MECHANICAL STABILIZATION OF LATERITIC SOIL USING RECLAIMED ASPHALT

BY

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PGD/CE/08/024

DEPARTMENT OF CIVIL ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

NIGER STATE, NIGERIA

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A PROJECT REPORT SUBMITTED TO THE

DEPARTMENT OF CIVIL ENGINEERING,

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY,

, FEDRAL UNIVERSITY OF TECHNOLOGY MINNA,

IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF

POST GRADUATE DIPLOMA (PGD) CERTIFICATE

FEBRUARY, 2011

DECLARATION

I hereby declare that this Project was wholly done by me under the supervision of Engr. Mustafa Muhammad Alhaji of the Civil Engineering Department, Federal University of Technology, Minna. During the *2010/2011* academic session.

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Jiya Ibrahim Ndadzan Date

(pGD/CFIOS/024)

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CERTIFICATION

This is to certify that Project titled 'Mechanical Stabilization of Lateritic Soil Using Reclaimed Asphalt (RA) was carried out by Jiya Ibrahim Ndadzan *(pGD/CEI08/024)* for the Award of Post Graduate Diploma Certificate in Civil Engineering, Federal University of Technology Minna, Niger State.

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Engr. M. M .A1haji Date

(Supervisor)

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Engr. Prof. S. Sadiku Date

H.O.D (Civil Engineering Department)

.~.............~..................

External Examiner Date

DEDICATION

I dedicate this piece of work to Almighty Allah Whom in His infinitive Mercy made it possible for me to under gone this course of studies successfully,

ACKNOWLEDGEMENT

Glory be to Almighty Allah for His Guidance and Protection throughout my course of studies in the University. I wish to express my profound gratitude to my supervisor Engr. M. M. AIhaj, who patiently gone through this report writing with great devotion and effected corrections, my school department H.O.D Engr. Prof. S. Sadiku, Engr. Dr. T.Y. Tsado, Engr. Prof. O.D. limo, Engr. Dr. P.N. Ndoke, Dr. A. Amadi, Dr. 1.1.Agwa, Engr. S. Oritola, Engr. R. Adesuji, Engr. I. limo, Engr. 1. Olayemi, Engr. I. Abdulqadir, Engr. Dr. Ogwoeleka, Engr. Mrs. O. Gbadebo, Engr. M. AIhassan, Engr. Kolo S.S and other members of staff for their counseling and advice; and the Lab. Attendant Mall. U.M. Baddegi who guided me through my practical works in the Laboratory. I extend my appreciation to all well- wishers especially, my office department H.O.D Engr. A. Sadeeq. Also to -Engr, I. Dada, Engr. A. kolo, Mall. A. Z. Evuti and others of Niger State Agricultural Development Project, Department of Engineering Services Minna, Niger State for their counseling and support throughout the successful period of my studies. I should also thank the members of my family household who patiently bear with me during the course of studies.

ABSTRACf

This Project report presents a study of Mechanical Stabilization of Lateritic Soil using Reclaimed Asphalt (RA). The aim of this project is to determine the compaction 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 compaction test. The stabilization was done at various percentages of the admixture. The results obtained at 00/0,5%, 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.

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ABBREA VIATIONS / SYMBOLS USED IN THIS PROJECT REPORT

AASHTO = American Association State Highway Organization

BS = British Standard

BSH = British Standard Heavy

BSS = British Standard Sieve

lIMA = Hot Mixed Asphalt

LL = Liquid Limit

MC = Moisture Content

MDD = Maximum Dry Density

OMC = Optimum Moisture Content

PI = Plasticity Index

PL = Plastic Limit

RAP = Reclaimed Asphalt Pavement

Pb = Bulk density

Pd = Dry density

w = water content

CHAPTER ONE

INTRODUCTION

1.1 Preamble

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, 1998). 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-alumino silicate minerals, leaching of the combined silica and base, and the permanent deposition of sesquioxides within the profile),(Osinubu 2003.) The silica that is left unleached 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 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 if left untreated.

1.2 Justification

Lateritic soils are found in abundance in most third world nations especially those in the tropics. Lateritic soils are used in buildings, road embankments, production of bricks, pottery and many other construction works. Waste asphalt material is obtained in road rehabilitation works or from producing firms. Large quantity of waste asphalt can be recycled to rehabilitate road surface, surface dressing of sub-grade as stabilizing agent and heavy cut lumps can be used to control erosion. The Laboratory test for compaction characteristics of lateritic soils stabilized with waste asphalt is conducted to determine the effect on its engineering performance when used in construction works, and to predict the most effective proportion to be adopted to enhance its field application.

1.3.1 Aim and objectives

Aim

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

Objectives

1. To obtain a deficient lateritic soil
2. Classify the soil according to AASHTO classification
3. Conduct compaction test on the natural soil
4. Carry out compaction on the soil admixed with 0,5,10,15 and 20% reclaimed asphalt and obtained compaction characteristics
5. Prepare a soil specimen at the predetermined optimum moisture content and maximum dry density.
6. Obtain the optimum mixture to give the higher strength

CHAPTER TWO

Literature review

2.1 Laterite

Laterite is a form of 'Soil' in engineering application. The term 'Soil' has various meanings, depending upon the professional field in which it is being considered. Soil is considered by the engineer as a complex material produced by the weathering of the solid rock. The formation of soil is as ·sresult 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 form the crust of the earth. Soil is interest to Civil engineer 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 connotations by various workers. The early workers were mainly guided by the scientific study of the form and structural characteristics 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 o Laterite. Most of the very early observations were confined to the morphological features of Laterite and its field setting (Newbold 1844). To these pioneers Laterite is a brick stone (Buchanan 1807), iron clay (Voysey 1833), red ferruginous clay (Foote 1873) indurate clay (Foote 1876), Ferruginous bonded clay (Lake 1890) et-al. From the beginning of the twentieth century there has been a shift in emphasis towards chemical properties, geochemistry of weathering and economic aspect of Laterite. Holland (1903) outlined the broad chemical changes involved in Laterization and strongly attributed an origin due to tropical weathering. Maclaren (1906) advocated that Laterization was brought about the action of carbonated waters in the presence of humus in areas of hot climate with heavy rain fall.

