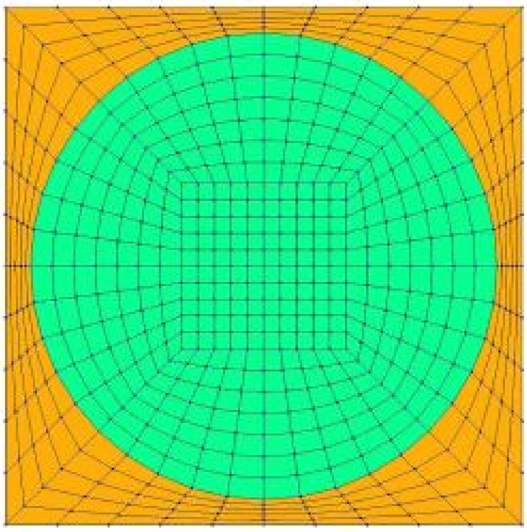
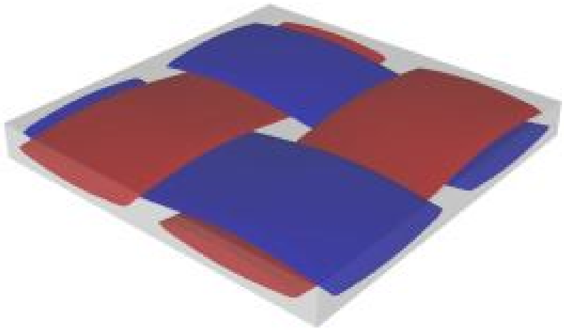
Predict thermoelastic properties of plain woven composites

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

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/$^\circ$C)	−0.70	63.00
$\alpha_{22} = \alpha_{33}$ (ppm/$^\circ$C)	10.00	63.00

