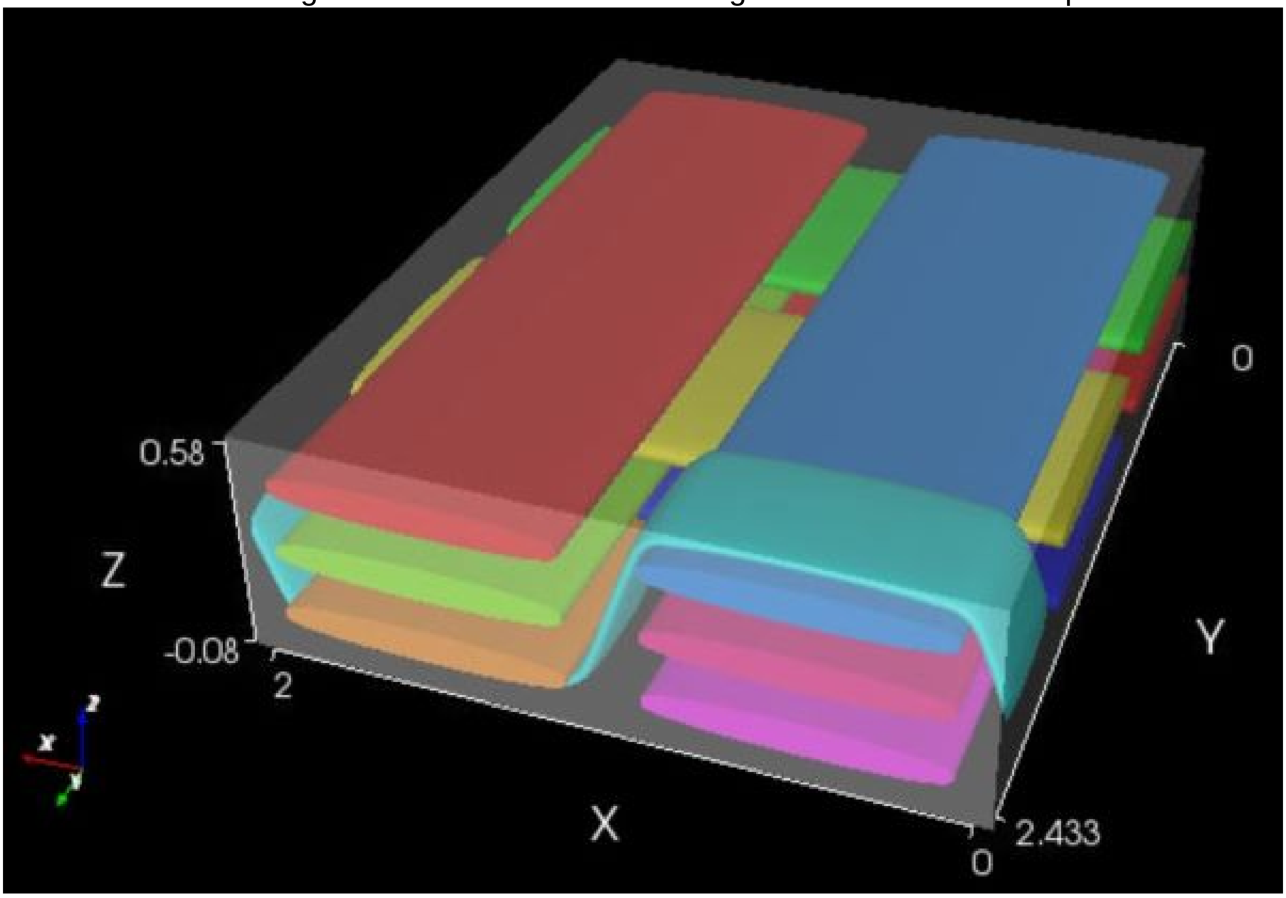
Predict failure index, strength ratio, and failure envelope of 3D orthogonal woven plate

