Predict failure envelope of a fiber-reinforced composite laminate

Problem Description

The failure envelope of a fiber-reinforced composite laminate is predicted using the MSG plate model. The failure envelope is in terms of plate stress resultants (N11 vs N22) in this example and the failure criterion used for each lamina is Hashin. The layup is assumed to be [0/45/-45/90]s with thickness 0.127 mm in each lalyer.

Software Used

Gmsh4SC 2.0

Solution Procedure

Below describes the step-by-step procedure you followed to solve the problem.

1. step 1

- Open Gmsh4SC and create a new model (Change the default name). Click Material->Thermoelastic and input the lamina properties as shown in Fig. 1. Click add and close.

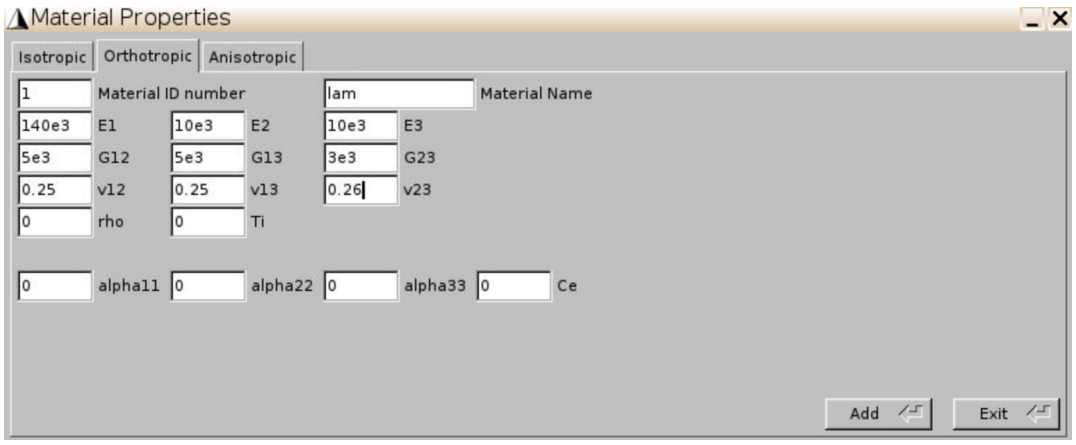


Fig. 1

- Click Geometry->Common SG-> 1D SG->Fast generate. Select the material defined in the above and input the layup and thickness of each layer as shown in Fig. 2.

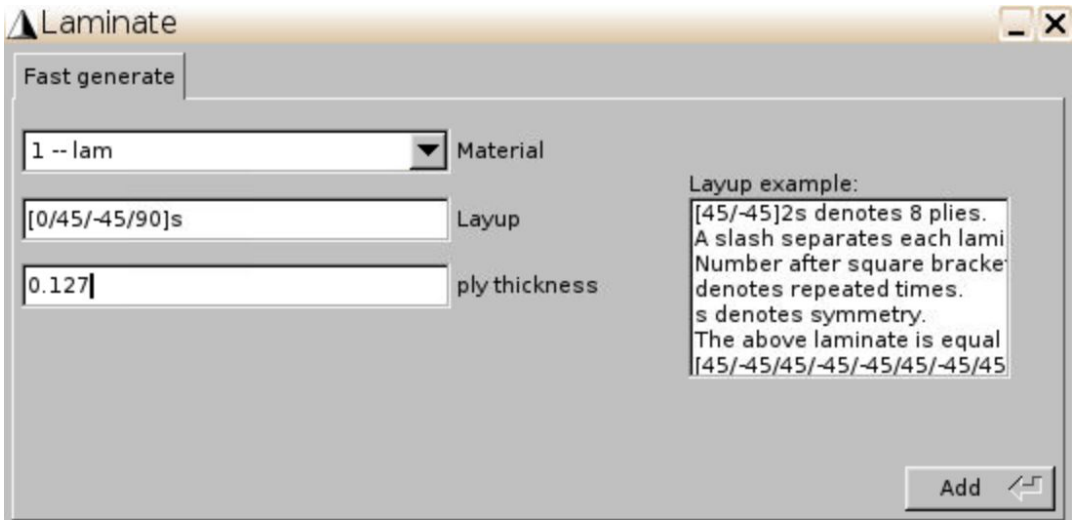
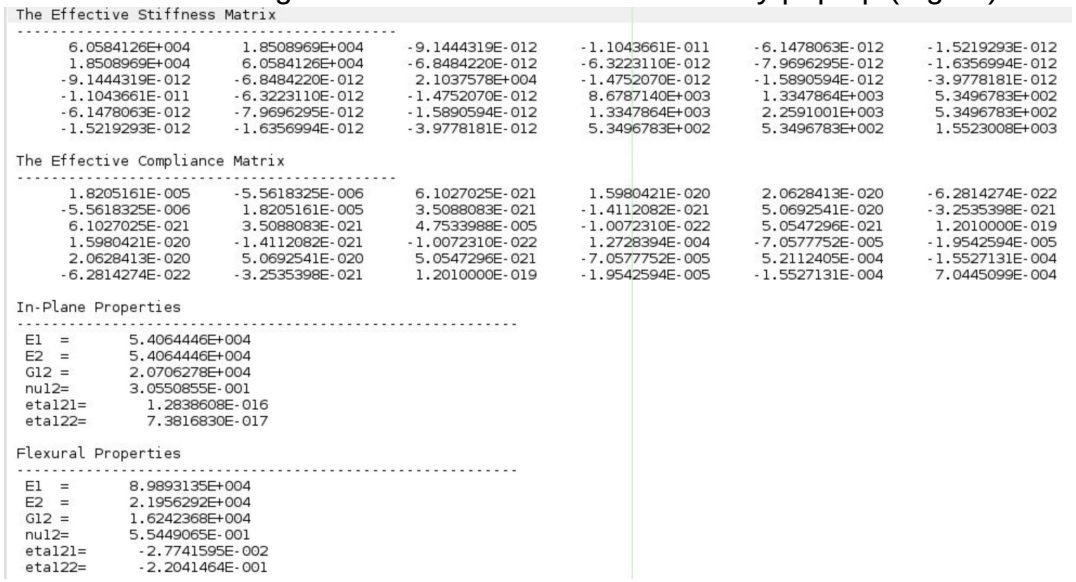