2.1.2 Definition and physical description of Laterite.

Laterite is soil type rich in iron and aluminum, formed in hot and wet areas. Nearly all Laterite are rusty-red because of iron oxides. Francis Buchanan Hamilton first described and named Laterite formation in Southern 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 thick on the stable areas of the African Shield. Laterite can be either soft or broken in to smaller pieces or firm and physically resistant. Lateritic soils form the upper most part of the Lateritic cover.

2.1.3 Formation of Laterite

Laterites are formed from the leaching of parent sedimentary (granites, basalts, gabbrons, peridotites); metamorphic rocks (schist, gneises, migmatites); igneous rocks ions, predominantly iron and aluminum. Laterite formation is 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 quarz and oxides of titanium, zircon, iron, tin, aluminum and which remain during the coarse of weathering.Laterites Vary significantly according to their location,climate and depth.

2.1.4 Uses of Laterite

Building blocks

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

Road building

Generally, surfaced roads in most part of the World are with crushed Laterite, stone or gravel base. In Nigeria, during the early 1970's, road embankments were constructed using Laterite in place of stone as a base course.

2.2 Asphalt

Asphalt or (Bitumen) is a sticky, black and highly viscous liquid or semi-liquid that is present in most crude petroleum and in some natural deposits. Until the 20th century, the term *asphaltom* was also used. In American English, asphalt (or asphalt cement) is the carefully refined residue from the distillation process of selected crude oils. Outside the U.S, the product is often called Bitumen.

2.2.1 Asphalt concrete

Asphalt concrete is a composite material commonly used in construction project such as road surfaces, airports and parking lots. It consists of asphalt (used as a binder) and mineral aggregate mixed together, then laid down in layers and compacted. Asphalt concrete has different performance characteristics in terms of surface durability, tire wear, braking efficiency and roadway noise.

2.2.2 Back ground of Asphalt

Asphalt or Bitumen can sometimes be confused with tar, which is a similar black thermo-plastic material produced by the destructive distillation of coal.During the early-and mid-20th century when town gas was produced, tar was a readily available product and extensively used as the binder for road aggregates. However, since the 1979s, when natural gas succeeded town gas, asphalt (bitumen) has completely overtaken the use of tar in these applications.

In the ancient Middle East, natural asphalt deposits were used for mortar between bricks and stones, to cement parts of carvings, such as eyes, in to place, for ship caulking, and for water proofing.

In 1838, edition of Mechanics magazine cities an early use of asphalt in France. When the existence of asphaltum was discovered in large quantities in the vicinity of 'Neufchatel' it was principally used in the construction of air- proof granaries, and in protecting the water-courses in the city of Paris, which at that time made the water unusable.

Among the earlier uses of asphalt in the United Kingdom, was for etching. William Salmon's polygraphice(1673) provides a recipe for vanish used in etching. The first British patent for the use of asphalt was Cassell's patent asphalt or bitumen in 1834. Then on 25th November 1837, Richard Tappin Claridge patented the use of Seyssel asphalt for use in asphalt pavement.

2.2.3 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 over laid with a new layer of asphalt concrete. Asphalt concrete that is removed from a pavement is usually stock -piled for later use as a base course material or as a stabilizing agent. This reclaimed, commonly known by the acronym 'RAP' (Recycled or Reclaimed Asphalt Pavement) is crushed to a consistent gradation and added 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.

(http://en.wikipediaorglwiki/Asphalt-concrete)

2.3 AdmixtlUe Stabilization

Stabilization, in a broad sense, incorporates 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-field pavements, where the main objective is to increase the strength or stability of soil. Methods may be by improvement of a soil property of the existing soil without any admixture or modification of properties with the help of admixtures.

2.3.2 Mechanical Stabilization

Mechanical Stabilization involves two operations:

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

,f ii Densification or compaction

The particle size distribution and composition are the important factors governing the

CHAPTER THREE

MATERIALS AND METHODOLOGY

3.1 Materials

The soil material used in performing the laboratory tests include lateritic soil. The lateritic soil used in this project work was obtained along Minna-Bida road. An admixture material RA (Reclaimed Asphalt) was used to stabilize the lateritic soil for the experiment. The RA material was obtained along Shiroro road, Minna during the road rehabilitation activities.

3.2 Methodology

A reasonable quantity of lateritic soil was collected from site by method of disturbed sampling. Little quantity was taken instantly and preserved to determine the natural moisturecontent. The soil sample was pulverized and air -dried in the laboratory, The sample was sifted through sieve 2mm size, BS which was kept for subsequent experiments. The admixture material, RA was pulverized and sifted through sieve 5mm size, BS 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 20010.

3.2.1 Natural moisture content determination.

This is the natural moisture content of the soil as obtained from the site. The mass of the representative sample was weighed and note taken, then the sample was oven-dried for 24 hours. The weight of the dried sample was taken; and the difference between the two weights were noted. The water content of a soil sample represents the weight of free water contained in the sample expressed as s percentage of its dry weight, Mathematically, moisture content,

$$W = \frac{w2-w3}{w3-w1} \times 100\%$$

Where W_1= weight of the empty can

W_2=weight of can + wet soil

W_3=weight of can + dry soil

The result of the natural moisture-content determination is presented in Table3.1

Table 3.1Ntdlll'lll moisture content determination

Weight of can (g)	WI	22.5	24.8	23.7
Weight of can +wet sample (g)	W2	28.8	26.9	29.8
Weight of can +dry sample (g)	W3	27.7	26.7	28.6
Moisture content (%)	--	21.15	10.53	24.49
Average moisture content (%)			18.72	

engineering behavior of soil. Significant changes in the properties was made by addition of waste-asphalt at certain proportions. For Mechanical Stabilization, the primary purpose is to have a soil resistant to deformation and displacement under loads, soil materials can be divided in to two fractions:

Granular fractions retained on a 75 micron BS Sieve

11 Fine soil fraction passing a 75 micron BS Sieve

The granular fraction imparts strength and hardness.

