On lateral spreading and stability of column supported embankments

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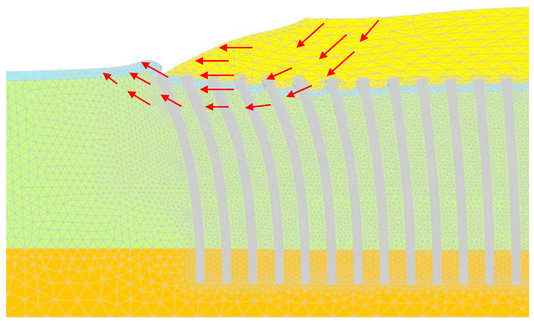
Motivation

Column-supported Embankments are now a popular ground improvement technique. Vertical load transfer mechanism is well understood. However, less attention has been given to basal stability (Fig 1), specially to the:

- Consequences of fracturing in the rigid inclusion (unreinforced grouted columns). Since, industry is considering codifying design to preclude column yielding, making the system less efficient.
- Importance of the subsoil conditions and efficacy of geosynthetic in the lateral spreading.



(a)

(b)

Fig 1. a.) Lateral spreading of a CSE case undrained. b) Failure case scenario in Japan (Chai, 2019)

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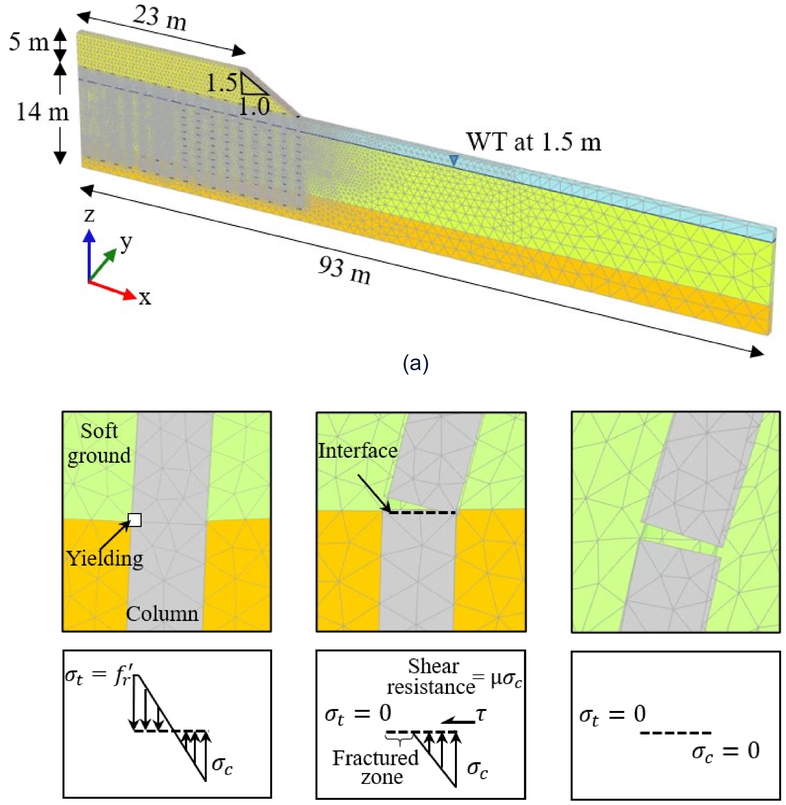


(a)

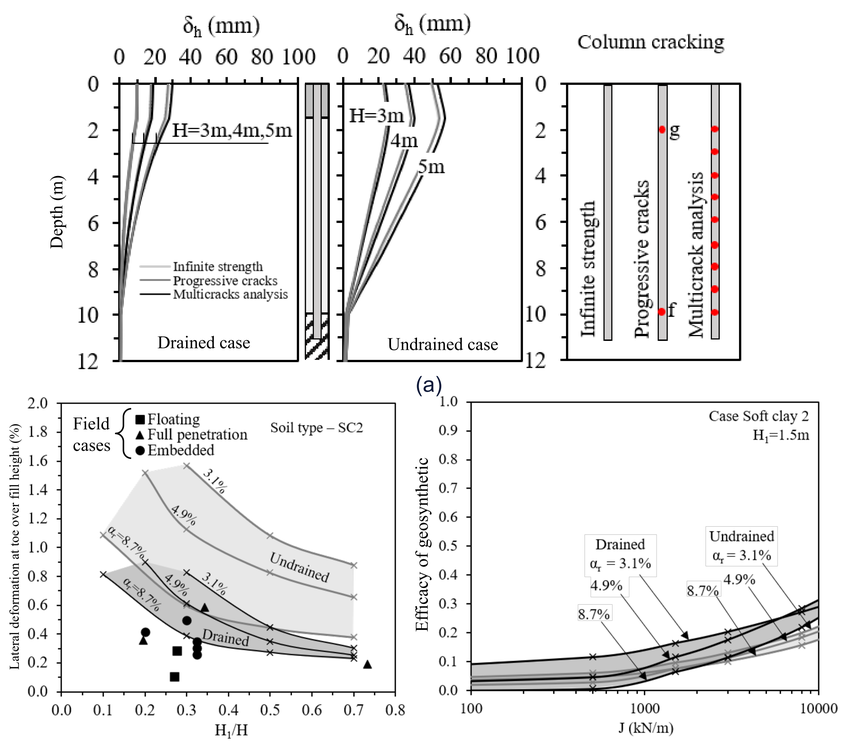
(b)

Fig 2. Finite element analysis a.) Modeling fracturing with interfaces, b.) FE mesh and model geometry.

Methodology

The methodology to assess the problem is explained as follows:

- A collective examination of lateral spreading performance help to define typical CSE geometric conditions, and subsoil profiles (Fig 2.a).
- A 3D parametric Finite Element (FEM) study for the typical area of replacements (α_r), clay compressibility, crust thicknesses (H_1), and geosynthetic stiffnesses (J).
- Column fracturing was modeled using horizontal interfaces, allowing the separation of the element (Fig 2.b).



(a) (b) (c)

Fig 3. Results of the FEM analysis; a) Comparison of response using three techniques: 1. Considering infinite columns strength, 2. Activating defined interfaces when yield strength was reach, 3. Defining all cracks every meter after the installation of the columns; b.) Normalized clay crust with fill height vs lateral deformation In the toe over fill height; c.) Stiffness of geosynthetic versus its efficacy to reduce lateral spreading.

Results

Based on the collective field case data examination and the numerical results, the following observations were made:

- Fracturing of the columns does not have appreciable influence on the lateral response (Fig 3. a).
- The undrained condition is the critical condition. The higher area of replacement, the lower the lateral deformation. The existence of a crust help to decrease lateral deformation. No significant effect was found on the use of the geosynthetic.