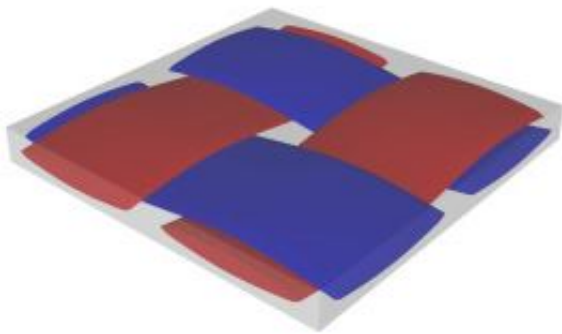
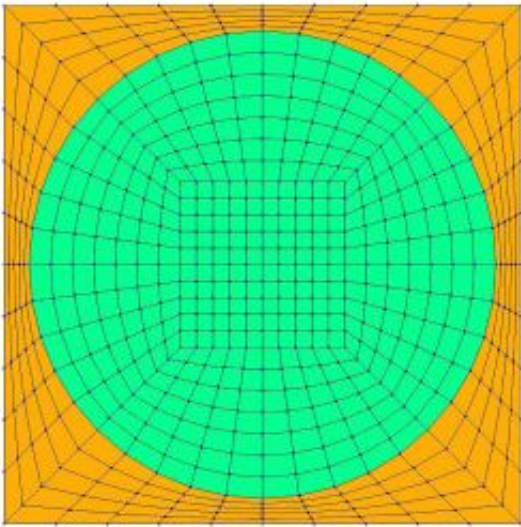


Predict thermoelastic properties of plain woven composites

Problem Description

The MSG solid model is used to predict the effective thermoelastic properties of a plain weave composite using a two-step approach. This problem is the example 4.1 in the paper “Liu, X., Yu, W., Gasco, F. and Goodsell, J., 2019. A unified approach for thermoelastic constitutive modeling of composite structures. Composites Part B: Engineering, 172, pp.649-659.”

The first step predicts the effective thermoelastic yarn properties based on the fiber and matrix properties at the microscale. The second step takes the effective yarn properties and matrix properties to predict the effective properties of weave composites. The microscale and mesoscale models are given as



The fiber and matrix properties are given as

PREDICT THERMOELASTIC PROPERTIES OF PLAIN WOVEN COMPOSITES

Properties	T300 carbon fiber	Epoxy resin
E_1 (GPa)	230.00	3.45
$E_2 = E_3$ (GPa)	40.00	3.45
$G_{12} = G_{13}$ (GPa)	24.00	1.28
G_{23} (GPa)	14.30	1.28
$\nu_{12} = \nu_{13}$	0.26	0.35
ν_{23}	0.40	0.35
α_{11} (ppm/°C)	-0.70	63.00
$\alpha_{22} = \alpha_{33}$ (ppm/°C)	10.00	63.00

The youtube video of this problem can be obtained
<https://youtu.be/s8LLMRTB-hg>

Software Used

The example will be solved using the [TexGen4SC 2.0](#).


Solution Procedure

Below describe the detailed step by step procedure you followed to solve the problem.

* step1 Create mesoscale plain weave SG with the yarn geometries given as

PREDICT THERMOELASTIC PROPERTIES OF PLAIN WOVEN COMPOSITES

Weave Wizard ✕



This wizard will create a 2d textile weave model for you.

Warp Yarns:

Weft Yarns:

Yarn Spacing:

Yarn Width:

Fabric Thickness:

Create 3D weave

Create layered textile

Create default domain

Add 10% to domain height

Refine model

Force in-plane tangents at nodes

Shear textile

Number of weave layers:

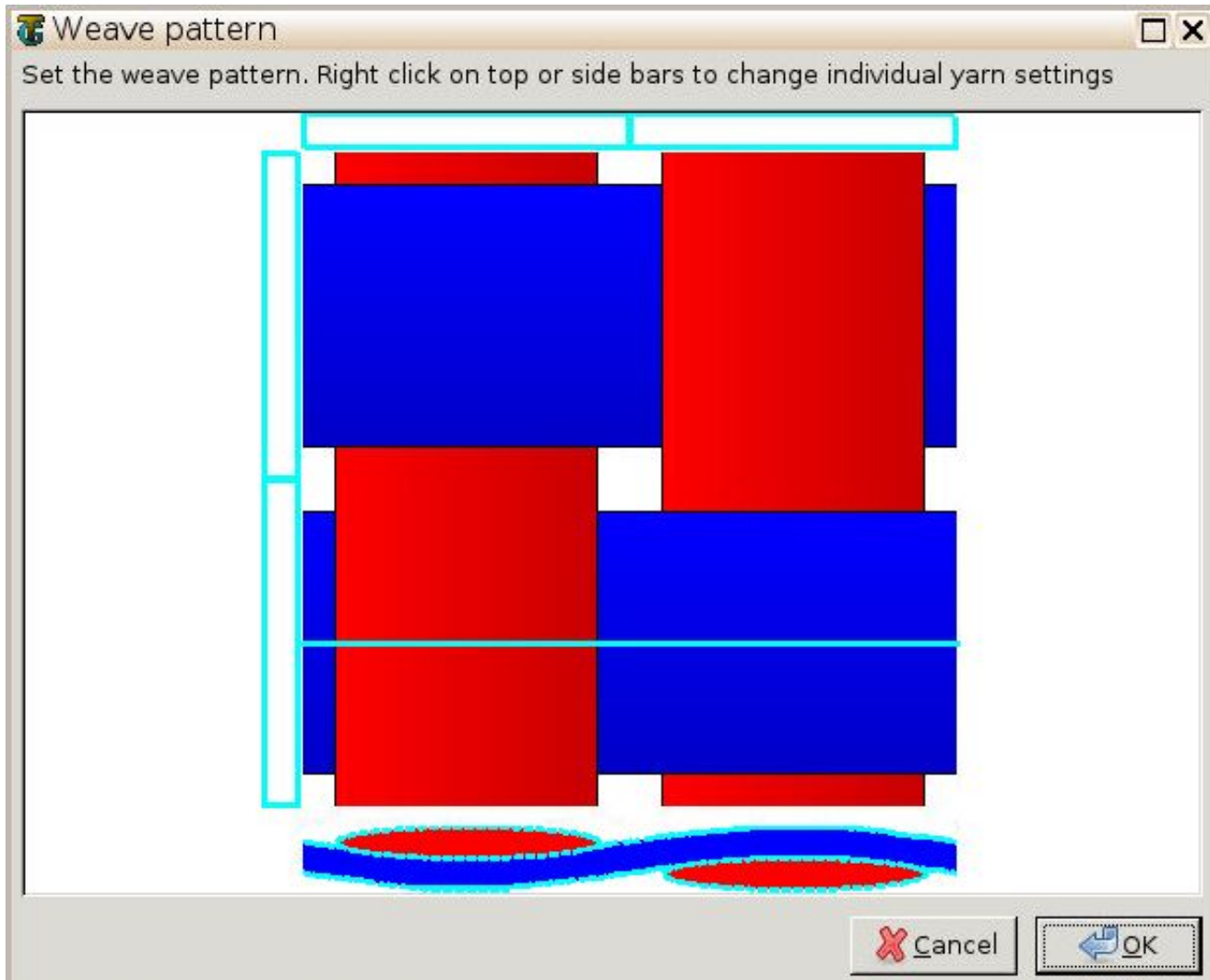
Create sheared domain

Gap size:

Shear angle (degrees):

* step 2 Create plain weave pattern as

PREDICT THERMOELASTIC PROPERTIES OF PLAIN WOVEN COMPOSITES



* step 3 Go to Homogenization->Microscale and select thermoelastic analysis. Keep the default material properties. The fiber volume fraction 0.64 as

PREDICT THERMOELASTIC PROPERTIES OF PLAIN WOVEN COMPOSITES

The screenshot displays the TexGen software interface with the SwiftComp Wizard dialog box open. The wizard is titled "SwiftComp Wizard" and contains the following settings:

- Microscale model:** Square pack Hexagonal pack
- Type of analysis:** Elastic Thermoelastic Viscoelastic Thermoviscoelastic
- Matrix properties:**
 - Em: 3.45e3 nu: 0.35
 - Alpha: 63e-6
- Fiber properties:**
 - E1: 230e3 E2: 40e3
 - G12: 24e3 G23: 14.3e3
 - nu12: 0.26 nu23: 0.40
 - Alpha1: -0.7e-6 Alpha2: 10e-6
- Volumne fraction:** vf: 0.64

At the bottom of the wizard, there is an "Import" button for "Import viscoelastic or thermoviscoelastic properties" and three navigation buttons: "< Back", "Finish", and "Cancel".

Click finish and the microscale homogenization will be performed and the results will be automatically pop up. Note

PREDICT THERMOELASTIC PROPERTIES OF PLAIN WOVEN COMPOSITES

The Effective Stiffness Matrix

1.5185483E+005	6.3992650E+003	6.3992585E+003	-9.2122914E-004	0.0000000E+000	0.0000000E+000
6.3992650E+003	1.6526234E+004	5.8068538E+003	-8.0148033E-001	0.0000000E+000	0.0000000E+000
6.3992585E+003	5.8068538E+003	1.6526207E+004	7.9775675E-001	0.0000000E+000	0.0000000E+000
-9.2122914E-004	-8.0148033E-001	7.9775675E-001	3.4005346E+003	0.0000000E+000	0.0000000E+000
0.0000000E+000	0.0000000E+000	0.0000000E+000	0.0000000E+000	5.1221347E+003	-4.3591410E-004
0.0000000E+000	0.0000000E+000	0.0000000E+000	0.0000000E+000	-4.3591410E-004	5.1221349E+003

The Effective Compliance Matrix

6.7482041E-006	-1.9336128E-006	-1.9336134E-006	-2.8901142E-013	0.0000000E+000	0.0000000E+000
-1.9336128E-006	6.9586866E-005	-2.3702177E-005	2.1961046E-008	0.0000000E+000	0.0000000E+000
-1.9336134E-006	-2.3702177E-005	6.9586977E-005	-2.1911876E-008	0.0000000E+000	0.0000000E+000
-2.8901142E-013	2.1961046E-008	-2.1911876E-008	2.9407142E-004	0.0000000E+000	0.0000000E+000
0.0000000E+000	0.0000000E+000	0.0000000E+000	0.0000000E+000	1.9523110E-004	1.6614945E-011
0.0000000E+000	0.0000000E+000	0.0000000E+000	0.0000000E+000	1.6614945E-011	1.9523109E-004

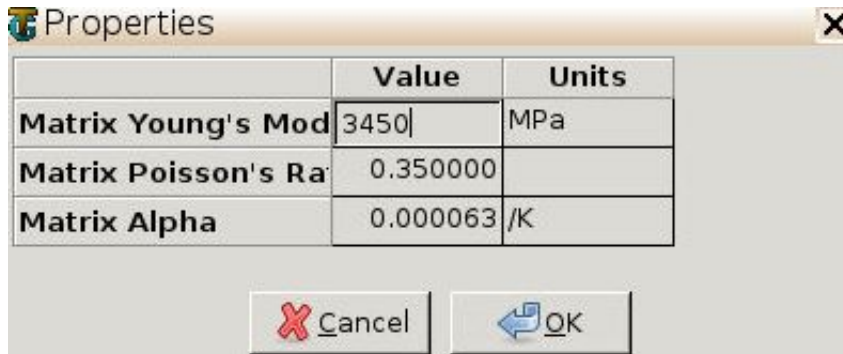
The Engineering Constants (Approximated as Orthotropic)

E1 =	1.4818757E+005
E2 =	1.4370528E+004
E3 =	1.4370505E+004
G12 =	5.1221349E+003
G13 =	5.1221347E+003
G23 =	3.4005344E+003
nu12=	2.8653739E-001
nu13=	2.8653748E-001
nu23=	3.4061280E-001

