

Predict effective failure strength constants of fiber-reinforced unidirectional composites

Problem Description

The effective initial failure strength constants of fiber-reinforced unidirectional composites are predicted using the MSG solid model. A square packed mechanical model is used as shown in Fig. 1. The MSG solid is used to first perform homogenization analysis to get the effective properties of this composite. Then, the MSG-based initial failure analysis is carried out for computing the effective strength constants, which can be used in the upper scale models (e.g., yarn or lamina).

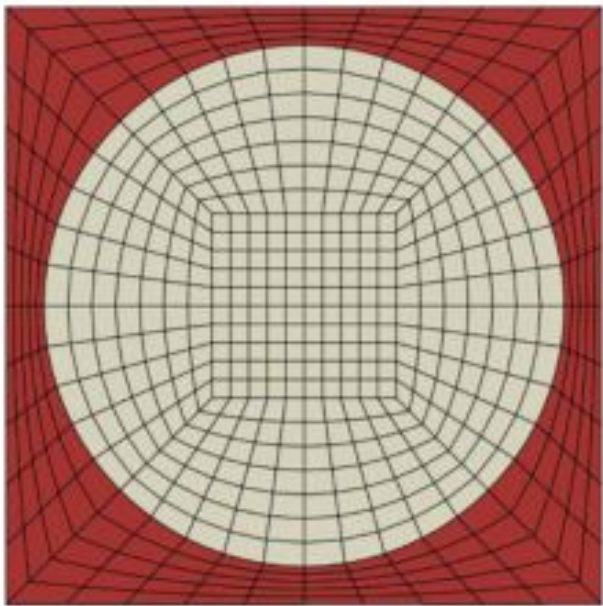


Fig. 1

The maximum stress criterion is used for both matrix and fiber. There are different built-in failure criteria in [SwiftComp](#) which can be found in the [SwiftComp](#) user manual. In addition, advanced users can also code user-defined failure criterion with the [SwiftComp](#) executable file. In this example, the fiber is usually assumed to fail only in the fiber direction and the transverse strength constants of the fiber is usually not available. Moreover, the failure in the transverse direction of the composite is dominated by the matrix. Therefore, fictitious fiber strength constants in the transverse directions are used to ensure the failure only occurs in the fiber direction.

The elastic and strength constants of fiber and matrix is given in Fig. 2. The detailed information can be found in the Ref 1.

| Material | E_1 (MPa) | E_2 (MPa) | G_{12} (MPa) | G_{23} (MPa) | ν_{12} | X (MPa) | X' (MPa) |
|----------|-------------|-------------|----------------|----------------|------------|-----------|------------|
| Fiber | 230,000 | 15,000 | 15,000 | 7000 | 0.20 | 2500 | 2000 |
| Matrix | 4200 | 4200 | 1567 | 1567 | 0.34 | 69 | 250 |

Fig. 2

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 matrix and fiber properties as shown in Fig. 3 and Fig. 4.

