

DEEP SOIL MIXING AS AN EFFECTIVE STABILISATION TECHNIQUE FOR SOFT GROUND IMPROVEMENT

I.P. Rajanayake, K.H.S.M. Sampath *

Department of Civil Engineering, University of Moratuwa, Moratuwa

Soft peat soils, characterised by high compressibility, low shear strength, and significant organic content, pose major challenges for civil engineering and infrastructure development in Sri Lanka. Deep soil mixing (DSM) has emerged as a promising in-situ stabilisation technique, offering the potential to transform weak peat into a material suitable for supporting structures. This study investigates DSM as an innovative stabilisation technique for soft ground improvement by determining optimal proportions of peat, cement, and rice husk ash through a detailed literature review and preliminary experiments. Laboratory testing characterises the behaviour of DSM-treated soil, providing data to develop and validate a robust numerical model. A comprehensive parametric analysis is then conducted to evaluate the effects of column diameter, length, and area replacement ratio, to identify optimal DSM design parameters for effective geotechnical engineering applications.

Peat samples were collected from the Kelaniya Thorana junction and carefully cleaned to remove organic debris, undecomposed wood fragments, and gravel particles, ensuring consistency and reliability in subsequent testing. Initial characterisation included determination of natural moisture content, density, pH, ash and organic content, and undrained shear strength, following relevant standards. RHA was sourced from a brick industry in Matara and processed to ensure high pozzolanic reactivity. Laboratory-scale DSM columns were prepared by manually mixing the peat with 25% cement and 5% RHA by wet weight, maintaining approximately 60 rpm. The columns were cured in their natural peat environment, reflecting realistic field conditions and potentially enhancing strength development compared to submerged or laboratory-controlled curing methods, as supported by recent studies.

Mechanical properties were evaluated using unconfined compressive strength (UCS) testing and stress-strain analysis after 28 days of curing. The treated peat columns exhibited an average UCS of 706 kPa and an elastic modulus of 24,000 kPa, compared to 120 kPa for untreated peat, indicating a 200-fold increase in stiffness and a substantial gain in load-bearing capacity.

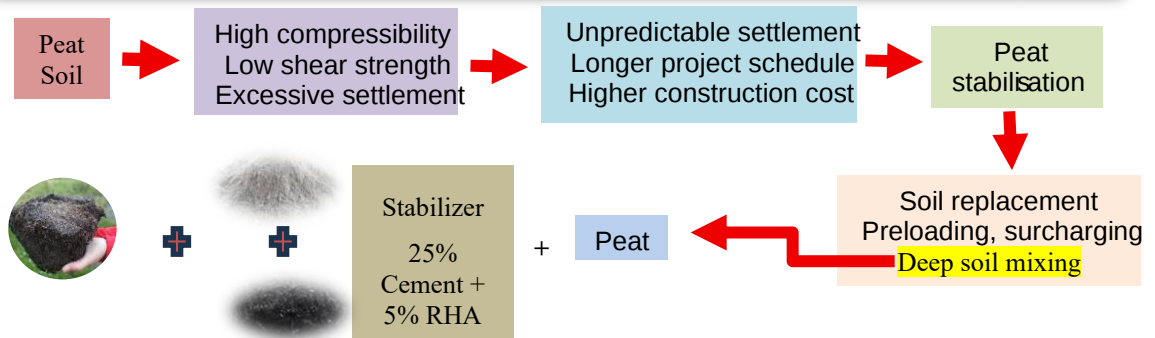
Settlement behaviour was analysed through both laboratory loading tests and finite element (FE) modelling. The FE model was calibrated and validated against experimental results, achieving an overall average error of 11.82%, which is well within the accepted threshold for geotechnical modelling. The DSM-treated samples demonstrated approximately 55% to 60% reduction in settlement under typical loading conditions compared to untreated peat, confirming the effectiveness of the treatment. A parametric study was conducted by varying the area replacement ratio, column length, and settlement. The settlement decreased when both the column length and area replacement ratio were increased.

