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GEOPOLYMER AS A NEW LANDFILL SOIL LINER DESIGN

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ABSTRACT

The study investigates a green technology geopolymer as an additive in enhancing the properties of landfill soil liner. Soil liners are used to contain waste in modern landfills. Geopolymer can be considered the key factor that could enhance laterite's properties in the performance of hydraulic conductivity. In this study, geopolymer paste consists of palm oil boiler ash mixed with an alkaline solution of sodium hydroxide and sodium silicate. Boiler ash is another industrial waste product from the combustion of coal. Laterite mix was mixed with different percentages of boiler ash-based geopolymer to improve the properties of soil liner application. This research aims to determine the optimum percentage of geopolymer mixed with laterite as an additive and reduce the value of hydraulic conductivity. Based on results, the increases in geopolymer content are associated with a decrease in hydraulic conductivity, leading to a significant reduction in hydraulic conductivity. An empirical model was successfully developed from this study. The empirical model in predicting hydraulic conductivity, k, was developed as alternative guidelines for engineers to design landfill soil liners without conducting laboratory testing that takes a long time and can reduce the cost and time.

Keyword: Geopolymer, Soil Liner, Landfill, Palm oil boiler ash

1. INTRODUCTION

Increased population and rapid urbanization have increased the amount of municipal waste and become challenging in developing countries like Malaysia. The main component of a landfill is the landfill liner or known as the soil liner. The soil liner is a barrier layer between waste and groundwater. The generation of daily waste has created a harmful liquid waste known as leachate. It is a crucial aspect in designing soil liner in landfill to ensure that the leachate does not infiltrate the groundwater but drains into the collection tank for treatment process. It, therefore, becomes essential to develop a product that is environmentally friendly and capable of soil stabilization. According to Abdullah et al., (2020) and Zainuddin et al., (2021), geopolymers have a low shrinkage potential and excellent adhesion to aggregates, making them effective soil stabilizers. Given the above benefits, this study innovates the use of geopolymer as a potential material in developing new green technology in landfill area.

2. METHODOLOGY

All laboratory tests were based on existing engineering practice guideline standards of British Standard (BS) and American Society Testing Materials (ASTM). Basic properties test conducted includes Particle Size Distribution (PSD), Potential Hydrogen (pH), Plastic Index (PL), Liquid Limit (LL), Plasticity Index (PI), and Linear Shrinkage (LS) according to BS 1377: Part 2:1990. XRF and SEM analyzed micro-mechanism observations to determine sample particles' chemical composition and structure. The empirical formula developed using Minitab 16 software to evaluate the statistical analysis by the correlation and regression analysis.

3. FINDINGS

The addition of geopolymer as additives in laterite has significantly given positive results on soil strength and chemical alteration in geopolymerization. The addition of geopolymer turns laterite to alkaline soil and gives the effect of less soluble and does not absorb or allow leachate infiltration. Geopolymer content to laterite satisfies the requirement for plasticity index and liquid limit in soil liner accordingly. Moreover, the presence of geopolymer also led to the reorientation of soil particles and a reduction in the size of interparticle pores. Meanwhile, the developed model in this study can easily determine and predict hydraulic conductivity with various percentages of geopolymer in designing landfill soil liner without/with minimal field or lab test. Geopolymer as new technology develops in soil stabilization and hence, resulting in the effective soil liner design.

4. CONCLUSION

Geopolymer at different percentages has different effects on the laboratory sample, resulting in good knowledge and understanding about the properties of the product. Preliminary and main laboratory tests of the laterite- geopolymer mix provided a good prediction of hydraulic conductivity, *k* for soil liner application from statistical validation of physical and engineering properties. Empirical formulas and nomograph in predicting hydraulic conductivity, *k*, based on available variables (LL, Clay and geopolymer content) were developed as alternative guidelines for engineers to design landfill soil liners without conducting laboratory testing that takes a long time and thus can reduce the cost and time.

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