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

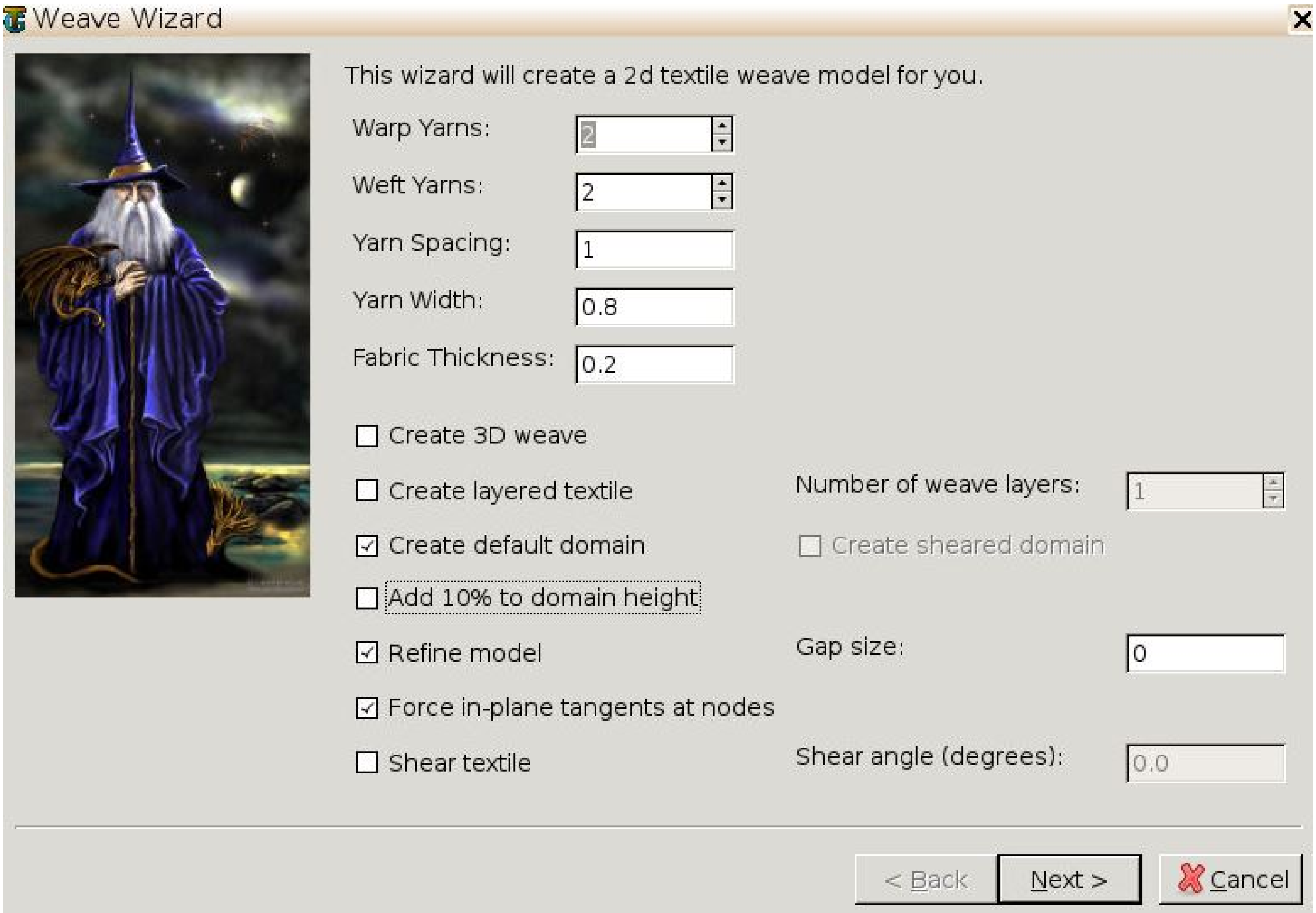
Software Used

The example will be solved using the TexGen4SC 2.0.