The findings of this study provide robust evidence that the use of DSM with cement and RHA is an effective and sustainable solution for improving soft ground in peat-rich regions, offering significant benefits for infrastructure development and environmental management.

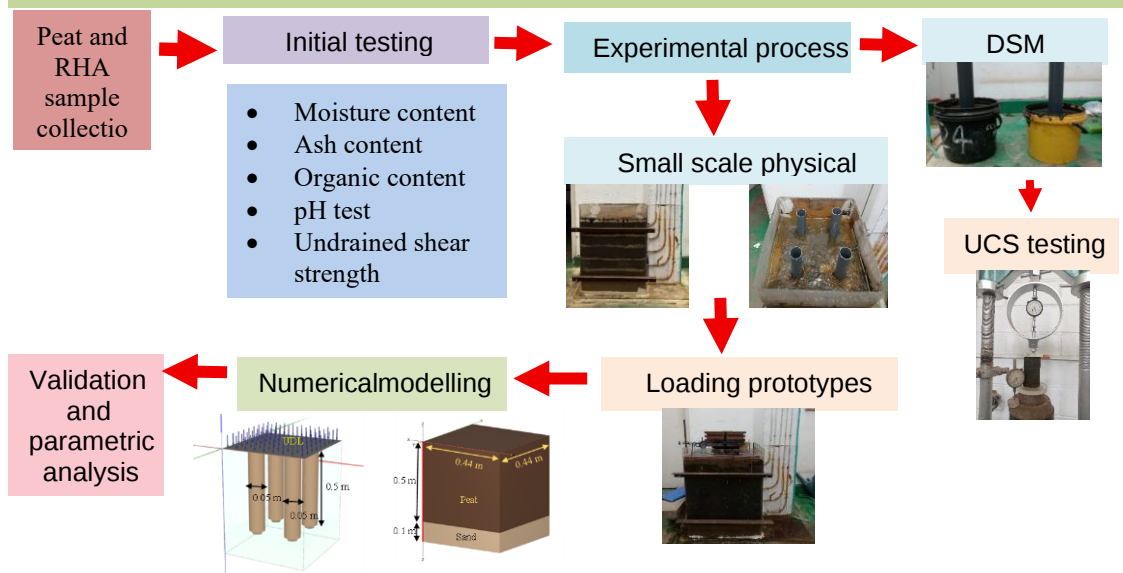
Keywords: Area replacement ratio, Deep soil mixing, Finite element modelling, Peat stabilization, Rice husk ash

* Correspondence: sampathkh@uom.lk

Deep Soil Mixing as an Effective Stabilisation Technique for Soft Ground Improvement

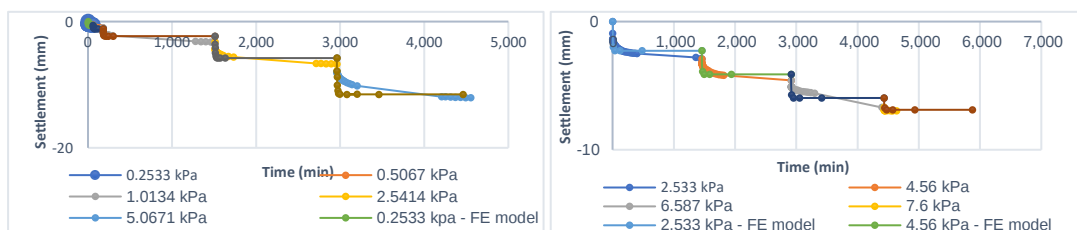


Methodology



Results

Model validation - settlement vs time graphs for natural and DSM-treated peat



The DSM-treated peat achieved an unconfined compressive strength (UCS) of 706 kPa, and the elastic modulus increased significantly from 120 kPa (untreated) to 24,000 kPa (treated).

The treated peat settlement reduction was between 55% and 60%, demonstrating the high effectiveness of the stabilisation technique.

Higher Area replacement ratio, larger diameter, and longer DSM columns effectively minimise settlement in stabilised peat under load.