The fine provides cohesion or binding property

Mechanical stabilization has largely been 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 the maximum use of the locally available materials as many materials are found to be quite satisfactory.

2.4 Compaction

Compaction is a process by which the soil particles are artificially rearranged and packed together in to a closer state off contact by mechanical means in order to decrease the porosity (or voids ratio) of the soil and aggregate of matter is also increased by driving out air. For any soil, for giving amount of the compactive effort, the density obtained depends on the moisture content. At very high moisture content, the maximum dry density (MDD) is achieved when the soil is compacted to nearly saturation, where (almost) all the air is driven out. At low moisture content, the soil particles interfere with each other; addition of some moisture will allow greater bulk densities, with a peak density where this effect begins to be counteracted by the saturation of the soil.

In 1933, Engineer Ralph R. Proctor conducted a compaction test on a soil sample to determine the maximum practically-achievable density of soils and aggregates. This practice is frequently used in geotechnical engineering. Proctor showed that there existed a definite relationship

between the soil water content and degree of dry density to which a soil might be compacted. Proctor's interest in geotechnical engineering began during his under graduate studies where he was motivated by the publications of Sir Alec Skempton about the behavior of natural soils. Skempton formulated concepts and porous water coefficients that are still widely used today. Proctor took a step further and formulate his own experimental conclusions to determine a solution foe the in-situ behaviors of clay and ground soils. Later, Skempton adopted his idea and expounded upon the compaction of the soil to establish the maximum practically-achievable density of soils and aggregates. From this, the bulk density, moisture content and dry density could be determined by simply measuring the weight of the soil.

2.4.5 Uses of compaction

-It leads to an increase in shear strength of soil

-It helps to improve the stability and bearing capacity of a soil

-It reduces the permeability of soil.

-Detrimental settlement can be prevented.

2.4.6 Factors affecting c01llJlllClion

Witer content: it has been seen by laboratory experiments that as the water content is increased, the compacted density goes on increasing, till a maximum dry density is achieved after which further addition of water decreases the density.

Anwllllt of c01llJlllClion: the amount of compaction greatly affect the maximum dry density and water content of a given soil. The effect of increasing the compactive energy results in an increase in the maximum dry density and decrease in the optimum water content.

Method of c01llJlllClion: the density obtained during compaction, for a given, greatly depends upon the type of compaction or the manner in which the compactive effort is applied.

Type of soU: well graded coarse-grained soils attain a much higher density and lower optimum water contents than fine grained soils which require more water for lubrication because of the greater specific surface.

Addition of admixtures : the compaction properties! characteristics of a soil can be modified by a number of admixtures other than soil material. These admixtures have special application in stabilized soil construction .

Hydrometer

3.2.3 Procedure

Particles passed through 75J.1Dsieve (BS) along with water were collected and put in to a lOOOmlJar hydrometer analysis. More water was added to make the soil water suspension just lOOOml.A dispersive agent, sodium hexametaphosphate (2g) was mixed with the suspension. The suspension was vigorously shaken horizontally by keeping the jar in-between the palms of the two hands. The jar was put on the table. A graduated hydrometer was carefully inserted in to the suspension minimum. disturbance. At different time intervals, the density of the suspension at the centre of gravity of the hydrometer is noted by seeing the depth of sinking of the stem. The temperature of the suspension is noted for each recording of the hydrometer reading. Hydrometer readings were taken at a time interval of 0.5minute, 1.0 minute, 2.0 minutes,4.0 minutes, 15.0 minutes, 45.0 minutes, 90.0 minutes, 3hrs. 6hrs. and 24hrs. By using the monogram given in BS3720, the diameter of the particles for different hydrometer readings was found out.

3.2.4 Liquid limit test (Cone penetration method)

The air dried sample of Laterite was collected, sieved through 425um sieve (BS). 200g of the sample was placed 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 0.00 mm mark. Then Penetrometer brass cup was well filled with the sample, leveled with spatula and placed under the Penetrometer. The knob was adjusted until there is slight contact between the tip of the cone and the surface of the soil sample in the brass cup before penetration. The knob was pressed which released the 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 its moisture content at the mixture. {thus, soil pats were prepared at various water contents) and depth of penetration (x) for each pat was noted. A graph is plotted (fig.4.7) representing water content (w) on the x-axis and cone penetration (x) on the y-axis. The best fitting straight line is then drawn. The water content corresponding to a cone penetration of 20mm is then taken as the liquid limit. Table 3.3 shows the result of the test.

3.2.5 Plastic limit determination

To determine the plastic limit, the soil specimen, passing 425um sieve, (BS) was mixed thou roughly with clean water until the soil mass becomes plastic enough to be easily molded with fingers. The plastic soil mass was left for time to allow water to permeate through the soil mass. A ball was formed 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 in to thread of uniform diameter through its length. When a diameter of 3mm was reached, the soil was remolded again in to a ball. This process of rolling and remolding was repeated until the thread starts just crumbling at a diameter of 3mm. The crumbled threads were 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 content.

The Plasticity index, PI is calculated from the relation:

PI= LL-PI

added for the :first trial was dependent upon the probable optimum water content for the soil. The initial water content was about 8% for the test sample. The empty mould attached to the base plate was weighed without collar. The collar was then attached to the mould. The mixed soil was placed in the mould and compacted by giving 25 blows of the rammer, (4.5 kg weight falling freely through 45cm height) uniformly distributed over the surface, such that the compacted height of soil was about 1I5th the height of the mould. Before putting the second installment of soil, the top of the :first compacted layer was scratched with the help of a sharp edge to ensure grip. The second, third, fourth, and fifth layers were thus compacted. Each layer was given 25 blows. The compacted layer projected not more thanlOmm. in to the collar. The collar was removed and the soil was trimmed off to make it level with the top of mould. The weight of the mould, base plate and the compacted soil was taken. A representative sample was taken from the centre (at the top and bottom) of the compacted specimen and kept in an oven for water content determination. The bulk density p, and the corresponding dry density Pd, for the compacted soil are calculated from the following relation:

Where

w = mass of wet compacted specimen (g)

v = volume of the mould (cnr')

w = water content (%)

CHAPTER FOUR

4.0 DISCUSSION OF RESULTS

4.1 Natural Moisture content

The natural moisture content of representative lateritic soil was found to be 18.72% as shown in Table 3.1

4.2 Gradation

From the grain size distribution analysis, an indicator of the spread (or range) of grain, and based on the Sieve analysis carried out, the soil can be classified as A-6 by AASHTO classification.