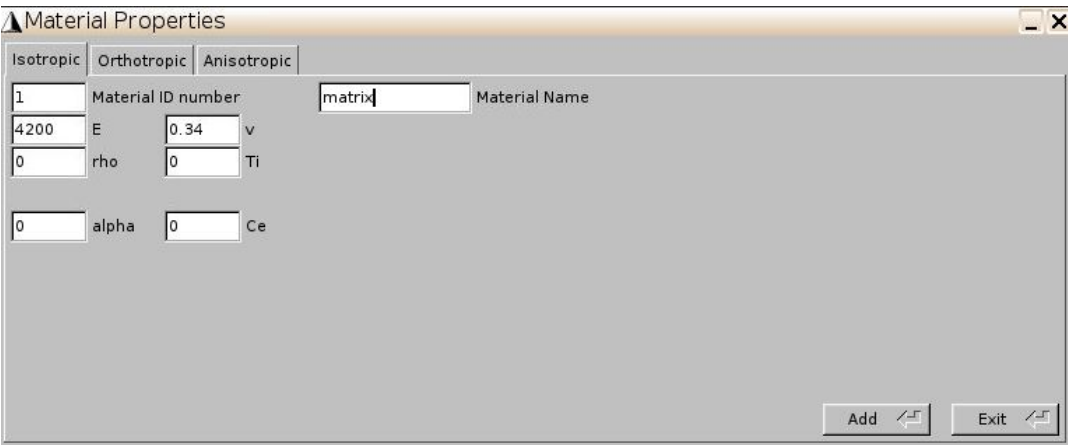


Fig. 3

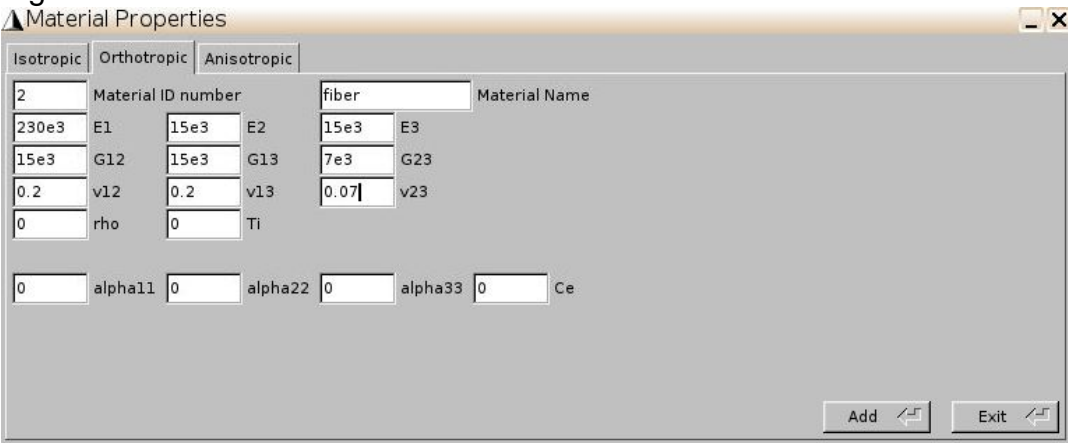


Fig. 4

- Click Geometry->Common SG-> 2D SG->Other 2D SGs. Select Square Pack Microstructure and the corresponding fiber and matrix materials as shown in Fig. 5. In this example, the fiber volume fraction is assumed to be 0.6.

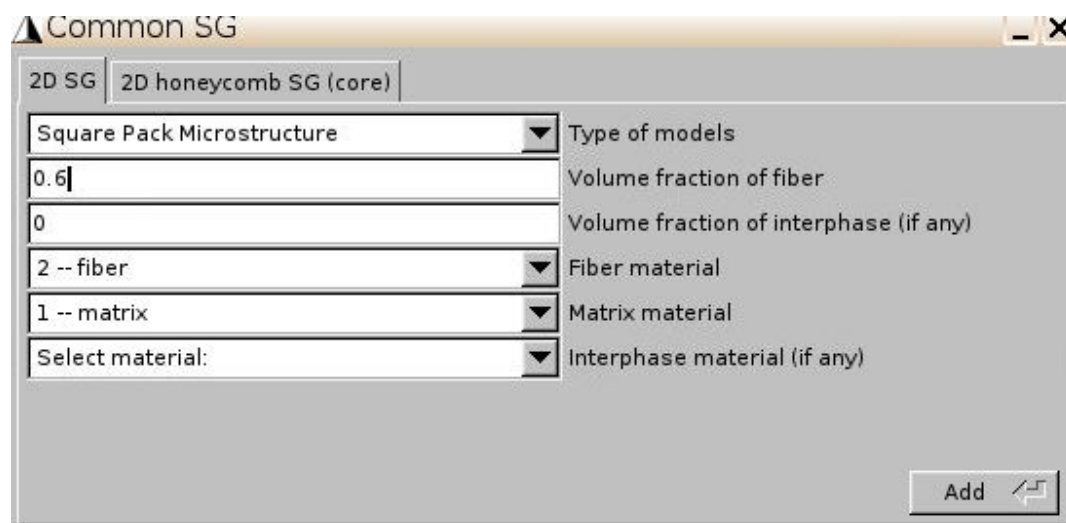


Fig. 5

* Click Mesh->Generate 2D mesh->Generate (Fig. 6.).

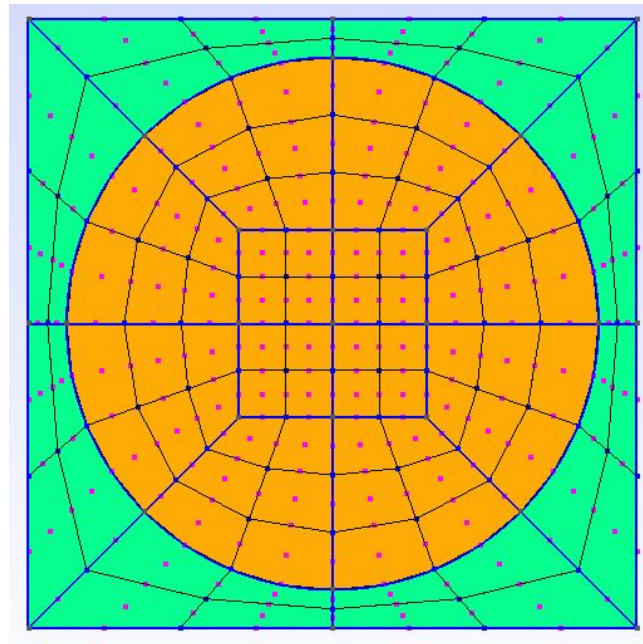
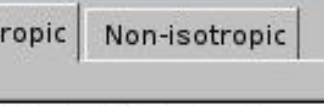



Fig. 6

* Click [SwiftComp](#)->Homogenization->Solid model. Keep the default parameters and click save and run. The homogenization results will automatically pop up (Fig. 7.).

