Textile Research Journal Article

Finite Element Simulation of a Yarn Pullout Test for Plain Woven Fabrics

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Abstract In this study, a three-dimensional (3D) model of a yarn pullout test for plain woven fabrics is introduced. The main focus of the study is on the realization of a 3D fabric geometrical model, the incorporation of anisotropic material properties and the validation of yarn and fabric finite element meso-models using experimental results. The material properties of yarn and fabric were assumed to be linear orthotropic. The required engineering constants were obtained from experimentally-measured tensile, compression and shear diagrams. The accuracy of the applied engineering constants was investigated by finite element (FE) modeling of yarn pure bending. The yarn pullout test was modeled with the Abaqus FE package. The fabric sample was modeled with solid elements for the weft and warp yarns in the interlacing points, which are directly involved in the yarn pullout, plus shell elements for the parts of the fabric that undergo only shear deformation. The effects of the geometrical model and material anisotropy were investigated and the predicted force–displacement profiles of the yarn pullout test were compared with experimental measurements.

Key words plain woven fabric, finite element three-dimensional modeling, bending, yarn pullout test, anisotropic material

Introduction

The movement of yarns in a fabric is a phenomenon occurring in different types of deformation of fabrics. The yarn pullout test is an experimental approach to investigate the interactions between yarns within a fabric and to evaluate the yarns' resistance against movement, in particular for large-scale deformations, such as tearing, yarn running, and ballistic impact.

During the last three decades, several analytical models have been reported to simulate the mechanical behavior of woven fabrics in a yarn pullout test. These models, which were developed by Pan and Young Youn [1], Pan [2], Sebastian et al. [3], Kirkwood et al. [4,5] Motamedi et al. [6], Badrossamay et al. [7], and Valizadeh et al. [8], are based on different physical models, such as the shear lag theory, spring models, vibration theory, and the force-balance method. However, no numerical studies have been

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