Problem Description

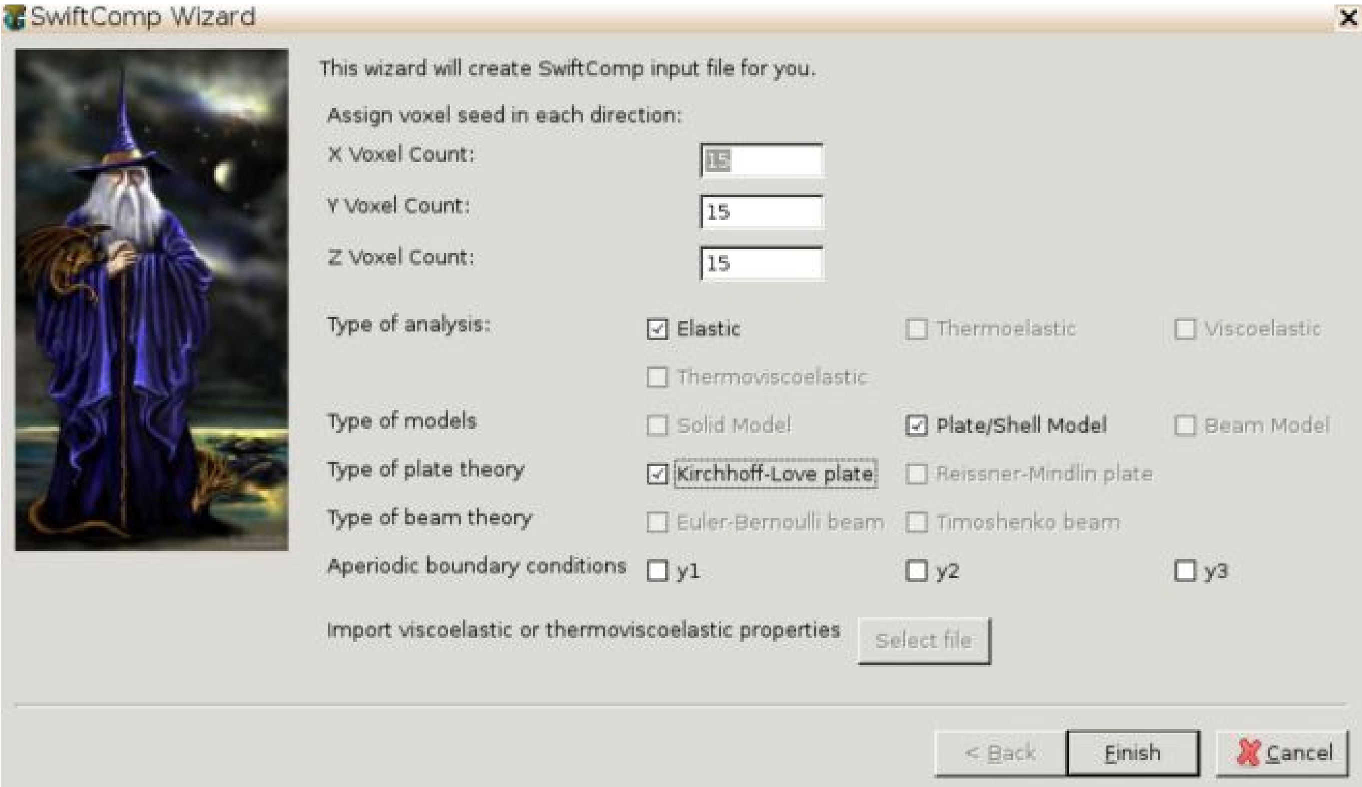
In this example, failure index, strength ratio, and failure envelope of a 3D orthogonal woven plate are predicted using MSG failure functions. For computing failure index and strength ratio, an external load can be defined. Since we are using MSG plate model, the load is in terms of plate stress resultants such as {N11, N22, 2N12, M11, M22, 2M12}. Therefore, the corresponding strength constants are also in terms of plate stress resultants. For the failure envelope analysis, a biaxial loading case is assumed with N11:N22 = 1:1.

Solution Procedure

* step 1 The SG of an 3D orthogonal woven plate is first created as shown in the figure below, which is created using the 3D weave function in texgen4sc with the default parameters.



* step 2 Once the SG is created, we need to perform homogenization analysis using mesoscale function just as in the previous example. Note that this example is using MSG plate model as shown in the figure below.



The results will pop up. Note that the results are plate stiffness/compliance matrix as shown here.