Fig. 2

* Click SwiftComp->Homogenization->Plate model. Keep the default parameters and click save and run. The homogenization results will automatically pop up (Fig. 3.).



The Effective Stiffness Matrix

6.0584126E+004	1.8508969E+004	-9.1444319E-012	-1.1043661E-011	-6.1478063E-012	-1.5219293E-012
1.8508969E+004	6.0584126E+004	-6.8484220E-012	-6.3223110E-012	-7.9696295E-012	-1.6356994E-012
-9.1444319E-012	-6.8484220E-012	2.1037578E+004	-1.4752070E-012	-1.5890594E-012	-3.9778181E-012
-1.1043661E-011	-6.3223110E-012	-1.4752070E-012	8.6787140E+003	1.3347864E+003	5.3496783E+002
-6.1478063E-012	-7.9696295E-012	-1.5890594E-012	1.3347864E+003	2.2591001E+003	5.3496783E+002
-1.5219293E-012	-1.6356994E-012	-3.9778181E-012	5.3496783E+002	5.3496783E+002	1.5523008E+003

The Effective Compliance Matrix

1.8205161E-005	-5.5618325E-006	6.1027025E-021	1.5980421E-020	2.0628413E-020	-6.2814274E-022
-5.5618325E-006	1.8205161E-005	3.5088083E-021	-1.4112082E-021	5.0692541E-020	-3.2535398E-021
6.1027025E-021	3.5088083E-021	4.7533988E-005	-1.0072310E-022	5.0547296E-021	1.2010000E-019
1.5980421E-020	-1.4112082E-021	-1.0072310E-022	1.2728394E-004	-7.0577752E-005	-1.9542594E-005
2.0628413E-020	5.0692541E-020	5.0547296E-021	-7.0577752E-005	5.2112405E-004	-1.5527131E-004
-6.2814274E-022	-3.2535398E-021	1.2010000E-019	-1.9542594E-005	-1.5527131E-004	7.0445099E-004

In-Plane Properties

E1 =	5.4064446E+004
E2 =	5.4064446E+004
G12 =	2.0706278E+004
nu12=	3.0550855E-001
eta121=	1.2838608E-016
eta122=	7.3816830E-017

Flexural Properties

E1 =	8.9893135E+004
E2 =	2.1956292E+004
G12 =	1.6242368E+004
nu12=	5.5449065E-001
eta121=	-2.7741595E-002
eta122=	-2.2041464E-001

Fig. 3

2. step 2

- Click SwiftComp->Static failure->Input failure constants. Assign failure criterion “Hashin” to the material (Fig. 4). Note that the lam is non-isotropic material. Input strength constants as shown in Fig. 5.

