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Influence of Specimen Pre-Shear and Wrinkling on the Accuracy of Uniaxial Bias Extension Test Results

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Abstract

The influence of unintended specimen pre-shear and out-of-plane wrinkling on the accuracy of shear angle and axial force results, measured during a uniaxial bias extension (UBE) test on engineering fabrics, is examined. Three techniques of measuring test kinematics are investigated, including manual image analysis, 2-D and 3-D full-field analysis. Error introduced by specimen pre-shear is shown to influence test results in different ways, depending on analysis technique. Procedures to take specimen pre-shear error into account when interpreting results are demonstrated, though an important recommendation resulting from this investigation is to minimise pre-shear as much as possible. Out-of-plane wrinkling is shown to create significant errors in kinematic data when using 2-D analysis methods (up to 20% overestimates of measured shear angle). It is shown that wrinkle-error can be corrected if 3-D stereoscopic analysis methods are employed.

Key words: fabric, bias extension test, wrinkling, digital image correlation

1 Introduction

Typically, the uniaxial bias extension (UBE) test is used to measure the shear stiffness of both apparel (Cooper, 1963) and engineering fabrics, such as glass, carbon and aramid fabric (Boisse et al., 2016; Cao et al., 2008; Harrison et al., 2008). Test results are used to determine the shear-related constitutive parameters of engineering fabric models (Boisse et al., 2011; Gong et al., 2016; Harrison et al., 2017). The latter are of significant interest due to their utility in simulating the forming response of engineering fabrics during the manufacture of advanced composite products, with the ultimate goal of reducing production cost and improving part quality and design. Aside from providing a relationship between shear stress and shear strain, (the latter often quantified by the fabric shear angle) the kinematics of a UBE test specimen are usually only used to determine the point at which intra-ply slip becomes an important deformation mechanism (Harrison et al., 2008; Härtel and Harrison, 2014). Recent developments in the characterisation and modelling of engineering fabrics have demonstrated that valuable extra information can be collected when conducting a modified version of the standard UBE test (Harrison et al., 2017); modification to the