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Slope Stability Assessment and Evaluation of Remedial Measures Using Limit Equilibrium and Finite Element Approaches

Manuel Neves[1*], Victor Cavaleiro[2], Alexandre Pinto[3]

[1]*CH2M Hill, Glasgow, U.K.*

[2]*UBI, Covilhã, Portugal*

[3]*JetSJ, Lisbon, Portugal*

manuel.neves@ch2m.com, victorc@ubi.pt, apinto@jetsj.com

Abstract

Slope stability is a recurrent theme amongst all branches of civil engineering and is of major significance on large scale infrastructure projects such as highways, railways or canals, where having more cost effective designs becomes a crucial drive on any scheme. The aim of this paper is to numerically back-analyse the stability of an existing experimental embankment built under the supervision of PhD students at UBI, making use of one of the region's most abundant resource, its granitic residual soil, very commonly used in road schemes. This is part of an on-going study of this natural resource, which has begun by undertaking a laboratory geotechnical characterisation of the granitic residual soil in question. To better understand the potential of the residual soil, this paper is primarily focused on the determination of the Margins of Safety using different calculation methods (LEM and FEM), to allow for an expedite assessment of the stability of granitic residual soil slopes, for different soil properties, geometries, applied loads and groundwater conditions. Additionally, this paper also tries to quantify the merits of some of the most common remediation techniques, drawing a comparison between their effectiveness. However, the remedial options discussed and analysed should be perceived as concept ideas as their gain in terms of MoS will likely vary from case to case. Furthermore, the benefits of combining the effects of more than one remedial options has been excluded from this study.

The parametric study has made use of one LEM based software (SLOPE/W) and one FEM based software (PLAXIS 2D), which have allowed for some conclusions to be drawn for each set of conditions, in particular due to changes in groundwater levels and applied surcharges at the crest.

Keywords: Slope stability, EasyChair, significance, Word documents, conference management

* Corresponding author. Tel.: +44(0) 141 552 2000; fax: +44(0)141 552 2525.

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1 Introduction

Slope stability plays a major role in civil engineering projects, particularly in transportation and infrastructure schemes, and its assessment requires not only an adequate understanding of its triggers but especially a solid understanding and critical analysis of the mechanics behind the software used to arrive at a given conclusion.

This work is part of the on-going study, currently being undertaken at UBI, of one of the region's most abundant resource, its granitic residual soil; which by being a very common construction material in the area, particularly in highway schemes, has raised an interest on its behaviour from a slope stability perspective.

This particular type of soil and its properties, although usually falling within a rather well-defined range of values, have been the subject of significant analysis in order to expedite the design and stability assessment of future and existing earthworks.

An experimental embankment was completed in November 2010 (Figure 1) using the granitic residual soil of the area to help with the study of its geotechnical properties. The embankment shoulders were constructed with varying gradients, from 45º to 80º to the horizontal, having remained stable since its construction. In addition, a surcharge of 10kPa was applied to the crest of the slope, near its steepest section, without any evidence of instability.

Figure 1: (a) View of the experimental embankment; (b) Steepest slope face (80º).

2 Factors Influencing Slope Stability

Slope movement often is a complex process which involves a continuous series of events from cause to effect, making it rather difficult to pinpoint a single trigger to the movement. It is largely determined by lithology and stratigraphy (influencing strength, deformability and permeability), as well as the hydrogeological conditions, the topography of the terrain and the weather conditions. A combination of these may trigger a failure event along one or more sliding surfaces, which induces the movement of the unstable mass.

Saturation, however, appears to be the primary cause of landslides, especially if resulting from rainfall. Its magnitude depends on both weather conditions (distribution and duration of precipitation and changes in temperatures) and topography. Additionally, human activities can also play a crucial role in slope stability. Disturbing or changing drainage patterns, destabilising slopes and removing