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Analysis and Assessment of Index Properties of Laterite Soils Found in Landmark University Campus Omu-Aran, Kwara State

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ABSTRACT

Laterites are highly weathered and altered residual soils usually formed in the tropical and sub tropical regions due to the in-situ weathering and decomposition of rocks, index properties of some laterite soils which are sensitive to methods of Tests preparation and testing procedures. In addition, water content determination using oven temperatures of different magnitude usually gives significant variation for some laterite soils. This study examines moisture content determination using different oven temperatures on the soil samples in the laboratory, and to investigate the presence of loosely bound water of hydration. The study shows that the soil samples did not contain loosely bound molecular water in a significant amount, and pre-treatment variation has not change the index test results, whereas the test procedures have shown some influence on the soil samples.
Keywords: *Laterite Soils, Pre-treatment, Testing Procedures.*

INTRODUCTION

Soil Engineering properties of laterites are highly influenced by the presence of sesquioxides. The sesquioxides within the fine fraction of many tropical soils tend to coat the surface of individual soil particles of coarser size. These factors usually reduce plasticity, but intensive remoulding of the soil usually breaks down the aggregations and the sesquioxides coatings result increase of soil plasticity. Laterite soil is a widely available material in Landmark University Omu-Aran Kwara state. The Engineering properties of the soils have not been studied satisfactory as expected, even though many constructions of buildings are still on-going on the campus everywhere. To use laterites as a construction materials, detail Engineering properties need to be known. Thus, the objective of this study is to discover the influence of drying temperature on moisture content values and effect of pre-treatments and testing procedures on index properties of laterite soils found on the university campus

METHODOLOGY

Effect of temperature variation on moisture content determination has been checked in the laboratory using different drying oven temperatures on the soil samples. The temperatures were 105^{o}c and 50^{o}c with maximum relative humidity 30^o/$_o$. Different presentment methods have been applied on soil samples tested in the laboratory. These methods were air drying (AD), oven drying (OD) and as received (AR) or at the natural moisture content. Sample tested for the three pre-treatment methods were prepared in the following manner (Lyon, 1971).

As Received (AR) - at natural moisture content.
Air dried (AD) – dried to constant weight under room temperature.
Oven dried (OD) – dried in an oven for 24 hours at 105°c.
Soil is considered to be at its moist condition if its field moisture content was about 13% (Lyon, 1971). Regarding air drying one can use equivalently oven at a temperature of 50°c with maximum relative humidity 30% (Blignt, 1997).
The effect of different testing procedures on the Atterberg limits was checked by varying mixing time.

BACKGROUND INFORMATION

Sensitivity to test procedures

Sensitivity of soil test procedure is related with the property of self-hardening under cycles of wetting and drying which could be important for the performance of certain lateritic soils. The factors which influence the sensitivity of certain lateritic soils to test procedures. This sensitivity can be attributed to three basic factors. As described below (CIRIA 1995).

Loss of water of hydration on drying

The water of hydration in the sesquioxides of iron and aluminium may be driven off by oven-drying at 105°C the standard temperature for testing temperate region soils. This water normally takes no part in the engineering performance of the material, but is reflected in the test results as higher moisture content.

Aggregation of clay-size particles

The sesquioxides within the fine fraction of tropical soils tend to coat the surface of individual soil particles. The coating can reduce the ability of the clay minerals to absorb water. It can also cause a physical cementation of adjacent grains, thus producing aggregated particles of coarser size, both factors reduce plasticity, both intensive remoulding of the soil breaks down the aggregations and the sesquioxide coating, with an attendant increase in plasticity.

Irreversible changes in plasticity on drying

When laterites dry, sons which contain hydrated oxides of iron and aluminum may become less plastic. This is partly because dehydration of the sesquioxides creates a stronger bond between the particles, which is resistant to penetration by water. Drying is also accompanied by shrinkage, which brings the particles closer together, and the attractive forces become so strong that water no longer penetrates. The process cannot be reversed by re-wetting. The effect takes place during air-drying but becomes more pronounced on oven-drying at higher temperatures.

