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Nota Técnica:
Desarrollo sostenible de las carreteras africanas

Technical Note:
Sustainable development of roadways in Africa

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RESUMEN

La tecnología de Dallas Roadway Products (DRP) constituye una metodología eficaz para mejorar la construcción de las capas inferiores del firme de calzadas y con ella la resistencia de las bases y subbases de las carreteras. En esta investigación se recogen muestras del terreno que constituye las carreteras existentes en las seis regiones geopolíticas nigerianas. Al incorporar a las muestras el DRP LS-40 (lignosulfonato) y el DRP SA-44 (ácido sulfúrico), la mezcla acelera una reacción química no reversible que produce una modificación permanente del entramado del suelo. La reacción de las sustancias químicas con la arcilla del suelo aumenta su plasticidad. A los suelos sin plasticidad se agregan materiales arcillosos, procediéndose a continuación a la pulverización del material resultante. Según los resultados obtenidos, las sustancias químicas de estabilización de suelos de DRP pueden transformar los suelos pobres, inapropiados o deficientes en materiales adecuados para servir como bases o subbases de las carreteras.

Palabras clave: DRP, estabilización, construcción, suelos, carreteras.

SUMMARY

Dallas Roadway Products (DRP) soil stabilization technology can effectively improve road foundation construction and with it the strength of roadway subgrades and sub-bases. Soil samples were collected from roads in Nigeria's six geo-political regions. DRP LS-40 (lignate sulfonate) and DRP SA-44 (sulfuric acid) were added to the soil materials. The mixture precipitated a non-reversible chemical reaction that involved a permanent change in the soil structure. The chemicals reacted with the clay content, increasing the soil material plasticity. In non-plastic soils, clay materials were added to the soil, which was then pulverised. The study showed that DRP soil stabilisation chemicals can render poor, unsuitable or marginally deficient soils apt for use as a sub-base or base in roadway construction.

Keywords: *DRP, stabilisation, construction, soil, roads.*

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1. INTRODUCTION

The increasing rate of road pavement failure, especially few months after construction, along major highways in Nigeria is generating a lot of concern to all stake holders involved in the road construction and maintenance Industry – the Governments at all levels, the Federal Ministry of Works, Housing and Urban Development, road construction companies, contractors and Highway Engineers (1). Consequently, attentions have presently been placed on all aspects of the road pavement, more especially on the road construction materials and quality control during construction, to determine the cause of failure and find a lasting solution to the problems identified. As part of her effort to contribute meaningfully to the on-going attempt to find a lasting solution to the menace of road failure, the firm of Messrs Open-Ended Ventures (Africa) Limited introduced a particular brand of soil stabilization chemicals to road (soil) materials (Dallas Roadway Products Soil Stabilization Chemical) in order to improve the quality and ultimately increase the life span of roads. Such soil stabilization chemicals, when introduced to the soils used for the road pavement, have the capability of increasing the quality of the material and also lower the cost of road construction drastically from the present high cost. As a result, the Federal Government of Nigeria, through the Federal Ministry of Works (FMW) and Federal Road Maintenance Agency (FERMA) decided, in conjunction with Messrs Open-Ended Ventures (Africa) Limited to carry out laboratory tests on this particular brand of soil stabilization chemical materials to determine its effect on road soil materials and hence, its possible introduction into the road construction specification in Nigeria. Ekiti State Government through its Ekiti State Ministry of Works and Infrastructure commissioned the construction of a 15.8 km road to Messrs Fiat International Limited to use the DRP Soil Stabilization technology as a pilot project in its Ekiti Road Revolution Program. Researchers such as Joel (2) and Omotosho (3) have worked on laterite stabilization for road work in Nigeria using various stabilization agents. Similarly, Bell (4) has applied lime stabilization technology to stabilize clay minerals and soils to improve their use for construction. The main objective of our study was to find lasting solution to frequent road failure through construction fault by adopting sustainable Dallas Roadway Products (DRP) soil stabilization technology.

2. METHODOLOGY

A detailed site investigation was carried out starting from the month of November 2007 through January 2009 at the different site locations. Test samples were collected from all the sites while site exploration was engaged for the Ido – Ipere – Iludun Road, South-West which is a pilot project. The site exploration involved the following:

(i) Geological appraisal of the project area with special emphasis on studying the nature, type, and disposition of soil and rock outcrops.
(ii) Assessment and determination of the nature and strength of the sub-grade soil materials of the proposed new alignment.
(iii) Estimating the availability and suitability of fill, sub-base and base course' materials, and subsequently establishing borrow areas from where borrow pits soil samples were taken for laboratory tests and analysis.
(iv) Identification of rock outcrops which may be suitable for use as sources of coarse aggregates, and
(v) Sourcing of fine aggregates and water for concreting purposes and other construction works.

