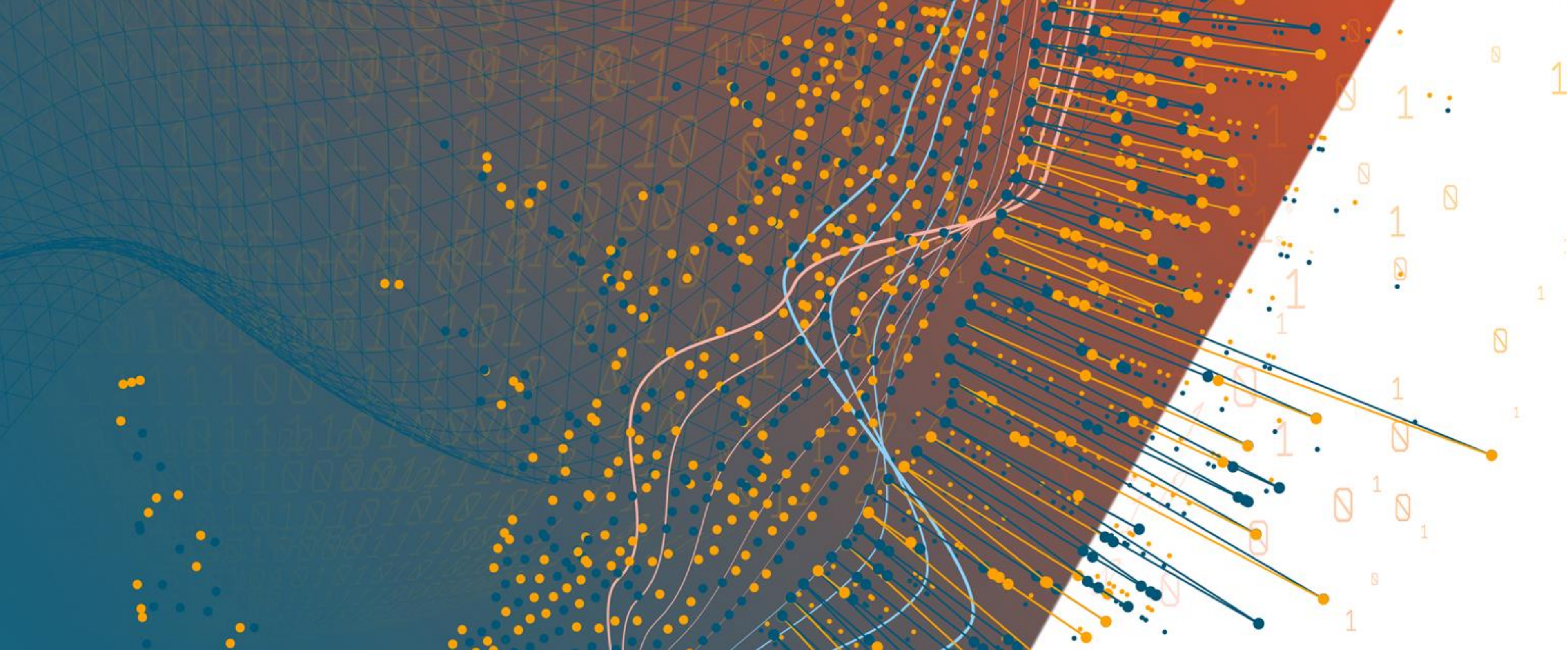

ALTAIR STUDENT WEBINAR SERIES – STRUCTURAL SIMULATION AND OPTIMISATION

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Marius Müller / Altair Ambassador / September 23, 2021

Speakers profile

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**
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Marius Müller
Altair Ambassador

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Agenda

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Altair Student Webinar series – Structural Simulation and Optimisation