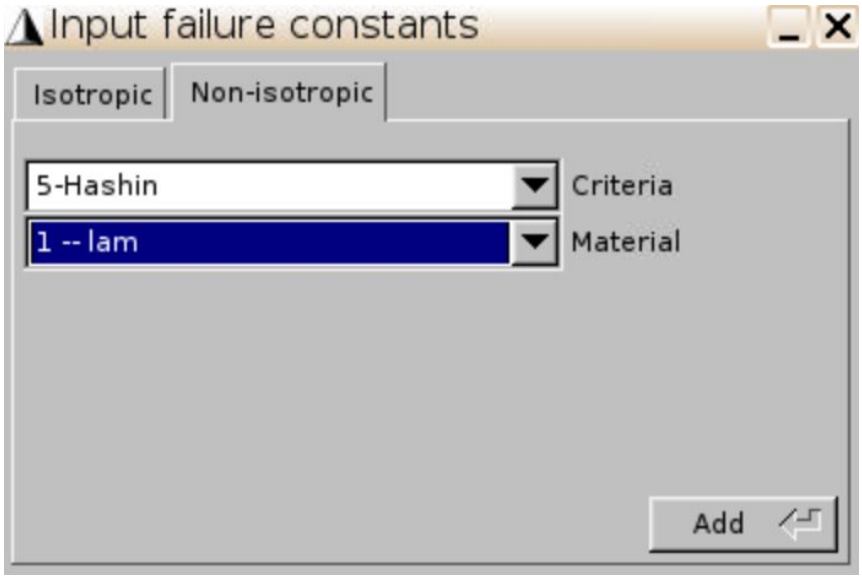


Fig. 4

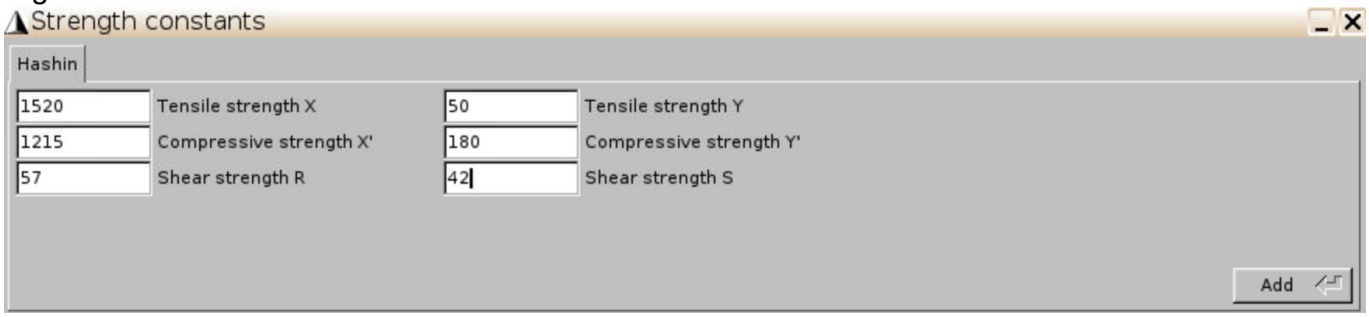


Fig. 5

- Click SwiftComp->Static failure->Failure envelope. Select “stress-based” and click add. Choose plate tag and select X axis as N11 and Y axis as N22 as shown in Fig. 6.

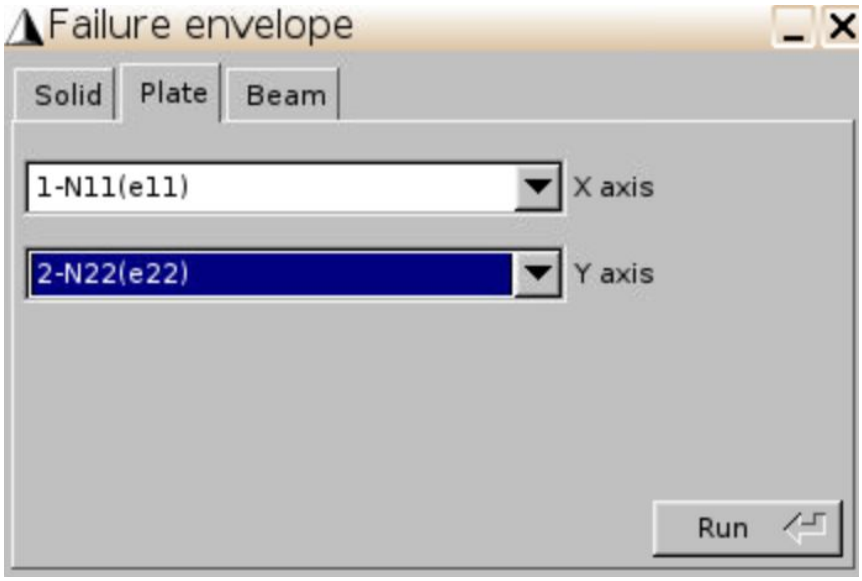


Fig. 6

* The results will automatically pop up (Fig. 7). Users can use this file to plot the failure envelope using any software (e.g., python) and the plotted failure envelope is given in Fig. 8.