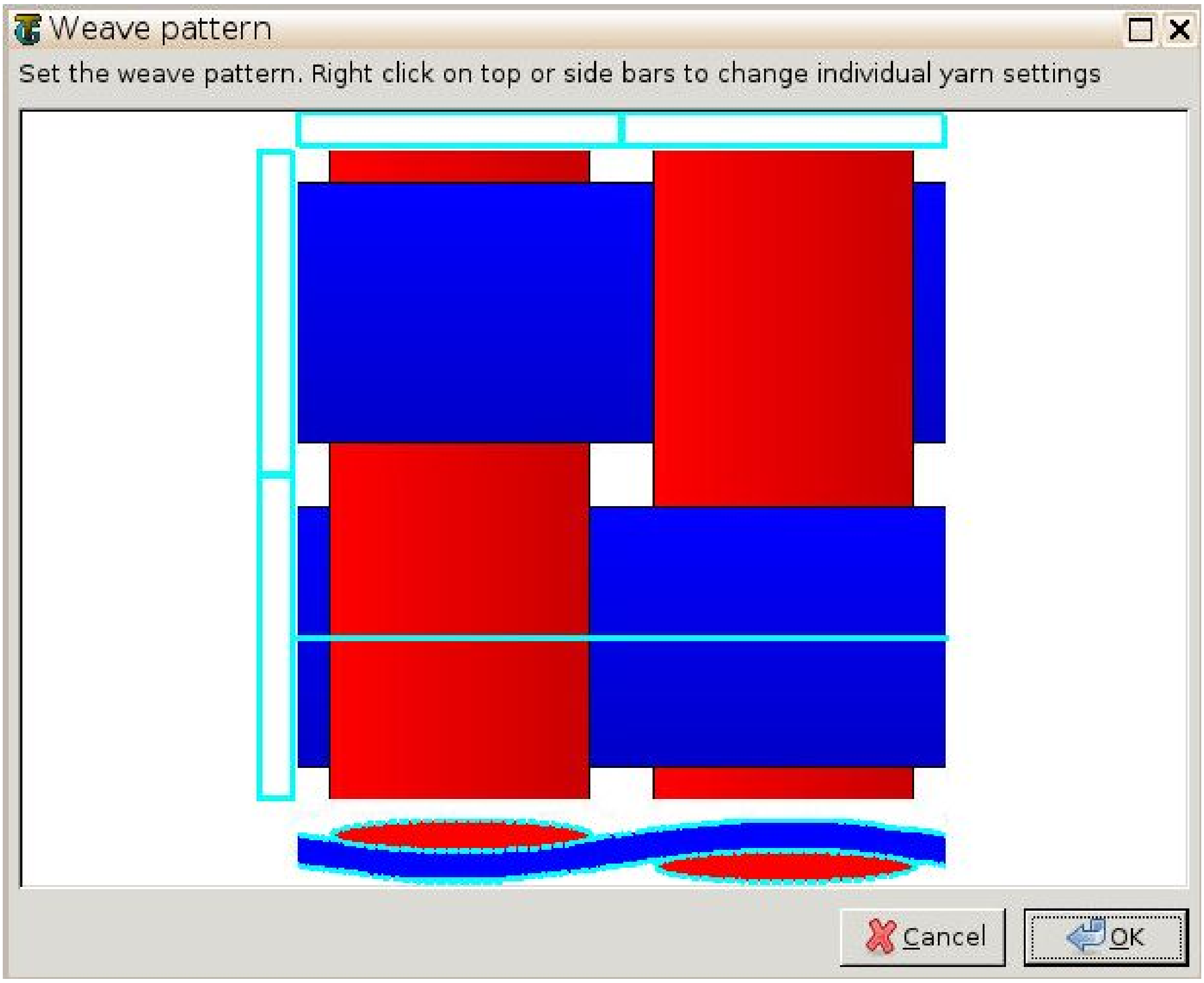
Solution Procedure

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

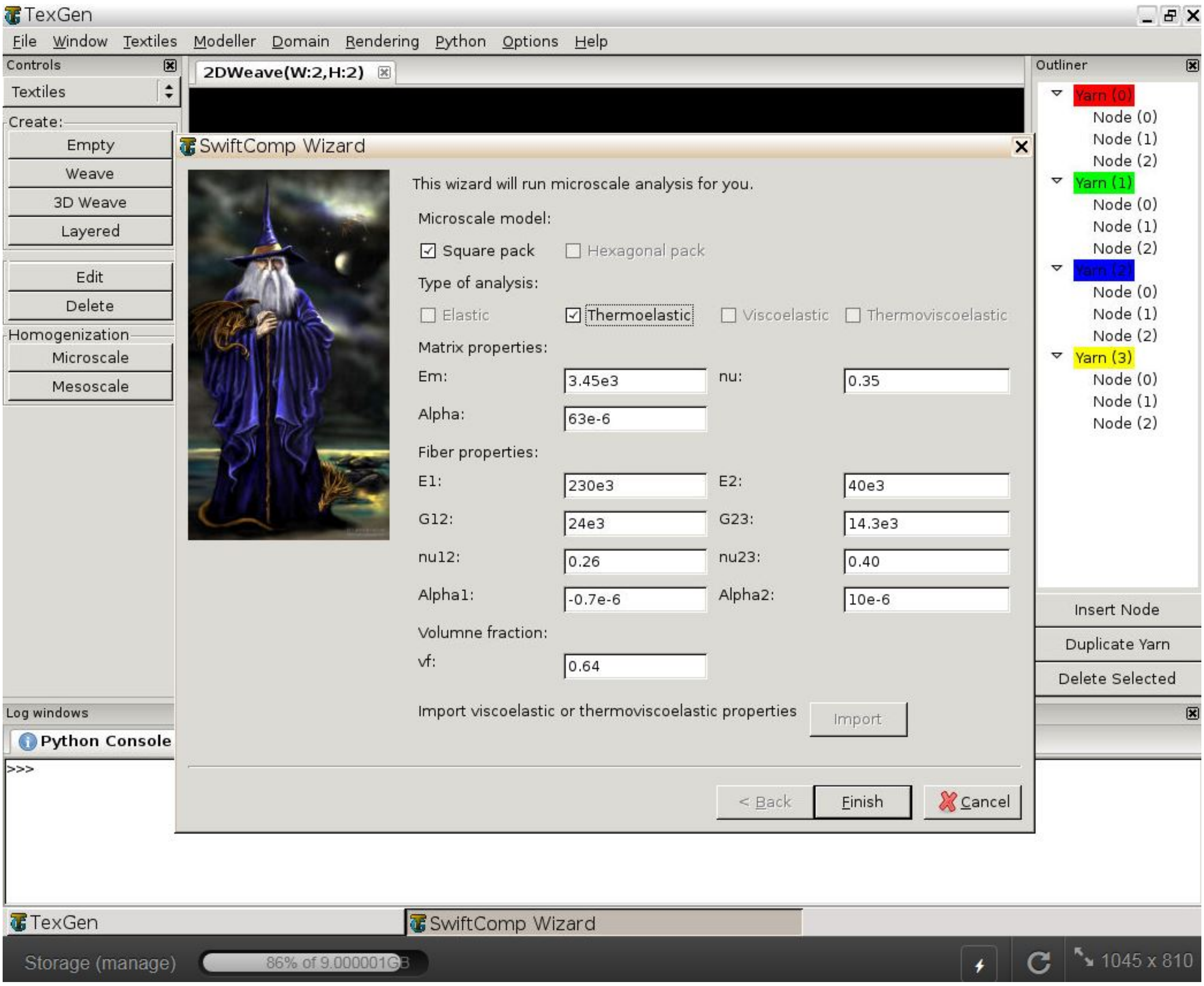
* step1 Create mesoscale plain weave SG with the yarn geometries given as



