UNIVERSITI TEKNOLOGI MARA

THE DEVELOPMENT OF SUSTAINABLE SOIL STABILIZER UTILIZING CERAMIC DUST

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ABSTRACT

One of the most common approaches to dealing with problematic soils is stabilization, which aims to lessen their unfavourable characteristics. Cement and lime, which have excellent strength properties, are often employed in soil improvement projects. However, they require much energy to manufacture and contribute to worldwide CO_2 emissions. In order to mitigate the adverse effects caused by cement and lime, sustainable stabilizers must be developed from nontraditional sources like waste and by-products. The primary goal of the study was to examine the viability of using Ceramic Dust (CD), an industrial by-product, as a soil stabilizer, on its own or in combination with Hydrated Lime (L), Ordinary Portland Cement (OPC), or Ground Granulated Blast Furnace Slag (GGBS). This study examined the stabilizer`s engineering characteristics by conducting laboratory experiments such as Atterberg limits, Standard Proctor Compaction, Unconfined Compressive Strength (UCS), linear expansion (LE), durability, California Bearing Ratio (CBR), and permeability. During the preliminary stage of the research, compacted cylinders of laterite soil (LS) stabilized with primary stabilizers, denoted as $S1_L$, $S1_P$, $S1_G$, and $S1_C$; secondary stabilizers of $S2_L$ and $S2_P$; and tertiary stabilizers of $S3_L$ and $S3_P$ were fabricated. The cylinders were cured for 7, 28, 60, 180, and 365 days prior to UCS and durability index tests. The findings indicated that LS stabilized with $S1_C$ decreases the Plasticity Index (PI), lowers the Optimum Moisture Content (OMC), and raises the Maximum Dry Density (MDD). Integrating CD with OPC and GGBS ($S3_P$) significantly increased the strength, reduced the linear expansion (0.5%), highest CBR value obtained (125%), exceeded the 80% threshold for durability index, and lowest hydraulic conductivity of 2.9042×10^{-5} attained. The production of Calcium silicate hydrates (C-S-H) and Portlandite (CH) substantiates that a strong and compacted soil structure was obtained by employing $S3_P$ with a 10:40:50 blending ratio, which was detected in the X-ray diffraction (XRD) and Scanning Electron Microscopy (SEM) tests; indicating the development of hydrated cementitious products. The utilization of $S3_P$, using a mix composition of 10:40:50 at 30% dosage in soil stabilization is effective in enhancing the engineering properties of the soil. Using the CD as raw material in producing soil stabilizers is an innovative step towards enhanced recycling of industrial waste and by-product materials, reducing the use of natural resources and producing a new and environmentally friendly product.

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CHAPTER 1
INTRODUCTION

1.1 Research Background

Soil is used as a construction material in various civil engineering projects to support a foundation. It is noteworthy to state that not all soils are suitable for construction in their natural states. The properties that make soils unsuitable for the construction of engineering structures in their natural state are generally referred to as problematic soil, which could cause low load-bearing capacity in building foundations, breakage, and cracking of road structures, and pose different levels of challenge to a geotechnical engineer. Problematic soils are characterized by clayey materials and, when used for engineering purposes without treatment, could result in structural cracks in buildings and damage to underground infrastructures (Dauda et al., 2019). Lateritic soil, commonly used for construction applications in its natural form, has a low bearing capacity and strength due to its high clayey content (Oyelami & Van Rooy, 2016). Furthermore, the existence of water can lead to the weakness or inadequacy of sub-grade soils, characterized by a low ability to support loads and pronounced inclination to undergo substantial expansion (Jalal et al., 2020). Consequently, the load tempted by construction may result in bearing capacity failure and excessive settlement.

There have been reports of damage to foundations and structures worldwide due to low load-bearing capacity soils. These include the development of settlements and cracks in the structures (Panigrahi & Pradhan, 2019), which eventually endure the structure's collapse. Moreover, heaving, shear failure and high swelling potential (Cheng et al., 2021; Jalal et al., 2020) are among the unfavourable characteristics of clay soils in geotechnical engineering. Hence, appropriate stabilization is necessary to modify soil properties and solve all these problems. On this ground, it is understandable that the geotechnical properties of soil should be improved before being used for engineering purposes. Otherwise, the soil is bound to cause damage in their natural states. Such soils need to be stabilized to ensure a favourable engineering performance. Therefore, soil stabilization is the most efficient method for improving the soil's engineering qualities.

Soil stabilization is a widely-adopted technique for favourably modifying the