- 3D Meshing
- What is Optimisation?
- 3D Topology Optimisation

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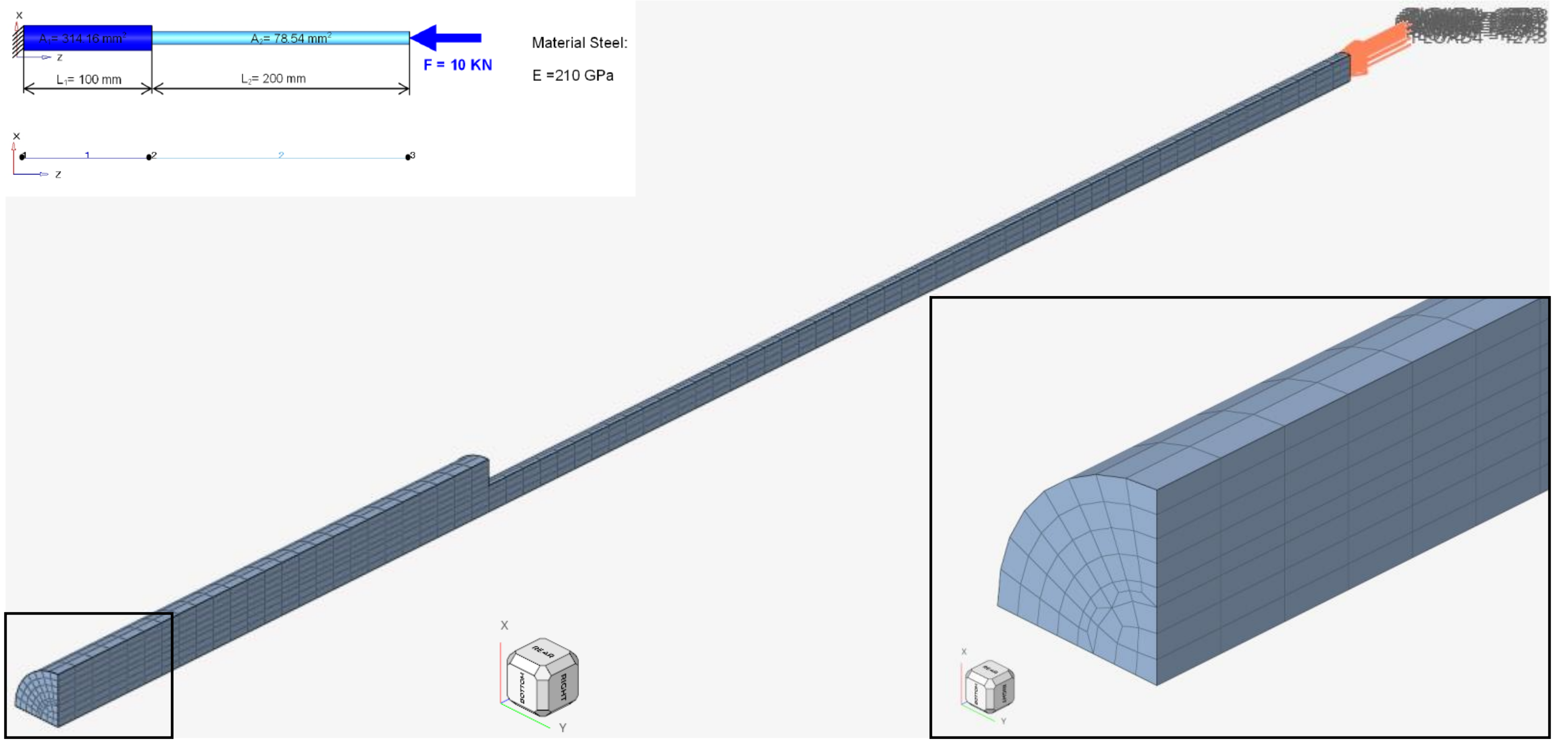
3D Meshing

3D Meshing

Shaft Under Axial Load



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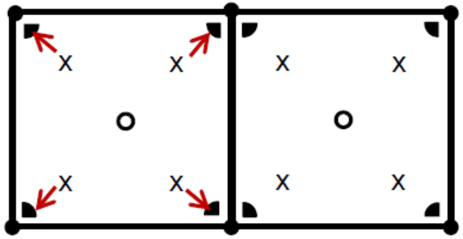
3D Meshing

Stress Evaluation: Extrapolation to Nodes

- Stresses are always numerically calculated at the integration points (IP).
- In OptiStructTM by default, element stresses for shell and solid elements are output at the element centroid only. Stress output at nodes is an extrapolation, the most simple option to achieve this is bilinear extrapolation



x Integration Points (IP)

o Centroid

● Element nodes

◢ "Corner data" = nodal results (participation of element to a node)

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:

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

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

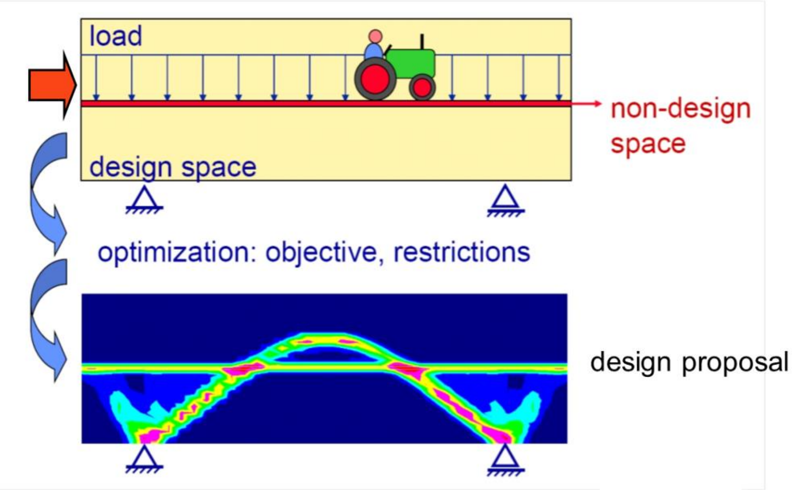
- **Design variables:** Values that can be changed in a model; e.g. the thickness of a plate (free-size optimisation) or element density threshold (topology optimisation)
- **Responses:** Values that can be measured from a model; e.g. normal strain
- **Constraints:** Limits on the responses which must 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

