OBAFEMI AWOLOWO UNIVERSITY

A STUDY OF STABILISATION OF CLAY SUBGRADE SOILS USING PERIWINKLE SHELL ASH

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DEDICATION

This project is dedicated

To

My Late Mother

Deaconess Dorcas Temilola Fajobi

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LIST OF ACRONYMS

AASHTO	America Association of State Highway and Transportation Officials
ASTM	American Standards for Testing and Materials
BS	British Standard
CaO	Quicklime
CBR	California Bearing Ratio
EDX	Energy Dispersive X-ray
FTIR	Fourier Transform Infrared Spectroscopy
GPS	Global Positioning System
LI	Liquidity Index
LL	Liquid Limit
MDD	Maximum Dry Density
N	Number of Blows
OMC	Optimum Moisture Content
pH	Measure of Acidity
PI	Plasticity Index
PL	Plastic Limit
PSP	Periwinkle Shell Powder
PSA	Periwinkle Shell Ash

q_{u}:	Unconfined compressive strength
SEM	Scanning Electron Microscope
UCS	Unconfined Compressive Strength
USCS	Unified Soil Classification System
USDA	United State Department of Agriculture
w	Water Content

ABSTRACT

This study determined the geotechnical properties of selected clay subgrade soils, and characterised the soils and periwinkle shell ash. It also determined the stabilising potential of blends of periwinkle shell ash, cement and lime on the geotechnical properties of the soil, as well as, the optimum periwinkle shell ash for stabilisation of clay subgrade soils. This was with a view to establishing the suitability and optimum content of periwinkle shell ash as a stabilizer of clayey subgrade soil for road construction.

Soil samples were collected from six different locations within Osun State, Southwest, Nigeria. Periwinkle shells were collected from a depot site at Ikorodu, Lagos State. The natural moisture contents of the samples as received, were determined using British Standard BS (1377) method, after which the samples were air dried in the laboratory at room temperature. The geotechnical properties [grain size distribution, liquid and plastic limits, specific gravity, compaction, California Bearing Ratio (CBR) and Unconfined Compression Strength (UCS)] of the soil samples were determined, using standard methods. The periwinkle shells were washed in water, sun-dried, fired inside a muffle furnace at 1000^{o}C into ash form, and sieved through 0.425 mm sieve. The Periwinkle Shell Ash (PSA), were subsequently added to the soil samples in incremental values of 2, 4, 6, 8 and 10 percent by weight and the corresponding geotechnical properties were determined. Samples of the formulations were also stabilised using 2, 4, 6 and 8 percent by weight for lime and cement, and their effects on the geotechnical properties evaluated. The characterisations of the soil samples and the PSA were carried out using Fourier Transform Infrared (FTIR), Scanning Electron Microscope (SEM), and Energy Dispersive Spectroscopy (EDX) techniques. The optimum formulating mix was determined based on the plasticity and compaction characteristics of the stabilised soils.

The results obtained showed that the selected soils in their natural state belong to A-2-7 and A-7-5 soil classifications, with medium to high plasticity. The FTIR, SEM and EDX results showed that the clay samples are aluminosilicate with different aluminium, silicon and oxygen concentrations. The periwinkle shell ash has calcium and oxygen as its dominant component with traces of sodium and magnesium. The addition of PSA improved the plasticity index of the soil samples with the addition of 6 to 8 % giving the best result for the compaction and CBR. The 6 % PSA addition to the soil gave the optimum value for UCS of the samples. The mixture of lime and PSA in varying proportions also enhanced the plasticity index of the soils at 5 % lime and 4 % PSA mix, while 5 % lime and 8 % PSP improved the compaction characteristic and CBR values of the soils. For cement and PSA mix, 7 % cement and 6% PSA improved the plasticity index of the soils from 14.5 % to 9.2% and CBR value from 10.5 % to 38.44 %. Furthermore, the study showed that the geotechnical values obtained by adding PSA to the soil alone at the 6% to 8% by weight to the soil of soil were not significantly different ($p < 0.05$) compared with the lime stabilised soils.

