REINFORCED SOIL PILES USING PORTLAND CEMENT–RICE HUSK ASH (RHA) AND MULTI WALLED CARBON NANOTUBE (MWCNT) MIX FOR DEEP MIXING METHOD APPLICABLE TO LOW RISE BUILDING AND BRIDGE FOUNDATION

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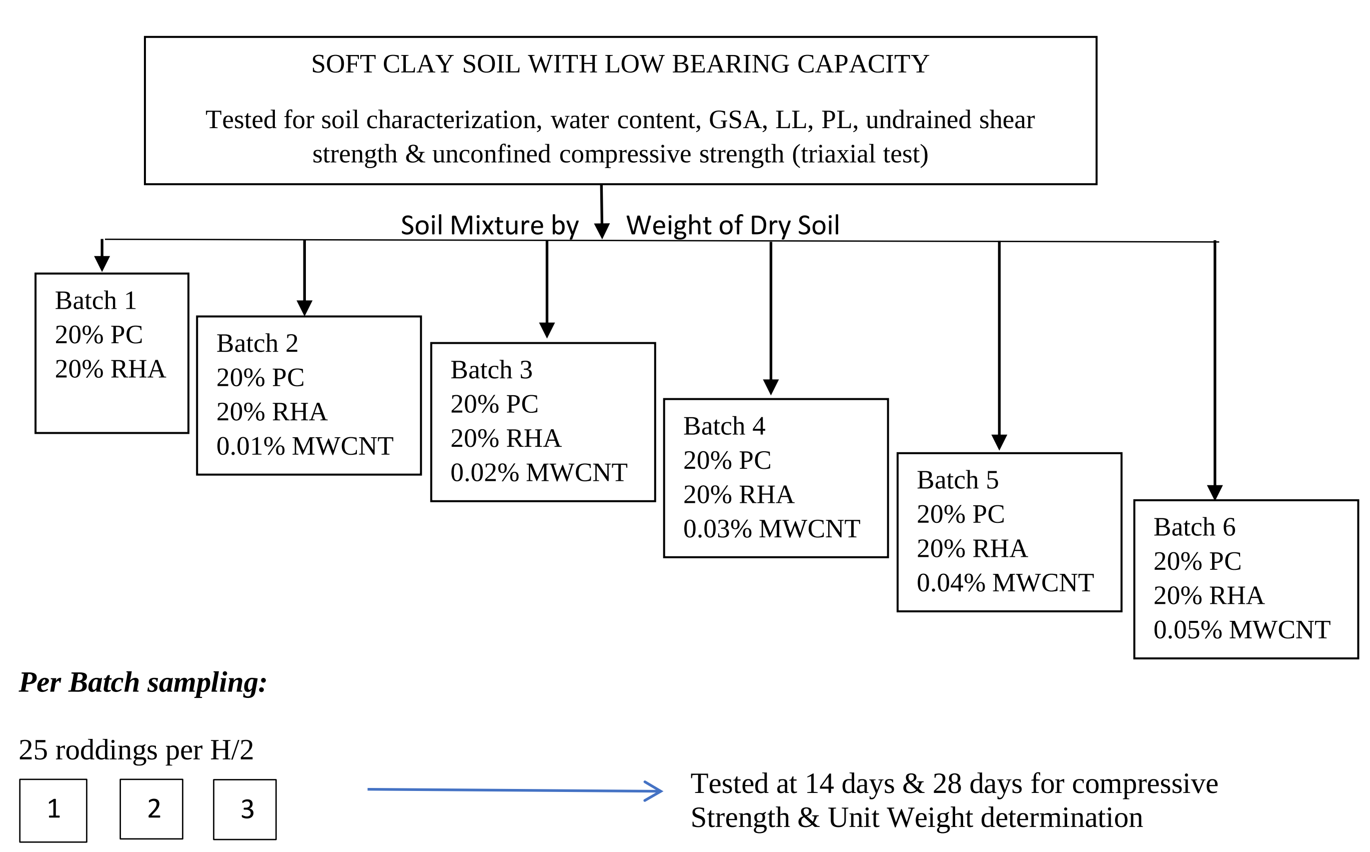
ABSTRACT

