TECHNISCHE UNIVERSITÄT
CHEMNITZ

Mechanical Engineering
Institute of Lightweight Structures
Department of Lightweight Structures
and Polymer Technology

Task for Project Work

Course of studies:	Merge Technologies for Resource Efficiency
Name, first name:	N.N.
Matriculation No.:	12345
Supervisor:	Dr.-Ing. Sascha Müller Dr.-Ing. Mario Naumann
Topic:	**Derivation of Effective Anisotropic Material Cards for Carbon Fiber Reinforced Plastics with Non-Circular Cross-Sections using Micromechanical Homogenization**

The project work is to be done as individual work in English or German.

Issue date:	00.00.2025
Duty date:	00.00.2025
Day of submission:	

Prof. Dr.-Ing. habil. Prof. h.c. Dr. h.c. Prof. L. Kroll
Supervising university lecturer

Explanation to the content of the task

For the efficient simulation of composite components on a macroscopic level, homogenized material properties are required that accurately represent the behavior of the heterogeneous microstructure. While composites with circular fibers are transversely isotropic in the laminate plane, non-circular fiber shapes lead to fully anisotropic behavior. This behavior must be captured in the material cards for an accurate component simulation.

In this work, effective engineering constants for composites with various fiber shapes will be determined using numerical homogenization based on representative volume elements (RVEs) in ANSYS Mechanical.

1. Research on the state of the art

- Research on homogenization theories for heterogeneous materials (e.g., rule of mixtures, RVE-based approaches).
- Study of the numerical determination of effective material properties using FEM.
- Identification of mechanical properties for typical carbon fibers and epoxy matrix systems.
- Research on the influence of fiber arrangement and shape on transverse isotropy.

2. Integration into the FEM program ANSYS

- Familiarization with ANSYS Workbench and ANSYS Mechanical.
- Parametric model generation of RVEs with different fiber shapes (circular, polygonal, lobular).
- Implementation of periodic boundary conditions (PBCs) to simulate representative load cases.

3. Numerical investigations using finite element analysis

- Performing simulations under defined uniaxial and pure shear loading conditions on the RVE.
- Application of homogenization theory to calculate the volume-averaged stresses and strains.
- Derivation of the components of the full elasticity tensor (C_{ij}) and the engineering constants (E, G, v).

4. Parameter studies

- Systematic investigation of the influence of the fiber cross-sectional shape and the fiber volume fraction on the effective material properties.
- Quantification of the degree of anisotropy in the transverse plane (comparison of E_2 and E_3).
- Creation of final, complete material cards for the investigated configurations for use in macroscopic simulations.
- Comparison of the numerically determined properties with analytical models (e.g., rule of mixtures) and evaluation of the deviations.

The task can be extended or shortened during working. The guidelines for the preparation of scientific work shall be taken into account. Discussions with other institutions and persons require the approval of the supervisors.