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Behavior of a 31 m high excavation supported by anchoring and nailing in residual soil of gneiss

Maurício Ehrlich, Rafael Cerqueira Silva *

Federal University of Rio de Janeiro (COPPE/UFRJ), Rio de Janeiro, Brazil

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ABSTRACT

A 31 m high excavation located at Niterói/RJ in residual soil from gneissmigmatite with high N_{SPT} (>40) was performed for a building construction. Two levels of anchored walls were considered in order to guarantee stability. When the construction of the upper wall was almost completed, a crack parallel to the direction of the wall formed in the hilltop. It was decided that the construction works would cease in order to perform additional studies. The presence of reasonably continuous soil layers of different colors (gray, white, and red), with thicknesses varying from a few millimeters to some centimeters, clearly observed in the face of the cut slope. The inclination of these soil layers varied along the length of the excavation, and they were in an orientation that was unfavorable for the stability of the cut. Laboratory tests were performed and the presence of high activity clay mineral and low shear resistance parameters was determined for the gray clayey sand soil. Those weakness planes, i.e., the thin layers of gray clayey sand, had not been properly detected in the previous studies that supported the design of those walls. Considering these new findings, the original project was reviewed, and it was decided that soil nailing would be used for accomplish the excavation to the original planned level. The upper wall was also reinforced with additional anchors. Load measurements in the nails indicated that the stress state in the soil mass corresponded to the active condition at the final level of excavation. Significant lateral movements were measured and varied according to the direction and inclination of the cited weakness planes. It was observed that the reliquiae planes were fundamentally important to the behavior of the excavation.

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1. Introduction

In Praia de Boa Viagem, Niterói/RJ, a 31 m high excavation in residual soil of gneiss–migmatite was performed prior to construction of two buildings. The excavation was planned to be supported by two levels of anchored walls (Fig. 1). In the tieback anchors the free length varies with depth and anchored length was equal to 8 m. When the construction of the upper wall was almost completed, a crack parallel to the direction of the wall formed in the hilltop. It was decided that the construction works would cease in order to perform additional studies.

Laboratory tests were performed and the presence of soil layers with the presence of high activity clay mineral and low shear resistance parameters was observed, and they were in an orientation that was unfavorable for the stability of the cut. Considering these new findings, the original project was reviewed, and it was decided that soil nailing would be used for accomplish the excavation to the original planned level. The excavation was monitored and results show that the reliquiae soil layers were one of the most important factors controlling the behavior of the excavation.

The effect of discontinuities on the behavior of excavations has been reported by a number of authors (Lee and Hencher, 2009; Styles et al., 2011; Deng et al., 2011). Nevertheless, in general, those case studies are related to excavation in rock mass. The present study calls attention to the effect of the reliquiae soil layers on the observed behavior of an excavation in young residual soil and has highlighted the importance of the correct definition of the geological and geotechnical conditions for the understanding of the collapse mechanism, aiming more realistic stability analysis.

2. Events

In 2003, a retaining structure was designed that comprised two levels of anchored walls supported by micropiles (Fig. 1) to guarantee the stability of the planned excavation. Topographic measurements and a subsoil profile evaluation by standard penetration tests (SPT) supported the design of the anchored retaining walls. The inclination of the original slope varied from 35° to 40°, and its surface was covered by low, developed vegetation.

* Corresponding author.
E-mail addresses: me@coc.ufrj.br (M. Ehrlich), rafael@enggeotech.com.br (R.C. Silva).

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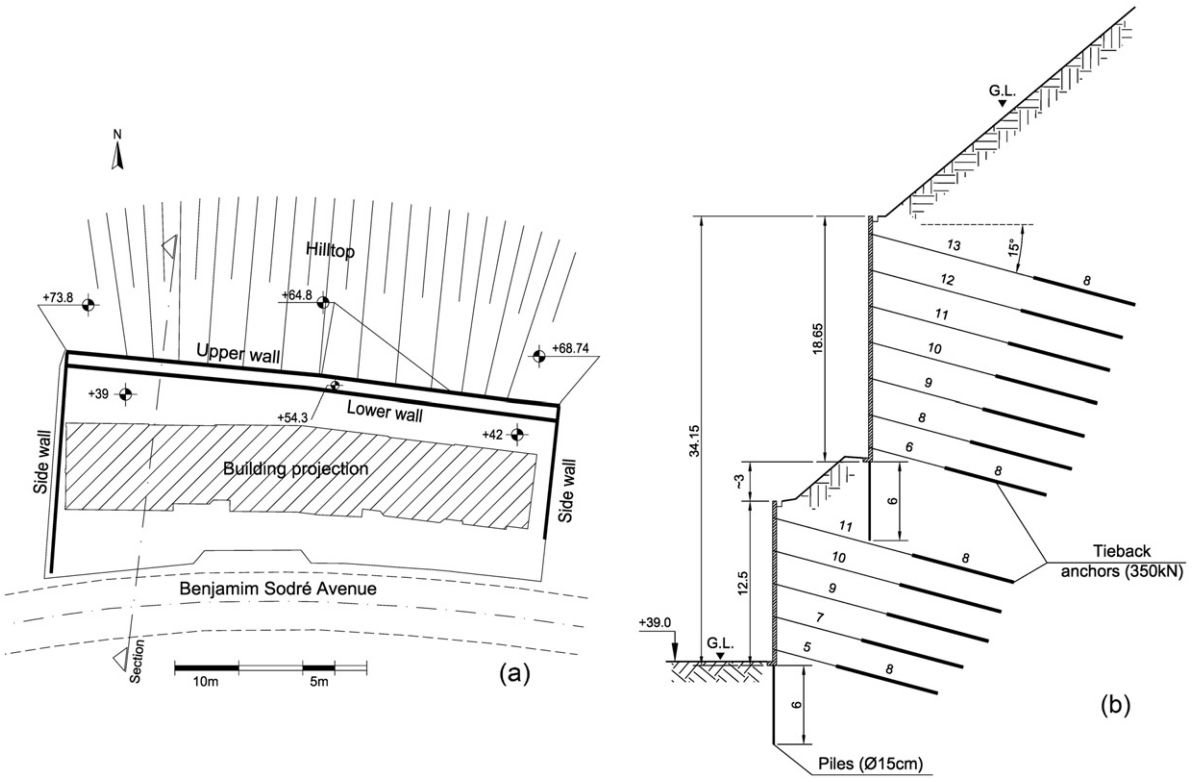

