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Technical note

Biaxial tensile behavior of spunbonded nonwoven geotextiles

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ABSTRACT

Geotextiles can be successfully employed for any geotechnical application when they are able to sustain pre-defined levels of tensile stresses. The biaxial tensile test has an advantage over other tensile test methods in that it does not allow "necking" during deformation which simulates the operational conditions of geotextiles under confined stresses. In this study, the model for uniaxial tensile behavior of nonwovens has been modified to investigate the biaxial tensile behavior of spunbonded geotextiles. The model has included the effect of fiber re-orientation, stress-strain behavior of constituent fibers, and physical characteristics of nonwovens when the geotextile specimen is laterally constrained. A comparison is made between predicted and experimental stress-strain curves obtained from previous work (Bais-Singh and Goswami, 1998). Theoretical findings of biaxial tensile behavior obtained using the layer theory are also critically discussed. In addition, it has been revealed that fiber re-orientation is a key factor in translating the random spunbonded nonwoven geotextiles to anisotropic structures under defined biaxial tensile stresses.

1. Introduction

Spunbonded nonwoven geotextiles are generally produced by extruding and drawing molten polymer in the form of filaments. This procedure is similar to the filaments or yarns produced in a melt extrusion process; however, the filaments are collected in the form of a web having almost random orientation characteristics. These geotextiles consist of continuous filaments instead of short staple fibers, leading to better mechanical characteristics in comparison to other nonwovens. Thus, they can be employed in numerous applications, such as embankments on weak foundations, railroad track structures, road structures on non-uniform soil, etc. in which relatively high load bearing characteristics are essentially required. In such applications, these geotextiles are often subjected to principal stresses in their plane which are primarily of tensile nature (Giroud, 1992). Various methods, such as wide strip tension method and multiaxial tension test method have been compared with the uniaxial tension test in the past to evaluate and understand the tensile behavior of geotextiles (Merry and Bray, 1996; Bray and Merry, 1999; Andrejack and Wartman, 2010). The nonwoven geotextiles often exhibit "necking" under these uniaxial tension tests, leading to heterogeneous deformation and complex strain behavior at failure. Ideally, the tensile tests should be determined in a manner such that the operational conditions of geotextiles under confined stresses are simulated. The occurrence of lateral contraction in a geotextile under these operational conditions is limited and can be easily represented by a strip biaxial tensile test. In a strip biaxial tensile test, the specimen is laterally constrained and a uniform strain is applied in the test direction (Bais-Singh and Goswami, 1998; Dash et al., 2007; Munro et al., 2009). Thus, it is our intention to understand and predict the biaxial deformation of nonwoven geotextiles under laterally constrained condition.

Limited research work has been carried out in predicting the biaxial tensile deformation of nonwoven geotextiles. Bais-Singh and Goswami (1998) theoretically formulated the biaxial tensile model of spunbonded nonwoven structures by extending their model of uniaxial tensile response (Bais-Singh and Goswami, 1995). They validated their model for four spunbonded nonwovens out of which the results of two nonwovens were published (Bais-Singh and Goswami, 1998). They found a discrepancy between the experimental and theoretical results of certain nonwovens and it was attributed to fiber re-orientation during the application of tensile load. Recently, we have established that fiber re-orientation can be accounted in a uniaxial tensile model based on the fundamental principles of stereology and stochastic behavior of nonwoven structures (Rawal et al., 2007, 2010a, 2010b). In this study, the experimental results of the biaxial tensile behavior of

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