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Performance of ground anchorsbuilt in a flysch deposit

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Abstract

The ultimate pull-out tensile load of ground anchors is strongly dependent onsoil nature,grout injection and effective stress state around the bulb. In this paper, the comparison between the results of conventional pull-out testson instrumented anchors built in a flysch formation and those of small scale pull-out tests performed in the laboratory,on undisturbed soil samples recovered at the depth of the anchor bulb,allowed to closely examine the skin friction that can be mobilizedin undrained conditionsat the soil-structure interface.The experiments highlight a strong scale effect, probably depending on the real size androughness ofthe lateral surface of the bulb.In fact, theirregular bulb profiledue to flysch features strongly contributes to the pull-outstrength.

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1. Introduction

Ground anchorsallow to improvethe mechanical response of retaining structuresbuilt in unstable slopesleadingto the increase of their safety factor and, hence, of the slope. In particular, the role of ground anchors is to transferthrough skin friction the forceinduced by the unstable soil body to the stable formation located beneath the sliding surface. The pull-out tensile load is affected by grout injection,anchorsize, number of strands andsoil properties. Usually, the pull-outforce is the more burdensome aspect of the design that requires a special care.

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In flysch deposits the performance of ground anchors is often uncertain because of the following reasons:

- the bulb involves layers of clay shale and of competent rock, which behave quite differently;
- tensile stressesare often applied in undrained conditions; induced excess pore pressures around the anchor then play a prominent role on the anchor behavior.

A problem then raises in the assessment of the ultimate tensile force that is generally roughly solvedthrough a total stress approach using the undrained cohesion $c_u$that is usually measured in the laboratory along compressive stress paths. In contrast, the application of the pull-out force induces in the soil around the anchor a complexstress pathtypically characterized by a decrease of the normal stress in the anchor direction.

This paperreports the results of pull-out tests performed on anchors built in a flysch deposit. An anchor was instrumented with an optical fibre that allowed to determinethe distribution of the mobilized skin friction at the soil-bulb interface. The average value of the skin friction was then compared to the value measured on small scale pull-out tests performed in the laboratory on undisturbed soil samples. All samples were takenat the depth of the bulb.The comparison between these experiments allowed to closely examine the anchor performance.

2. The problem

In December 2013, a landslide took place nearby the town of Castelnuovo di Conza (Fig.1), Southern Italy, interrupting the access road to some houses located in a rural area.Urgent measures were then adoptedto re-establish the normal traffic conditions.In order to stabilize the slope, some retaining walls anchored with injected bulb anchors were built. The design was strongly influenced by site morphology and mechanical soil properties. In particular, two types of retaining walls were built: the first one, reinforced with 30 m long injected bulb anchors, was located in the uppermost part of the slope; the second type, reinforced with 25 m long anchors, was builtat the slope toe. All anchors,having an inclinationof25° to the horizontal, presented a bulb length of 10m.

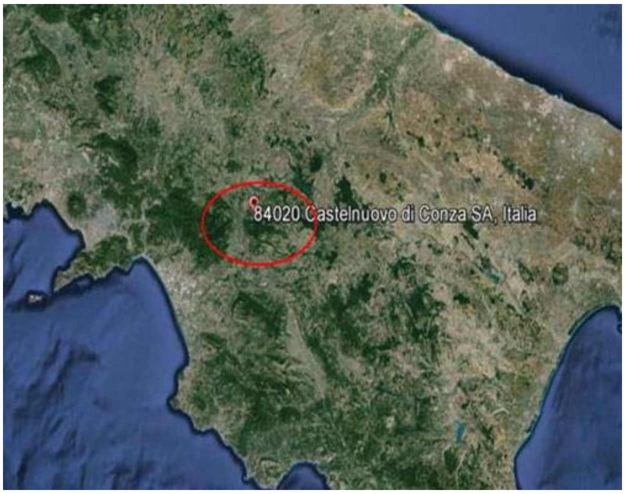

Fig. 1. Study area In the Southern Italy Apennine

3. Nature and properties of the subsoil

Site investigations included a number of boreholes reaching a maximum depth of 25 m.
A stratigraphic section of the site is shown in Figure 2. The soil profile includes: (*a*) a 6-7 m thick softened clayey cover with marlyinclusions; (*b*) a 5-6 m thick flysch formation locally consisting of highly fissured and sheared clay