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Recent developments in “COMPOSITES DREAM” for meso-FE modelling of advanced materials

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Abstract. Composites Dream is a powerful software package of multi-scale finite element (FE) modelling and analysis for advanced composite materials. Composites Dream consists of WiseTex, MeshTex and SACOM which are originally developed by KU-Leuven and Osaka University respectively. In recent years, we are continuously developing some features to generate finite element model for several kinds of textile composites. In this paper, we present the recent developments in Composites Dream including meso FE-modelling of a cylindrical braided composites with inlay yarn, a bi-axial non-crimp fabric with stitch modelled by beam element, a layered unidirectional non-crimp fabric etc. In addition, we also present a short fiber modelling capability associated arbitrary orientation tensor.

1. Introduction

Recently many kinds of composite materials and many type of composite sheets are produced for various industries. In order to design new products using such composite materials, a simulation software is strongly required to evaluate their characteristics. However, recent composite materials have complex structure so it is very difficult to generate numerical model for simulation. We have been developing the commercial software named “Composites Dream” which is modeling and simulation tool for textile composites. Composites Dream consists of WiseTex [1] [2], MeshTex [3] and SACOM [4] which are originally developed by KU-Leuven and Osaka University respectively. In this paper, we present the recent developments in Composites Dream to generate finite element models which are cylindrical braided composites, multi-ply stitched fabrics and random mat with short fiber reinforcements.

2. Modeling of Braided Tube

Figure 1 shows a schematic image of the braided fabric. It is very difficult to generate finite element model of cylindrical braided composites in especially when inlay yarn must be taken into account. The parameters which can be specified to generate braided tube are tube length, tube diameter, number of yarns, braided angle, consideration of inlay and braiding pattern which are shown in Figure 2. It is very easy to generate solid mesh for finite element analysis to simulate the complicated braided fabrics using Composites Dream. Figure 3 shows some examples by setting various generating parameters. Resin matrix can be taken into account by superimposed simulation. Figure 4 shows superimposed model of braided fabric and resin matrix. Braided yarn is modeled by solid element so that the deformation of the braiding yarn section along the braiding axis can be simulated [5].