4.3 Atterberg limit

The result obtained from the Atterberg test, Liquid limit, LL = 4()01o and Plastic limit, PL = 22.07%

Then Plasticity Index, PI = LL - PL

= 40-22.07

= 17.93%

4.4 Compaction

The tabulated results for compaction tests at various percentage stabilization are shown in the Appendix.

Ph = bulk density

Pd = dry density

The results of the compaction characteristics at zero percent stabilization is given in the table below ..

Table 3.4 *Compaction testfor Lateritic soil using (BSH) effort* at *zero percent (0%) Stabilization*

Wgt. of empty mould	Wgt. Of Mould + Sample	Can No.	Wgt. Of Can	Wgt. Of Can + wet sample	Wgt. Of Can + dry sample
(g)	(g)		(g)	(g)	(g)
4864	6460	S6	24.3	35.5	35.2
		Cl	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

4.4.1 Results

From the results obtained. it is unique that on every stabilized specimen at various percentages, when water content was increased the bulk densities also increase. With incremental water content, the bulk densities reached maximum and then fall at very high moisture. The corresponding dry densities exhibit similar results. This is an indication that maximum bulkJ dry density is attained at moderate water content. Further increase in moisture decreases these characteristics.

These characteristics are summarized in the Tables below for various stabilizing content per percentage.

Table 4.1 *Compaction characteristics for zero percent (0%) stabUization*

No. of Trials	1	2	3	4	5
Bulk Density, ρ_b (g/cnr')	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/cnr')	1.03	1.60	1.83	1.64	1.52

Table 4.2 *Compaction characteristics for five percent (* 5%) *stabUization*

No. of Trials	1	2	3	4	5
Bulk Density, ρ_b (g/cnr')	1.71	1.81	2.15	1.95	1.94
Moisture Content (%)	4.04	8.27	11.92	23.57	26.22
Dry Density, ρ_d (g/cm')	1.64	1.67	1.92	1.58	1.54

Table 4.3 *Compaction characteristics/or ten percent (10%) stabilization*

No. of Trials		1	2	3	4	5
Bulk Density, Pb	(glcm)	1.73	1.72	2.10	1.96	1.82
Moisture Content	(%)	9.83	10.84	13.09	23.93	29.91
Dry Density, Pd	(g/cnr')	1.58	1.60	1.86	1.58	1.40

Table 4.4 *Compaction characteristics/or fifteen percent* (15%) *stabUization*

No. of Trials		1	2	3	4	5
Bulk Density, Pb	(glcm)	1.68	1.92	1.99	1.88	1.83
Moisture Content	(%)	1.50	10.32	21.20	27.78	30.01
Dry Density, Pd	(g/cnr')	1.66	1.74	1.64	1.47	1.41

Table4.5 Compaction characteristics/or twenty percent (20%) stabUization

No. of Trials		1	2	3	4	5
Bulk Density, Pb	(glcm)	1.64	1.75	2.13	1.97	1.86
Moisture Content	(%)	3.61	8.26	14.70	21.95	30.45
Dry Density, Pd	(g/cnr')	1.58	1.62	1.86	1.62	1.43

From the above summary tables, it is obvious that the increased bulk/dry densities to maximum are a function of water content in every mixture.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

In this research study, Laboratory experiments were carried out to investigate the response of lateritic soil to mechanical stabilization using "Reclaimed Asphalt Pavement" (RAP). The following conclusions can be drawn from the results obtained of the tests:

i The lateritic soil studied can be classified as A-6 soil according to AASHTO soil classification system.

ii The behavior of Laterite soil varies even with same standard measures adopted for one aim and objective on a homogeneous material.

iii A reclaimed Asphalt pavement has potential to be recycled for various activities in engineering application.

5.2 Recommendation

As a result of increasing the engineering performance of the lateritic soil, based on the investigation carried out and the conclusions drawn; I recommend that a similar research be carried out with a varying stabilizing content in lateritic soil and, or other stabilizing agents.

REFRENCES

Ackroyd (1963): Development in soil engineering. Geotechnical engineering publishers. (www.Dupla.com/eo37.htm)

Arun K.. J.and Dr. Punmia B .C: Soil Mechanics and Foundations (2005)

Bajeh I. and Osinubi K.1. Bituminous stabilization of Laterite Spectrum journal, Vol. 1, No.2, 1994

Eihard Mitscherlic, (1833) (http://www.devilsfinder/2%/chempvs0092.htm)

Smith Geoffrey Nesbit (1990): Elements of Soil Mechanics

Wikipedia, the free encyclopedia: (http://en.wikipedia.orglwiki/soils)

APPENDICES

The Tables and Figures below show the compaction tests on lateritic soil admixed with a "RAP" material at various stabilizing content.