Identification of sensitivity to test procedures

To identify susceptibility of lateritic soils to the effect of clay mineral aggregation, to drying (dehydration of sesquioxides), bulk sample at its natural moisture content should be tested in laboratory. The following tests should be conducted (CIRIA, 1995).

a) Loss of water of hydration

Two test portions should be prepared for moisture content determinations one should be oven dried at 105 °C until successive test weighing show that no further weight loss is talking place, and the moisture content should be then determined. The other sample should be air-dried or oven dried at no more than 50 °C until successive test weighing show no further weight loss, and the moisture content hen determined. The two results should be compared. A.B. Fourie recommends the moisture variation 4-6% or more indicates that structural water is present (Blight,1997).

b) Disaggregation of clay-size particles on mixing

A.B. Fourie suggested five air dried test portions should be mixed with water to give the range of water contents suitable for liquid and plastic limit determinations. The mixing time should be no more than 5 minute, and the mixed samples should be left to cure overnight before testing. After determining the moisture content for each test liquid limit test point on a paet of each test portion, the reminder should then be mixed for a further 25 minutes before again determine the liquid, limit. A.B. Fourie suggests a "> 5%" difference between the liquid limit of the specimens 5 minutes and 30 minutes mixing times indicates a breakdown of the aggregations of clay sized particles within the material (Blight, 1997)

c) Drying and wetting

Some guidance may be obtained by comparing the atterberg limits of soil prepared from natural moisture content with those of oven dried soil re wetted to the point of the test. With no further research, it indicates the preparation of laboratory specimens should simulate sensibly the likely filed procedure with respect to wetting and / or drying of the soil prior to compaction. This is not covered in this paper for the detail one can see in (Abebaw 2005).

Laboratory Testing Procedures

Moisture Content Determinations

Moisture contents of the soil samples were determined in the laboratory according to AASHTO T262-93 (2000); Blight, 1997; CIRIA 1995. Graying oven temperatures of 105 °C with maximum relative humidity (RH) 30% were used to dry the samples.

Grain Size Analysis

Dry preparation

The soil sample brought from the field was first air or oven dried at temperature of 105 °C and then pulverized before it was screened through the nest of sieves. The preparation followed the procedure detailed in AASTO T88-00. The air dried soil samples were prepared by spreading the material out in trays in the laboratory and leaving it open to the air for at least 10 days pr equivalently put inside oven at temperature of 50 °C with maximum relative humidity 30% for at least 5 days. The room temperature was about 20 °C. The oven dried samples were prepared by drying the soils overnight at 105°C. Apart from the method of preparation of the soil samples, sieve analysis tests were carried out accordance to AAHTO T87-86.

Wet Preparation

Wet soil sample preparations were carried out on moist soil samples for grain size anayyisi tests following the procedures mentioned in (AASHTO T!$^ -96; Blight, 1997).

Atterberg Limits

For the determination of the Atterberg limit, Values, air and oven dried soil samples were tested following the procedure given in AASHTO T*(-02 and T90-00 except some variations in sample preparation. The air and oven dried soil samples were prepared as mentioned in testing procedures of grain size analysis. Wet sample preparations were also carried out on moist soil samples portion of the soil samples passing No.40 (0. 425mm) sieve were kept wet for a period of 24 hrs for moisture content equilibration. The effect of disaggregation of clay size particles upon manipulation during Atterberg limit testing were checked by conducting atterberg limit tests on the soil sample according to the procedures mentioned in (AASHTO T89-02, T90-00; CIRIA, 1995 and Blight, 1997).

Laboratory Test Results and Discussions

For the determination of index properties of laterite soils, disturbed samples were collected from football Gold close to strider site

Effect of Temperature on Moisture Content Determination

The values of the mixture content variation using oven temperatures of 105°C and 50°C with maximum relative humidity (RH) 30% are compared and summarized in table 1. From the test results, one can see that the differences in moisture contents for all sites under cons ideation are below 4%, which means that the soil under investigation does not contain loosely bound water of hydration.

