SHEAR STRENGTH CHARACTERISTICS OF WASTE ASPHALT-LATERITIC SOIL MIXTURE

BY

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PGD ICE/OS /030

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A THESIS SUBMITTED TO THE DERTMENT OF CIVIL ENGINEERING IN PARTIAL FULMENT OF THE REQUIREMENTS FOR THE AWARPOST-GRADUATE DIPLOMA (PGD) IN CIVILNEERING

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NIGER STA

FEBRUARY

DECLARATION

I, Mohammed Yakubu Ahmed hereby declare that this project was carried out by me in the department of Civil Engineering under the supervision of Engr. Mustapha Mohammed Alhaji. All information utilized and their sources have been acknowledged by means of references.

Mohammed Yakubu Ahmed Date

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s,

CERTIFICATION

I. Mohammed Yakubu Ahmed hereby certify that this work has been supervised, read through as part of the requirements of the award of Post Graduate Diploma in Civil Engineering from the Federal University of Technology, Minna, Niger State, Nigeria.

Engr. Mustapha Mohammed A. Date
(Project Supervisor)

Engr. Dr. Prof. S. Sadiku Date
(Head of Department)

External Examiner Date

DEDICATION

This project is dedicated to Allah, the Almighty who is very loving and remains the source of my success in life.

ACKNOWLEDGEMENT

First and foremost, 1 would like to say a very big thanks to Allah Almighty (or- his support over my life, and His grace with which he saw me through my studies.

Special thanks go to my parents, Alh. Ahmadu Yamakanta and Haj. Fati Tasalla for their moral and financial support all through this research work.

I must remember to appreciate the wise counsel given to me by my one and only supervisor. Engr. Mustapha Mohammed who helped me so well throughout this project work.

My heartfelt gratitude goes out for my beloved wife Haj. Fatima Yakubu for her love and caring.

Lastly, to all my colleague and friends as well. my love for you all will remain with me for all time to come.

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CHAPTER FIVE

ABSTRACT

This project report presents a study of Mechanical Stabilization of Lateritic soil using reclaimed asphalt pavement (RAP). The aim of this project is to determine the shear strength characteristics of stabilized soil. The laterite soil used in this project was obtained along Minna-Bida road and the reclaimed asphalt was obtained along Shiroro Hotel road, Minna during rehabilitation activities. Standard laboratory tests that were carried out include, particles size analysis (gradation), Atterberg limits (for index analysis), test for moisture content and shear strength test. The stabilization as done at various percentage of the admixture. The results obtained at 0%, 5%, 10%. 15% and 20% showed increase and fall in bulk density and the corresponding maximum dry Density (MOD) and the Optimum Moisture Content (OMC) behaves alike.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

To an engineer, soil is any uncemented or weakly cemented accumulation of mineral particles formed by the weathering of rocks and contains void spaces between particles, which are filled by water and or air (Craig, 1988). Laterite is a soil group, which is commonly found in the leached soil of the humid tropics and is formed under weathering systems that cause the process of laterization (decomposition of ferro-alurninia solicate mineral, leaching of the combined silica and base, and the permanent deposition of sesquioxides within the profile), (Osinubi, 2003). The silica that is left uncleaded after laterization will form secondary clay silicate minerals.

In tropical countries including Nigeria, a lot of laterite gravels and pisoliths occur which are good for gravel roads. (Osinubi and Bajeh, 1994). But there are instances where a laterite may contain a substantial amount of clay minerals that its strength and stability cannot be guaranteed under load especially in the presence of moisture. These types of laterite are common in many tropical regions including Nigeria where in most cases sourcing for alternative soil may prove economically unwise but rather to improve the available laterite soil to meet the desired objective. Meanwhile, soil improvement could be by modification or stabilization or both. Soil modification is the addition of a modifier (cement, lime etc) to a soil to change its chemical properties. Soil stabilization however, is the treatment of soils to enable their strength and durability to be improved such that they become totally suitable for construction beyond their classification ifleft untreated.