1	2.9603131E+002	0.0000000E+000
2	-3.8414985E+002	0.0000000E+000
3	0.0000000E+000	2.9603131E+002
4	0.0000000E+000	-3.8414985E+002
5	3.0054693E+002	7.5136732E+001
6	-5.1437779E+002	-1.2859445E+002
7	3.0520244E+002	1.5260122E+002
8	-5.5785911E+002	-2.7892956E+002
9	3.1000446E+002	2.3250335E+002
10	-6.0937033E+002	-4.5702775E+002
11	3.1496000E+002	3.1496000E+002
12	-6.7136211E+002	-6.7136211E+002
13	2.5655733E+002	-8.3231453E+001
14	-2.8083131E+002	9.1106333E+001
15	2.1283816E+002	-1.3809646E+002
16	-2.1942127E+002	1.4236780E+002
17	1.7910612E+002	-1.7431498E+002
18	-1.7939303E+002	1.7459422E+002
19	1.5607747E+002	-2.0253647E+002
20	-1.5341711E+002	1.9908421E+002
21	-5.1437779E+002	-1.2859445E+002
22	3.0054693E+002	7.5136732E+001
23	-5.5785911E+002	-2.7892956E+002
24	3.0520244E+002	1.5260122E+002
25	-6.0937033E+002	-4.5702775E+002
26	3.1000446E+002	2.3250335E+002
27	-6.7136211E+002	-6.7136211E+002
28	3.1496000E+002	3.1496000E+002
29	-3.1590313E+002	6.0859855E+001
30	2.7703162E+002	-5.3371120E+001
31	-2.6697123E+002	1.0286590E+002
32	2.4757139E+002	-9.5391007E+001
33	-2.3054393E+002	1.3324531E+002
34	2.2149970E+002	-1.2801810E+002

Fig. 7

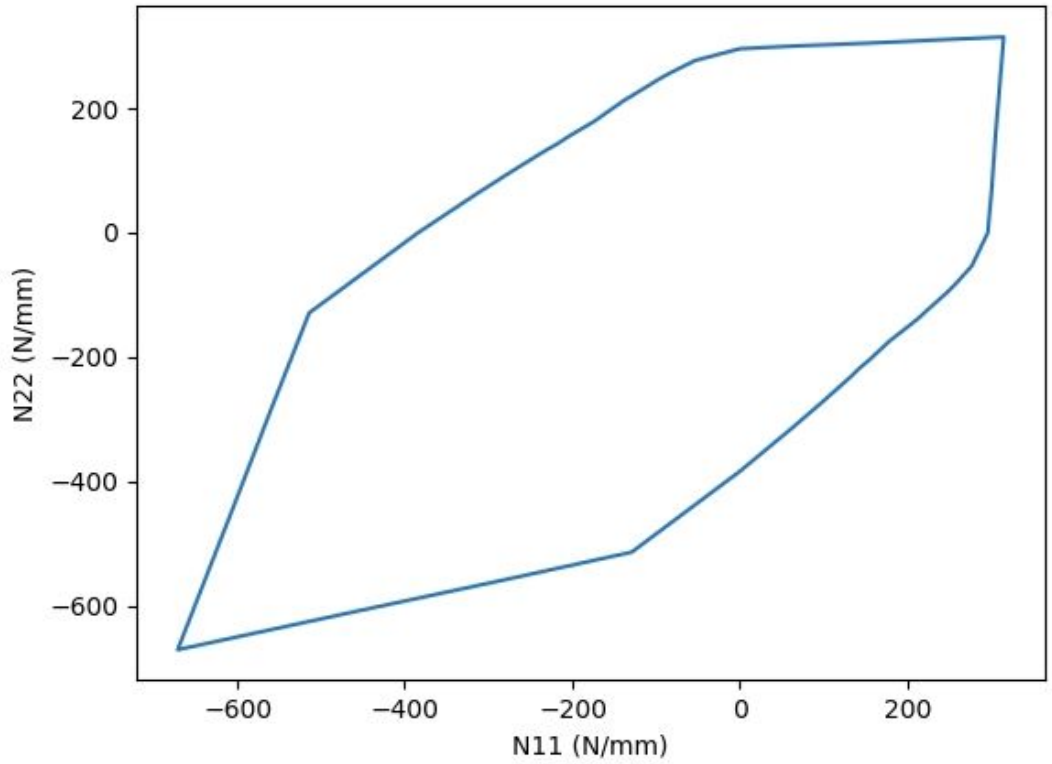


Fig. 8