2. step 2

- 
- Input failure constants
- Isotropic | Non-isotropic
- 1-Max principal stress Criteria
- 1 -- matrix Material
- Add



Strength constants

Max principal stress

69 Tensile strength 250 Compressive strength

Add

Fig. 9

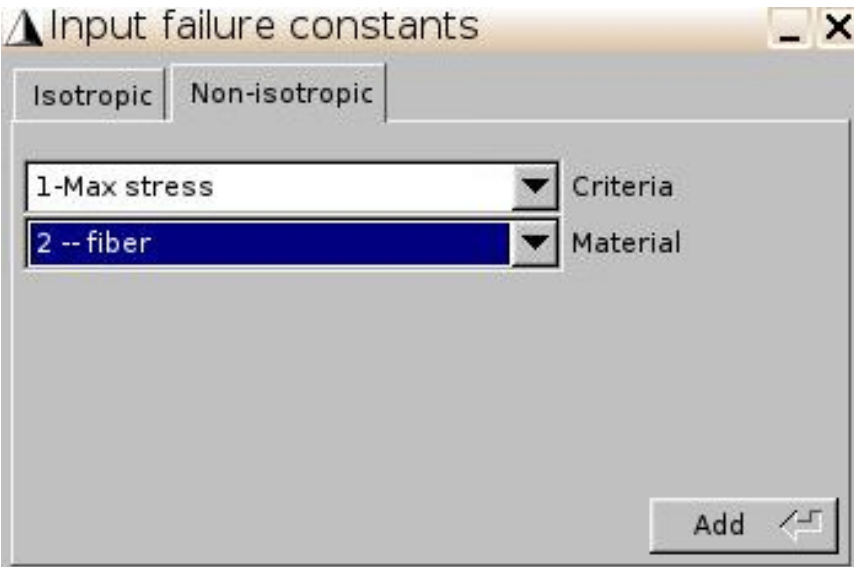


Fig. 10

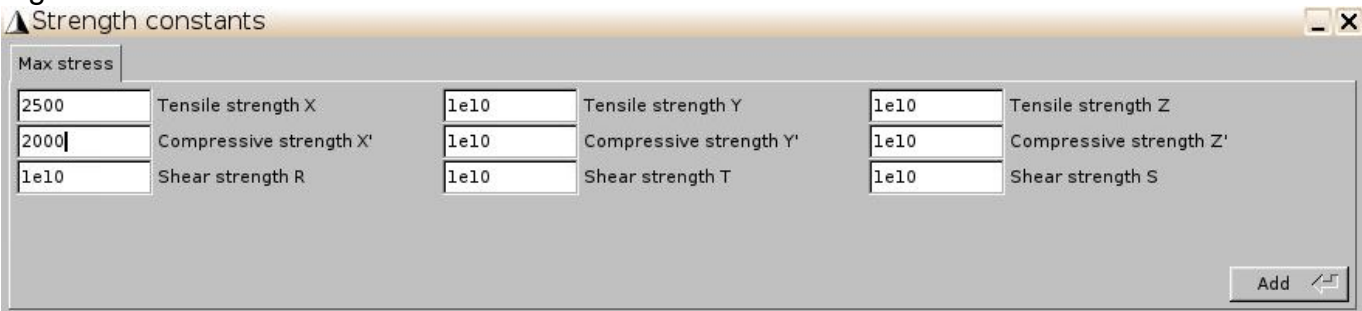


Fig. 11

- Click Effective strength constants and select stress-based failure criterion. Click run. The effective failure strength constants for this fiber-reinforced unidirectional composite is obtained as shown in Fig. 12.

| Initial Failure Strengths: Positive Negative | |
|--|----------------|
| ----- | |
| 1.5188224E+003 | 1.2150579E+003 |
| 5.2647021E+001 | 1.9075007E+002 |
| 5.2647021E+001 | 1.9075007E+002 |
| 6.1353391E+001 | 6.1353391E+001 |
| 4.8869771E+001 | 4.8869771E+001 |
| 4.8869771E+001 | 4.8869771E+001 |

Fig. 12

References

1. Liu, X., Gasco, F., Goodsell, J. and Yu, W., 2019. Initial failure strength prediction of woven composites using a new yarn failure criterion constructed by deep learning. *Composite Structures*, 230, p.111505.