1.2 JUSTIFICATION

Laterite soils are found in abundance in most third world nations especially those in the tropics. Laterite soils are used in binders, road embankments, production of bricks. pottery and many other construction works. Waste-asphalt materials is obtained in road rehabilitation works for from production firms. Large quantities of waste asphalt can be recycled to rehabilitate road surface, surface dressing of subgrade as a stabilizing agent and heavy cut lumps can be sued to control erosion. The laboratory test for compaction characteristic of lateritic soils stabilized with waste asphalt is conducted to determine the effect on its engineering performances when used in construction works and to predict the most effective proportion to be adopted to enhance its field application.

1.3 AIM AND OBJECTIVE

Aim

The aim of this project is to investigate the response of laterite soil to stabilization using scarified waste asphalt materials.

Objectives

i. To obtain a deficient laterite soil

ii. Classify the soil according to HASHTOclassification

iii. Conduct test and the natural soil

iv. Carryout completion test in the soil admixed with 0, 5, 10, 15, and 20% reclaimed asphalt and obtained the shear strength characteristic.

v. Prepare a specimen at the predetermined optimum moisture content and MDD.

vi. Obtain the optimum mixture to give the higher strength

1.4 SCOPE OF WORK

The soil samples used in the study were taken from a depth of between 1.0m and l.2m along Minna-Bida road during the dry season using the method of disturbed sampling. The tests were carried out on samples of lateritic soil. The tests were carried out in accordance with procedures in I.S: 2720 (part VII) - 1980/87. The scope of the work include

1. Preliminary analysis of the lateritic soil samples together with treated samples such as natural moisture content, sieve analysis, as well as atterbery limit was conducted to characterized the soil
2. Tests were carried out on the soil samples and soil sample treated with scarified asphaltic concrete percentage ranging from 0% to 5% to 10% to 15% and 20% respectively.

   These tests are

i. Particle size distribution
ii. Atterbery limits
iii. Shear strength characteristics

CHAPTER TWO

2.0 UTERA TURE REVIEW

2.1 LATERITE

Laterite is a form of 'soil' in engineering application. The term 'soil' has various meanings, depending upon the general professional field in which it is being considered. Soil is considered by the engineer as a complex materials produced by the weathering of the soil rock The formation of soil is as a result of the geologic cycle continually taking place on the face of the earth. In civil engineering, the term "soil' is applied to the natural products of weathering and mechanical disintegration of rocks which from the crust of the earth. Soil is interest to civil engineers because it is always used in the construction of engineering structures.

2.1.1 Origin of laterite based on recent study

Since first named and described by Buchanan in 1807, the term 'laterite' has been used with different conations by various workers. The early workers were mainly guided by the scientific study of the firm and structural characters while discussing the classification and origin of laterite, whereas the present day workers lay emphasis on chemical and mineralogical composition in the treatment of various features of laterite. Most of the very early observations were confirmed to the morphological features of laterite and its field setting (Newbold 1844). To these process laterite is a brickstone (Buchanan 1807), lronclay (Viysey, 1833), zed ferriginous clay (Foote 1983), indurated clay (Foote 1876), ferruginous bared clay (Lake 1890) etc. From the beginning of the twentieth century there has been a shift in emphasis to wards chemical properties, geochemistry of weathering and economic aspects of laterite. Holland (1903) outlined the broad chemical changes in valued in lateralization and strength attributed an origin due to tropical weathering. Madaren

(1906) advocated that latfitization was brought about by the action of carbonated water in the presence of humid in areas of hot climate with heavy rainfall.

2.1.2 Definition and physical description oflaterite

Laterite are soil types rich in iron and aluminium, formed in hot and wet tropical areas. Nearly all laterite are rusty-red because of iron oxides. Francis Buchanan - hamitton first described and named a laterite formation in sourthern India in 1807. He named it Laterite from the Latin word Later, which means a brick. It has also been used for any reddish soil at or near the earth's surface. Laterite covers are trick on the stable areas of the African shield. Laterite can be either soft or easily broken into smaller piece or firm and physical resistant. Lateritic soils from the uppermost part of the laterite cover.