Fig. 1. Retaining structures of the original design (dimensions in meters): (a) excavation plant and (b) and cross section.

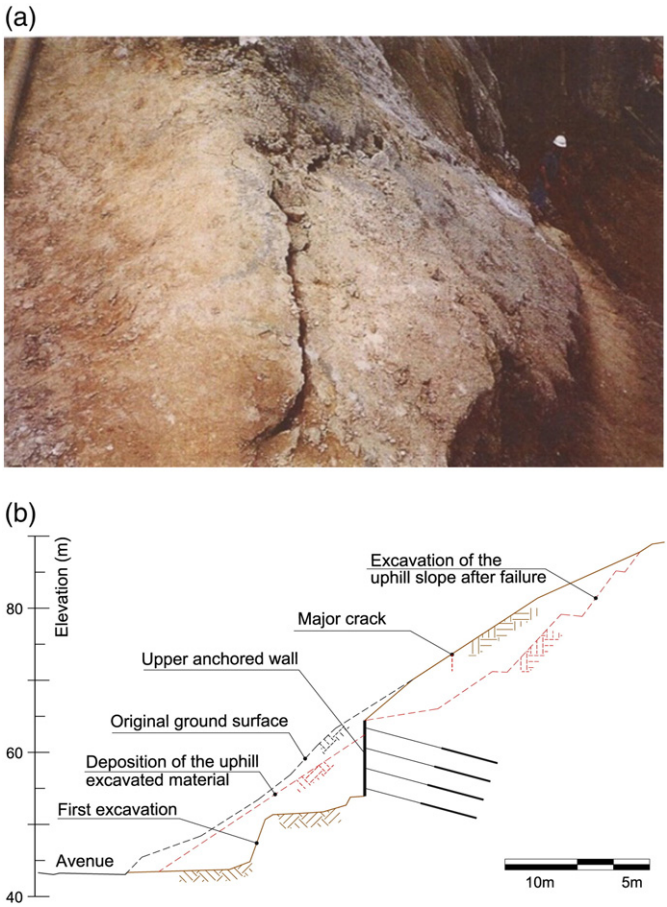

Fig. 2. Crack in the hilltop and geometry of the slope in different periods during the sequence of events.

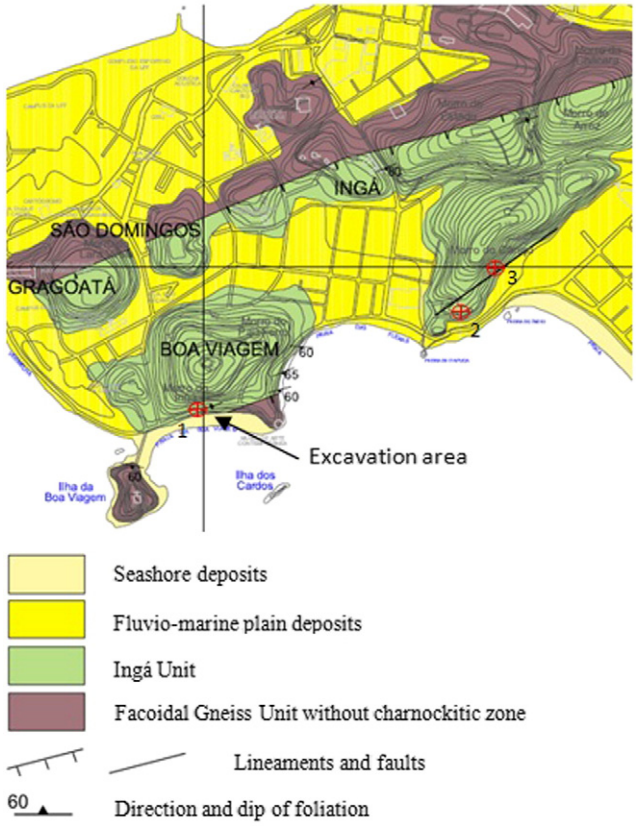

Fig. 3. Geologic map of the neighborhoods of Boa Viagem and Icarai, Niteroi/RJ (UFF, 2004) and the area under analysis (Location 1).

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