CHAPTER 9

DESIGN OF ENGINEERED SANITARY LANDFILL LINER USING LATERITE SOIL

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9.1 INTRODUCTION

Landfills are the final repositories for discarded, unwanted, and unusable wastes. It remains the predominant option for the management of municipal solid waste (MSW) in the world for decades (Camba et al., 2014). In most undeveloped countries and some developing countries, virtually all wastes are discarded in open, unengineered dumps. Sometimes wastes are burnt to conserve space. A controlled dump consists of a refuse disposal area in which the waste is disposed of in cells that range in thickness and are covered daily with soil to minimise air pollution and enhance aesthetics. The sanitary landfill has all the aforementioned qualities and represented a dramatic improvement over the open and control dumping because of the controlled placement of waste which greatly reduced the number of rodents and insects, dramatically reduced public health risks, and generally contributed to major aesthetic improvements in waste disposal (Daniel, 2012). Engineered sanitary landfills also have liners to contain the migration of leachate from the wastes against groundwater contamination in a manner that is protective of human health and the environment.

Most regulatory agencies and researchers specify a minimum criterion of 30% fines content in the design of compacted soil liners to fulfill the hydraulic conductivity requirements of less than 1×10^{-9} m/s. At this percentage requirement, laterite soils are vulnerable to leachate permeation which will contaminate the groundwater. Therefore, this research aims to determine the effects of gradation on the engineering properties of laterite soil with respect to hydraulic conductivity (k), volumetric shrinkage strain (VSS), and unconfined compressive strength (UCS). In order to satisfy the regulatory requirements of $k \leq 1\times10^{-9}$ m/s, VSS ≤ 4% and UCS ≥ 200 kN/m^2, tests were carried out on natural soil L1 (30% fine) and two reconstituted soil samples namely L2 (40% fine) and L3 (50% fine).

9.2 LANDFILL LINER

Landfill liners provide economical and environmentally safe disposal of MSW. The primary purpose of the liner system for waste containment facilities is to prevent or minimise the infiltration of leachate through the hydraulic barrier. Liners provide the final line of defence against groundwater contamination. They are used to minimise the infiltration of water into buried wastes or to control the release of leachate from the wastes. Liners for waste containment may be classified into three (Daniel, 2012):

(1) Geosynthetic clay liners.

(2) Composite liners.

(3) Soil liners.

This work investigates the design of soil liners using laterite soil.

9.2.1 Soil Liners

According to Daniel (2012), soil liners can be divided into naturally occurring clay liners and compacted clay liners (CCL). Natural clay liners are naturally occurring formations of low hydraulic conductivity clay-rich soils. They normally contain significant amounts of clay minerals.

Compacted clay liners are constructed primarily from naturally occurring soil materials containing a significant quantity of fines obtained from borrow pits. Other processed materials used in constructing compacted clay liners include bentonite-soil blends (Amadi & Eberemu, 2013; 2012), pozzolanic ash (Eberemu et al., 2013; Moses & Osinubi, 2015), etc. Compacted soil liners have been used for many years as engineered hydraulic barriers for waste containment facilities. In recent years, improved understandings of how compacted soil liners should be constructed and tested are evolving.

In this work, the material adopted for the design of the liner is laterite soil which is a residue of rock decay that is red in colour and has a high content of oxide of iron and hydroxide of aluminium and a low proportion of silica. They are formed under weathering system productive of the process of laterization, the important characteristic of which is the decomposition of ferro-alumino silicates minerals and the prominent deposition of sesquioxides (Al_2O_3 and Fe_2O_3) within the profile to form the horizon of material called laterite. The geotechnical characteristics and field performances of laterite are influenced by their mode of formation, degree of weathering (degree of decomposition, sesquioxides enrichment: laterization and dehydration desiccation/hardening), morphological characteristic, chemical and mineralogical composition as well as environmental condition (Gidigasu, 2012). Some researchers (i.e., Amadi & Osinubi, 2016; Aziz et al., 2016; Bello, 2015; Eberemu, 2008; Osinubi et al., 2015a; Osinubi & Nwaiwu, 2006) have examined the geotechnical characteristics of laterite soil as a hydraulic barrier material, but this work differs to an extent as it considers the effects of fines content of laterite soil at different gradation in order to establish the minimum requirement of the fines content used in the design of liners and covers.