In all cases, investigation and/or exploration was carried out by excavation of test-pits. For the sub-grade materials, test-pits were dug along the centre-line of the road alignment at every 500 m interval. However, at the paved end, the investigation was carried out at every 1000 m.

The preparation for and methods of taking samples as well as their handling and sizes were in accordance with the Civil Engineering Code of Practice: CP2001: "Site Investigations".

2.1. Sub-Grade Investigation

For all the roads, soil samples were taken at specific locations identified by the FERMA, FMW, EKSG and CRSG-MW staff. The locations were known to have bad soil materials and the samples were taken on the road sections which had failed. The samples taken for the Chief Obot road was at intervals of 500 m on the road corridor of 750 m of the urban road which had existing lateritic material. In the case of the Ido – Ipere – Iludun road, the road length which was investigated is described as follows; In evaluating the sub-grade conditions, exploration was restricted to the proposed road corridor from Ido at Chainage 0+000 to Ipere (CH. 10+100) and Iludun at Chainage 15+150.

At every 500 m intervals along the project road, 1m long by 1m wide and 1 m depth test-pits were excavated manually. The strata log at each test-pits location and visual description of the soil materials was made on the field, while sufficient samples were taken for further laboratory tests to confirm, or otherwise, the deductions made from visual inspection and examination of the soil profile in the field. Groundwater was encountered only in the test-pit dug at Chainage 9+000.

2.2. Borrow Area Investigation

A total of seven (7) borrow areas were located and sampled along the Ido – Ipere – Iludun project road at the following location Chainages:

1. Borrow Area I - CH.1 + 425 LHS
2. Borrow Area II - CH.1 + 475 RHS
3. Borrow Area III - CH.2 + 875 RHS
4. Borrow Area IV - CH.4 + 025 RHS
5. Borrow Area V - CH.10 + 450 LHS
6. Borrow Area VI - CH.12 + 345 RHS
7. Borrow Area VII - CH.13 + 600 LHS

Selected samples from these locations were subjected to compaction test at West African Standard and California Bearing Ratio (CBR) determination at Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) at both unsoaked and soaked (24 hrs) conditions to give an insight into the possible loss of strength of the materials in wet conditions (5).

2.3. Coarse Aggregates

A massive outcrop of granite gneiss was found along Ido- Ipere section of the project road at approximately Chainage 5+000 (RHS). This outcrop can be mined and crushed into suitable sized aggregates for concreting works and possible use in road base and asphaltic concrete. The volume of rock outcrop available at this location, based on visual examination, is quite appreciable and therefore adequate for the proposed road construction/rehabilitation project.

2.4. Fine Aggregates

Fine aggregates for construction works (sand size) can be sourced from the banks of the five streams and rivers which flow across the project road at various locations. The standard procedure of washing, screening and distribution should be used to obtain coarse to fine well-graded sand for construction works.

2.5. Water for Construction Purposes

The water in the five streams and rivers were sampled and tested to determine the acidity level (pH) and sulphate content of the water. This was to determine if it would be necessary to adopt special precautions to protect the concrete and reinforcement of structures in the area against attack from acids and sulphate in ground water, which might weaken the concrete and subsequently lead to failure. pH was determined using pH meter while sulphate was determined by turbidimetry method (6). The result of the tests however, does not indicate the need for any special precautions. However, the use of Portland cement, dense concrete and well embedded reinforcement is recommended for all concrete structures (culverts, bridges, etc.) that will be provided along the stream and rivers along the project road.

2.6. Laboratory Tests

For the purpose of this study, the Materials Testing and Research Laboratory at the State Ministry of Works and Transport, Ibadan and the Welaf Geotechnical Laboratory Services Limited, Lagos were used for the soil samples taken from the project. The laboratory at Ibadan was recently re-equipped and certified by the World Bank during the Multi-State Roads Project, while the Welaf laboratory at Lagos had been in existence and had experiences which spanned two decades.

All the tests were carried out according to the procedures set out in the British Standard methods for testing soils for civil engineering purposes. The tests can be grouped into the following classes:

(i) Soil classification tests (7).
(ii) Soil Strength tests (8).
(iii) Chemical test (9).

