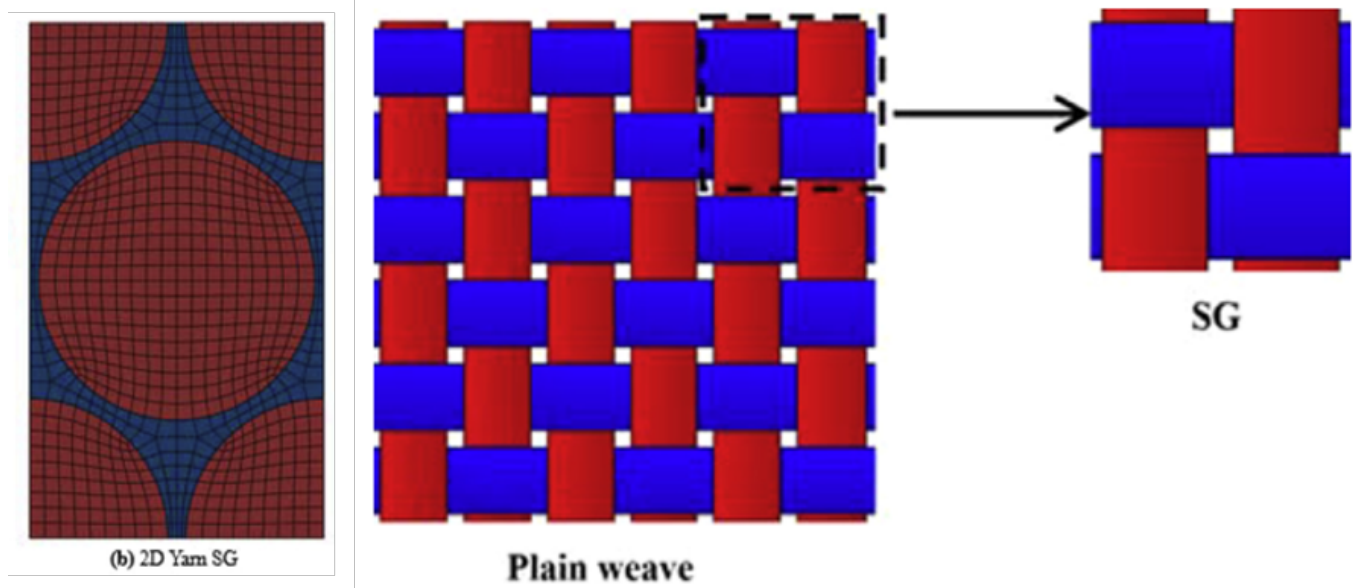


Predict elastic properties of plain woven composites

Problem Description

The MSG solid model is used to predict the effective properties of a plain weave composite using a two-step approach. This problem is the first example in the paper “Liu, X., Rouf, K., Peng, B. and Yu, W., 2017. Two-step homogenization of textile composites using mechanics of structure genome. Composite Structures, 171, pp.252-262.”

The first step predicts the effective 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

Table 1

Mechanical properties of the constituents for epoxy 3601/carbon T-300 plain woven composite.

Elastic constants	Matrix	Fiber
E_1 (GPa)	4.51	208.8
$E_2 = E_3$ (GPa)	4.51	43
$G_{12} = G_{13}$ (GPa)	1.7	7.42
G_{23} (GPa)	1.7	7.42
$\nu_{12} = \nu_{13}$	0.38	0.2
ν_{23}	0.38	0.499