3D Topology Optimisation

Topology Optimisation

Overview

- Topology optimisation is a mathematical method that optimises material layout within a given design space.
- Example: Structurally supporting a bridge span



Topology Optimisation

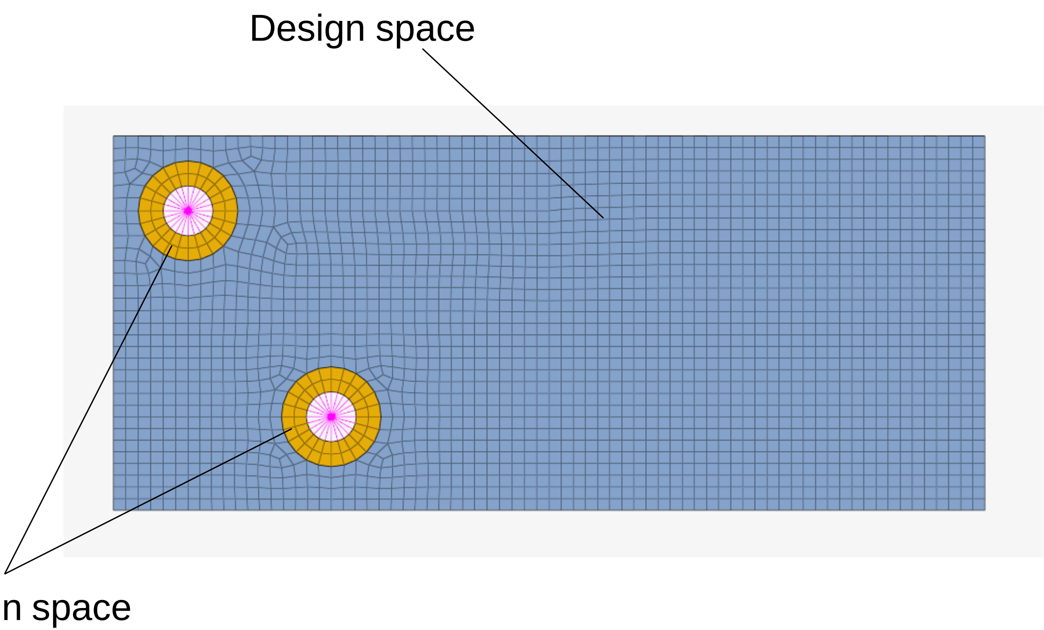
Design Variables

- OptiStruct™ solves topological optimisation problems using the density method, also known as the SIMP method (Solid Isotropic Material with Penalisation)
    - The density of each element is directly used as the design variable.
    - The density varies continuously between 0 (void) and 1 (solid).
    - For displaying results with HyperView™, all elements with a density below a certain value will be removed, i.e. they are considered void. The plotted elements will be considered solid.

Topology Optimisation

Example: Motorbike Brake Handle

https://www.bikebandit.com/aftermarket-parts/control-brakes/levers-shifters/parts-unlimited-replacement-power-motorcycle-clutch-lever/p/24914



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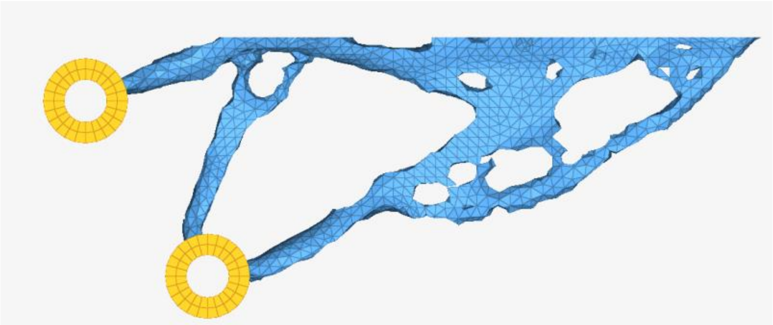
Topology Optimisation



Example: Motorbike Brake Handle – 2nd Optimisation

- Design variables:
  - Add Maxdim 5.0.
- Responses:
  - Delete existing responses and create a static stress and mass response.
- Constraints:
  - Delete existing constrains and create a static stress constraint and set upper limit to 100 MPa.
- Objective:
  - Delete existing objective and create an objective to minimise mass.

THANK YOU

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