2.1.3 Formation of Laterite

Laterites are formed from the leading of parent sedimentary (granitesd, basalts, gabbros, peridotites) metamorphic rocks (schists, gneisses, migmatites, igneous rocks ion, predominantly iron and aluminum. Laterite formation if favoured in low topographical areas of gentle crests which prevents erosion of the surface cover. The mineralogical and chemical compositions of laterites are dependent on their parent rock. Laterites consist mainly of quartz and oxides of titamium zircon, iron, tin, aluminum and manganese, which remain during the course of weathering. Laterites very significantly according to their location, climate and depth.

2.1.4 Uses of Laterite

i. Building blocks

When moist, laterite can be easily cut with a spade into regular sized blocks. Laterite is mined while it is below the water table, so it is wet and soft. It is common practice to remould disturbed laterite to required brick size.

2.2.3 Known uses of Asphalt

Ancient Times

In the ancient middle east, natural asphalt deposits were used on mortar between bricks and stones, to cement part of carvings, such as eye, into place, on ship caulking and for water proofing.

Early use in Europe

In 1838 edition of mechanics magazine cites on early use of asphalt in France. When the existence of asphalt was discovered in large quantities in the vicinity of 'neufchatel' it was principally used in the construction of air-proof grannies, and in protecting the water-course in the city of paris, which at that time made the water unstable.

Early use in tbe United Kingdom

Among the earlier uses of asphalt in the United Kingdom was for etching. Williams Salmon's polygraphic (1673) provides a recipe for vanish used in etching. The first British Patient for the use of asphalt was Cassell's patent asphalt or bitumen in 1834. Then on 25 November 1937, Richard Tappia Elaridge patented the use of sessile asphalt for use in asphalt pavement.

2.2.4 RECYCLING OF ASPHALT

Asphalt concrete is often considered as being 100% recyclable. Several in-place recycling techniques have been developed to rejuvenate oxidized binders and remove cracking. although the recycled material is generally not very water-tight or smooth and should be overlaid with a new layer of asphalt concrete. Asphalt concrete that is removed from a pavement is usually stockpiled for later use as a base course material or as a stabilizing agent. This reclaimed materials, common known by the acronym 'RAP' (Recycled or reclaimed Asphalt pavement) is crushea to a consistent gradation and applied to the HMA mixing process.

In the scope of this project, RAP in this context is considered as 'waste-asphalt' which is used to stabilize laterite to investigate its performance characteristics.

2.3 ADMIXTURE STABILIZATION

Stabilization, in broad sense, incorporated the various methods employed for modifying the properties of a soil to improve its engineering performance. Stabilization is being used for a variety of engineering works, the most common application being in the construction of road and air-filled pavement, where the main objective is to increase the strength or stability of soil. Methods of stabilization may be grouped under two main types.

a) Improvement of a soil property of the existing soil without any mixture.

b) Modification of the properties with the help of admixture compaction and drainage are the examples of the first type, which improve the shear strength of soil. Examples of the second type are: mechanical stabilization, stabilization with cement, lime, bitumen and chemicals etc. mechanical stabilization method will be discussed in this chapter.

2.3.1 Mechanical stabilization

Mechanical stabilization involves two operations

i) Changing the composition of soil by addition or removal of certain constituents.

ii) Densification or compaction

The particle size distribution and composition the important factors governing the engineering behavior of a soil. Significant changes in the properties was made by addition of waste-asphalt at certain proportion. For mechanical stabilization, the primary purpose is to have a soil resistant to deformation and displacement under loads, soil materials can be divided in two fractions:

i) Granular fraction retained on a 75 micron IS sieve and

ii) Fine soul fraction passing a 75micron sieve.

The granular fraction impact strength and hardness. The fine fraction provides cohesion or binding property.

Mechanical stabilization has been largely used in the construction of cheap roads. Although there are guides of specification for gradation requirements of the bases and surfacing, emphasis should be laid on making the maximum use of the locally available materials as many materials are fund to be quite satisfactory under load conditions.

CHAPTER THREE

MATERIALS AND METHODOLOGY

3.1 Materials

The soil material used in performing the laboratory test, include lateritic soil. The lateritic soil used in this project work was obtained, along Minna-Bida road. An admixture material, 'RAP' (reclaimed Asphact payment) was used to stabilize the lateritic soil for the experiment. This was obtained along Shiroro road, Minna during the road rehabilitation activities.

