U20MM User Manual

U20MM is a micromechanics utility, developed within the Composites Group of the University of Twente, Enschede, The Netherlands. It computes the thermoelastic properties of unidirectional (UD) as well as woven fabric (WF) composites. This manual contains a description of the different functions available in U20MM. A more in–depth treatise of micromechanics of continuous fibre reinforced polymers, both WF [16] and UD [15], are available separately.

Fabric Model

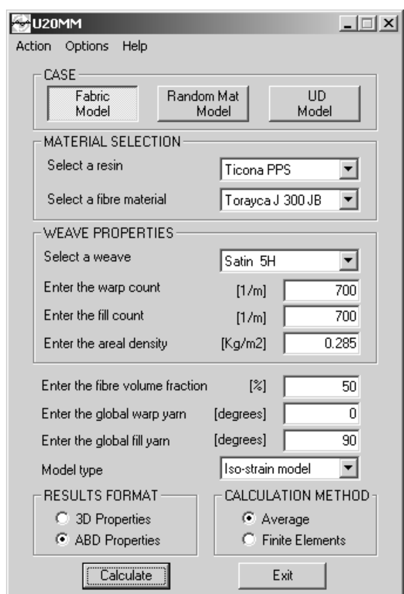

Figure 1: Default mode - Fabric Model

The **fabric model** is the default mode of U20MM. It allows the selection of both resin and fibre type. Several resins and fibre can be chosen from a library. A window requesting the input of material properties pops up when the **user defined** resin or fibre type is selected.

Fourteen different weave types can be selected from the library. Currently, a user-defined weave type is not available. The weave is described with a warp and fill count (the number of bundles per meter in the warp and weft direction, respectively) and the areal density (mass per square meter of fabric).

The fibre volume fraction of the woven fabric composite can be varied, but care must be taken with high (>70%) values; the local fibre volume fraction within the bundles may become too high. Further, the micromechanics are not limited to orthogonal weaves. Both the angle of the warp and the fill yarn can be varied.

A distinction is made between averaging models. The option **model type** can be chosen as iso–strain or iso–stress. Under iso-stress conditions, the in–plane thermoelastic properties are averaged assuming that the stiffnesses of the different 'cells' (see theory) are connected in series. Iso-strain implies a parallel connection of the cells.

The results can be calculated in two formats (**results format**): full three–dimensional or in terms of the classical laminate theory (CLT) stiffness matrix and thermal forces. When using the **ABD properties**, a choice can be made between **average** and **finite elements**. The difference between the two methods is explained in the theoretical background. In general, the differences are negligible.

Advanced fabric control

More control of the fabric geometry is given in the **configuration** menu which can be found under **options** on the main taskbar, see figure 2.

The option **Gauss points** sets the number of Gauss integration points in the numerical integration scheme that is used for the evaluation of the thermoelastic properties. More integration points results in more accurate results yet longer computing times.

Two pairs of sliders control the undulation and fibre height of the bundles in the weft and warp direction, respectively. The undulation is a measure for the waviness of the bundles in the fabric. The fibre height is the thickness of a bundle relative to the thickness of the fabric layer. Figure 3 shows a cross–section of an elliptical yarn.

