Geotextiles and Geomembranes 29 (2011) 116–129

Contents lists available at ScienceDirect

Geotextiles and Geomembranes

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

Numerical analysis of the behaviour of mechanically stabilized earth walls reinforced with different types of strips

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ARTICLE INFO

Article history:
Received 8 November 2009
Received in revised form
17 October 2010
Accepted 18 October 2010
Available online 12 November 2010

Keywords:
Numerical modelling
Mechanically Stabilized Earth (MSE) structures
Deformation and stability
Geosynthetic and metallic reinforcements
Experimental parameters
Soil constitutive models

ABSTRACT

A mechanically stabilized earth (MSE) wall behaves as a flexible coherent block able to sustain significant loading and deformation due to the interaction between the backfill material and the reinforcement elements. The internal behaviour of a reinforced soil mass depends on a number of factors, including the soil, the reinforcement and the soil/structure interaction and represents a complex interaction sol/structure problem. The use of parameters determined from experimental studies should allow more accurate modelling of the behaviour of the MSE structures.

In this article, a reference MSE wall is modelled from two points of view: serviceability limit state "SLS" and ultimate limit state "ULS". The construction of the wall is simulated in several stages and the soil/interface parameters are back analysed from pullout tests. An extensive parametric study is set up and permits to highlight the influence of the soil, the reinforcement and the soil/structure parameters. The behaviour of MSE walls with several geosynthetic straps is compared with the metallic one. Several constitutive models with an increasing complexity have been used and compared.

The results obtained from stress-deformation analyses are presented and compared. The use of geosynthetic straps induces more deformation of the wall but a higher safety factor. To design theses walls the important parameters are: the soil friction, the cohesion, the interface shear stiffness and the strip elastic modulus.

It is shown that for wall construction that involves static loading conditions, the modified Duncan–Chang model is a good compromise but induces slightly lower strip tensile forces due to the fact that it do not take into account of dilatancy before failure.

1. Introduction

The MSE wall is a composite material formed by the combination of soil and metallic or synthetic strips able to sustain significant tensile loads. The reinforcing strips give to the soil mass an anisotropic cohesion in the direction perpendicular to the reinforcement (Schlosser and Elias, 1978). The presence of the strips improves the overall mechanical properties of the soil. The design methods used in these structures are based on the internal and external stability analysis using limit equilibrium methods. For the internal stability, the common method is based on the verification of the strip long-term tensile force and the adherence or bond capacity at the soil/strip interface (AASHTO, 2002; NF P 94-270, 2009; BS 8006, 1995). Although sometimes described as excessively conservative for the synthetic reinforcement (Elias et al., 2001; Koerner and Soong, 2001; Allen et al., 2002; Bathurst et al., 2005), this straightforward design methodology allows verifying the structure stability (Yoo and Jung, 2006; Quang et al., 2008) but does not make it possible to determine the deformation state of the structure.

In order to make new steps in the optimization of the design method, it is essential to understand the behaviour of such structures. Several studies, experimental, theoretical or numerical, have been carried out with this objective.

The experimental studies present the inconvenience that they are expensive and time-consuming. They are commonly focused on the definition of the parameters of new elements such as new reinforcement types, new facing panels or the interface between soil and new reinforcement types (e.g., Park and Tan, 2005; Yoo and Kim, 2008; Won and Kim, 2007).

The theoretical studies are mainly dedicated to the definition of new anchorage models taking into account the actual behaviour of the new reinforcement (e.g., Leshchinsky, 2009; Ling et al., 2005;

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doi:10.1016/j.geotexmem.2010.10.011