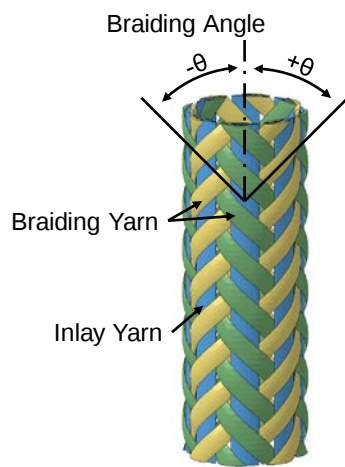


Figure 1. Schematic image of a braided fabric

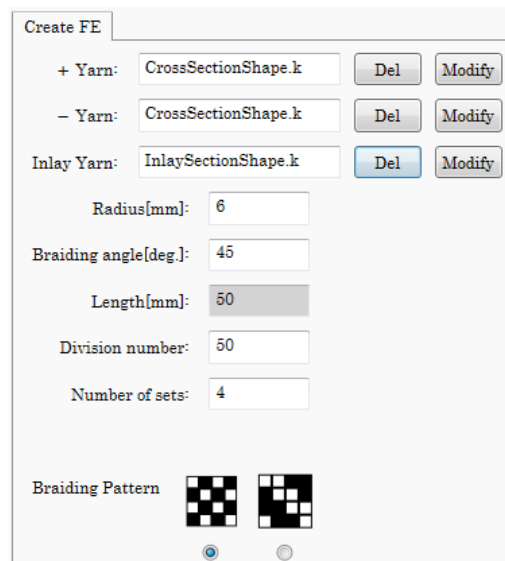


Figure 2. Input dialog of braided tube

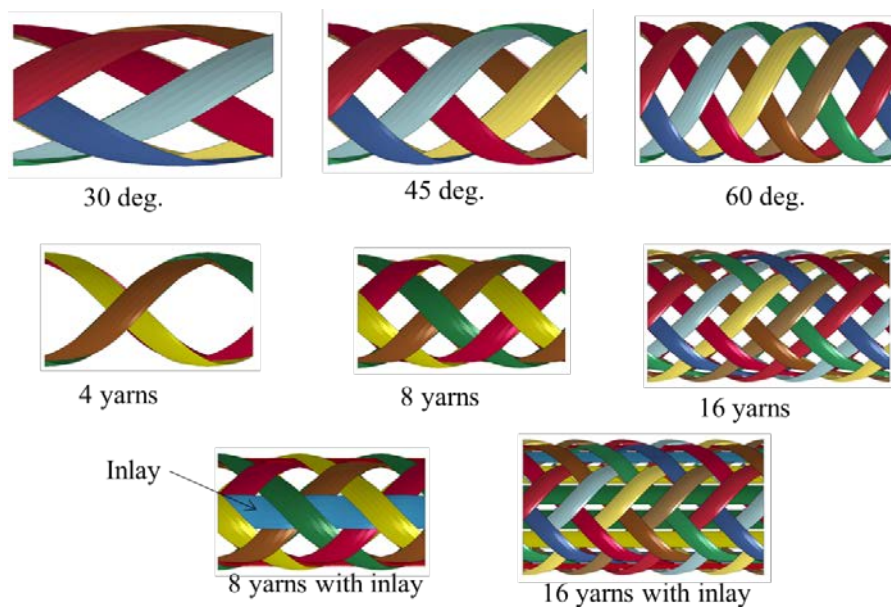


Figure 3. Example of various types of braided tube



Figure 4. Superimposed geometry of fiber and matrix

3. Modelling of Non-Crimp Fabrics

There is a growing need for using non-crimp fabric in automotive industry because of cost and draping deformability. Figures 5 and 6 show a biaxial non crimp fabrics and figures 7 and 8 show a unidirectional non crimp fabrics. Figure 9 shows numerical FE-model for biaxial NCF generated by Composites Dream. In Composites Dream, fiber yarns are modeled by solid element and stitching yarns are modeled by beam element (Figure 10). Unidirectional yarn and stitching yarn are discontinuous so that friction sliding and initial tension of the stitching yarn can be taken into account. It is also available to laminate biaxial fabrics and the direction of the yarn in each layer has arbitrary angle. Figure 11 shows a simple example of draping simulation. It can be seen gaps between straight yarns as shown figure 12.

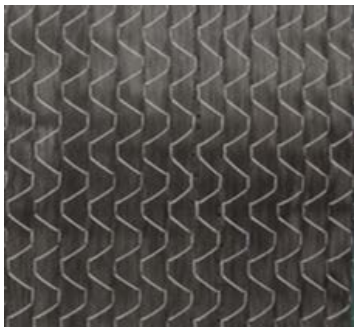


Figure 5. Biaxial-NCF(front face)



Figure 6. Biaxial-NCF(back face)



Figure 7. UD-NCF(front face)

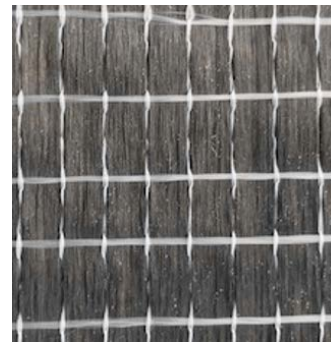


Figure 8. UD-NCF(back face)