3.2. Methodology:

A reasonable quality of lateritic soil was collected from site by method of disturbed sample. Little quantity was taken instantly and preserved to determine the natural moisture content. The soil sample was pulverized and air-dried in the laboratory. The sample was *served* through *sieve* 2mm sized which was kept for subsequent experiments. The admixture material, RAP was pulverized and *served* through sieve 5mm size is which was used to stabilize the soil specimen. The experiment was carried out in laboratory by stabilizing the soil with the admixture at various percentages of 0%,5% 10%, 15% and 20%.

3.2.1 Natural Moisture Content Determination.

This is natural moisture content of the soil sample as obtained from the site. Three empty cars were weighed, filled with the representative sample of lateritic soil. The cans with the samples were weighed and were then *even* -dried on 24 hours weighed of the water in the sample was determined by the difference in weight of wet sample and the weight of dried sample. The water content, 10 of a soil sample represents the weight of free water contained in the sample expressed as a percentage of its by weight.

Mathematically, moisture content, (w) = $\frac{Wz - W3}{W3 - W1}$ X 100%

Where Wi = weight of the empty can

W2 = weight of the can + wet soil

W3 = weight of the can + dry soil

Table 3.1 Natural moisture content Determination Table

Weight of the car (g)	Wl	22.5	24.8	23.7
Weight of can + wet soil (g)	W2	28.8	26.9	29.8
Weight of Can + dry soil (g)	W3	27.9	26.7	28.6
Moisture content (%)		16.7	10.5	24.4
Average moisture content (%)			17.23	

3.2.2 Procedure

The method employed for the determination of grain size distribution was sieve-washing method. A weight of 300% of arrived representative sample was taken and washed through a set of British standard (BS) sieves of 2mm rested on 75mm Sieve until the sample was substantially clean. The amount retained on the sieves was collected together and dried in an oven on 24 hours. The dried sample was weighed and the result record. Sieves ranging from 5.00mm, 3.25mm, 2.00mm 1.8mm, 850mm, 600mm, 425mm, 300mm, i50mm and 75mm were arranged in order of size in descending manner and under neath is a pan which serves as a receiver. The oven dried soil was poured into the top most sieves, covered with a lid and vibrated for 15 minutes or threatment after which the mass of the particles retained on each sieve was weighed, percentage mass retained cumulative percentage mass and percentage passing were calculated and res It record in table 3.2. The weight ofthe sample after washing and dried completely is 106.4 g.

Table 3.2 Particle Size Distribution on Laterite Soil Sample

Mass of Soil =300 after washing.

Sieve Sizes	Weight of empty Sieves (g)	Weight of Sieve Soil sample (g)	Weight of Sample retained (g)	Percentage mass retained (%)	Cumulative Percentage mass retained (%)	Percentage passing (%)
5.00mm	4.78.7	488.4	9.70	3.23	3.23	96.77
3.35mm	469.0	478.0	9.00	3.00	6.23	93.77
2.00mm	423.0	441.1	18.10	6.03	12.26	87.74
1.18mm	388.0	398.4	10.40	3.46	15.72	84.28
850mm	356.3	362.8	6.50	2.16	17.88	82.12
600mm	468.7	477.9	9.20	3.06	20.94	79.06
475mm	436.2	445.9	9.70	3.23	24.17	75.83
300mm	314.2	326.9	12.70	4.23	28.40	71.60
150mm	421.2	439.2	18.00	6.00	34.40	6.56
75mm	369.7	372.8	3.10	1.03	25.43	64.57
Pan	272.3	272.4	0.10	0.03	35.46	64.54

3.2.3 Liquid limit test (can penetration method)

The dried sample of Uterate was collected, sieve through 425Jl.msieve. 200g of the sample was place on a plastic plate. A small amount of water was added to make a uniform mixture. The height of the cone penetrometer was adjusted to O.OOmm mark. Then the electrometer brass cup was well filled with the soil sample, leave with spatula and placed under the penetrometer. The knob was adjusted until there is slight contact between the tip of the cone on the surface of the soil sample in the brass before penetrometer to penetrate in to the sample. The depth at which the penetration occurred was taken and noted. A piece was cut from the penetrated point to determine its moisture content at the mixture. (Thus, soil pats were retained on each sieve was weighed, percentage mass retained cumulative percentage mass and percentage passing were calculated and result record in table 3.2. The weight of the sample after washing and dried completely is 106.4 g.

