学 位 論 文 の 要 約

三　重　大　学

所　属	三重大学大学院生物資源学研究科 共生環境学専攻	氏　名	NAHAR　NAJMUN

学位論文の題名

Environment-Friendly Sustainable Ground Improvement Using Agro-Waste Aggregate
（農業廃棄物骨材を用いた環境に優しい持続可能な地盤改良）

学位論文の要約

The demand for construction materials is increasing daily to build new houses, roads, and other engineering projects for the growing world population. Consequently, the per capita consumption of cement is also growing as the primary binding material in the construction sector. An enormous amount of carbon dioxide (CO_2) releases into the atmosphere, contributing to about 8% of CO_2 emissions globally during cement production, causing environmental problems and human health hazards. Environmental scientists always recommend the usage of various cementitious recycled wastes as cement alternatives. Agricultural wastes utilization, including palm oil fuel ash, rice husk ash (RHA), and sugarcane bagasse ash, have increased in construction industries over the late 1960s. RHA, a natural carbon-based agricultural by-product, contains the highest reactive and amorphous silica (85-95%) among all agricultural wastes, attracting all agricultural countries to use RHA in construction industries. It is produced from paddy rice by milling as rice husk and then formed as ash by the incineration process. Every year above 700 million tons of paddy rice are produced globally, and from the paddy, about 30-35 million tons of RHA can be made if all rice husks are burnt. RHA waste dumping is problematic in distant places as having a lightweight and throwing the waste in open areas, riversides, and low lands create environmental contamination and human health problems. Researchers have already discovered that RHA, as supplementary cementitious material, can partially replace the cement amount in ground improvement that is environmentally sustainable and economically feasible.

The chemical composition, particle size, pozzolanic reactivity, and state of silica in RHA are all determined by the incineration process (burning conditions, temperature, time, and cooling) as well as the grinding status. Several studies have used pulverized and sieved RHA with various cement ratios for clayey soil stabilization, but few have evaluated the effectiveness of controlled burn and as-obtained RHA on cement-treated silty sand soil. The present study used unpulverized RHA as agricultural waste aggregate for A-2-4 soil (as per the AASHTO classification) stabilization. The current research is necessary to enhance as-obtained, locally available, and abundant RHA in ground improvement for new residences, highways, commercial buildings, tunnels, and earth dams in rice- producing nations for sustainable construction performance. The use of RHA waste in ground improvement can be reduced $CO2$ emissions indirectly by dropping cement production, environmental pollution, waste disposal difficulties, construction price, and natural resource consumption, as well as can be improved the strength and stability of the soil.

Mainly, two different groups of specimens comprising of soil-RHA (soil with 0%, 5%, 10%, 15% RHA), and soil-RHA-cement (soil with 0%, 5%, 10%, 15% RHA and 0%, 2%, 4%, 6% cement) combination were prepared to assess the concept of this study. Specimens of soil-RHA combinations were cured for 7-day before the laboratory testing, but different curing days were considered for the soil-RHA-cement combinations types. In the laboratory, RHA mixed soil was subjected to standard Proctor compaction tests, California bearing ratio (CBR) tests, unconfined compressive strength (UCS) tests, constant head permeability tests, direct shear tests, consolidated-drained (CD) triaxial compression tests, scanning electron microscopy (SEM) tests, and X-ray diffraction (XRD) analysis. The compaction test calculated the optimum moisture content (OMC) and maximum dry density (MDD). CBR experiments were used to determine the bearing capability (CBR value). The UCS and modulus of deformation values were acquired from the UCS testing. Permeability tests were used to calculate the permeability coefficient values. The direct shear and triaxial tests were used to calculate the cohesion and angle of internal friction. SEM and XRD examinations were used to understand better the microstructural changes and development of soil, RHA, and cement mixture types.

From the experimental investigation on the addition of unpulverized and controlled burn RHA with soil, it is observed that soil with 0%, 5%, 10%, and 15% of RHA combinations improved the compactability, bearing capacity, unconfined compressive strength, shear strength, and microstructure of soil. Based on the test results of soil-RHA-cement combinations, the OMC of the soil mix types increased with the increase of RHA, but MDD decreased. The CBR, UCS, shear strength, and permeability coefficient values of soil showed more significant improvement when cement was added with RHA aggregate. The SEM images and XRD analysis revealed the microstructural development, inter- particle bonding, and chemical reactions of the stabilized soil's soil, RHA, and cement particles. The strength qualities of the specimens proved the feasibility of unpulverized RHA and cement binders as sustainable construction materials for ground improvement.