Table 4.6 *Compaction testfor Lateritic soil using (BSH) effort atjive percent (5%) Stabilization*

Wgt. of empty mould (g)	Wgt. Of Mould + Sample (g)	Can No.	Wgt. Of Can (g)	Wgt. Of Can + wet sample (g)	Wgt. Of Can + dry sample (g)
4833	6446	S9	27.7	46.3	45.6
		S8	25.4	45.1	44.4
4833	6545	C5	23.3	39.4	38.1
		D2	25.7	41.0	39.9
4833	6862	C4	25.1	43.4	41.1
		SI	23.0	45.1	42.1
4833	6676	A7	15.9	50.9	44.4
		A8	22.4	54.6	48.3
4833	6663	C8	25.5	62.4	54.9
		C6	26.2	69.1	60.0

Table 4.7 Compaction test for Lateritic soil using (BSH) effort at ten percent (10%) Stabilization

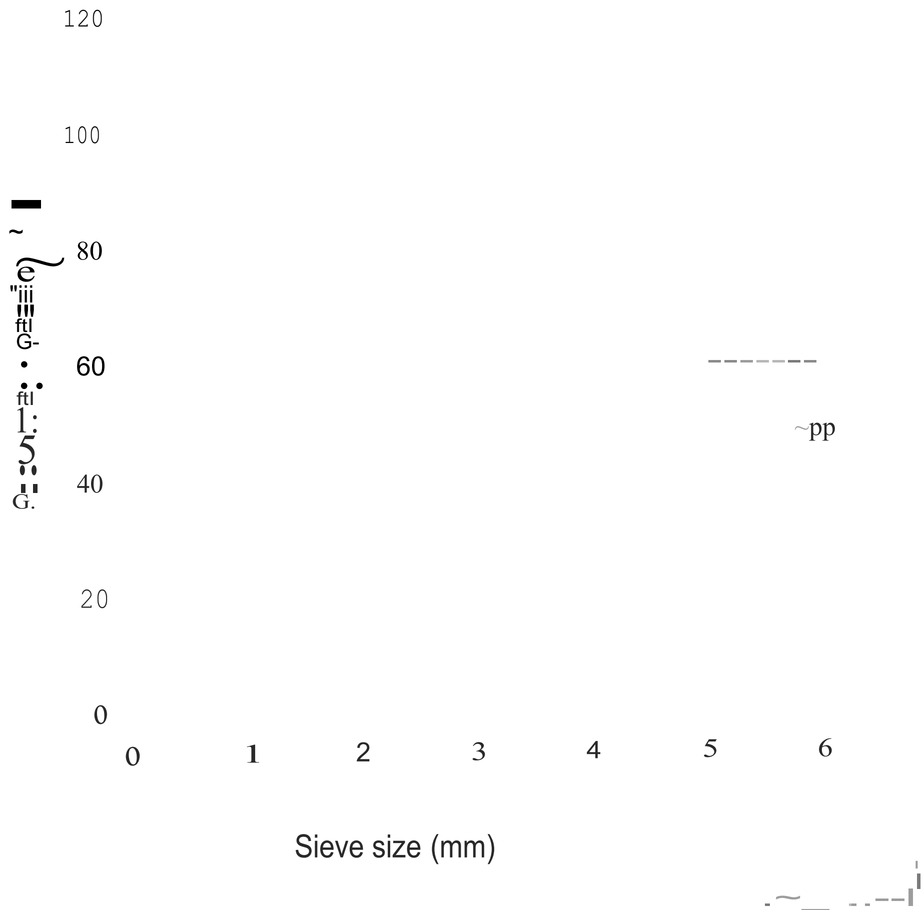
Wgt. of empty mould (g)	Wgt. Of Mould + Sample (g)	Can No.	Wgt. Of Can (g)	Wgt. Of Can + wet sample (g)	Wgt. Of Can + dry sample (g)
4862	6492	A9	22.0	29.77	29.01
		S6	24.3	35.80	34.90
4862 -	6490	C4	25.1	36.80	35.80
		C9	20.3	28.80	27.90
4862	6835	Sl	23.1	40.10	37.50
		D2	25.7	40.70	38.40
4862	6715	C1	24.1	46.10	41.90
		C10	27.8	52.90	48.00
4862	6580	S4	22.6	46.40	40.90
		S5	23.2	49.80	43.70

Table 4.8 Compaction test for Lateritic soil using (BSH) effort at fifteen percent (15%) Stabilization

Wgt. of empty mould (g)	Wgt. Of Mould + Sample (g)	Can No.	Wgt. Of Can (g)	Wgt. Of Can + wet sample (g)	Wgt. Of Can + dry sample (g)
4837	6424	S1	23.10	31.00	30.89
		C5	23.00	34.54	34.35
4837	6647	A9	21.92	30.60	29.77
		C1	23.90	35.60	34.53
4837	6712	C10	27.63	57.90	52.68
		D2	25.53	53.67	48.68
4837	6607	S4	22.42	48.87	43.17
		C9	20.12	46.07	40.38
4837	6563	S6	24.15	45.50	40.55
		C4	25.00	49.20	43.64

Table 4.9 *Compaction test for Lateritic soil using (BSH) effort at twenty percent (20%) Stabilization*

Wgt. of empty mould (g)	Wgt. Of Mould + Sample (g)	Can No.	Wgt. Of Can (g)	Wgl Of Can + wet sample (g)	Wgt. Of Can + dry sample (g)
4837	6387	5b	25.0	37.40	37.00
		7p	22.33	34.66	34.20
4837	6491	A7	24.6	38.24	37.25
		D9	23.47	37.25	36.15
4837	6843	9a	24.6	45.70	43.10
		A4	24.34	47.94	44.80
4837	6693	6e	23.8	46.50	42.30
		All	23.64	42.62	39.30
4837	6589	Al	23.54	46.35	41.02
		2b	25.27	48.00	42.70



