ALTAIR STUDENT WEBINAR SERIES – DESIGN COMPOSITE STRUCTURES WITH SIMULATION

Marius Müller / Altair Ambassador / September 24, 2021

Speakers profile

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Altair Student Webinar Series 2021

Speaker Profile

- **Bachelor's degree** in Mechanical Engineering from Graz University of Technology
- **Altair Ambassador** since October 2018
- FEA-Consultant of **TU Graz Racing Team**
- Former team principal of **TERA TU Graz**
- Part time **Project Collaborator** (FEA Engineer) at Institute of Materials Science, Joining and Forming, Working group Tools & Forming
  Graz University of Technology
- Part time **FEA Engineer** at **PJ Messtechnik GmbH**
  (https://pjm.co.at/en/; https://at.linkedin.com/company/pjm)

Marius Müller
Altair Ambassador

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Agenda

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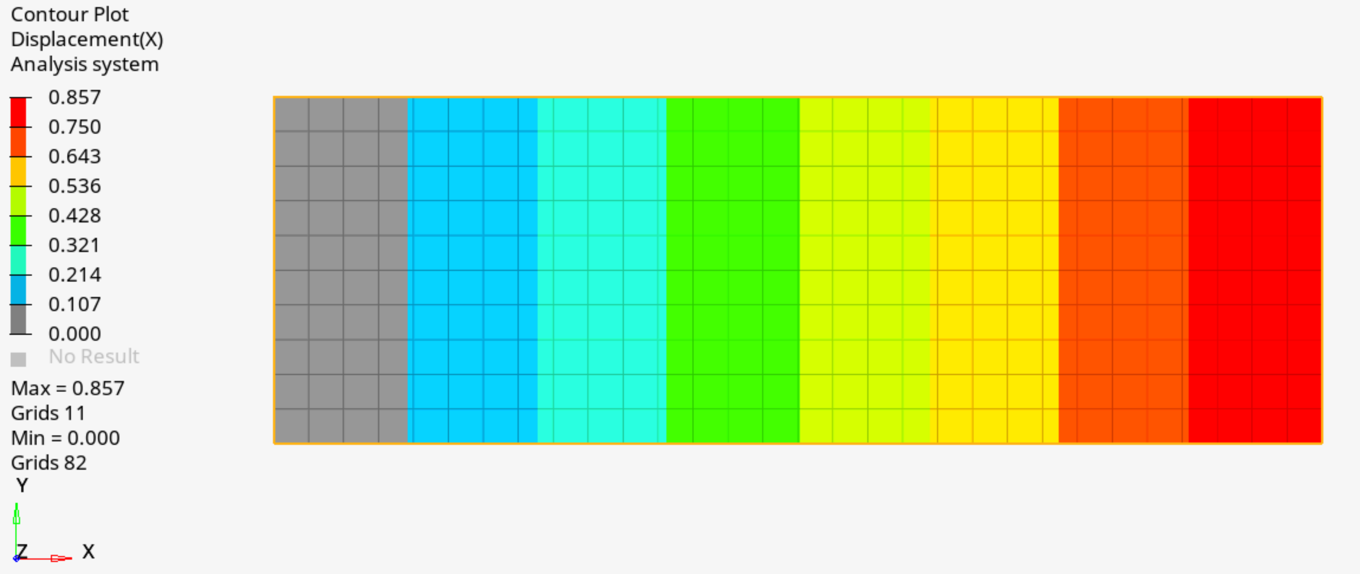
Altair Student Webinar series – Structural Simulation and Optimisation