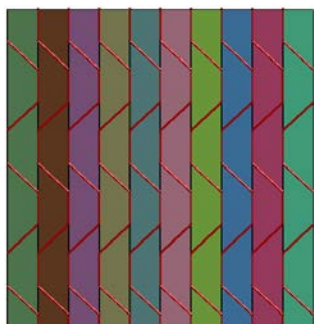


Figure 9. FE-model of Biaxial NCF

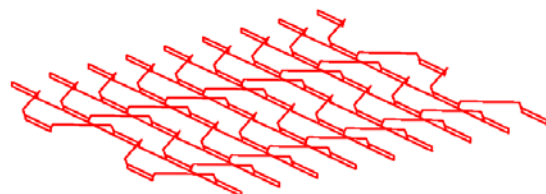
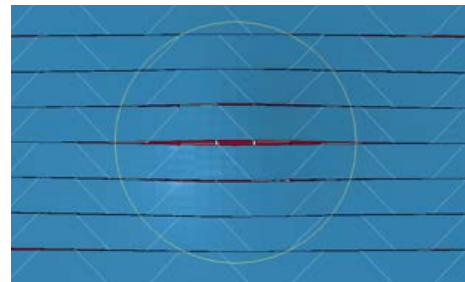
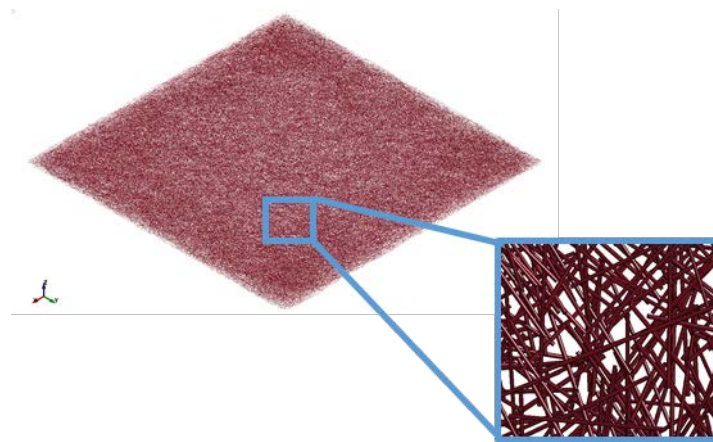


Figure 10. Beam elements of stitching

**Figure 11.** Draping deformation**Figure 12.** Gap opening between yarn

4. Modelling of fiber mat

A sheet just like non-woven fabric composed of the arbitrary oriented fiber is modeled by beam elements as shown in figure 13. The each fiber is assumed a straight line but has distribution in diameter and length. It is available to choose from uniform distribution, normal distribution and the Weibull distribution as a distribution function. The orientation distribution are specified by arbitrary orientation tensor. Multi-layer which has different orientation tensor respectively is available. The contacts between fibers are also generated automatically. Figure 14 shows input dialog for generating fiber mat. After generating fiber as beam element, it is possible to create voxel mesh. Each voxel element is distinguished whether it is fiber or space by the center coordinate of each element. The fiber element is automatically defined the anisotropy along the fiber axis.

**Figure 13.** Example of fiber mat

Panel 1: Fiber Generate Area

Parameters:

- Area coordinate
- Cut Area
- Solid Mesh
- Property

Panel 2: Fiber

Parameters:

- Fiber Length
- Fiber Diameter
- Property
- VF
- Penetration

Panel 3: Fiber Orientation

Parameters:

- Orientation Tensor
- Thickness

No.	Name	Thick	Xx	Yy	Zx	Xy	Zy	Zz	66[°]	6E[°]
1		0.5	1	0	0	0	0	0	89	91
2		0.5	0	1	0	0	0	0	89	91

Figure 14. Input dialog for generating randomly oriented fiber mat

5. Conclusions

In this paper, we showed the recent developments in “Composites Dream” to generate finite element models for advanced composite materials such as braided tube, non-crimp fabrics and randomly oriented fiber mat. These developments are useful for the engineers of composite materials to simulate and evaluate the characteristics as stiffness, strength and deformability. These finite element models are exported for LS-Dyna or ABAQUS which are major finite element solver. We have been developing new modeling tools for more complicated composite materials like randomly oriented chopped carbon fiber tape reinforced thermoplastics sheet.

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