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3.2.4Plastic Limit Determination.

To determine the plastic limit, the soil specimen, passing 425lffil sieves, was mixed thoroughly with clean water until the soil mass becomes plastic enough to be easily molded with fingers. The plastic soil mass left for enough time to allow water to permeate through the soil. A ball was turned with about 8g of this plastic soil mass and rolled between the fingers on a plastic plate with just sufficient pressure to roll the mass into thread of uniform diameter through its length.

When a diameter of 3mm was reacted, the soil was remolded again into a ball. This process of rolling and remolding at a diameter of 3mm. The crumbled threads are kept in an oven for water content determination. The test was repeated twice with fresh samples. The plastic limit, PL was then taken as the average of two water.

The plasticity index is calculated from the relation Pl=LL-PL.

Table 3.3 shows the result of plastic limit determination

Table 3.3 Liquid limit and plastic limit for lateritic soil.

	LIQUID LIMIT					PLASTIC LIMIT	
NO OF TRiNALS	1	2	3	4	5		
Penetration(mm)	98	111	164	183	231		
Can No.	S2	S9	Cs	C9	S1	D3	(.1
Weight of can (g)	26.1	29.8	23.4	20.3	23.1	22.2	25.1
Weight of can +wet sample (g)	30.6	35.6	29.7	28.4	32.1	24.5	28.3
Weight of can + dry sample (g)	29.5	34.1	28.0	26.1	29.4	24.1	27.7
Moisture content (%)	32.35	34.88	36.96	39.66	42.27	21.05	23_08
						Ave=22.07	

3.2.5 COMPACTION TEST

Procedures

The test consists in compacting soil at various water contents in the mould (944cm^3) in five layers. 2.5kg of air-dried representative soil sample was mined thoroughly with a small quantity of water. The mixture was allowed to soak for maturing time of about 5 to 15minutes to permit proper absorption of water. The quantity of water that was added for the first trial was dependent upon the probable optimum water content on the soil. The initial water content was about 8% for the test sample. The empty mould attached to the base plate was weighted without collar. The collar was the attached to the mould. The mixed soil was placed in the mould and compacted by giving 25 blows of the rammer, (4.5kg weight falling freely through 45cm high) uniform distributed over the surface.

The table below shows the results of compaction characteristics for stabilization of lateritic soil with the reclaimed asphalt pavement (RAP) at various percentages.

Table 3.4 Compaction test for Lateritic soil using (BSH) effort at zero percent (0-0/0) stabilization

Wgt. Of empty mould (g)	Wgtof mould + sample (g)	Can No. (g)	WgtofCan (g)	Wgt.OfCan + wet sample (g)	Wgt.OfCan + dry sample (g)
4864	6460	S6	2.43	35.5	35.2
		CI	24.0	31.4	31.2
4864	6585	S10	22.7	34.0	33.0
		C3	26.0	38.1	37.1
4864	6880	S3	30.1	45.8	43.6
		Dl	24.1	45.7	42.6
4864	6771	C2	22.5	47.9	43.1
		S7	27.6	50.9	46.4
4864	6686	C9	20.2	44.2	39.0
		S4	22.6	50.9	44.9

Table 3.4.1 Compaction characteristics for zero percent (00/0) stabilization

No. of trials	1	2	3	4	5
Bulk Density, Pb	1.60	1.82	2.14	2.02	1.93
Moisture content (%)	2.77	13.94	16.53	23.32	27.29
Dry density [g/cm'')	1.03	1.60	1.83	1.64	1.52

3.2.6 Shear Strength Test

Materials used for the experiment include triaxial machine specimen mould, specimen extruder, tampering rod, tuber membrane, water vacuum supply, electronic weighing balance, oven evaporation dish and rubber strip.