The youtube video of this problem can be obtained

https://youtu.be/bsPJ_8lxZn8

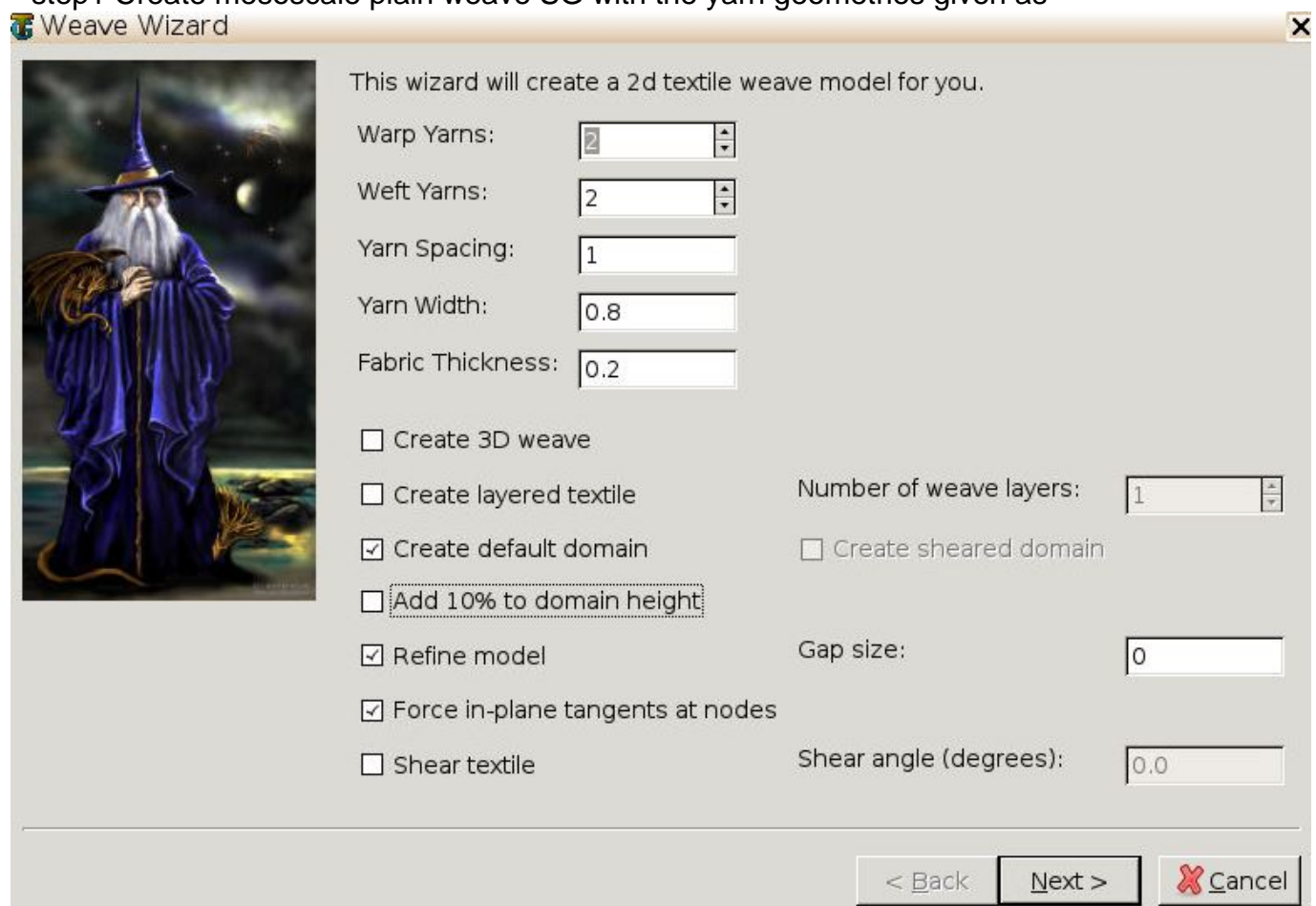
Software Used

The example will be solved using the [TexGen](#)4SC 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



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:

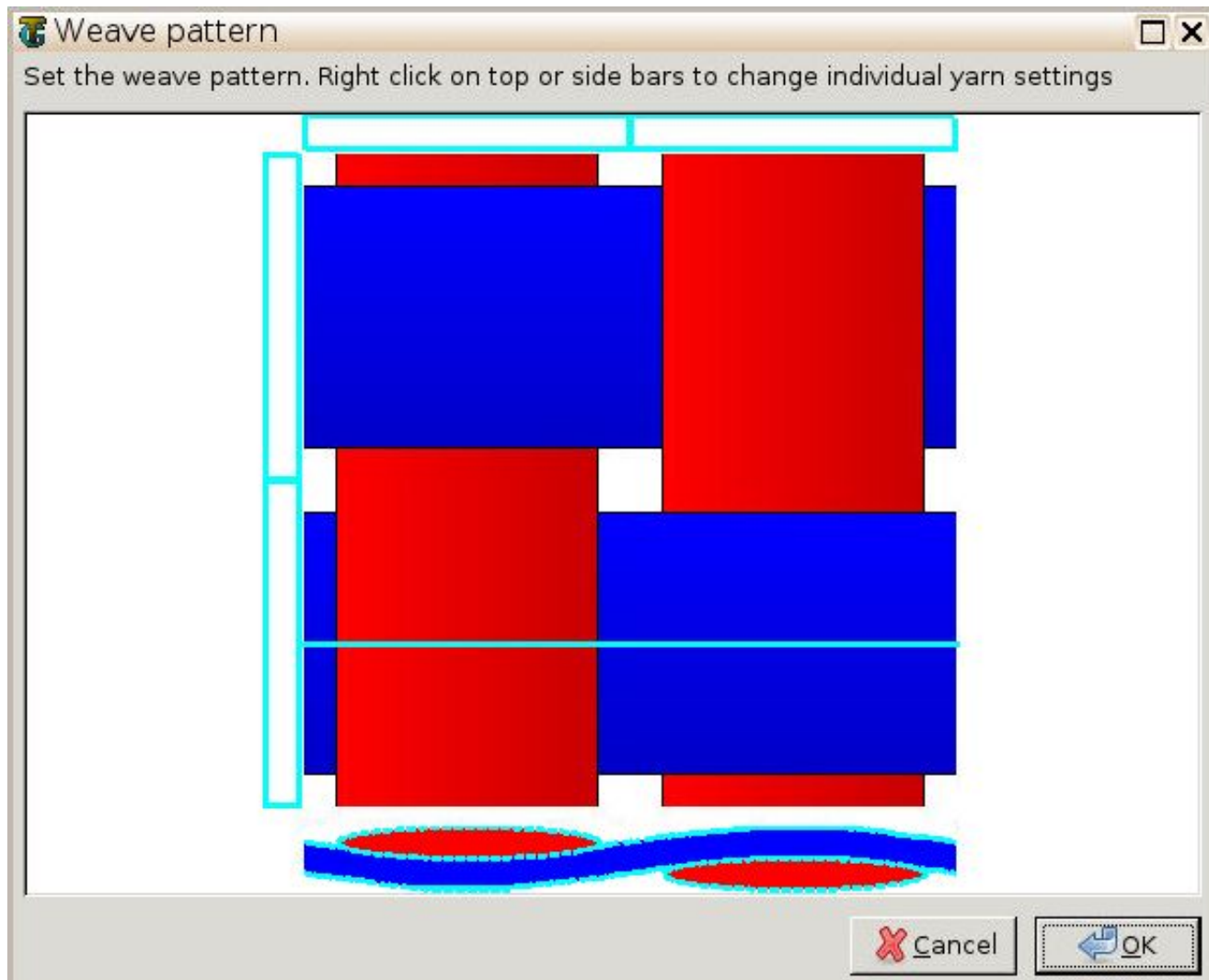
☐ Create sheared domain

Gap size:

Shear angle (degrees):

< Back Next >  Cancel

* step 2 Create plain weave pattern as



* step 3 Go to Homogenization->Microscale to select the hexagonal micromechanical model and define the elastic properties of fiber and matrix and fiber volume fraction 0.8 as

PREDICT ELASTIC PROPERTIES OF PLAIN WOVEN COMPOSITES

SwiftComp Wizard

This wizard will run microscale analysis for you.

Microscale model:

☐ Square pack ☒ Hexagonal pack

Type of analysis:

☒ Elastic ☐ Thermoelastic ☐ Viscoelastic ☐ Thermoviscoelastic

Matrix properties:

Em: nu:

Alpha:

Fiber properties:

E1: E2:

G12: G23:


nu12: nu23:

Alpha1: Alpha2:

Volumne fraction:

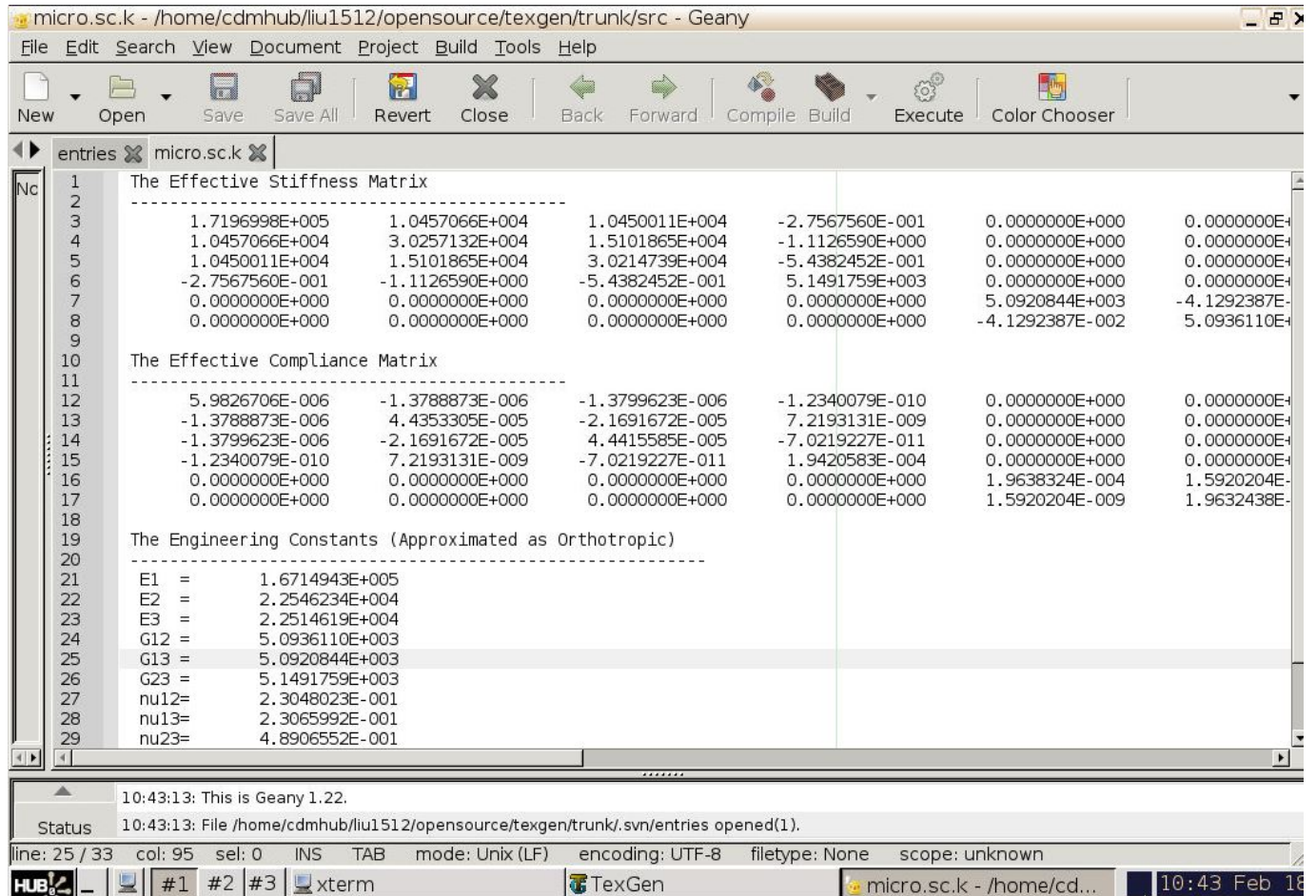
vf:

Import viscoelastic or thermoviscoelastic properties

< Back Finish  Cancel

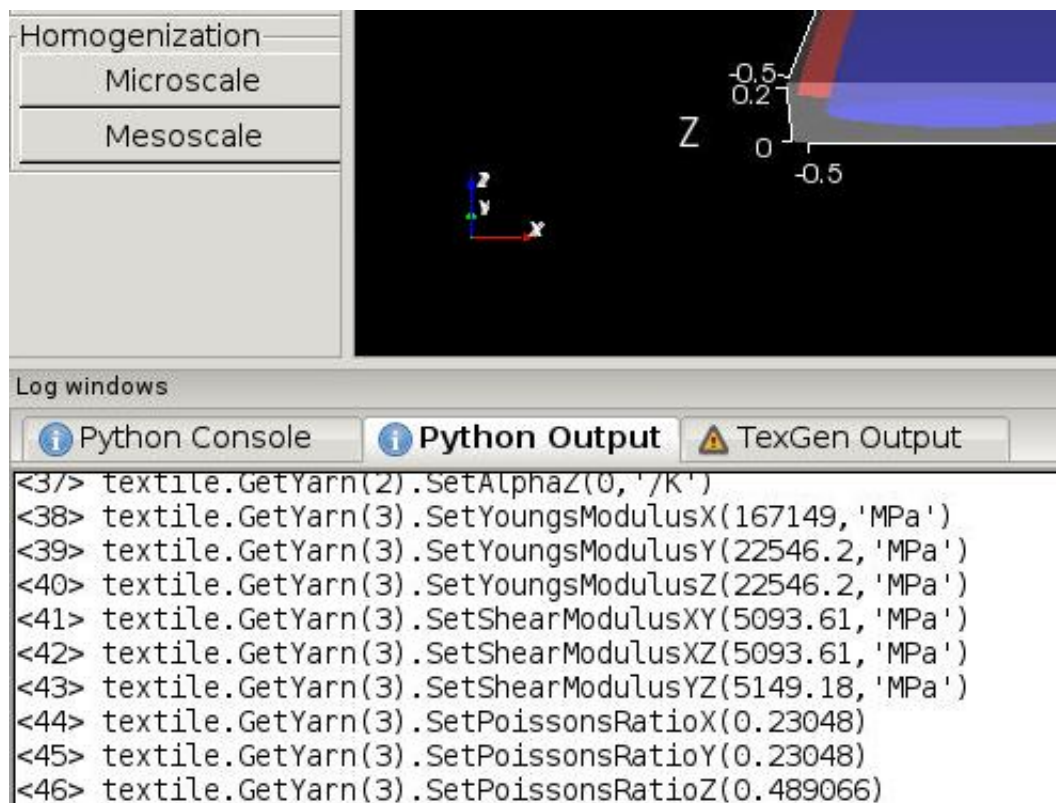
Note the CTEs will not be used for the elastic analysis. Click finish and the microscale homogenization will be performed and the results will be automatically pop up

