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Analysis of the Behaviour of Stone Column Stabilized Soft Ground Supporting Transport Infrastructure

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Abstract
This paper presents an analytical and numerical study on the behavior of stone column stabilized soft ground supporting transport infrastructure. Analysis has been carried out on the response of reinforced soft ground under static and cyclic loadings relevant to transport corridors.

*Keywords:*Consolidation, cyclic load, settlement, soft clay, stone column

1 Introduction

Stabilizing soft ground by installation of stone columns has numerous benefits including improved bearing capacity, accelerated consolidation, increased slope stability and liquefaction control (Fatahi*et al.* 2012). Compared to prefabricated vertical drains (PVDs), the stone columns are stiffer and provide for faster dissipation of excess pore water pressure from soft clay (Basack *et al*. 2015a).

Transportation routes subject the ground to cyclic loading due to passage of vehicles in addition to the dead loadfrom an embankment (Basack *et al.* 2015b). The embankment loading induces a non-uniform strain condition across the embankment cross section, i.e., a 'freestrain'condition (Indraratna *et al.* 2013).

This paper developsan analytical and numerical model based on fast lagrangian finite difference technique on the behavior of stone column stabilized soft ground under static and cyclic loads. The solution is based on unit cell approachassuming free strain vertical deformation. The arching, clogging and smear effects are taken into account (Indraratna *et al.* 2013). The modified cam-clay theory (Roscoe and Burland 1968) is employed to study the soil behaviour. The solutions developed have been validated and applied to selected case studies. The analyses performed, observations made and the conclusions drawn are described in this paper.

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2 Analytical and Numerical Modelling

The solution developed is based on unit cell analogy with free strain hypothesis considering arching, clogging and smear effects (Indraratna *et al.* 2013). The idealized problem (axisymmetric) is depicted in Figure 1a, where a single column of radius $r_c$is embedded fully into soft soil of initial depth of H, overlying a rigid, impervious base representing stiff clay or rock. The unit cell has an effective radius of r_e and its surface is carrying a uniformly distributed load with intensity,$\overline{w} = w_{sur} + \gamma_e H_e$, where, w_{sur} is the surcharge load on the embankment having a height of $H_e$and unit weight of γ_e. The analysis is based on the assumption of purely radial flow of pore water towards the column, obeying Darcy's law. For computation, the unit cell is discretized radially and depth-wise into number of elements n_r and n_z respectively (Figure 1b), while the computational time is also split into n_t divisions. The numerical model involves forward, backward and central difference techniques coupled with explicit procedure where grid size is adjusted in each of the computational steps performed.

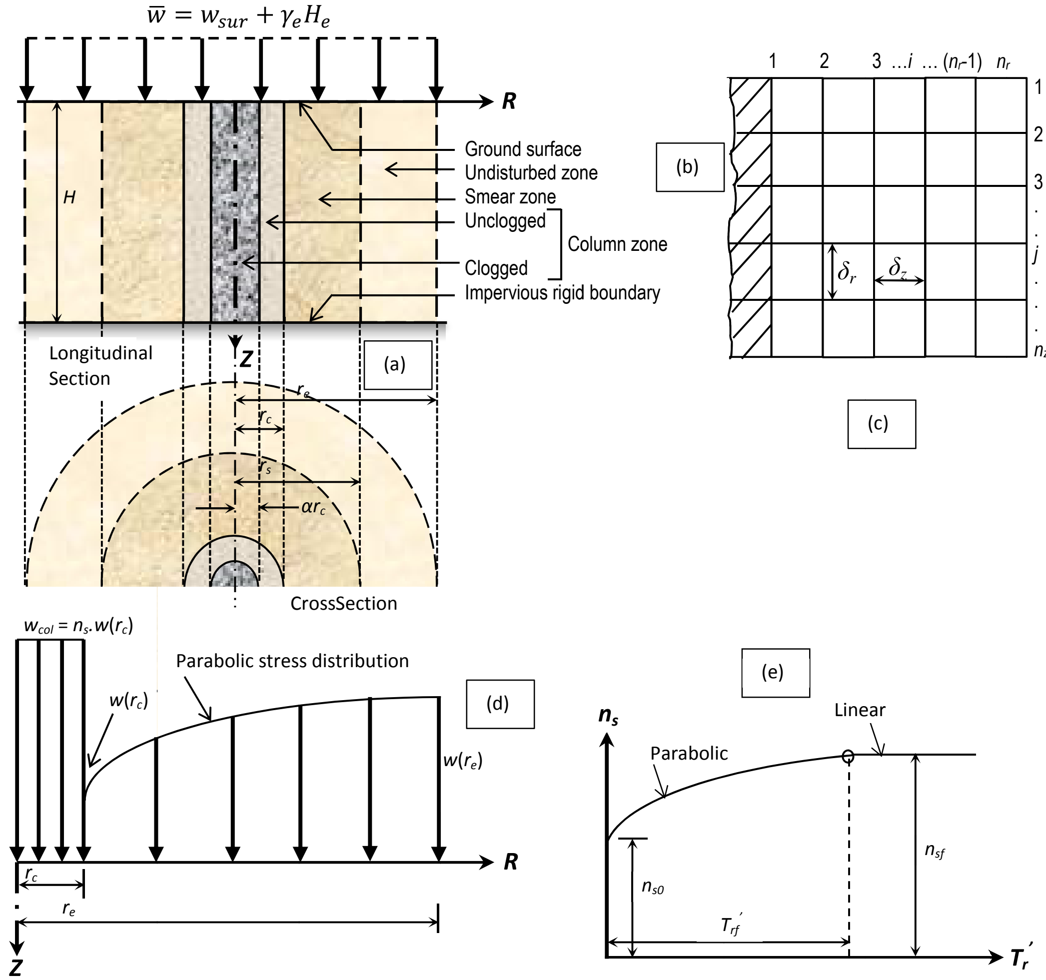

Figure 1: The idealized problem:(a) Unit cell sections, (b) Discretization of unit cell, (c) Stress components in column element, (d) Imposed vertical stress distribution, and (e) Variation of stress concentration ratio.