2.7. Soil Classification Tests

For proper identification and subsequent classification of all the soils encountered, the following laboratory tests were carried out on all soil samples obtained:

(i) Atterberg Limit's determination.
(ii) Grain size analysis, and
(iii) Determination of linear shrinkage.

The results of the above-listed tests were compiled and collated for proper identification of the soils.

2.8. Soil Strength tests

The soil samples were subjected to each of the following tests.

(i) Compaction test to determine the maximum dry density and Optimum Moisture Content (OMC) using the Standard Proctor Compaction method as specified for sub-grade soils in the Federal Ministry of Works Specifications for Roads and Bridges, and
(ii) California Bearing Ratio determination (CBR) at both unsoaked and soaked (24 hours) condition.

3. RESULTS

The typical summary of the test results in Ekiti are presented in Table 1 while values of the laboratory test on the road soil samples across the six geopolitical zone is presented in Table 2. The Atterberg's Limits determination test carried out on the sub-grade soil materials collected from the study areas at 500 m (27 stations) intervals indicated that the Liquid Limit values for soil samples ranged from 28-39% while the Plastic Limit ranged from 16-20%. Therefore, the Plasticity Index varied from 10-19%, while the linear shrinkage is 13. The result of grain –size distribution indicate that the soil material is predominantly sandy, containing approximately 57–98% of coarse to fine sand while the materials passing sieve No 200 (0.075 mm diameter sieve mesh size) is within a range of 10-26%. This consists of both silt and clays size materials.

When the soil was compacted under the Standard Proctor Compaction effort (2.5 kg rammer and 15 No. blows per layer for three layers), the Maximum Dry Density (MDD) value ranged from 1.75-1.9 mg/m^3 was achieved at an Optimum Moisture Content (OMC) which ranged from 13-20%. The soil sample was also subjected to CBR determination at both soaked and unsoaked conditions. The result indicates CBR value which ranged from 16-36% at unsoaked state and 13-28% after 24 hours soaking.

4. DISCUSSION

The result of the tests after DRP soil stabilization chemical treatment indicate an unsoaked CBR value 38% after seven days, with a mix ratio of 0.08 l/m^3 at CH 1+000 – a typical condition which confirms the suitability of the subgrade being stabilized for use as sub-base material along the length of the road corridor. The result of the Atterberg's Limits determination test carried out on the soil materials taken from the area indicate that the Liquid Limit for soil samples which were taken at seven stations intervals ranged from 30-60% while the Plastic Limit ranged from 19-36%. Therefore, the Plasticity Index ranged from 11-24%, while the linear shrinkage is between 5 and 11. Similarly, the soil material was subjected to grain –size distribution test by sieve analysis. The result indicates that the soil material is predominantly sandy, containing approximately 59-93% of coarse to fine sand while the materials passing sieve No 200 (0.075 mm diameter sieve mesh size) is within a range of 4-35%. This consists of both silt and clays size materials. The details of the result can be found in Table 2.

Table 1
Summary of Laboratory Test Results for Sub-Grade Soil along Ido-Ipere-Iludun Ekiti Road.

Chainage (Km)		0+030(LHS)	0+500(RHS)	1+000(LHS)	1+500(RHS)
Sampling Location		N07º50'45.8" E05º11'09.2"	N07º51'11.4" E05º11'09.2"	N07º51'155.1" E05º11'10.7"	N07º51'30.7" E05º11'14.1"
Sampling No		TP01/01	TP02/01	TP03/01	TP04/01
Sampling Depth(m)		0.00-0.90	0.00-0.80	0.00-0.80	0.00-0.90
Consistency properties	Liquid Limit%	31	30	30	30
	Plastic Limit%	20	18	19	18
	Plasticity Index%	11	12	11	12
	Linear Shrinkage%	4	5	4	5
Grading%	10.00	100	100	100	100
Passing B.S	2.40	83	82	84	85
Sieve (mm)	0.600	47	46	48	49
	0.425	38	36	38	18
	0.075	14	14	13	10
Soil Classificat-tion (AASHTO)		A-2-6	A-2-6	A-2-6	A-2-6
Proctor	Max Dry Density (Kg/m^3)	1800	1810	1800	1800
Compaction	Optimum Moisture Content (%)	18	17	19	18
CBR (%)	Unsoaked Soaked	18	20	19	20
		16	16	16	16
Swell (%)		0.058	0.055	0.060	0.061
Soaking period (Hour)		24	24	24	24
Specific Gravity		2.86	2.89	2.88	2.87
Ground water Level		Not encountered	Not encountered	Not encountered	Not encountered

CBR: California Bearing Ratio, LHS: Left Hand Side, RHS: Right Hand Side.