PREDICT ELASTIC PROPERTIES OF PLAIN WOVEN COMPOSITES

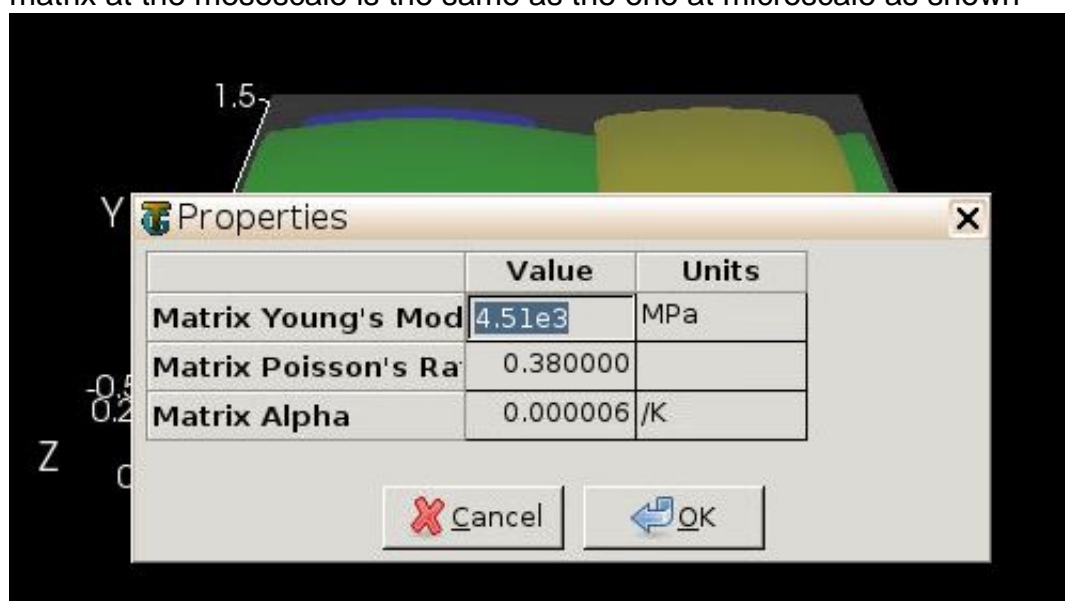


```
micro.sc.k - /home/cdmhub/liu1512/opensource/texgen/trunk/src - Geany
File Edit Search View Document Project Build Tools Help
New Open Save Save All Revert Close Back Forward Compile Build Execute Color Chooser
entries micro.sc.k
1 The Effective Stiffness Matrix
2 -----
3 1.7196998E+005 1.0457066E+004 1.0450011E+004 -2.7567560E-001 0.0000000E+000 0.0000000E+
4 1.0457066E+004 3.0257132E+004 1.5101865E+004 -1.1126590E+000 0.0000000E+000 0.0000000E+
5 1.0450011E+004 1.5101865E+004 3.0214739E+004 -5.4382452E-001 0.0000000E+000 0.0000000E+
6 -2.7567560E-001 -1.1126590E+000 -5.4382452E-001 5.1491759E+003 0.0000000E+000 0.0000000E+
7 0.0000000E+000 0.0000000E+000 0.0000000E+000 0.0000000E+000 5.0920844E+003 -4.1292387E-
8 0.0000000E+000 0.0000000E+000 0.0000000E+000 0.0000000E+000 -4.1292387E-002 5.0936110E+
9
10 The Effective Compliance Matrix
11 -----
12 5.9826706E-006 -1.3788873E-006 -1.3799623E-006 -1.2340079E-010 0.0000000E+000 0.0000000E+
13 -1.3788873E-006 4.4353305E-005 -2.1691672E-005 7.2193131E-009 0.0000000E+000 0.0000000E+
14 -1.3799623E-006 -2.1691672E-005 4.4415585E-005 -7.0219227E-011 0.0000000E+000 0.0000000E+
15 -1.2340079E-010 7.2193131E-009 -7.0219227E-011 1.9420583E-004 0.0000000E+000 0.0000000E+
16 0.0000000E+000 0.0000000E+000 0.0000000E+000 0.0000000E+000 1.9638324E-004 1.5920204E-
17 0.0000000E+000 0.0000000E+000 0.0000000E+000 0.0000000E+000 1.5920204E-009 1.9632438E-
18
19 The Engineering Constants (Approximated as Orthotropic)
20 -----
21 E1 = 1.6714943E+005
22 E2 = 2.2546234E+004
23 E3 = 2.2514619E+004
24 G12 = 5.0936110E+003
25 G13 = 5.0920844E+003
26 G23 = 5.1491759E+003
27 nu12= 2.3048023E-001
28 nu13= 2.3065992E-001
29 nu23= 4.8906552E-001
10:43:13: This is Geany 1.22.
Status 10:43:13: File /home/cdmhub/liu1512/opensource/texgen/trunk/.svn/entries opened(1).
line: 25 / 33 col: 95 sel: 0 INS TAB mode: Unix (LF) encoding: UTF-8 filetype: None scope: unknown
HUB #1 #2 #3 xterm TexGen micro.sc.k - /home/cd... 10:43 Feb 18
```