The soil sample was placed in a tray mixed with water corresponding to the optimum moisture content and the three layers. The sample was extruded into the rubber membrane with the aid of a sample extruder. Both end into a Perspex cell. The cell was then sealed by the use of bolts. Water was then pumped into the cell to full capacity with the aid of the pressure pump.

Vertical load was applied through a proving ring at a constant rate of strain until the soil sample failed in shear. The mode of failure was noted; the triaxial test was performed three times on similar samples using cell pressure of 50,100 and 150 KNjm2. The triaxial test was performed OII plain lateritic and stabilized lateritic soil samples.

Table 3.S Shear Strength for confined Test Result

Soil sample	Cell pressure (KNjM2)	Deviator stress (KNjM2)	Prtncipal Stress (KNjM2)
0% Scarified Asphalt	50	214	264
	100	378	478
	150	516	666
5% Scarified Asphalt	50	271	321
	100	296	396
	150	309	459
10% Scarified Asphalt	SO	164	214
	100	604	704
	150	667	817
15% Scarified Asphalt	50	113	163
	100	466	566
	150	447	597
20% Scarified Asphalt	50	209	259
	100	264	364
	150	334	484

Table 3.5.1 Average shear strength for Unconfined Test

Test No	Percentage Stabilization (0/0)	Shear stress (N/mm2)
1	0%	282.71
2	5%	279.00
3	10%	218.30
4	15%	510.00
5	20%	407.30

CHAPTER FOUR

DISCUSSION OF TEST RESULTS

4.1 DETERMINATION OF NATURAL MOISTURE CONTENTS

Results obtained from the experiment shows that average moisture content in the lateritic soil in its natural State was 17.23%

Result obtained from the particle size distribution of the soil gives the distribution in percentage of the various sizes present in the sample from gravel, dense sand, fine sand, and finally silt. The results of the particle size distribution carried out for the sample is show in table 3.2

4.2 ALTERBERG'S LIMIT TEST

Alterberg's limit test was carried out to determine the liquid limit, plastic limit and plasticity index of the soil. The result of the experiment is presented in table 3.3. The trend show that with increase in a corresponding increase in liquid limit and plastic limit but reduction in plasticity index.

4.3 SHEAR STRENGTH

This was carried out to determine soil parameters such as cohesion (c) and the angle of shearing resistance (0). The result obtained showed a small increment in cohesion. This increase in cohesion signifies the development of cementation linkage between soil particle and waste asphalt. The mixture of waste or scarified asphalt material and the soil, hydrate forming secondary cementations which contributes to inter-particle bonding, hence the higher the waste asphalt the higher the inter particle bonding and consequently in the strength as evident in the increase in cohesion (c) with a corresponding increase in an angle of shearing resistance (0).

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

From the result and data presentation in this research work the following conclusions were drawn.

The laterite was classified to be A-6 soil in accordance with A ASH TO Classification system.

There was an increase in plastic limit and liquid limit but decrease in the plasticity index.

The result of the research work shows that there is a significant change in the shear strength parameters of lateritic soil treated with scarified (waste) asphalt.

5.2 RECOMMENDATIONS

The result of this study can serve as a guide in the use of scarified (waste) asphalt as stabilizing agent in road pavement construction.