The study concluded that periwinkle shell ash in the range 6 % to 8 % by weight of soil can be used as stabil.iser in improving the strength of clay subgrade soil for road construction.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Soil can be defined as any uncemented or weakly cemented mass of minerals and organic materials that cover the solid crust of the earth. It is mainly formed by weathering and other geologic processes that occur on the surface of the solid rock at or near the surface of the earth (Craig, 1987; Punmia *et al.*, 2005). The properties and characteristics of any soil can be observed from different perspectives depending on the observer's area of view, which can be heterogeneous perspective, indicating its variation in engineering behaviour within the soil mass; anisotropic aspect, indicating variation of engineering property with direction. Soil is one of the most abundant and cheapest construction material. Even so, its usage can be greatly extended by enhancing its engineering performance (Bell, 1993).

Soils exist in many varieties and thus have different properties that merit special consideration by the geotechnical engineer. Geotechnical engineers deal with a material that is anisotropic and heterogeneous. Efforts were made to understand these materials using laboratory and in-situ tests. In the work of Adeyemi and Wahab (2008), it was discovered that the geotechnical properties of soil vary from one point to the other.

Subgrade is the soil upon which the pavement structure is placed or constructed at a selected location. It may consist of the undisturbed, local soil or materials excavated elsewhere and placed as fill. The surface above the subgrade is known as the formation level or finishing level (Thagesen, 1996). Although a pavement's wearing course is most prominent, the success or failure of a pavement is more often than not dependent upon the underlying sub-grade and the material upon which the pavement structure is built. Subgrades are composed of a wide range of materials although some are much better than others.

A subgrade's performance generally depends on two interrelated characteristics namely: *load bearing capacity and change in volumes*. The subgrade must be formed properly to prevent any possible damage to the road pavement. Consideration of factors such as choosing the right or suitable materials affecting the strength, materials specification, materials classification, and method of testing is vital for the road construction especially in earthworks stage (Thagesen, 1996; Pavement Interactive Series, 2011).

The need to carry out geotechnical tests on subgrade soil cannot be overemphasized in highway construction. This is because the strength and bearing capacity of the resulting subgrade should be determined in order to know if it would be able to carry the overlying pavement that would be placed upon it.

Das (1990) stated that soils with low strength are highly deformable and lack of strength leads to soil failure if overloaded. Poor soil conditions usually are attributable to an excess of groundwater or a lack of strength and associated deformability. Treatment methods are therefore aimed at preventing ingress of ground water into the site in question on one hand or removing it from the site, thereby improving soil strength on the other (Bell, 1993).

Soil treatment techniques may be either temporary or permanent. The type of technique chosen depends on the nature of the problem and the type of soil condition. Therefore, any important ground improvement work must be preceded by a site investigation to establish the type of soil that occurs at the site concerned (Bell, 1993). Obviously, an evaluation and selection of the most suitable improvement technique can only be made after a clear picture of ground conditions is established. Full scale testing on site should be carried out and samples are required for conventional laboratory testing to ascertain the properties of the soils concerned. This not only aids the selection of the treatment process but also is required for the design of the ground improvement programme. Cost is obviously a factor that enters into the equation (Tomlinson, 1995).

Soil stabilization techniques are the various methods used to alter or improve soil properties such as their strength, settlement and bearing capacity with the objectives of improving on the volume stability, strength and stress – strain properties, permeability and durability. The concept of soil improvement or modification through stabilization with the use of additives has been on ground for several thousands of years (Bell, 1993; Das, 2005).

In the past, soils have been stabilized with lime and other relevant available pozzolans. Although this process of improving the engineering properties of soils has been practiced for centuries, soil stabilization did not gain significance until after World War II (Ingles and Metcalf, 1972).

Although several studies (Little, 1969; Ola, 1975, 1977; Lyon Associates Inc., 1971; Gidigasu, 1976; Mesida, 1985; Gidigasu, 1991; Agbede, 1992; Ouf, 2001; Adeyemi *et al.*, 2003; Ayininuola and Agbede, 2009; Kalantari, 2010) have been carried out on tropical soils using various stabilizing agents, it was established that Portland cement, lime and bitumen are the most used stabilizing agents for a wide range of soils, such as granular materials, silts, clays and lateritic soils. As these conventional road