Table 2
Results of soil characteristics from the six geographical before and after treatment with DPR.

S/No	Description of Road	Zone	Natural Soil Characteristics							CBR (Natural)		CBR (After DRP Treatment)						Soil Classification
			Sample Location		LL	PL	PI	OMC (%)	MDD (mg/m³)	CBR (Unsoaked)%	CBR (Soaked) %	0.04 l/m³ of soil	0.04 l/m³ of soil	0.08 l/m³ of soil	0.08 l/m³ of soil	0.15 l/m³ of soil	0.15 l/m³ of soil	
												7 days	28 days	7 days	28 days	7 days	28 days	
1	Sagamu - Benin Rd (Benin - Ohusu Section), Edo State	South South	Ch 62+301		44	36	8	14.4	1.79	26	0.48	37	45	43	52			A-5
2	Chief Obot Estate Rd, Calabar	South South	Fill		39	18	21	14	1.92	17	14			25	34	29	40	
			Subgrade		31	14	17	12	1.88	20	16			27	37	33	45	
3	Okigwe - Owerri Rd, Imo State	South East	Amona Town		53	46	7	13.2	1.84	62	2.88	42	51	47	58			A-2-5
4	Ido - Iludun Rd, Ekiti State	South West	Ch 1+000		30	19	11	19	1.8	24	19			38				A-2-6
			Ch 1+425		34	20	14	12	1.96	36	33			56				A-2-6
			Ch 1+475		30	19	11	9.6	2.11	45	32	48	57	70				A-2-6
			Ch 2+876		-	-	-	9.1	2.2	85	75	55	66					A-2-6
5	Oke-Onigbin - Isanlu Rd, Kwara State	North Central	Ch 3+701		20	10	10	11	2.04	30	26			55	63	62	70	A-2-7
			Ch 5+401		40	17	23	15	1.82	15	11			32	39	37	45	A-2-7
			Ch 8+901		30	13	17	12	1.94	25	20			52	58	58	65	A-2-7
6	Dikwe- New Marte Rd, Bornu State	North East	Ch 5+200 - Ch 12+001	Lime Content 0%	47	25	22	22.4		3		13	14	9	21			A-7-6[36]
				Lime Content 3%								16	20	27	38			A-7-6[36]
7	Kaduna-Zaria Rd, Kaduna State	North West	Ch 15+801	Lime Content 0%	47	25	22	22.4	1.58	6		12	-	17	-			A-5[8]
				Lime Content 1%								20	-	28	-			A-5[8]
			Ch 16+901	Lime Content 0%	38	25	13	18	1.567	8		18	49	20	45			A-6[9]
				Lime Content 1%								23	22	29	31			A-6[9]
			Ch 18+451	Lime Content 0%	43	18	25	15.6	1.647	6		27	27	29	31			A-7-6[17]
				Lime Content 1%								-	20	-	22			A-7-6[17]
			Ch 20+101	Lime Content 0%	46	16	30	14.6	1.825	17		29	38	31	43			A-2-7[0]
				Lime Content 1%								24	25	34	34			A-2-7[0]

CBR-California Bearing Ratio, DRP- Dallas Roadway Products, MDD- Maximum Dry Density, OMC- Optimum Moisture Content, LL- Liquid Limit, PL-Plastic Limit, PI-Plasticity Index

When the soil was compacted under the Standard Proctor Compaction effort (2.5 kg rammer and 15 No. blows per layer for three layers), the Maximum Dry Density (MDD) value varied from 1.82-2.2 mg/m^3 was achieved at an Optimum Moisture Content (OMC) which ranged from 9.1-16.3%. Furthermore, the soil sample was subjected to CBR determination at both soaked and unsoaked conditions. The result shows that CBR value which ranged from 35-90% at unsoaked state and 33-70% after 24 hours soaking.

The result of the tests after DRP soil stabilization chemical treatment indicate an unsoaked CBR values of 56% after 7days with a mix ratio of 0.08 l/m^3 at CH1+425. Also, test on the soil samples at CH1+475 increases from 45% in 7 days to 57% in 28 days at a mix ratio of 0.04 l/m^3 and 70% in 7days with a mix ratio of 0.08 l/m^3. The test confirms a condition which presupposes the suitability of the borrow pit material which when stabilized can increase to the base course envelope.