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The Effective Stiffness Matrix
------------------------------------------
   2.3465290E+004   1.1176154E+003   5.3332831E-006   1.3668846E-004   2.8000076E-005   4.5222908E-002
   1.1176154E+003   4.6876025E+004  -1.4886148E-006   2.5025207E-005   4.1557023E-005   1.7199057E-002
   5.3332831E-006  -1.4886148E-006   1.8711398E+003   1.1012656E-001   4.2754330E-003   4.0978901E-005
   1.3668846E-004   2.5025207E-005   1.1012656E-001   3.7709755E+002   2.9800292E+001   1.8979951E-007
   2.8000076E-005   4.1557023E-005   4.2754330E-003   2.9800292E+001   1.2171061E+003  -2.6507946E-008
   4.5222908E-002   1.7199057E-002   4.0978901E-005   1.8979951E-007  -2.6507946E-008   5.4879443E+001

The Effective Compliance Matrix
------------------------------------------
   4.2664584E-005  -1.0172065E-006  -1.2074767E-013  -1.5352175E-011  -5.7089572E-013  -3.4838574E-008
  -1.0172065E-006   2.1357119E-005   2.0078655E-014  -9.9475385E-013  -6.8146296E-013  -5.8550387E-009
  -1.2074767E-013   2.0078655E-014   5.3443362E-004  -1.5622849E-007   1.9478330E-009  -3.9906505E-010
  -1.5352175E-011  -9.9475385E-013  -1.5622849E-007   2.6569747E-003  -6.5054826E-005  -9.0909000E-012
  -5.7089572E-013  -6.8146296E-013   1.9478330E-009  -6.5054826E-005   8.2321392E-004   6.2185037E-013
  -3.4838574E-008  -5.8550387E-009  -3.9906505E-010  -9.0909000E-012   6.2185037E-013   1.8221759E-002

In-Plane Properties
-------------------------------------------------------------
 E1  =      3.5513097E+004
 E2  =      7.0943628E+004
 G12 =      2.8350603E+003
 nu12=      2.3841941E-002
 eta121=     -2.2593576E-010
 eta122=      3.7569969E-011
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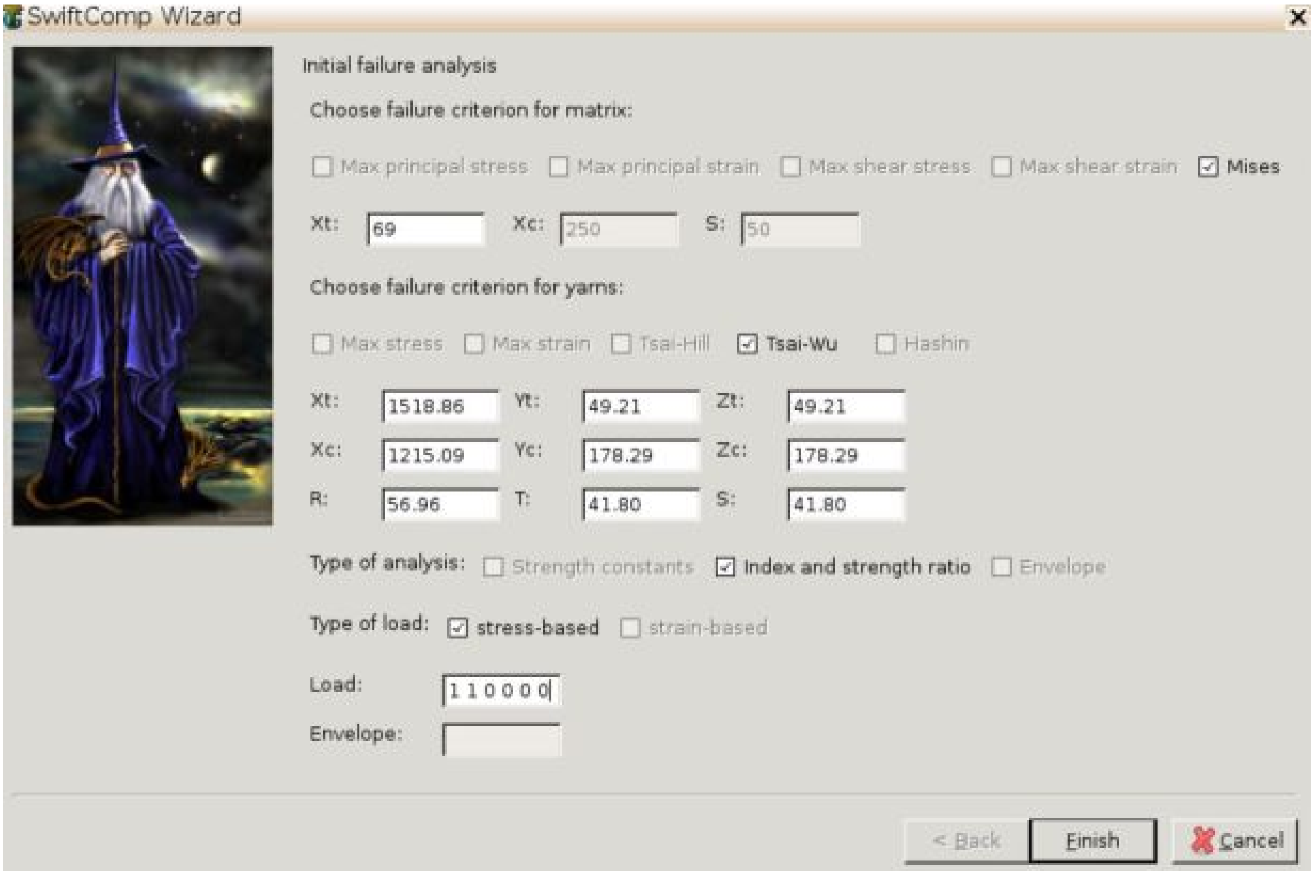
* step 3 Once the homogenization analysis is finished. We can perform the failure analysis by using the initial failure analysis as shown in the figure below. The load is assumed that N11=1 N/mm, N22=1 N/mm and other components are 0. The matrix failure criterion is Mises and the yarn failure criterion is Tsai-Wu.