Relationship between Percentage passing and the Sieve size

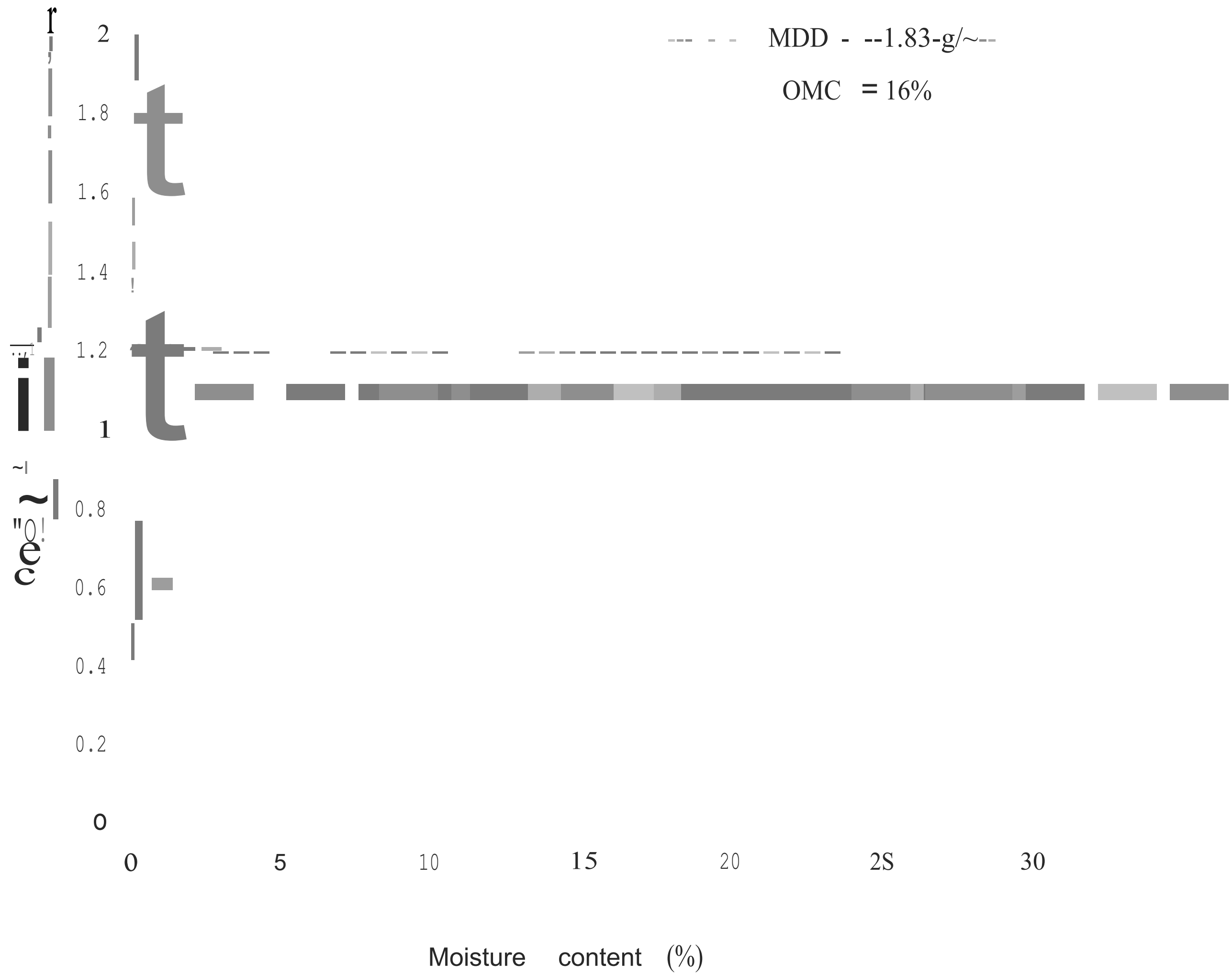


Fig. 4.2 Relationship between dry density and moisture content for zero (O%)stabilization

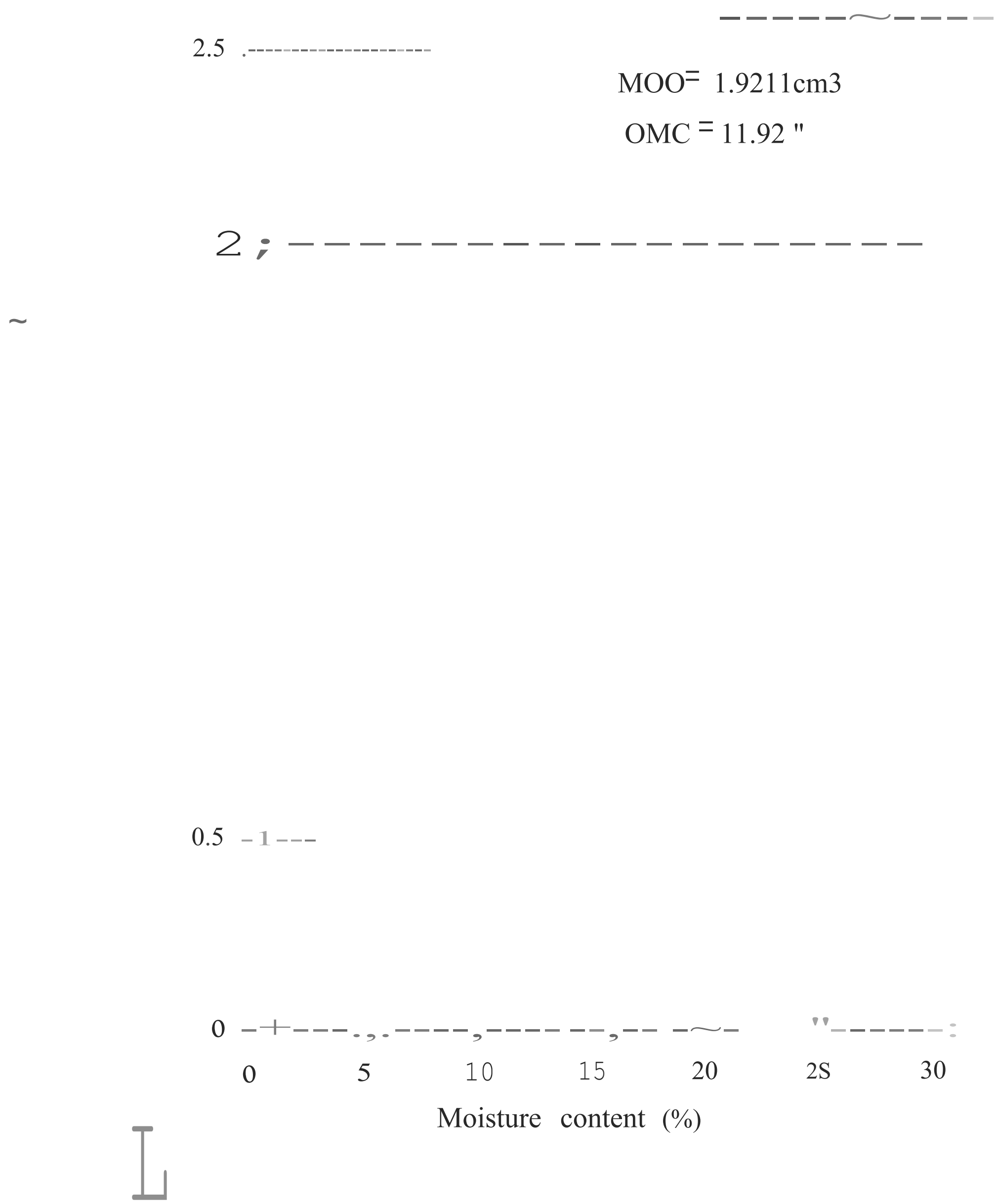


Fig.4.3 Relationship between dry density and moisture content for five (5") stabilization