As in many civil engineering works involving soils, it is usually necessary to determine the properties of the soil, and establish that they are capable of the following:

- sustaining the applied axle loads without permanent (serious) deformation; and
- retaining its strength at least throughout the design life of the pavement.

The structural design of a road pavement is the determination of the thicknesses of sub-base, base course, and surfacing to be placed on top of the (sub-grade) soil.

4.1. Sub-Grade (Pavement Foundation) Soil

The project road was grouped into two sections. The first section between Chainage 0 + 000 and 10+100 (Ipere), and the second section between Chainage 10+100 and 15+150 ending at Iludun town. Consequently, the results of the sub-grade investigation along the road indicate that the sub-grade soil materials in the first section fall into the A – 2 – 6 AASHTO soil class with only one location at Chainage 6+100 falling into the A – 3 soil class. The second section between Chainage 10 +100 and 15 + 150 have sub-grade soils which fall into the A – 2 – 6 , A – 3 and A – 1- b AASHTO soil classes.

The results of the Proctor Compaction test indicate that the Maximum Dry Density (MDD) vary between 1.75 and 1.96 mg/m^3 while the Optimum Moisture Content (OMC) vary between 13% and 20%. By this classification, the sub-grade soils are rated as good to fair sub-grade soils. The CBR value of the soil materials vary between 16 and 36% at the unsoaked state and 13 and 28% at the soaked state. Therefore, a minimum CBR of 12% in the soaked state is recommended for the pavement layer design. The existing sub-grade can be scarified, stabilized with 0.04 l/m^3 or 0.08 l/m^3 of DRP soil stabilization chemicals as the case may be and re-compacted at the desired moisture content and MDD to achieve the corresponding sub-base course value while materials from borrow pits are laid on top of the sub-base course to achieve the base course envelope after stabilization.

4.2. Construction Materials

The general specifications of the Federal Ministry of Works normally require base course materials to have a minimum CBR of 80% in the optimum condition after West African Standard or Modified AASHTO Compaction. It is also required that sub-base materials should have a minimum CBR of 30% in the optimum condition after soaking for 24 hours in water. The result of the laboratory tests carried out on the soil materials from the borrow areas show CBR values ranging between 35-90% in the unsoaked state at 100% MDD while the CBR values reduce to a range between 28-70% after soaking in water for 24 hours.

Results have shown that the materials from Borrow Areas 1, 2 & 5 are suitable for use as sub-base course materials while the soil materials at Borrow Areas 3, 4 and 7 which have unsoaked CBR values over 80% can be used as base course materials. The soil materials at Borrow Areas VI are suitable for use as ordinary fill materials.

4.3. Soil Stabilization

The increasing rate of road pavement failure, especially few months after construction, and the inability of the road to last the design life, in the country is generating a lot of concern to all stake holders involved in the road construction and maintenance Industry – the Governments at all levels, the Federal Ministry of Works, road construction companies, and highway engineers. Consequently, all searchlights are presently beamed on all aspect of the road pavement, more especially on the road pavement construction materials and quality control during construction, to determine the cause of failure and find a lasting solution to it.

After the treatment of the soil material with DRP soil stabilization chemical, it was obvious that using the 0.08 l/m^3 solution, the soil material found on the road was able to qualify for use as base course material as the test on the material after seven (7) days showed a marked increment of the CBR values to 70%. The result as shown present possibilities of the CBR meeting the 90% threshold and with a low factor of change when soaked, the materials shall ultimately increase the life span of the road.

4.4. Summary for Pilot Project (Ido – Ipere – Iludun Rd: South West)

Therefore, the control for the test at the Ido town end (between CH3+000 and 5+000) had a Maximum Dry Density (MDD) of 1.91 mg/m^3 while the Optimum Moisture Content (OMC) is 12.3%. This was used to calculate the relative compaction of the pavement materials at this section of the road pavement. Similarly, the control for the test at the Iludun town end (between CH13+300 and 15+000) had a Maximum Dry Density (MDD) of 1.96 mg/m^3 while the Optimum Moisture Content (OMC) is 15.8%. This was used to calculate the relative compaction of the pavement materials at this section of the road.

The result at the Ido town end indicated that the in-situ density varied between 1.82-1.90 mg/m^3 while the degree of compaction of the soil material range was 95.3-99.5%. Similarly, the result of the in-situ density test at the Iludun town end varied between 1.86 and 1.99 mg/m^3 while the degree of compaction of the soil range was 95.0-101.5%.