Soft soil conditions are characterized by low strength, show a large deformation upon loading, and do not satisfy the designed engineering properties; hence, they require reinforcement treatments. Chemical stabilization has been extensively used for soft soils. This study uses Portland cement, rice husk ask (RHA) and multi-walled carbon nanotube (MWCNT) to strengthen the soft soil that will replace concrete piles for bridges and low rise buildings. Soil reinforced by a bio-based filler and nanomaterial shows a significant improvement in its structural properties making this a viable, eco-friendly and sustainable new technology for construction application. Portland cement has been widely used for soil stabilization and the addition and optimal combination of rice husk ash (RHA) and MWCNT in soft soil remarkably increases both its average density and compressive strength by multiple orders of magnitude. This is attributed to the presence MWCNT for its packing density characteristics that increases its compressive strength by 401.29% as compared to the soil-Portland Cement-RHA mix samples.

METHODOLOGY

In this study, the influence of MWCNT's to be studied simultaneously with Portland cement and Rice Husk Ash (RHA) at:



This test method consists of applying a compressive axial load to molded cylinders or cores at a rate in conformance with ASTM C39, which is within a prescribed range until failure occurs. The compressive strength of the specimen is calculated by dividing the maximum load attained during the test by the cross-sectional area of the specimen.

CONCLUSIONS

Based from the laboratory test results the compressive strength of the soil significantly increased at 0.04% with MWCNT at 14 days curing and 28 days. Furthermore, the packing density characteristic of the MWCNT has manifested by the increase of unit weight at 0.04% MWCNT. However, it can be noted that the increase in the compressive strength and density starts to flatten after 0.05% MWCNT was added to the soil – Portland Cement – RHA. The following important findings are drawn:

1. The unit weight of the soil mixed with Portland cement – RHA – MWCNT increased by 148,051% at 14 days and 150,102% at 28 days.
2. From the conducted Scanning Electron Microscopy, the addition of MWCNT at 0.04% revealed a smooth texture as compared to the Soil mixed with RHA & Portland Cement
3. The soil mixed with Portland cement – RHA - MWCNT increased its compressive strength by 7,469% at 14 days and 9,471% at 28 days.

INTRODUCTION

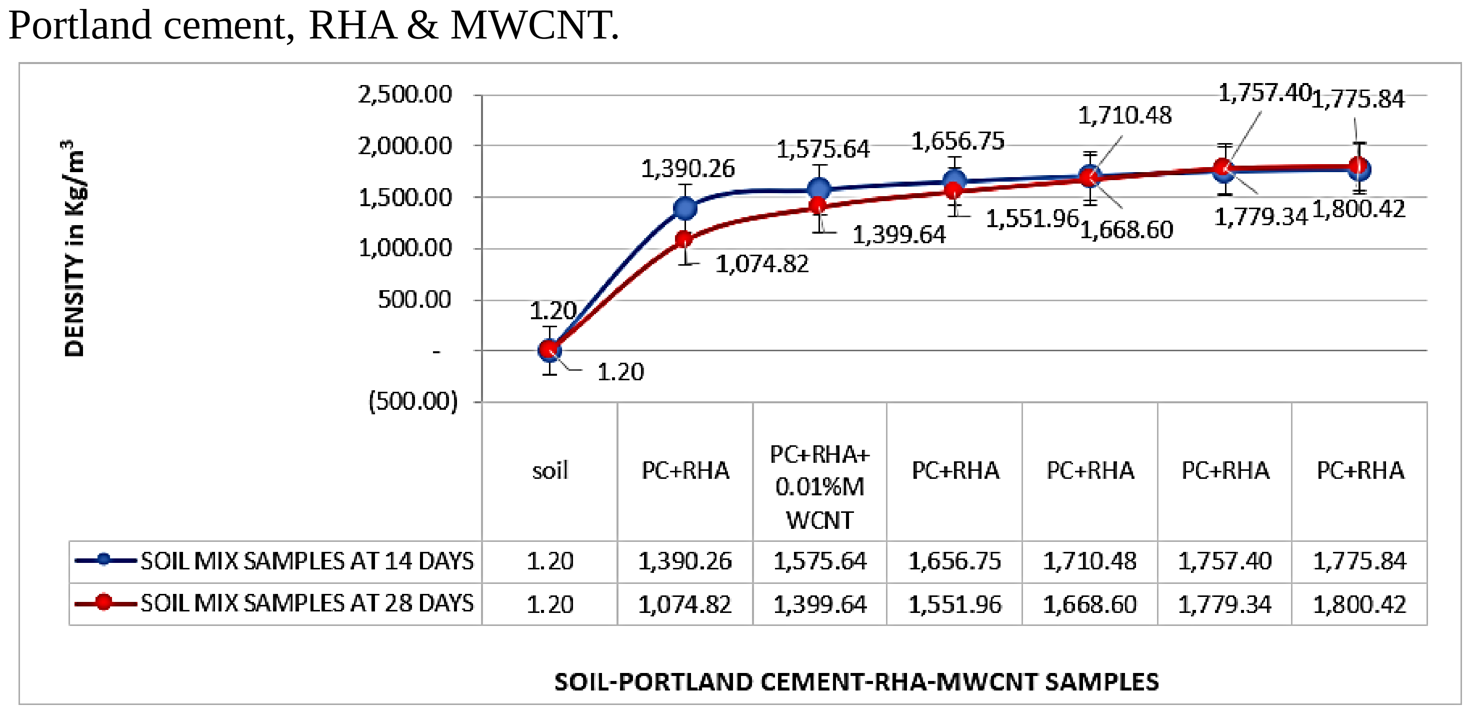
Most of the major cities in the Philippines are situated on alluvial soil, with loose soil clay & silt deposits (Department of Agriculture – BSWM – Lowland soil of the Philippines). To improve the bearing capacity of the soil, enhancement of its shear strength and limiting the settlement for medium rise buildings and bridges are essential to infrastructure and development of the cities.

