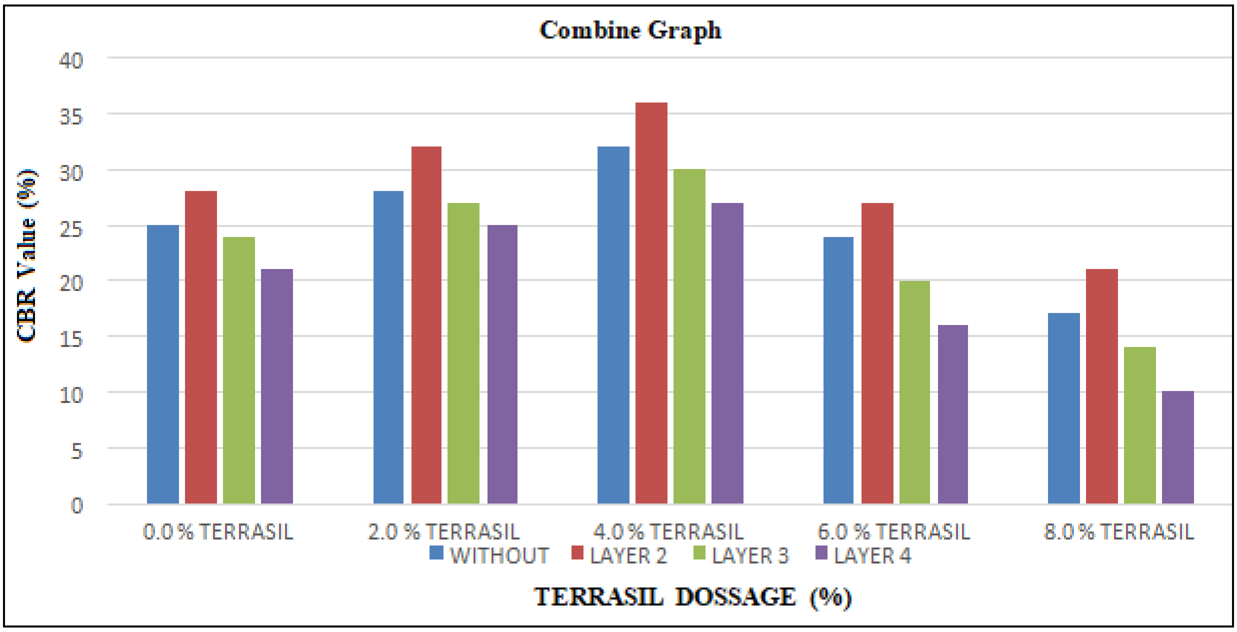

Figure 4: Comparison graph of CBR value against terrasil dosage at different layers of geotextile (Sandy Soil)

4. Conclusion and Recommendation

The following fact immerged from the study. There was variation in the chemical dosage of terrasil on the soil at different level, 0%, 2%, 4%, 6% and 8%. The geotextile was placed horizontally at 0/5layer, 2/5 layer, 3/5 layer, 4/5layer respectively. With the application of 4% of terrasil dosage, the highest CBR value was recorded which led to variation in the geotechnical properties of the soil such as liquid limit 35%, plastic limit 22%and plasticity index 13% at control to liquid limit 30%, plastic limit 23% and plasticity index 7% there by improving the soil class. Presence of terrasil in the soil of sample led to increase in Geotechnical properties such as C.B.R for sample A (clay) and Sample B (sand) from (14% and 26% to 22% and 36%) respectively hence, bearing Capacity of both soil was increased. There was increase in CBR value ranging from 0% to 4%and decrease in CBR value at 6% and 8% of terrasil dosage with respect to the inclusion at varying layers of the geo-textile. However the horizontal inclusion of geotextile at 2/5H of both soil samples recorded the highest CBR value. Soils behave differently based on their compositions and surrounding conditions. In other words, no assumption should be made that the stabilizer should be considered as suitable stabilization agent for all type of soil until they are tested with the sample.

References

[1] Akolade, A. S., & Olaniyan, O. S. (2014), Application of Geogrids on the Geotechnical Properties of Subgrade Materials under soaked conditions, International Institute for Science Technology and Education (IISTE) vol. 6, No. 7, 2014

[2] Al-Sinaidi Rahman and Ali Hassan Ashraf. Improvement in bearing capacity of soil by geogrid -an experimental approach. International Association for Engineering Geology and environment (IAEG) 2006; pp 1-5.

[3] Ampadu, S. I. K. (2007). A Laboratory Investigation into the Effect of Water Content on the CBR of a Subgrade Soil. Softbank EBook Centre, Tehran.

[4] Amu, O.O., Owokade, O. S., Shitan, O.I. (2011).Potentials of Coconut Shell and Husk Ash on the Geotechnical Properties of Lateritic Soil for Road Works.*International Journal of Engineering and Technology*, *Vol.* 3 (2), (2011), 87-94.

[5] Bergado, Dennes T, Long, Pham V. and Murthy, B.R. Srinivasa (2002) "A laboratory study of Geotextile-Reinforced Embankment on Soft Ground", Geotextiles and Geomembranes 20 (2002) 343–365.

[6] Kumar, P. Senthil and Rajkumar, R. (2012) "Effect of Geotextile on CBR Strength of Unpaved Road with Soft Subgrade" Electronic Journal of Geotechnical Engg., vol. 17, pp.1355-1363.

[7] Ravi Shanker, A.U., Chandrashekhar, A. and Prakash Bhat, H. (2012) "Experimental Investigation on Lithomargic Clay Stabilized with Sand and Coir", Indian Highways, pp.21-31.

[8] R. D. Barksdale, S. F. Brown, and F. Chan, *Potential benefits of geosyntethetics in flexible pavement systems.* National Cooperative Highway Research Program (NCHRP) Report No.315.Washington, DC: Transportation Research Board, National Research Council, 1989.

[9] Olaniyan O.S and Akolade, A.S. (2014). Reinforcement of Subgrade soils with the use of Geogrids. *International journal of science and research, vol 3 issue 6, June 2014.*

[10] Subaida, E.A., Chandrakaran, S. and Sankar, N. (2009) "Laboratory performance of unpaved roads reinforced with woven coir geotextiles" Geotextiles and Geomembranes 27 (2009) 204–210.

[11] Verma, Uday Kumar and Sharma, U.S. (2012) "Application of Coir Geotextiles in Rural Roads", **http://ieca.crhosts.com,** June 2012.

Licensed Under Creative Commons Attribution CC BY