Construction and Building Materials 387 (2023) 131659

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Characteristic evaluation of geopolymer based lateritic soil stabilization enriched with eggshell ash and rice husk ash for road construction: An experimental investigation

Arulanantham Anburuvel [*,1], Navaratnarajah Sathiparan [2], Gallaba Mudiyanselage Anuradha Dhananjaya, Anpalakan Anuruththan

Department of Civil Engineering, Faculty of Engineering, University of Jaffna, Sri Lanka

ARTICLE INFO

Keywords:
Eggshell
Rice husk ash
Road base
Soil stabilization
Unconfined compressive strength

ABSTRACT

In line with sustainable development, the road sector has initiated the use of agro-wastes in road construction to preserve natural resources, which have been commonly used in conventional construction. In that sense, this study investigates the merits and demerits of incorporating eggshell ash (ESA) and rice husk ash (RHA) into geopolymer based lateritic soil stabilization for roadbase construction. Atterberg limits, modified Proctor compaction, unconfined compressive strength (UCS) tests were conducted on lateritic soil samples stabilized with cement or geopolymer that comprises of the combination of ESA, RHA and sodium hydroxide solution (NaOH). Results from the experimental study revealed that an increase in ESA substitution level reduced the plasticity index of lateritic soil. Maximum dry density was slightly reduced in all soil mixes stabilized with ESA, RHA and NaOH. With reference to cement stabilization, UCS showed a marginal reduction of 8.2 and 13.2% in geopolymer combinations of 3E1R1N (3% ESA + 1% RHA + 1% NaOH) and 2E2R1N (2% ESA + 2% RHA + 1% NaOH), respectively. Notably, out of all mixes, the mix combination of 3E1R1N and 2E2R1N produced the lowest cost to strength and embodied energy to strength ratio, and relatively lower CO_2 emission to strength ratio. The authors believe that the proposed geopolymer stabilization method would be a competitive alternative to cement based lateritic soil stabilization for roadbase construction.

1. Introduction

The burgeoning demand, scarcity, environmental consequences pertained to production and escalating manufacturing costs associated with conventional road construction materials have compelled the construction industry to switch to cost-effective and sustainable alternative materials. To combat with the persisting issues, improving the engineering properties of in-situ soil, aka 'soil stabilization', and using it for road construction is recommended by researchers [1–3]. Soil stabilization is performed by mixing additives including cement, lime and fly-ash with problematic in-situ soils [4–8] to produce improved construction material. Blending additives to such problematic soils is envisaged to reduce plasticity and swell/shrinkage behaviour, and improve their bearing capacity and durability [9,10].

Contemporary literature have extensively reported soil stabilization methods entailing both compaction and incorporation of additives [6,11–13]. Findings from a study by Rocha et al. [14] highlight that additive is the primary contributor to the stabilization cost. Furthermore, the additives that are currently deployed in the industry including cement, lime and fly ash emit substantial amount of greenhouse gases during their production process [15–18]. Therefore, to sustain the merits of soil stabilization method, efforts have been taken to evaluate the prospects of deploying waste materials in place of conventional additives in soil stabilization, which are comparatively of low cost [11,19]. Also, this strategy will contribute to reduce carbon footprint associated with waste disposal and the production of existing additives.

Published literature report extensive works that employ suitable waste materials in soil stabilization to address environmental concerns, such as scrap tyre [20,21], rice husk ash [22,23], fly ash [24,25], ground granulated blast slag [26,27], bagasse ash [24,28] and eggshell powder

* Corresponding author at: Department of Civil Engineering, Faculty of Engineering, University of Jaffna, Ariviyal Nagar, Kilinochchi 44000, Sri Lanka.
E-mail address: aanbu007@eng.jfn.ac.lk (A. Anburuvel).
[1] ORCID: 0000-0001-5357-4137
[2] ORCID: 0000-0001-8570-0580

https://doi.org/10.1016/j.conbuildmat.2023.131659
Received 6 February 2023; Received in revised form 17 April 2023; Accepted 2 May 2023