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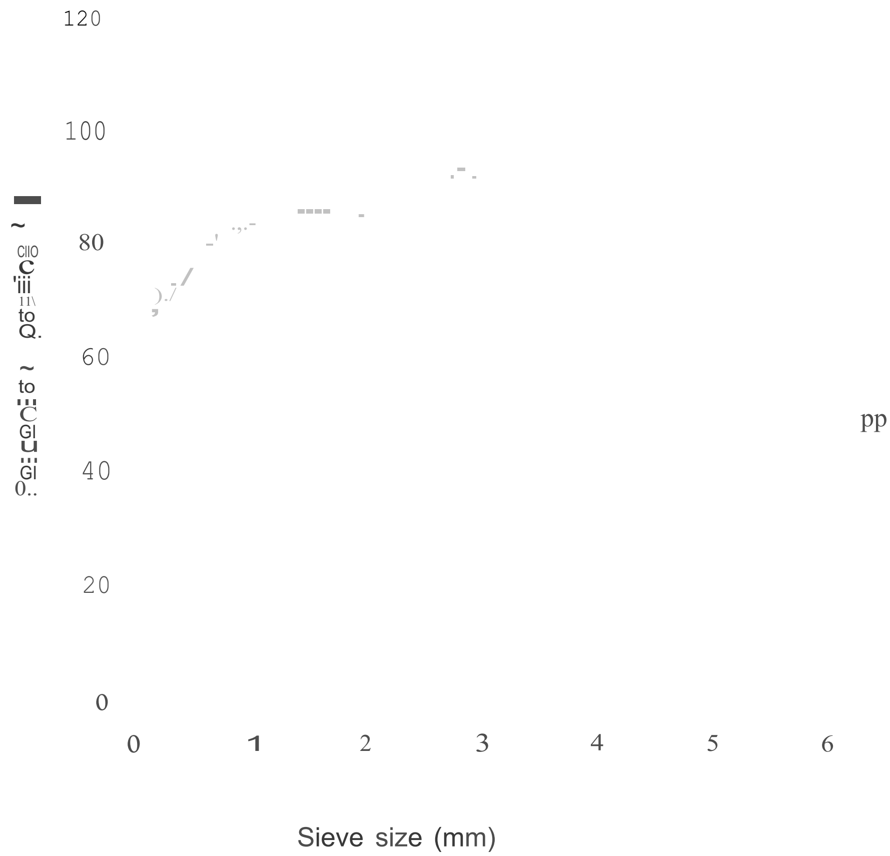
APPENDIX



Relationship between Percentage passing and the Sieve size

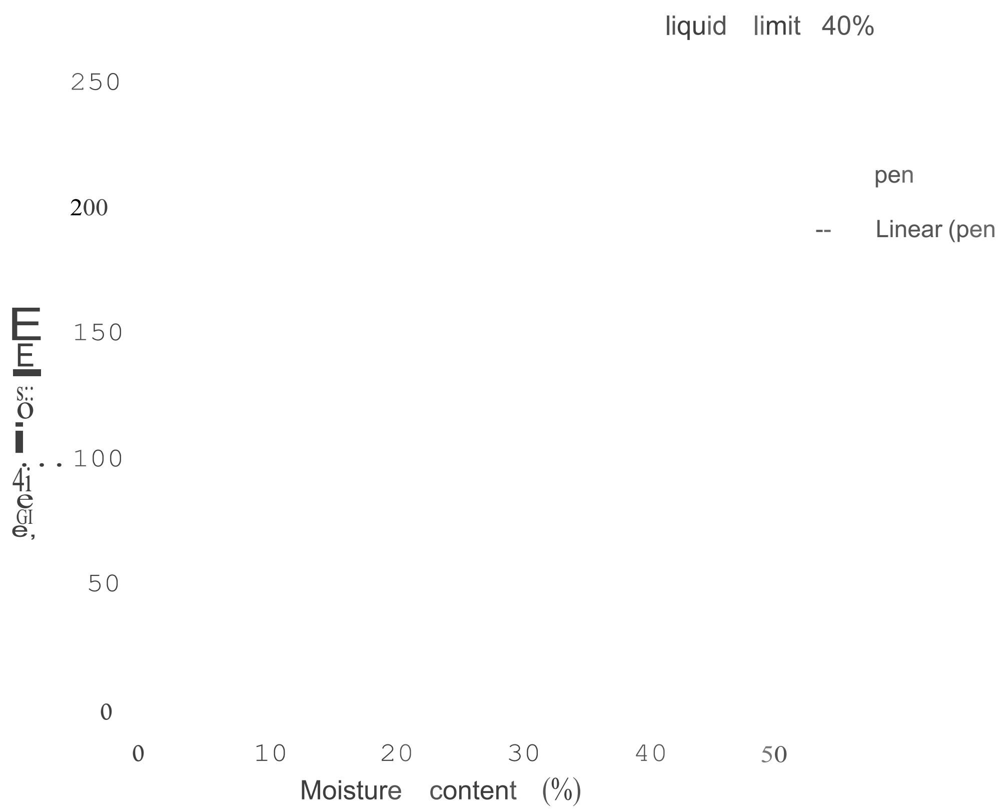


Fig. 4.7 Relationship between penetraion and moisture content for index analysis

1. 0% Stabilization

Test No.	Cell pressure	Compressive Strength	principall Stress
1	50	214	264
2	100	378	478
3	150	516	666