* step 4 The effective yarn properties will be automatically assigned to the mesoscale model as shown




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 ELASTIC 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 X 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

5.5192881E+004	1.1193455E+004	8.3917576E+003	2.4008072E-003	-2.0754118E-003	-3.4013701E-002
1.1193455E+004	5.5192864E+004	8.3917478E+003	-1.5216116E-003	-2.6163163E-003	3.1500869E-002
8.3917576E+003	8.3917478E+003	1.7043937E+004	3.5353661E-004	1.9397778E-005	2.5749239E-004
2.4008072E-003	-1.5216116E-003	3.5353661E-004	3.1451098E+003	-1.1508179E-002	-3.7381513E-004
-2.0754118E-003	-2.6163163E-003	1.9397778E-005	-1.1508179E-002	3.1451110E+003	3.7448191E-004
-3.4013701E-002	3.1500869E-002	2.5749239E-004	-3.7381513E-004	3.7448191E-004	3.4132294E+003

The Effective Compliance Matrix

1.9966261E-005	-2.7613106E-006	-8.4710358E-006	-1.5624814E-011	1.0930555E-011	2.2509221E-010
-2.7613106E-006	1.9966264E-005	-8.4710241E-006	1.2719805E-011	1.4839461E-011	-2.1114779E-010
-8.4710358E-006	-8.4710241E-006	6.7013482E-005	-5.1648939E-012	-1.3050012E-011	-1.1291980E-011
-1.5624814E-011	1.2719805E-011	-5.1648939E-012	3.1795392E-004	1.1634154E-009	3.4821750E-011
1.0930555E-011	1.4839461E-011	-1.3050012E-011	1.1634154E-009	3.1795380E-004	-3.4884149E-011
2.2509221E-010	-2.1114779E-010	-1.1291980E-011	3.4821750E-011	-3.4884149E-011	2.9297767E-004

The Engineering Constants (Approximated as Orthotropic)

E1 =	5.0084489E+004
E2 =	5.0084482E+004
E3 =	1.4922370E+004
G12 =	3.4132294E+003
G13 =	3.1451110E+003
G23 =	3.1451098E+003
nu12 =	1.3829883E-001
nu13 =	4.2426750E-001
nu23 =	4.2426686E-001

References

1. Liu, X., Rouf, K., Peng, B. and Yu, W., 2017. Two-step homogenization of textile composites using mechanics of structure genome. Composite Structures, 171, pp.252-262.