AMC TRR277

C01

Bridging Scales – From Geometric Part Details to Construction Elements

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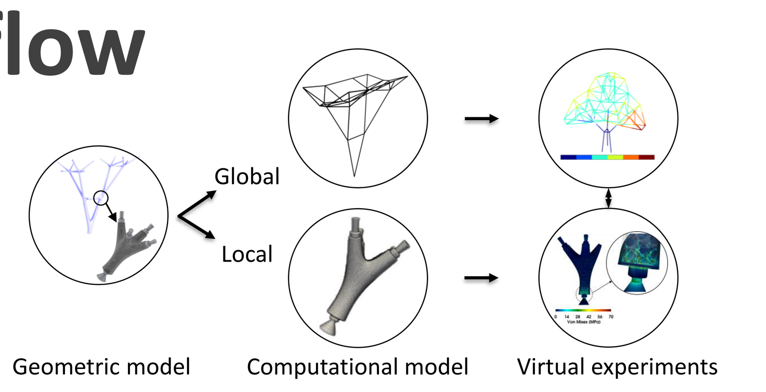
Project summary

This project formulated a consistent description for the relevant geometric models by utilizing V-models and procedural geometric modeling. Additionally, a global-local-global analysis workflow was investigated across scales. The seamless integration allows for numerical analysis of virtual experiments for AM products in construction based on as-designed and as-built models.

Workflow



Main outcomes of 1st funding period

Bridging scales
- A methodology to take all relevant scales into account was investigated.
- The interplay of scales was enabled by extending the finite cell method.

Validation using virtual experiments
- The finite cell method was extended to V- and fabrication information models.
- New numerical techniques for a precise evaluation of fluxes were developed.
- The methodology was validated with numerous mineral- as well as metal-based components.

Comparison of as-designed vs. as-built structures
- Methodology to compute on as-built geometries was further developed.
- The significance of as-built vs. as-designed

Key collaborations in 1st funding period

A03 C03 — on the validation of virtual experiments for mineral-based components

C02 — on integrating global and local analysis of structures

C04 — on a seamless workflow from a fabrication information model to a numerical analysis model

A06 A07 — on the validation of virtual experiments for steel-based components

Project status

Global-local-global analysis
A framework was developed in which local features can be integrated into a global analysis.