- 2D Meshing
- Composites
- What is Optimisation?
- Composite optimisation

2D Meshing

2D Meshing

Tensile Test



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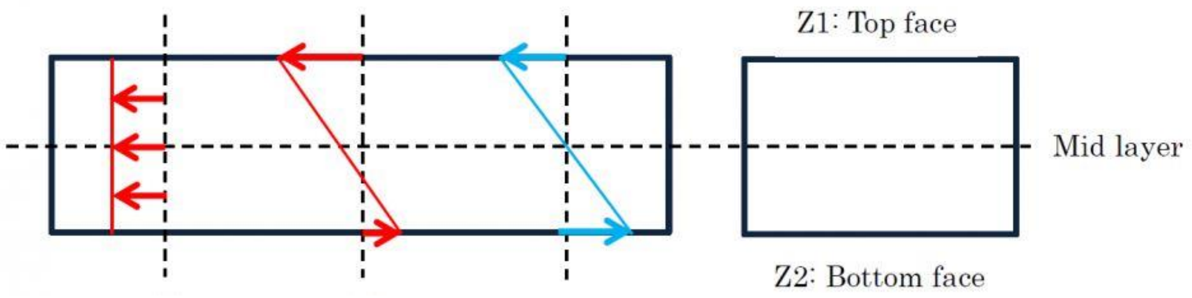
2D Meshing

Element Normal Direction

- Essential for load definition and post-processing of shell elements.
- Plays an important role in the definition of laminates, since the element normal direction defines the stacking direction in OptiStruct™.



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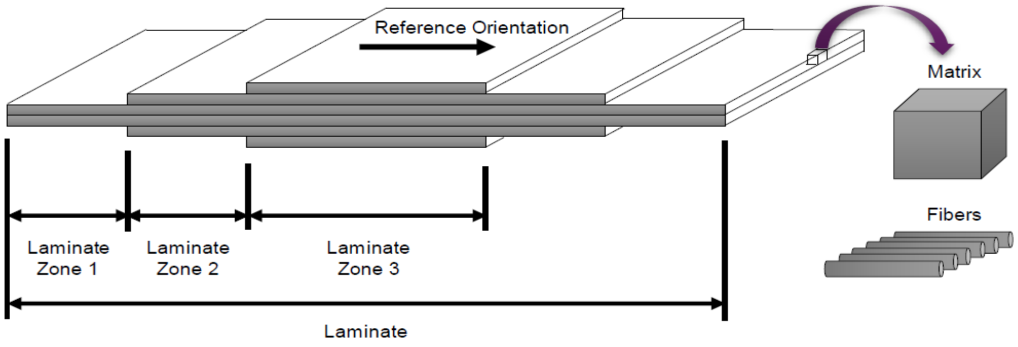
Composites

Composites

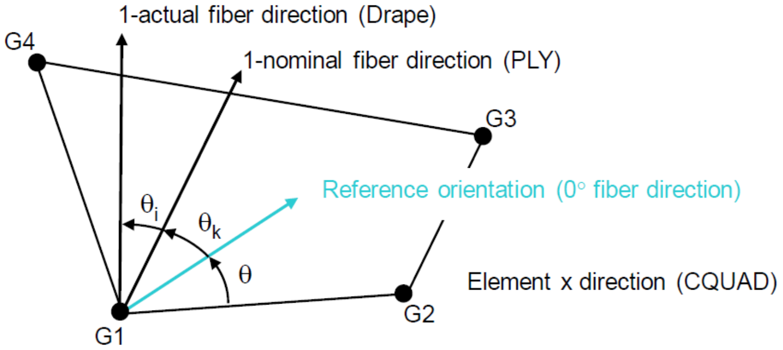
Overview

- Plies:
  Are made up of two or more constituents, typically fibre and matrix.
- Laminate:
  Are made by stacking plies in a given sequence (stack).
- Reference orientation:
  Define the common orientation fibre directions in a laminate rotate from.