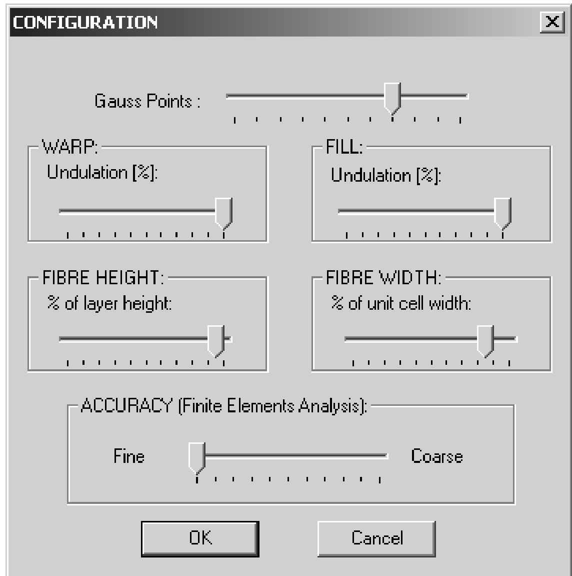

Figure 2: Configuration menu for advanced control of fabric parameters

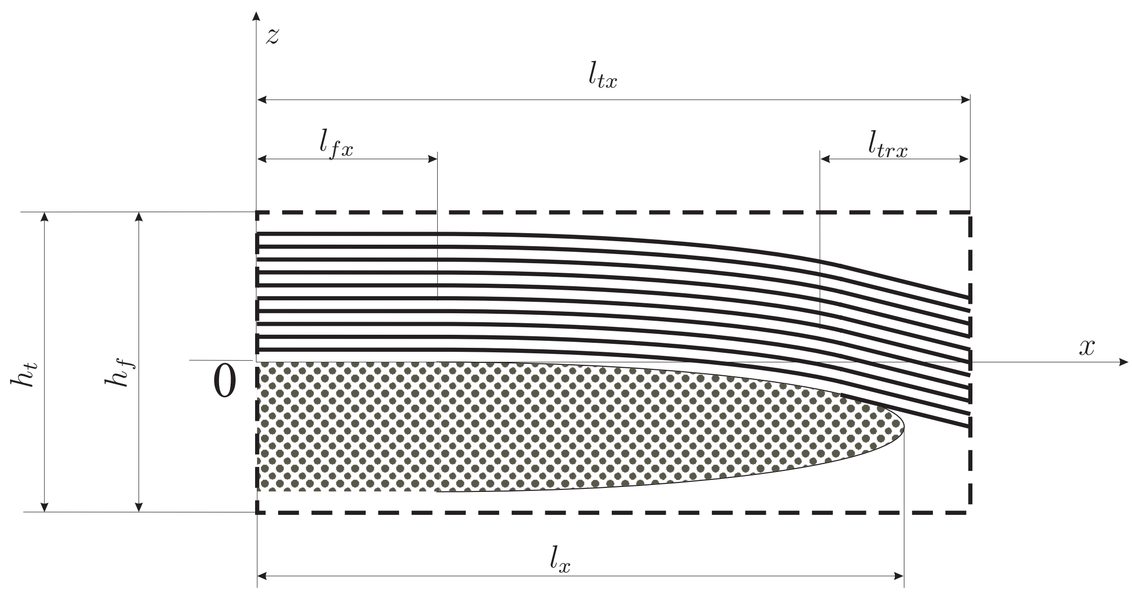

Figure 3: Cross–section of a warp and weft bundle

The parameters h_t and h_f represent the thickness of the fabric layer (including resin layer on top and bottom) and the thickness of the two bundles. The **fibre height** in

U20MM sets h_{rel}:

$$h_{rel} = \frac{h_f}{h_t} \tag{1}$$

Decreasing **fibre height** implies a higher fibre volume fraction within the bundles, which influences the thermoelastic properties of the composite material.

The elliptical shape and the undulation of the bundle are described by l_x, l_{fx}, l_{tx} and l_{trx}. The **undulation** in U20MM, here indicate with U_x, represents the ratio between the straight and the total length of the bundle according to:

$$U_x = 1 - \frac{l_{fx}}{l_x} \tag{2}$$

Hence, setting **undulation** to 100% corresponds to a bundle without a straight part. On the other hand, an **undulation** of 0% represents UD material.

The **accuracy** option defines the coarseness (and thus the computation time) if **finite elements** was chosen in the woven fabrics window.

UD Model & Random Mat Model

The models for the prediction of the thermoelastic properties of unidirectional (**UD Model**) and random mat (**Random Mat Model**) composites share the same input. The difference between the two models is that the random mat model uses an extra averaging step. In this step, the properties of quasi–isotropic (QI) composites are calculated, based on the properties of the UD layers.

The UD properties can be computed with different micromechanical models for UD laminae. A distinction is made between elastic and thermal properties. The models are discussed in more detail in the relevant section in the background theory.

Unlike the woven fabric model, no further advanced options are present for the UD and random mat models. The output is full three–dimensional only.