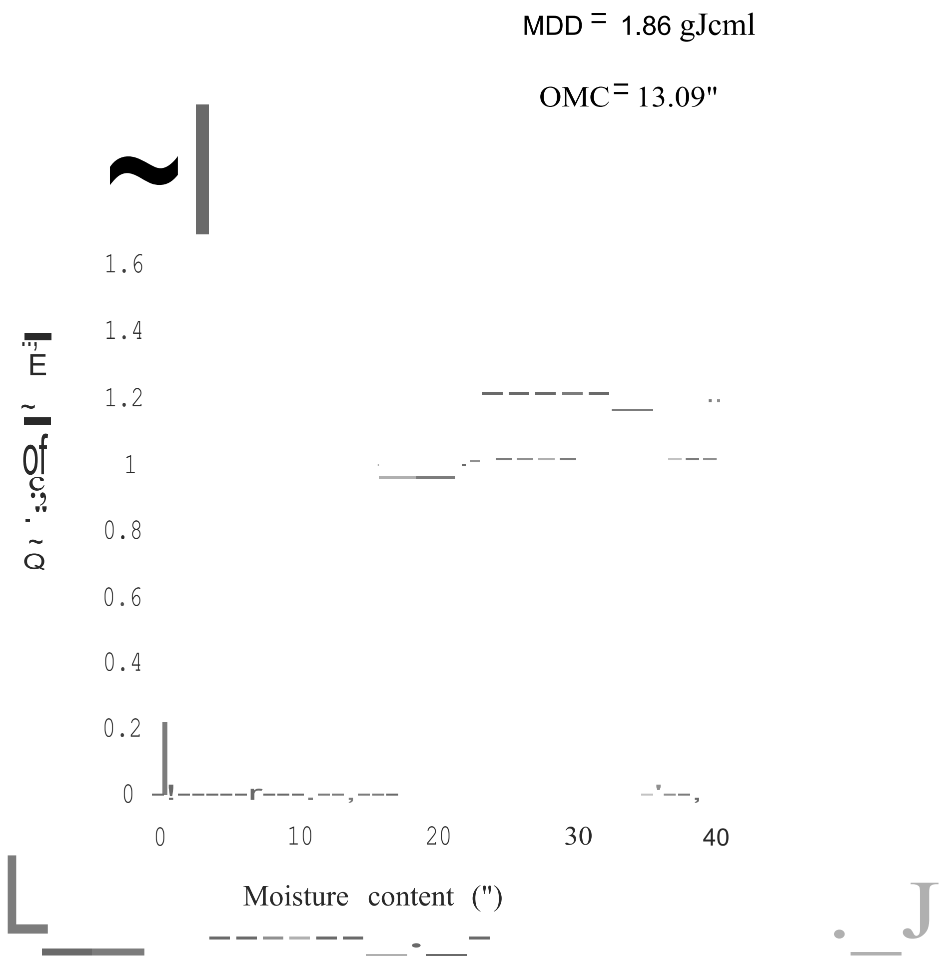


Fig.4.4 Relationship between dry density and moisture content for ten (10%) stabilization

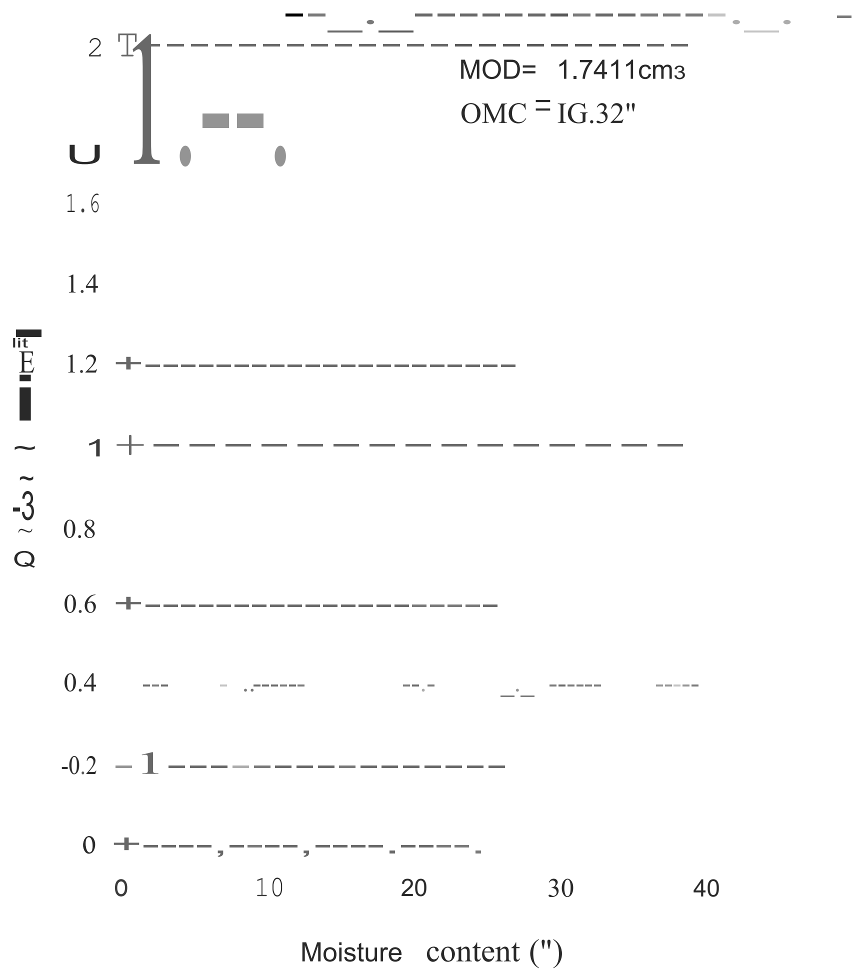


Fig.4.5 Relationship between dry density and moisture content for fifteen (15") stabilization