Table 1. Moisture Content Comparison by Different Oven Temperature

Designation	**Moisture Content Values [°C]**		**Difference [%]**
	105°C	50°c, RH = 30%	
Sp-1	20.3	19.8	0.5
Sp-2-1	27.9	26.0	1.9
Sp-3-1	19.8	18.9	0.9
Sp-3-2	16.8	14.5	2.3
Sp-2	27.4	25.2	2.3

Effects of Mixing Water

Water may be chemically reaching with the oxides of latertic soils during testing. In order to see this reaction Atterberg limits, free swell (FS) and Linear shrinkage (LS) tests were carried out with distilled and tap water at temperature of 20°c. the results are tabulated in Table 2. From the test results it can be seen that the respective results of Atterberg limits. Free well and Linear shrinkage tests vary insignificantly upon changing of testing water type. It is to reacting with the oxides of lateritic soils during testing.

Table 2: Test Results Comparison with Different Mixing Water.

Designation	Mixing water	LL (%)	PL (%)	PI (%)	FS %	LS (%)
Sp-2-1	Distilled	53	34	19	30	8.3
Sp-2-1	Tap	52	35	17	30	7.9

The grain size analysis test results for all soil samples under investigation at different testing conditions are summarized in table 3. The corresponding grain size distribution curves are shown in fig 1. The values obtained from the graduation tests were analyzed with respect to the effect of pretreatment in the following paragraph. Oven dried (OD) air dried (AD) and as received (AR) sample preparations were carried out to investigate the effect of pretreatment on grain size distribution. The test results sample under investigation. The test results are shown in table 3 and Figs. 1a & 1b. Water content prior to testing for moist soil sample are attached in table 3. From methods of pretreatment create a small change in cumulative percentage passing between OD and AR for sample Sp-1 the AR method of pretreatment resulted finer cumulative percentage passing for sample Sp-1 than both OD and AD. This is due to some coarse grain become weaker and breaking into finer size. Hence, when these soils are dried, the fine particles do not aggregate to from larger particles due to mineralogy alteration and / or development of larger capillary forces between particles.

Table 3: Percentage Amount of the Grain Size and Atterberge Limits at Different Testing Conditions

designation	Natural Moisture Content %	Testing Condition	Percentage amount of Particle sizes				Liquid limit (%)	Plastic limit (%)	Plasticity index (%)
			Gravel	Sand	Silt	clay			
Sp-1	19.8	Oven-dried Air-dried As received	74.1 74.1 61.3	16 12.7 19.8	7.9 9.8 13.1	2 3.4 5.8	54 56 54	36 36 34	18 20 20
Sp-2-1	26	Oven-dried Air-dried As received	75.4 79.2 63.7	8.6 6.5 14.2	11.5 9.9 15.3	4.5 4.4 6.8	53 56 54	35 38 38	18 18 20
Sp 2-2	29.4	Air-dried	65.8	9.9	16.5	7.8	59	37	22
Sp 2-3	33.5	Oven-dried Air-dried	63.1 63.4	12.1 10.8	18.8 19.1	5.9 6.7	64 67	42 43	22 24

Sp-3-1	18.9	Oven-dried Air-dried As received	76.1 78.5 53	8.5 6.9 16.4	12.3 11.1 21.9	3.1 3.6 8.6	52 54 58	35 34 36	17 20 22
Sp-3-2	14.5	Air-dried	56.8	13.4	21.5	8.3	58	37	21
Sg-1	35.6 25.2	Oven-dried As received Oven-dried	0 0 -----	24.4 25.9 ------	56.5 53.6 ------	19.1 20.5 ------	59 48	39 31	20 ----- -- 31
Sg-2		Air-dried	0	20.2	59.2	20 .6	54	34	20

Grain size distribution curve under different pre treatment conditions are shown in Figs. 1a & 1b.

