Geotextiles and Geomembranes 29 (2011) 83–91

Contents lists available at ScienceDirect

Geotextiles and Geomembranes

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

Numerical analysis of tensile behavior of geogrids with rectangular and triangular apertures

Yan-Li Dong [a,b], Jie Han [b,*], Xiao-Hong Bai [a]

[a] College of Architecture and Civil Engineering, Taiyuan University of Technology, Taiyuan 030024, PR China
[b] Department of Civil, Environmental, and Architectural Engineering, The University of Kansas, Lawrence, KS 66045, USA

ARTICLE INFO

Article history:
Received 12 December 2009
Received in revised form
5 September 2010
Accepted 16 October 2010
Available online 5 November 2010

Keywords:
Geogrid
Polymeric material
Tensile behavior
Stress–strain relation
Triangular aperture

ABSTRACT

Geogrids, made of polymeric materials, have been used as a construction material for many applications, such as walls, slopes, roads, building foundations, etc. In the past, geogrids were manufactured with apertures in a rectangular or square shape. Recently, geogrids with a triangular aperture shape have been introduced into the market. The new geogrids are manufactured with ribs oriented in three equilateral directions and expected to have a more stable grid structure, which can provide more uniform resistance in all directions. In this study, the numerical software – FLAC was adopted to investigate the responses of geogrids with rectangular and triangular apertures when subjected to a uniaxial tensile load at different directions relative to the orientations of ribs in air. The geogrid ribs were modeled using beam elements jointed rigidly at nodes (i.e., the angle between two adjacent ribs did not change) and subjected to tension in one direction. The numerical results showed that the stress–strain responses of the geogrids were different at different loading directions relative to the orientations of ribs. The effects of aperture shape of geogrid, and elastic modulus and cross-section area of geogrid ribs on the tensile stiffness of the geogrid were also evaluated. The geogrid with triangular apertures had more uniform tensile stiffness and strength distributions than the geogrid with rectangular apertures. An increase of the elastic modulus and cross-section area of the geogrid ribs could increase the stiffness of the geogrid with triangular apertures. The numerical results were verified by experimental data for geogrids with rectangular and triangular apertures.

1. Introduction

Geogrids are made of polymeric materials (mostly high-density polyethylene, polypropylene, or polyester) with a different manufacturing process (extruded and punched-drawn, knitting, or welding). Details of the geogrid manufacturing can be found in the textbook by Koerner (2005). The geogrid manufactured by the extruded and punched-drawn process is unitized and has rigid joints at nodes (i.e., the angle between two adjacent ribs does not change during loading) due to much larger thickness at nodes than ribs. The extruded and punched-drawn geogrids will be investigated in this study. In the past, geogrids were manufactured with apertures in a rectangular or square shape. They are used to carry tensile force in one or two directions along the ribs. The geogrid with one-directional tensile strength is commonly referred to as uniaxial geogrid, which is mainly used for walls and slopes (for example, Han and Leshchinsky, 2010). The geogrid with two-directional tensile strengths is commonly referred to as biaxial geogrid, which is mainly used for roads, foundations, and pile-supported embankments. The use of geogrids has been increasing steadily over the past 30 years and is expected to continue to rise.

Recently, geogrids with a triangular aperture shape have been introduced into the market. The new geogrids are manufactured with ribs oriented in three equilateral directions and expected to have a more stable grid structure, which can provide more uniform resistance in all directions. The geogrid with triangular apertures is expected to be used in the similar applications as biaxial geogrids especially when the loading is not only in two directions. Fig. 1 shows the products of the geogrids with rectangular and triangular apertures.

The uses of biaxial geogrids for subgrade improvement, base and ballast reinforcement, foundation reinforcement, and pile-supported embankments have been studied by many researchers, for example,

* Corresponding author. Department of Civil, Environmental, and Architectural Engineering, The University of Kansas, 2150 Learned Hall, 1530 W, 15th Street, Lawrence, KS 66045-7609, USA. Tel.: +1 785 864 3714; fax: +1 785 864 5631.
E-mail addresses: qianxinjie@yahoo.com (Y.-L. Dong), jiehan@ku.edu (J. Han), bxhong@tyut.edu.cn (X.-H. Bai).

0266-1144/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.geotexmem.2010.10.007