Thermal Coefficients

alpha11 =	-1.0548844E-007
alpha22 =	3.2031122E-005
alpha33 =	3.2031203E-005
2alpha23=	3.5804836E-011
2alpha13=	-0.0000000E+000
2alpha12=	-0.0000000E+000


* step 4 The effective yarn properties will be automatically assigned to the mesoscale model. However, users need to define the matrix properties for the mesoscale model. Usually, the matrix at the mesoscale is the same as the one at microscale as shown



* step 5 Go to File->Export->[SwiftComp](#) File, define the voxel mesh and run elastic analysis using the MSG solid model

PREDICT THERMOELASTIC PROPERTIES OF PLAIN WOVEN COMPOSITES

SwiftComp Wizard



This wizard will create SwiftComp input file for you.

Assign voxel seed in each direction:

X Voxel Count:

Y Voxel Count:

Z Voxel Count:

Type of analysis: Elastic **Thermoelastic** Viscoelastic
 Thermoviscoelastic

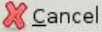
Type of models **Solid Model** Plate/Shell Model Beam Model

Type of plate theory Kirchhoff-Love plate Reissner-Mindlin plate

Type of beam theory Euler-Bernoulli beam Timoshenko beam

Aperiodic boundary conditions y1 y2 y3

Import viscoelastic or thermoviscoelastic properties

< Back Finish  Cancel

Save the sc file and click to the Homogenization->Mesoscale. The effective properties of the plain weave composite will be automatically pop up

The Effective Stiffness Matrix

4.5635314E+004	8.4195162E+003	4.6068627E+003	2.2448856E-003	-2.5142056E-003	-2.6281800E-001
8.4195162E+003	4.5635316E+004	4.6068633E+003	-1.4558735E-003	-2.6673318E-003	2.6309901E-001
4.6068627E+003	4.6068633E+003	1.0094700E+004	1.0940148E-004	-1.0018797E-004	1.6825075E-005
2.2448856E-003	-1.4558735E-003	1.0940148E-004	2.4542925E+003	-8.3763485E-005	-3.7121072E-004
-2.5142056E-003	-2.6673318E-003	-1.0018797E-004	-8.3763485E-005	2.4542924E+003	3.1468318E-004
-2.6281800E-001	2.6309901E-001	1.6825075E-005	-3.7121072E-004	3.1468318E-004	3.1236464E+003

The Effective Compliance Matrix

2.3465242E-005	-3.4050668E-006	-9.1547513E-006	-2.3074571E-011	1.9963429E-011	2.2611752E-009
-3.4050668E-006	2.3465242E-005	-9.1547526E-006	1.7441733E-011	2.1640479E-011	-2.2628812E-009
-9.1547513E-006	-9.1547526E-006	1.0741769E-004	-1.8451133E-012	-1.4942690E-011	2.4512516E-013
-2.3074571E-011	1.7441733E-011	-1.8451133E-012	4.0744940E-004	1.3905985E-011	4.8417429E-011
1.9963429E-011	2.1640479E-011	-1.4942690E-011	1.3905985E-011	4.0744941E-004	-4.1047513E-011
2.2611752E-009	-2.2628812E-009	2.4512516E-013	4.8417429E-011	-4.1047513E-011	3.2013867E-004

The Engineering Constants (Approximated as Orthotropic)

E1 = 4.2616223E+004
 E2 = 4.2616224E+004
 E3 = 9.3094538E+003
 G12 = 3.1236464E+003
 G13 = 2.4542924E+003
 G23 = 2.4542925E+003
 nu12 = 1.4511109E-001
 nu13 = 3.9014092E-001
 nu23 = 3.9014099E-001

Thermal Coefficients

alpha11 = 6.0266351E-006
 alpha22 = 6.0266337E-006
 alpha33 = 6.5698755E-005
 2alpha23 = -5.4495579E-012
 2alpha13 = 2.0414787E-011
 2alpha12 = -1.1392654E-012

References

1. Liu, X., Yu, W., Gasco, F. and Goodsell, J., 2019. A unified approach for thermoelastic constitutive modeling of composite structures. *Composites Part B: Engineering*, 172, pp.649-659.