INVESTIGATION OF THICKNESS EFFECTS IN BI-AXIALLY BRAIDED GLASS FIBRE LAMINATES USING A PARAMETRISED RVE MODEL

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ABSTRACT

Fibre-reinforced composites (FRP) offer several advantages due to their outstanding density-specific mechanical properties and the possibility of orienting the load-bearing fibres in the direction of the load. FRP therefore have a very high weight-saving potential and are established as a construction material for structural components in many areas. The trend in the various engineering disciplines (aerospace, wind power, etc.) is to design also essential load-bearing elements made of FRP with increased thickness. This is accompanied by a wide range of challenges in manufacturing and testing. While the difficulty in manufacturing is to ensure the production quality at the level of thin-walled laminates, the effort in the construction and design of thick-walled FRP is to consider possible reductions in the mechanical properties such as strength and stiffness [1]. This so-called *size effect* is not taken into account in many manufacturing guidelines and test standards and must therefore be included in the form of safety factors. This in turn reduces the weight-saving potential.

In this paper a novel approach is introduced to address manufacturing-induced size effects in braided composites. This approach involves the use of a fully parameterised representative volume element (RVE) model. To investigate the influence of structural parameters associated with thickness, such as nesting-induced undulation, roving displacements and fibre volume content, on the mechanical properties of bi-axially braided composites, a *Python*-based tool has been developed that combines different programs and algorithms to determine elastic stiffness parameters of the specific unit cell. A flowchart is shown in Figure 1.

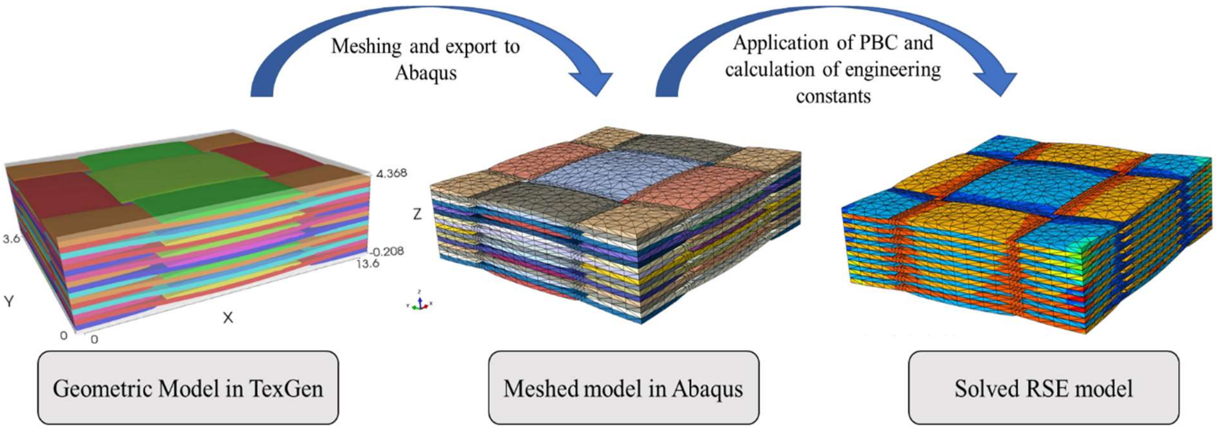

Figure 1: Schematic representation of the parametrised *Python* tool to calculate the mechanical properties of a bi-axially braided composites.

In a first step, a geometric model of the bi-axial braid is created using *TexGen* [2]. The geometric parameters of the laminate such as yarn width, layer height, spacing and offsets are defined. The specific geometric data are determined by computed tomography (CT) and microscopy.

The model created in this way is then meshed and transferred to *Abaqus*. A pre-analysis is performed to achieve the final geometry, in which the elastic parameters of the matrix material are temporarily lowered, and the laminate is compressed to its specified thickness, resulting in a nested model. This again is used to calculate the elastic parameters of the braided laminate.

For this purpose, the tool *easyPBC* (presented in [3]) is used to apply the required periodic boundary conditions (PBC). After the specific loads and displacements are applied, the elastic moduli are calculated and given out. The results are then compared with quasi-static experimental investigations on bi-axially braided composites (±30° and ±45°) of different thicknesses (t = 4 mm and t = 10 mm).

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