Composites

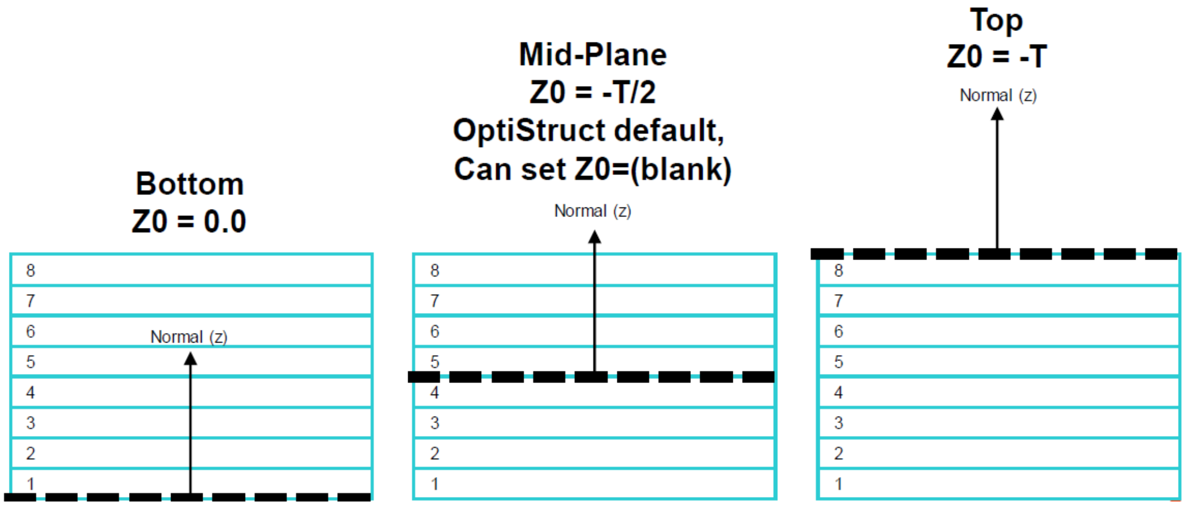
Material Reference and Ply Orientation



- Reference orientation:
  Rotation from the element x-axis at each element or the x-axis of a local system (material reference orientation).
- 1-nominal fibre direction (PLY):
  Orientation defined on a ply reference orientation:
- 1-nominal fibre direction (Drape):
  Typically from draping simulation; applies an additional rotation on the ply orientation.

Composites

Offset Options



What is Optimisation?

What is Optimisation?

Definition

- An optimisation is an act, process, or methodology of making something as fully perfect, functional or effective as possible
- The general optimisation problem can be defined as:

$$\text{Minimise f}(X) = f\,(X_1\,, X_2, X_3, \dots, X_n)$$

Subject to:

$$g_j(X) \leq 0.0 \qquad\qquad j = 1, \dots, m$$

$$X_i^L \leq X_i \leq X_i^U \qquad\qquad i = 1, \dots, m$$

- In this case, f(X) is the objective function to be minimised, and g_j(X) are the constraint functions that must be satisfied. Both are functions of the design variables X_i, which can have lower and upper bound limits. There are m constraints and n design variables for any optimisation problem. Exactly one response must be the objective function; all other responses can be constraint functions.

What is Optimisation?

Classical approach:

- Creation and analysis of a design
- Interpretation of the analysis
- Updates for a new design
- Again analysis
- Proving that the updates are satisfying

What is Optimisation?

An Approach with OptiStruct TM

- Creation of a finite element model
- Definition of design variables, objectives and constraints
- OptiStructTM automatically evaluates the analysis results, defines updates for a new improved design, and finally returns to the analysis

- **Design variables:** Values that can be changed in a model; e.g. the thickness of a plate (free-size optimisation) or element density threshold (topology optimisation)
- **Responses:** Values that can be measured from a model; e.g. normal strain
- **Constraints:** Limits on the responses which must be satisfied for a feasible design; e.g. normal strain must not be greater than 1.5 percent
- **Objective:** A single response of the model which is to be minimised or maximised; e.g. mass should be minimised, or compliance should be minimised

Composite Optimisation

What is Optimisation?

Overview

- **Composite Free-Size Optimisation:**
  What ply shapes, for each ply layer, would build the most efficient composite part?

- **Composite Size Optimisation:**
  How many plies of each ply shape are required to satisfy strength and manufacturing engineering requirements?

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