* step 2 Create plain weave pattern as



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



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

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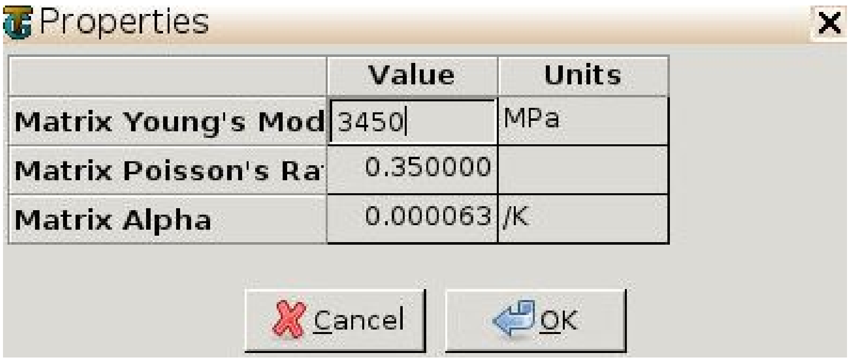
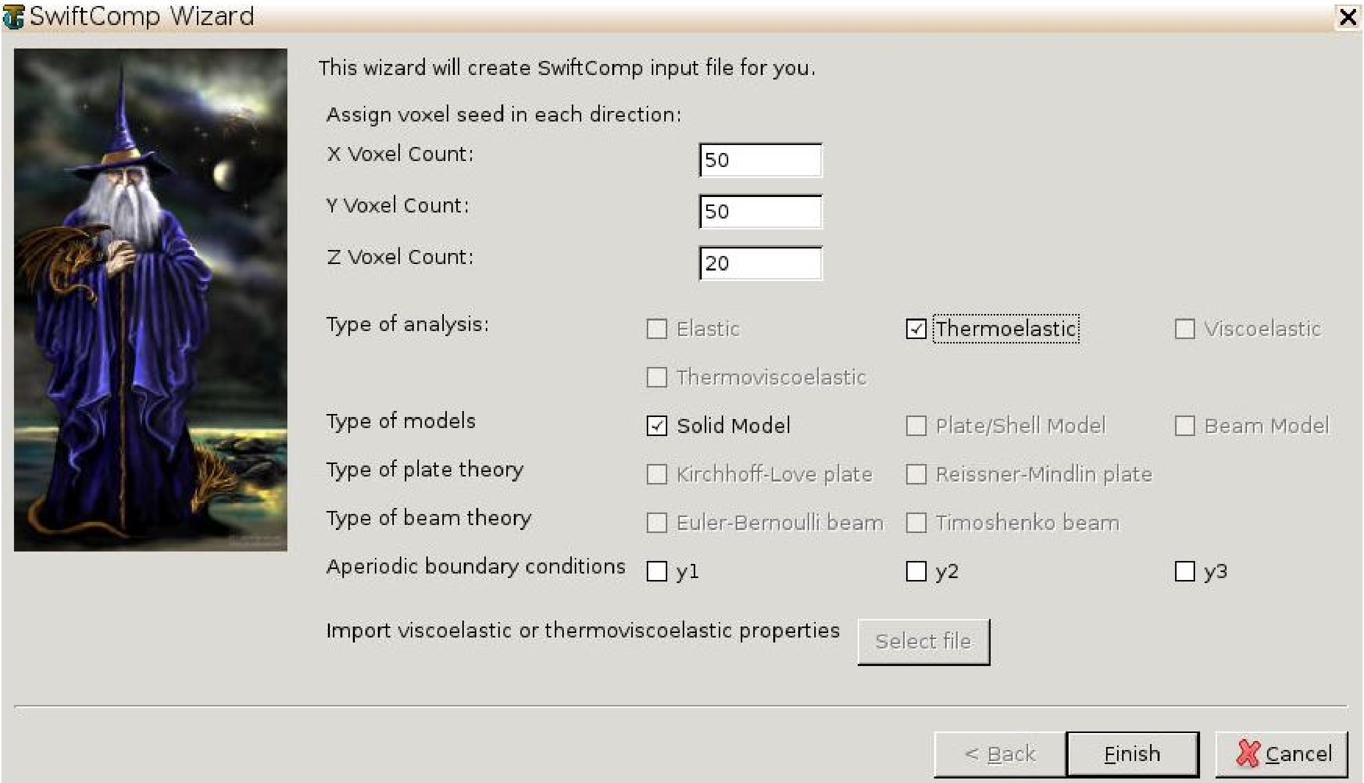
* step 4 The effective yarn properties will be automatically assigned to the mesoscale model. However, users need to define the matrix properties for the mesoscale model. Usually, the matrix at the mesoscale is the same as the one at microscale as shown



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



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.