The Dynamic Cone Penetration method was used to assess the in-situ CBR of the pavement structure. The results of the in-situ CBR test (May 2008) as presented in the Table 2 showed that the number of blows recorded for the base course layer material varies between 22 and 35 blows with a corresponding CBR values of between 70.7 and 112.2%; only four locations gave CBR values less than the required 80%. Similarly, the number of blows recorded for the sub-base course layer varies between 16 and 41 blows. The corresponding CBR values range between 40.7-134.9%, which are generally adequate for the sub-base course of a road pavement (4). From the foregoing, the results of the tests indicate that both the sub-base and the base course' layers materials are generally adequate except for few locations on the base course which fell slightly below the required 80%. However, since the DRP soil stabilization chemical which was applied on the pavement soil materials increases the strength of the soil materials appreciably with time (28 days), the four locations with CBR values between 70 and 72% were expected to achieve the required 80% as the test were carried out within 7 days of the roadway application.

4.5. Summary for All Roads in the Other Zones

The tests carried out on poor and unsuitable sub-grade and borrow pit materials found in the South-South and South-East Zones were improved to qualify them as sustainable sub-base material (Table 2). With the understanding that soils in the zones are traditionally silty and low clay in nature, it is expected that further laboratory test should be engaged to understand the proper workability of the soils to effect an increase in the unsoaked CBR value. Nevertheless, it is evident from the tests undertaken that the influence of water on the soil which causes a major depletion of its strength – a situation which results in the reduction of the CBR value of the soil substantially, can be permanently corrected with the application of the stabilization chemical. The tests carried out on marginally suitable sub-grade soils as found in the South-West and North-Central Zones were improved to qualify them as sub-base materials while borrow pit materials which qualified for use as sub-base material were stabilized for application as base-course materials. This is a confirmation of the capability of the DRP soil stabilization chemical to effect improvement in soil characteristics.

The tests carried out on poor and unsuitable sub-grade and borrow pit soils found in the North-West and North-East Zones were improved to qualify them as sustainable sub-grade and sub-base materials as the case may be. The application of the DRP soil stabilization chemicals to soils found in the region showed remarkable improvements in which soils which traditionally are carted to spoils were stabilized for use as sub-grade materials. In addition, the introduction of a concentrate of lime (1-3%) to soils found predominantly in the North-East Zone – the Black Cotton Clay soils – resulted in remarkable improvement in the soils characteristics (4). In which case, soils that are traditionally unsuitable and are always recommended to be carted-to-spoils can now be stabilized to qualify for use as sub-base material.

From the foregoing, it is evident that the DRP soil stabilization chemicals can fully stabilize poor, unsuitable and marginally deficient soils for use as sub-base in roadway construction. The DRP technology is capable of effecting sustainable roadway development as the addition of the DRP soil stabilization chemicals at the different mix ratios of 0.04, 0.08 and 0.15 l/m^3 confirms that the more plastic the natural soil materials, the better the effect of the DRP soil stabilization chemical on the soil and the higher the percentage increase as measured on the CBR scale.

The capability of the DRP soil stabilization technology which is evident from the tests as compiled above, and noted from the field application of the pilot project in the

South-West Zone, confirms the ability of the DRP chemical to increase the strength of the sub-grade soil from the sub-grade quality to sub-base or sub-base quality to base course quality on addition of the necessary quantity of the DRP soil stabilization chemical. The technology as noted will reduce the thickness of the road pavement; reduce the cost of road construction and time (duration) of the construction.

5. CONCLUSION AND RECOMMENDATION

From the test results obtained for the soils at the Ido – Ipere – Iludun Road in Ekiti State, South West and other locations in the six geopolitical zones, it could be realistically concluded that the application of the Dallas Roadway Product's SA – 44 and LS – 40 proprietary chemical stabilizers causes remarkable improvement to different soil types as noted in the country. It is clear from the above that a detailed laboratory tests and analysis of the soil sample to be improved is a basic pre-requisite for the success of the DRP soil stabilization technology. Also the tests must be carried out at various mix ratios before the optimum level, which will achieve the desired result at the optimum cost to the project is determined. In this respect, we recommend herewith that representative projects be engaged on the identified roads at which soil samples have been taken and laboratory tests engaged. The result of which will confirm the level of savings which are attainable from the application of the DRP soil stabilization technology nationwide.

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