Geotextiles and Geomembranes 29 (2011) 491–501

Contents lists available at ScienceDirect

Geotextiles and Geomembranes

journal homepage: www.elsevier.com/locate/geotexmem

Earth pressure coefficients for design of geosynthetic reinforced soil structures

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ARTICLE INFO

Article history:
Received 17 September 2009
Received in revised form
16 March 2011
Accepted 1 April 2011
Available online 18 May 2011

Keywords:
Earth pressure coefficients
Reinforced soil
Internal stability
Limit equilibrium
Seismic loading

ABSTRACT

There are several methods proposed in the last two decades that can be used to design geosynthetic reinforced soil retaining walls and slopes. The majority of them are based on limit equilibrium considerations, assuming bi-linear or logarithmic spiral failure surfaces. Based on these failure mechanisms, design charts have been presented by several authors. However, the use of design charts is less and less frequent. The paper presents results from a computer program, based on limit equilibrium analyses, able to quantify earth pressure coefficients for the internal design of geosynthetic reinforced soil structures under static and seismic loading conditions. Failure mechanisms are briefly presented. Earth pressure coefficients calculated by the developed program are compared with values published in the bibliography. The effect of seismic loading on the reinforcement required force is also presented. To avoid the use of design charts and based on the obtained results, approximate equations for earth pressure coefficients estimation are proposed. The performed analyses show that the failure mechanism and the assumptions made have influence on the reinforcement required strength. The increase of reinforcement required strength induced by the seismic loading, when compared to the required strength in static conditions, grows with the backfill internal friction angle. The effects of the vertical component of seismic loading are not very significant.

1. Introduction

The main objective of the internal design of geosynthetic reinforced soil retaining walls and slopes is the definition of the required strength, and a minimum length of the geosynthetic layers. For a given vertical spacing between reinforcement layers, the internal stability analysis is used to determine a minimum value of the geosynthetic strength. The joint definition of the required strength and the vertical spacing between geosynthetic layers can also be achieved. Some methods have been proposed in the last decades and three different approaches can be distinguished. The first approach, limited to reinforced soil slopes, is an extension of the classical limit equilibrium slope stability methods (methods of slices) in which the reinforcement forces are included in the analysis (Wright and Duncan, 1991; FHWA, 2001). The second approach is based on considerations of limit equilibrium, such as two-part wedge or logarithmic spiral analyses (Schmertmann et al., 1987; Leshchinsky and Boedeker, 1989; Jewell, 1989). The third is a kinematic approach of limit analysis and can be performed as a continuum approach, where the soil and the reinforcements are homogenized, or a structural approach, in which the soil and the reinforcements are considered as two separate structural components (Sawicki and Lesniewska, 1989; Michalowski, 1997; Ausilio et al., 2000). This paper refers only to the second approach.

The Horizontal Slice Method (HSM) of analysis, which is a limit equilibrium method, has also been used to evaluate the stability of reinforced walls subjected to seismic loads (Shagholi et al., 2001). The original formulation of the HSM was improved by Nouri et al. (2006). The improved HSM has been used by several authors for the seismic stability analysis of reinforced soil slopes and walls with cohesionless backfill (Nouri et al., 2008; Shekarian et al., 2008) and, more recently, for the seismic analysis of reinforced retaining walls with cohesive-frictional backfill (Ghanbari and Ahmadabadi, 2010).

Limit equilibrium analyses are used to calculate the horizontal force due to lateral earth pressures which the reinforcement layers should support to reach the structure equilibrium. The failure surface associated with the maximum value of this horizontal force defines the critical surface. The reinforcement layers should extend beyond this critical failure surface and have design strength sufficient to maintain the equilibrium.

The horizontal force to be resisted by the reinforcement layers is equal to the resultant of the assumed earth pressure distribution. Thus, it is possible to define an earth pressure coefficient (or required coefficient). This paper presents results from a developed

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doi:10.1016/j.geotexmem.2011.04.003