C = 14.5

0 = 40o

Shear stress (KN/m2) against Principal Stress (KN/m2)

2. 5% Stabilization

Test No.	Cell pressure	Compressive Strength	Principal Stress
1	50	164	214
2	100	604	704
3	150	669	817

C 70.1
0 23°

Shear stress (KN/rnZ) against Principal Stress (KN/rnZ)

3. 10% Stabilization

Test No.	Cell pressure	Compressive Strength	Principal Stress
1	50		
2	100		
3	150		

C = 162.3

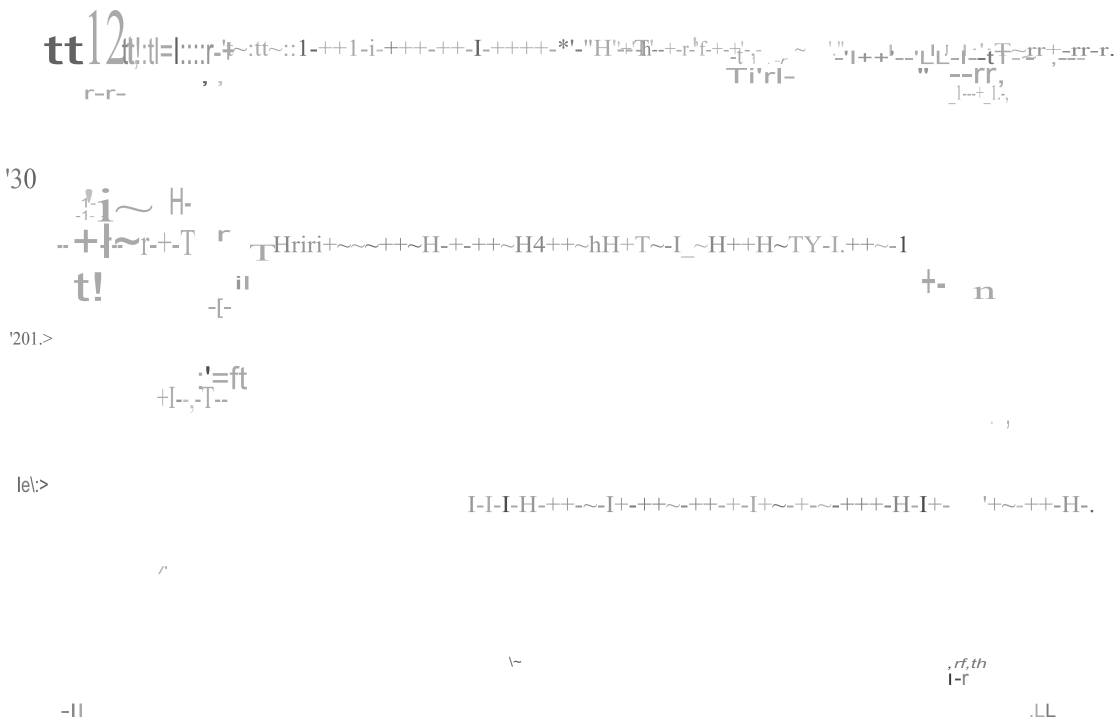
Ø = 26°

4. 15% Stabilization

Test No.	Cell pressure	Compressive Strength	Principal Stress
1	50	113	163
2	100	466	566
3	150	447	597

c = 0

ϕ = 45^0



Shear stress (KN/m^2) against Principal Stress (KN/m^2)

5. 20% Stabilization

Test No.	Cell pressure	Compressive Strength	Principal Stress
1	50	214	264
2	100	378	478
3	150	516	666

c 159

0 20°

Shear stress (KN/m²) against Principal Stress (KN/m²)

Dial puce calibrated
- to 0·1mm"

Te$t sam ple In

(A) Cone penetrometer

Compaction mould display