With the addition of RHA for stabilization at 20% Portland cement – 20% RHA mix the shear strength increased by **7109%** at 7 days and **11,763%** at 28 days (Cavero, Trinidad, SICEAS 2016). Furthermore, MWNTs have an excellent tensile strength and when integrated into a composite (*AZoNano*, 2013) and can significantly increase its strength.

The possibility of stabilizing soft clay soil by mixing rice husks ash with Portland cement aim to improve the strength properties of soft clay soil's low unconfined compressive strength. With the addition of MWCNT's packing density characteristic, the soil piles aims to investigate the compressive strength and density of the samples if it can replace the concrete piles or bored piles for medium rise buildings and short span bridges using the deep mixing method (DMM).

RESULTS AND DISCUSSIONS

Figures below supports the Packing Density characteristics and the increase in compressive strength of the MWCNT. The density of the samples increases as the MWCNT percentage added was increased. The MWCNT basically filled the air voids and bonded the soil, Portland cement and RHA making the samples more densified. The compressive strength of the soil visibly increased by 9471% when mixed with Portland cement, RHA & MWCNT.



	soil	PC+RHA	PC+RHA+ 0.01%MWCNT	PC+RHA	PC+RHA	PC+RHA	PC+RHA
SOIL MIX SAMPLES AT 14 DAYS	1.20	1,390.26	1,575.64	1,656.75	1,710.48	1,757.40	1,775.84
SOIL MIX SAMPLES AT 28 DAYS	1.20	1,074.82	1,399.64	1,551.96	1,668.60	1,779.34	1,800.42