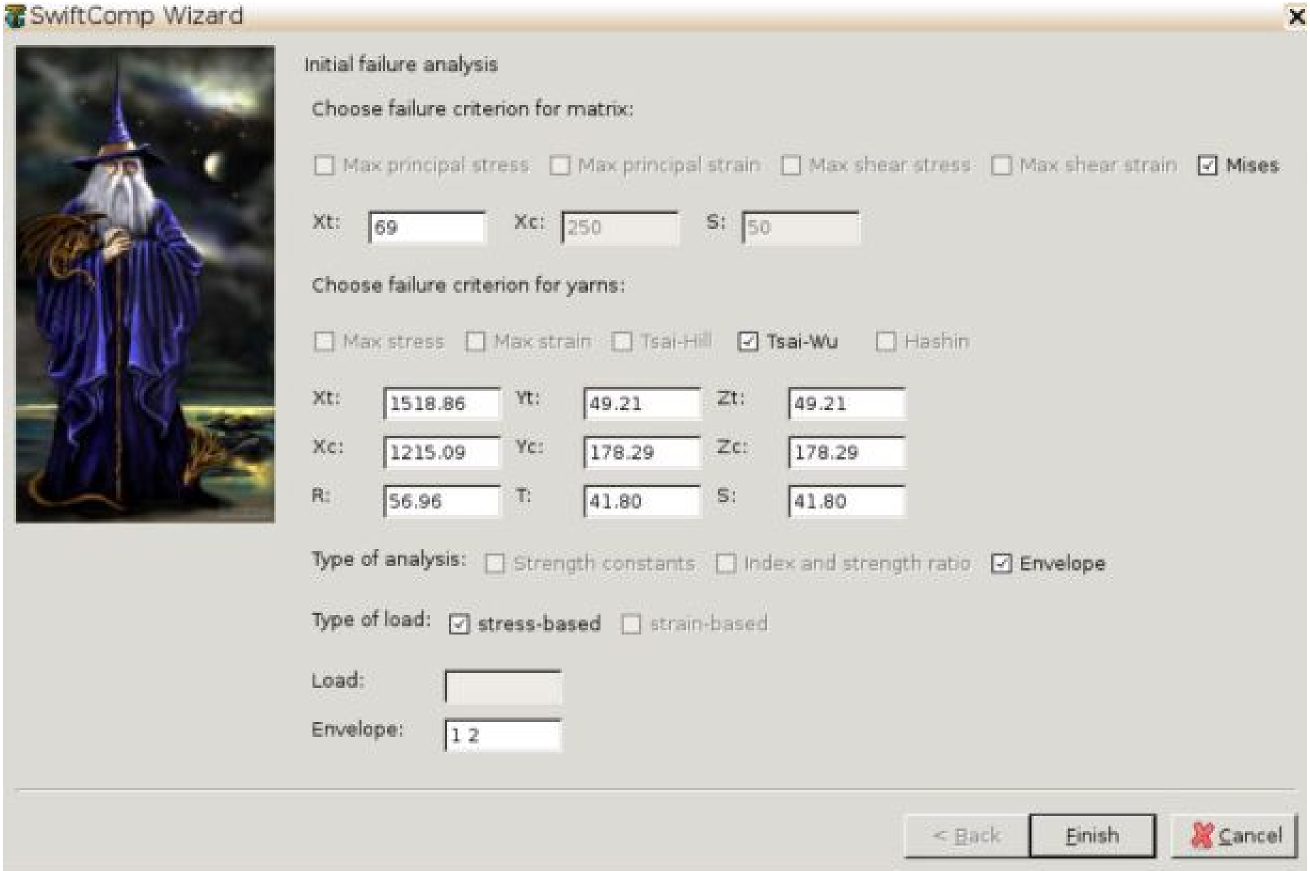


The results are the failure index (first column) and strength ratio (second column) as shown below:

test.sc.fi

1	2.7980992E-003	3.5738547E+002
2	2.2853606E-003	4.3756771E+002
3	2.0122313E-003	4.9696075E+002
4	1.9876429E-003	5.0310849E+002
5	1.9754270E-003	5.0621967E+002
6	2.0085003E-003	4.9788391E+002
7	2.3605184E-003	4.2363576E+002
8	2.8574179E-003	3.4996631E+002
9	1.9636977E-003	5.0924335E+002
10	1.3425460E-003	7.4485345E+002
11	1.1953621E-003	8.3656662E+002
12	1.1712002E-003	8.5382502E+002
13	1.2379212E-003	8.0780586E+002
14	1.7064759E-003	5.8600302E+002
15	2.7403341E-003	3.6491900E+002
16	2.3413599E-003	4.2710222E+002
17	2.0319362E-003	4.9214144E+002
18	1.8357956E-003	5.4472294E+002
19	1.8774802E-003	5.3262880E+002
20	1.8754991E-003	5.3319141E+002
21	1.8553801E-003	5.3897312E+002
22	2.0398963E-003	4.9022099E+002
23	2.1728593E-003	4.6022307E+002
24	1.8375566E-003	5.4420091E+002
25	1.4951278E-003	6.6883912E+002
26	1.4155522E-003	7.0643809E+002
27	1.3976349E-003	7.1549442E+002
28	1.4090984E-003	7.0967364E+002
29	1.7136374E-003	5.8355403E+002
30	2.1624672E-003	4.6243477E+002
31	2.2441061E-003	4.4561172E+002
32	1.9081643E-003	5.2406388E+002
33	1.7491718E-003	5.7169912E+002
34	1.8121274E-003	5.5183759E+002