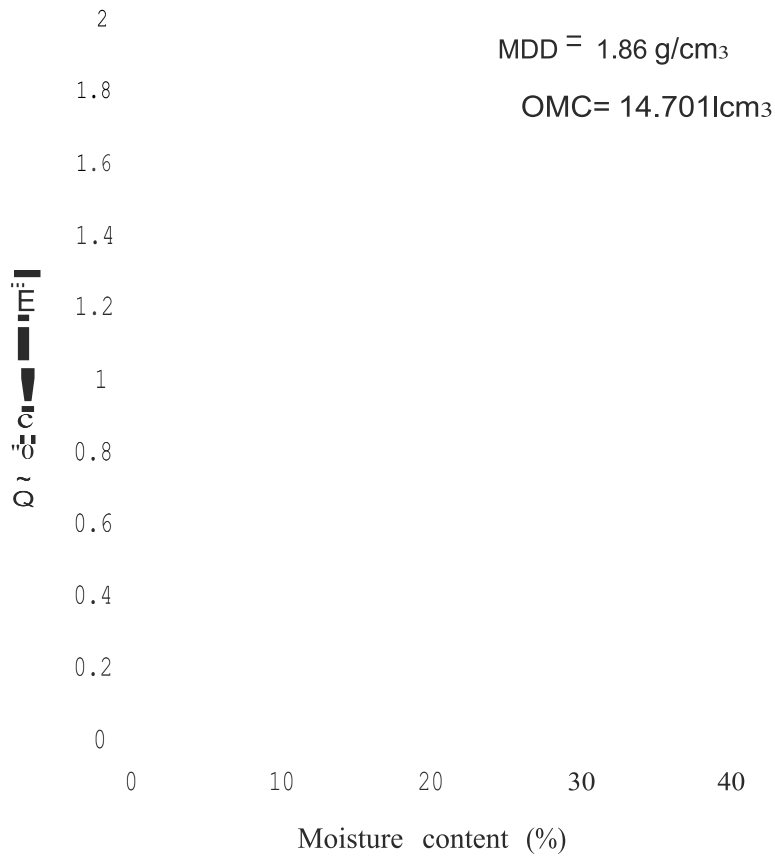


Fig.4.6 Relationship between dry density and moisture content for twenty (20%) stabilization

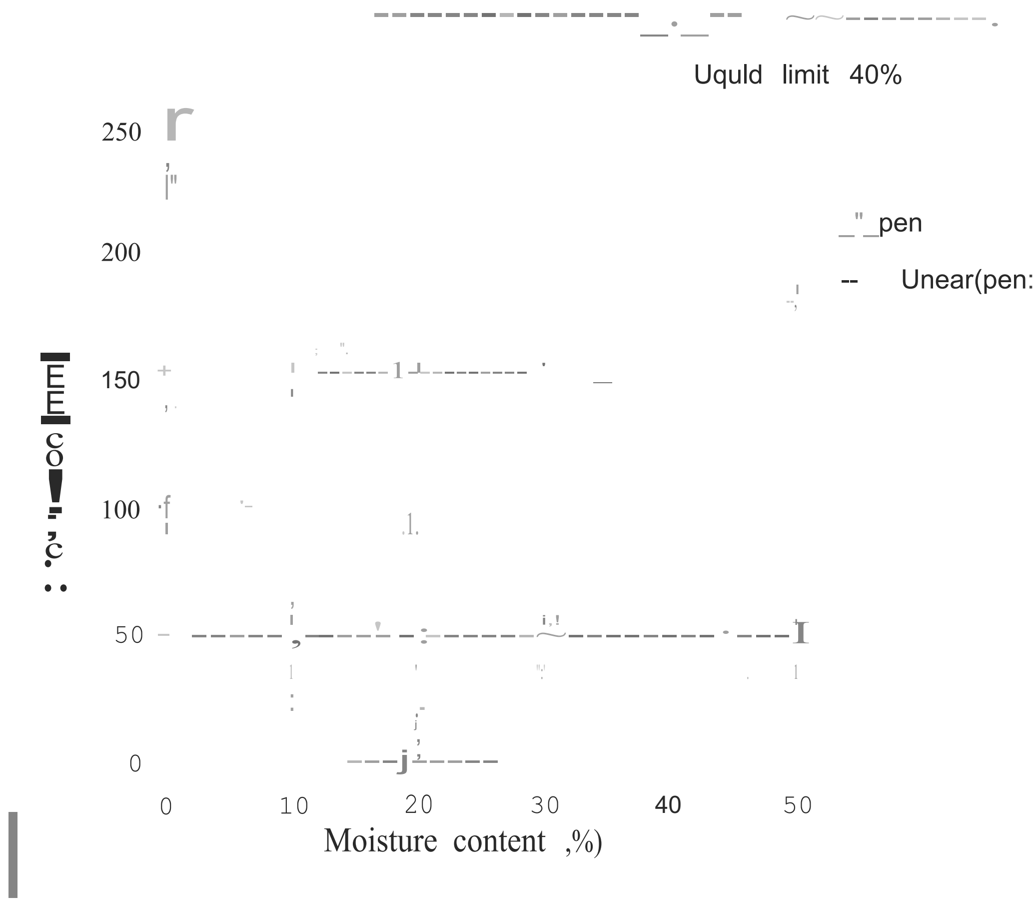


Fig. 4.7 Relationship between penetralon and moisture content for index analysis

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Compaction mould display