Figure 1 – Unit Weight of Soil Mix Samples

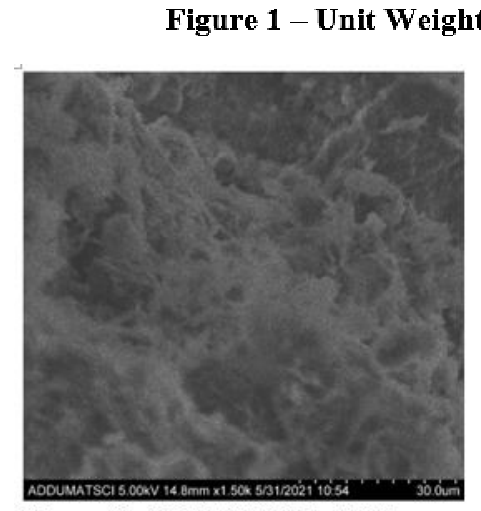


Figure 2- Soil-PC-RHA SEM

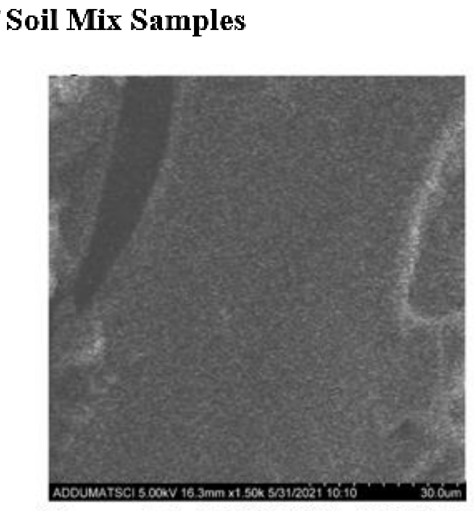
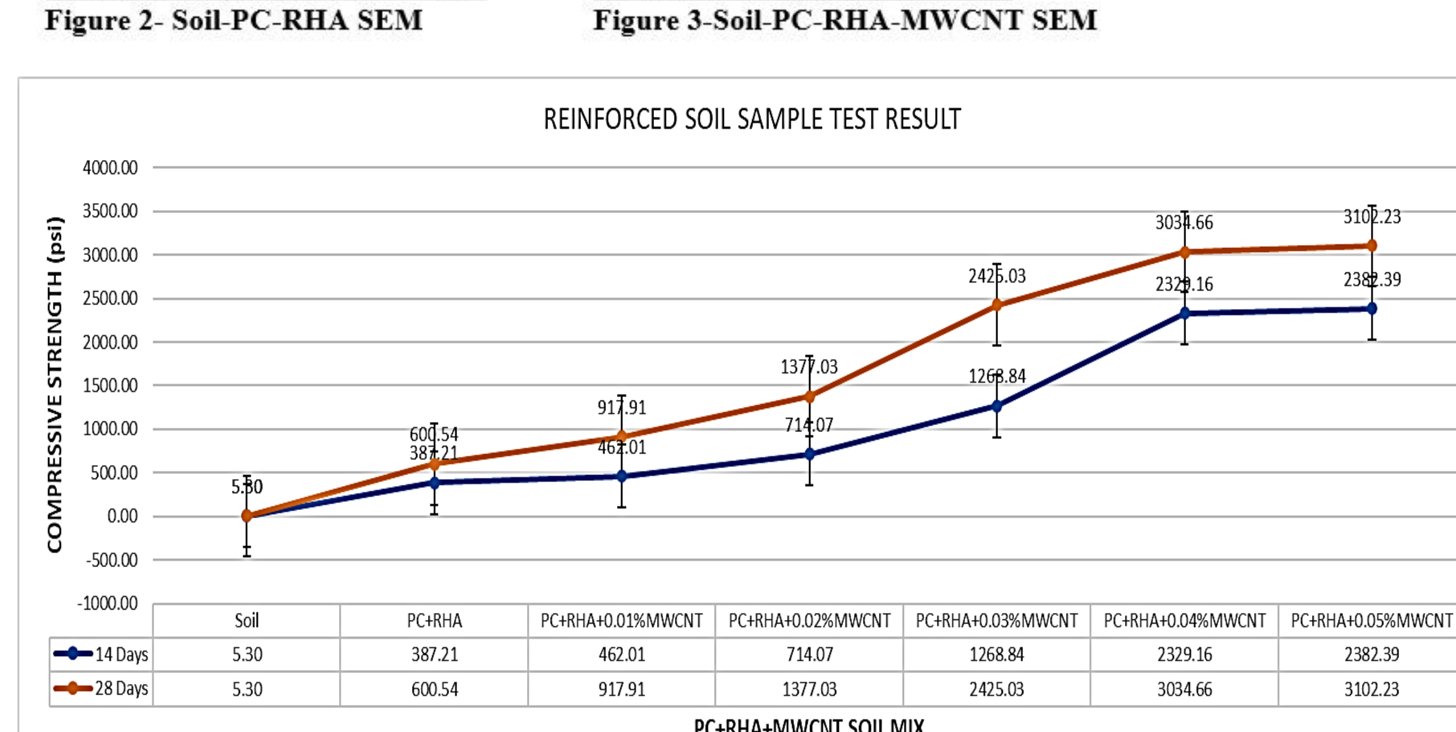


Figure 3-Soil-PC-RHA-MWCNT SEM



	Soil	PC+RHA	PC+RHA+0.01%MWCNT	PC+RHA+0.02%MWCNT	PC+RHA+0.03%MWCNT	PC+RHA+0.04%MWCNT	PC+RHA+0.05%MWCNT
14 Days	5.30	387.21	462.01	714.07	1268.84	2329.16	2382.39
28 Days	5.30	600.54	917.91	1377.03	2425.03	3034.66	3102.23