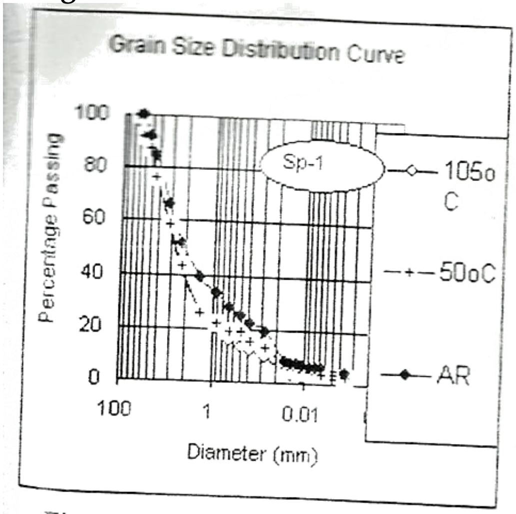

Fig. 1a) Sample Sp-1

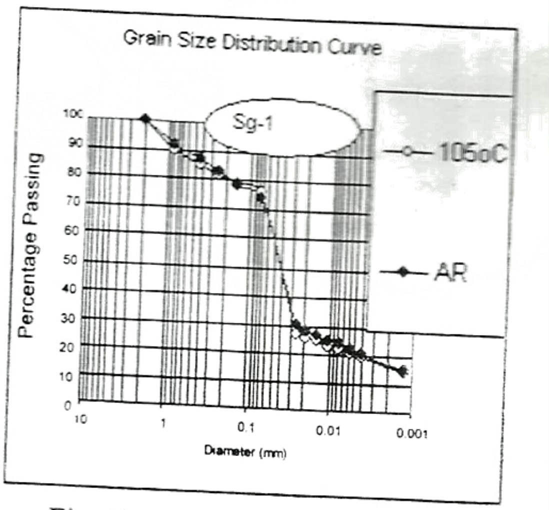

Fig. 1b) Sample Sg-1

Atterbery limit

Oven dried (OD), air dried (AD) and as received (AR) sample preparations were carried out to investigate the effect of pretreatment on plasticity characteristics of the soil samples under investigation. The test results are shown in Table 3. From the test result one can see that different pretreatment conditions create insignificant variation on Atterberg limit test (Lyon, 1971; AASHTO, 2004). Hence pretreatment has only slight effect on the values of Atterberg limits for the soil samples under investigation. Hence, when these soils are dried, the finer particles do not come together and reduce the available surface the plasticity characteristics. The gradation of the soil portion passing No 40 sieve has not significantly changed upon pretreatment variation. Since the gradation of the soil passing 0.425mm was not changed, the corresponding values of Atterberg limits also should not be changed significantly by such temperature variation prior to testing. Hence the test result shown in table 3 is in agreement with this fact. The effect of disaggregation of clay size particles upon manipulation during Atterberg limit testing were checked for the soil samples Sp-1, Sp-2-1, Sp-3-1 and Sg-1 the difference between liquid limit test values of the specimens 5 minutes and 30 minutes mixing were calculated and summarized in table 5. A "5%" difference indicates that aggregation of clay size particles are breaking down upon manipulation as mentioned in section 3 under 'Disaggregation of clay-size particles on mixing'

From the test result one can see that the soils are generally sensitive to handling and disturbance. The more the soil's structure is handled and disturbed, the finer the aggregates become in grading and the higher the Atterberg limit. Generally one can see from Table 4 that the greater duration of mixing (i.e, the greater the energy applied to the soil prior to testing), the larger the resulting of liquid limit, and to a lesser extent, the larger the plasticity index. This is in agreement with complied notes of Fourie A. B (Blight, 1997). Hence,

(1) Limit the mixing times for Atterberg limit tests not more than 5 minutes
(2) Use fresh material for each liquid limit and plastic limit determination.

Table 4 Atterberg Limit Values of Soil Samples at Different Mixing Times.