* step 4 Next, we want to perform a failure envelope analysis in terms of N11 and N22. The parameters are defined in the following:



The results are given as:

test.sc.fi

1	7.6150021E+001	0.0000000E+000
2	-1.5327679E+002	0.0000000E+000
3	0.0000000E+000	2.0823237E+002
4	0.0000000E+000	-2.9687614E+002
5	7.3318611E+001	2.5061235E+001
6	-1.6143597E+002	-5.5180871E+001
7	6.9117516E+001	4.7250494E+001
8	-1.6791831E+002	-1.1479323E+002
9	6.4810260E+001	6.6458916E+001
10	-1.7222834E+002	-1.7660951E+002
11	6.0769129E+001	8.3086648E+001
12	-1.7450098E+002	-2.3858662E+002
13	5.7016562E+001	9.7444933E+001
14	-1.7368422E+002	-2.9683738E+002
15	5.3557387E+001	1.0983958E+002
16	-1.5146692E+002	-3.1063993E+002
17	5.0384195E+001	1.2055372E+002
18	-1.3175019E+002	-3.1523725E+002
19	4.7481898E+001	1.2983934E+002
20	-1.1614138E+002	-3.1758881E+002
21	7.8953749E+001	-3.8475834E+001
22	-1.3952749E+002	6.7994699E+001
23	7.9894701E+001	-7.7868758E+001
24	-1.2166528E+002	1.1858014E+002
25	7.8944358E+001	-1.1541377E+002
26	-1.0514654E+002	1.5372040E+002
27	7.6497802E+001	-1.4911599E+002
28	-9.0921851E+001	1.7723257E+002
29	7.3115152E+001	-1.7815281E+002
30	-7.9100938E+001	1.9273781E+002
31	6.8543344E+001	-2.0041573E+002
32	-6.9478402E+001	2.0314978E+002
33	6.2749517E+001	-2.1405418E+002
34	-6.1643080E+001	2.1027984E+002