Location	NMC %	Testing Condition	Mixing Time	Liquid limit (%)	Plastic limit (%)	Plasticity index (%)	LL (30min) -LL (5min)
Sp-1	19.8	Oven-dried	5 Min 30 Min	53 60	33 34	20 26	7
Sp-2-	26.0	Air-dried	5 Min 30 Min	61 66	34 36	27 30	5
Sp-3-1	18.9	Air-dried	5 Min 30 Min	58 64	37 38	21 26	6
		As received	5 Min 30 Min	60 70	37 38	23 27	5
Sg-1	35.6	As received	5 Min 30 Min	41 70	41 47	23 23	6

Free Swell, Linear Shrinkage and Specific Gravity

The test result of both free swell, linear shrinkage and specific gravity on the soil samples with different testing conditions are summarized in Table 5. Free swell test results for both air and oven 105 ^{o}C dried samples are summarized in Table 5. From the test result one can see that the free swell of the soil under investigation ranges from 20% to 35% Those soils having a free swell less than 50% are considered as low in degree of expansion (Alemayehu and Mesfin, 1999). Hence all soil samples under investigation are non expansive soils. Moreover drying of soil sample by oven 105oC prior to testing do not affect the swell test results significantly. Linear shrinkage test results are summarized in Table 5 for both air oven 105^{o}C dried samples. The tests results show that air dried soil sample have slightly higher values for linear shrinkage than that of oven dried. The drying of soil samples at high temperature, oven 105^{o}C, cause solid particles come closer creating high cementation by sesquioxides. The specific gravity test result summary is shown in Table 5. From the test results one can see that air dried and oven dried pretreatment conditions give nearly similar values. Hence specific gravity test result do not change significantly upon drying prior to testing by oven 105^{o}C. aqll test result are from 2.80 to 3.03. the test result is in agreement with Morin W.J. and Todor P.C. (Lyon, 1971). They indicate that specific gravities of lateritic solis are very high even up to 3.4 such a high specific gravity test value is due to its high iron content.

Serial No	designation	Natural Moisture Content %	Testing Condition	Liquid limit (%)	Plasticity limit (%)	Free swell (%)	Linear Shrinkage (%)	Specific Gravity
1	Sp-1	19.8	Oven-dried Air-dried	54 56	18 20	20 30	7.1 8.6	3.00 3.02
2	Sp-2-1	26.0	Oven-dried Air-dried	52 53	17 18	30 35	7.9 8.6	2.85 2.86
3	Sp-2-3	33.5	Air-dried	67	24	35	12.1	2.85
4	Sp-3-1	18.9	Oven-dried Air-dried	52 54	17 20	25 30	10.0 10.7	3.01 3.03
5	Sp-3-2	14.5	Air-dried	58	21	30	10.7	3.02
6	Sg-2	25.2	Oven-dried Air-dried	48 54	17 20	20 30	10.0 15.7	 2.80

Classification of the Soil

The soils under investigation have been classified according to AASHTO M-145 and USC system. Accordingly, soil samples designated by Sp's fall under A-2-7 (GI=0) froup according to AAHTO classification system. Whereas the soil samples designated by Sg-1 and Sg-2 fall under A-7-5 with group index higher than 17. Classification according to USCS for soil sample Sg-1 and Sg-2 show that MH (Inorganic silts) and the rest soil samples show silt gravel (Abebaw, 2005).

CONCLUSION

Sassed on the test results investigation on the soil samples of area the following conclusions can be drawn:

1. The difference in moisture contents resulting from oven temperatures of 105°C and 50°C with maximum relative of humidity 30% for all soils under investigation are below 4%. Below 4% variation in moisture content indicates that the soils do not contain loosely bound water of hydration in significant amount. Hence one may use oven temperature 105 °C for water content determination. It is not too hot for the soils of Nejo-Mendi area.
2. The effect of disaggregation of clay-size particles upon test manipulation were obtained for some soil samples under consideration by varying liquid limit testing methods. The test results show that the soil under investigation contains concretionary which is broken down by testing manipulation. Force induced during test manipulation detaches the bond between particles due to the presence of sesquioxides. Hence, the Atterberg limit

tests should be conducted using fresh sample for each testing points and mixing time duration should be limited to only 5min.

3. The effect of pre treatments were checked by conducting index tests on oven dried at 105°C, air dried and as received (moist condition) soil samples. The corresponding test results show that the values under different conditions prior to testing generally result in no significant variation.
4. The specific gravity test results are between 2.80 and 3.03. the values are higher than the specific gravity of the temperate zone soils, which are between 2.65 and 2.70. The contributing factor for rise of the specific gravity is due to high amount of iron oxide.

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