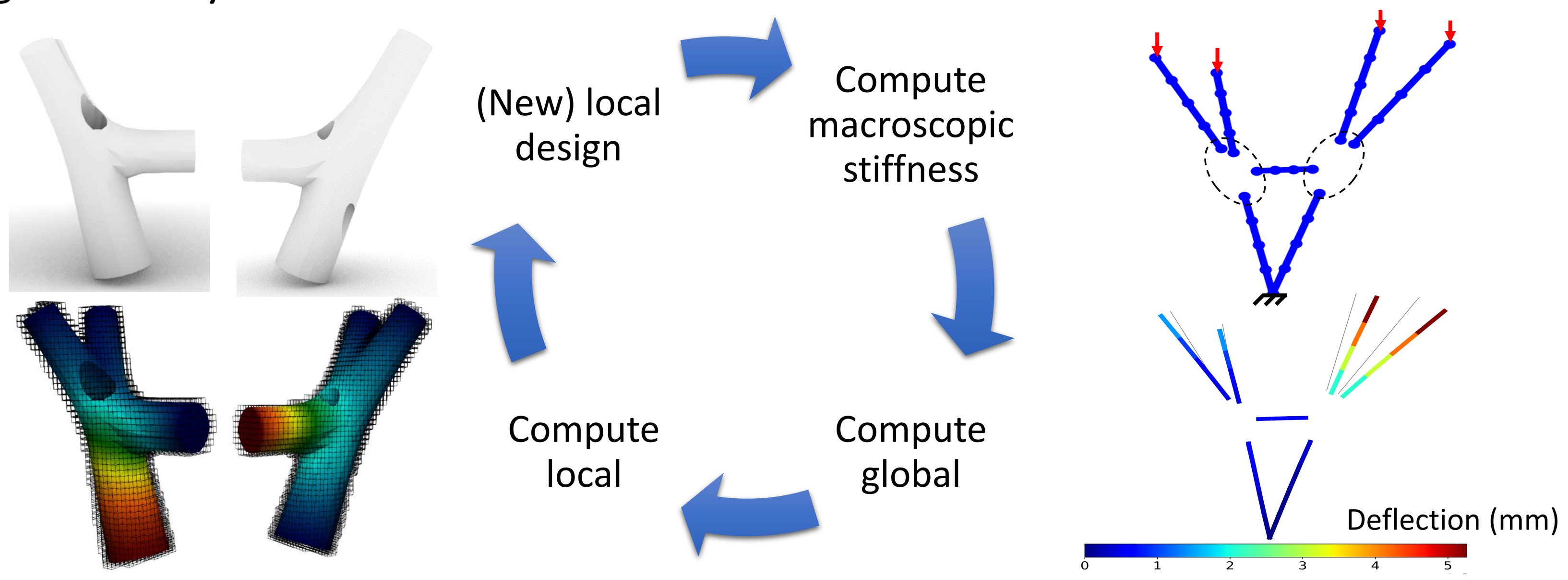


Fig 1: Integrating local and global analysis

Geometric models
The extension of the finite cell method to V-models and procedural models incorporates detailed volumetric information to enhance its applicability.

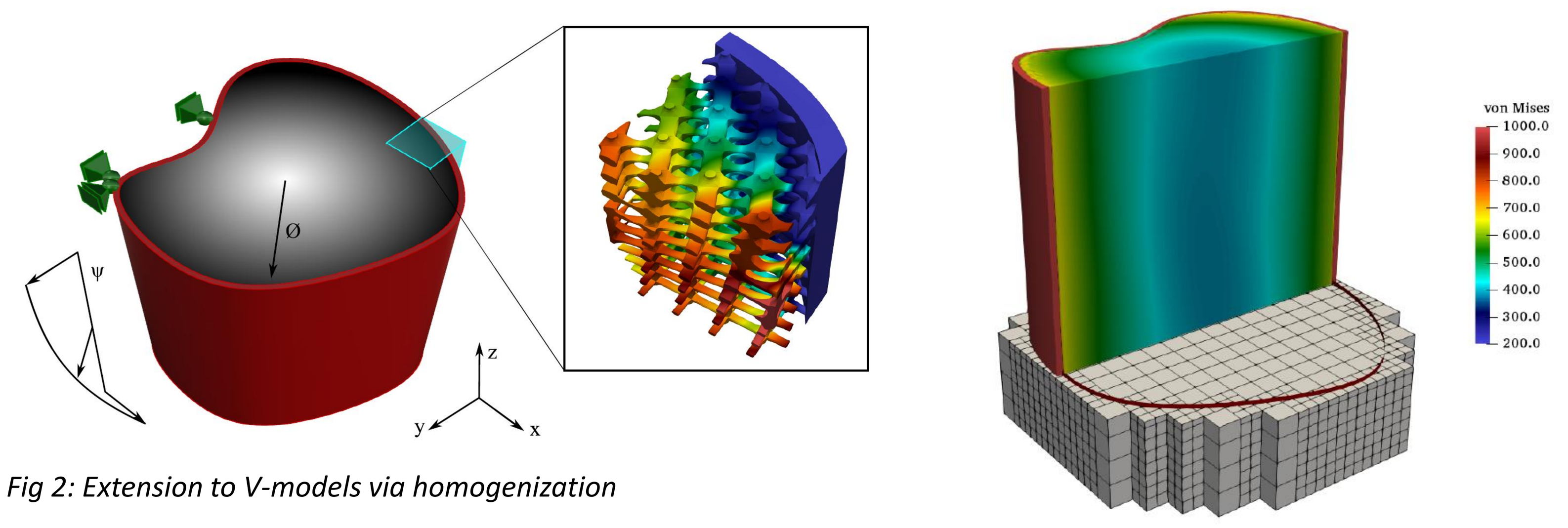


Fig 2: Extension to V-models via homogenization

A direct transition from a Fabrication Information Model (FIM) to a computational model was achieved.

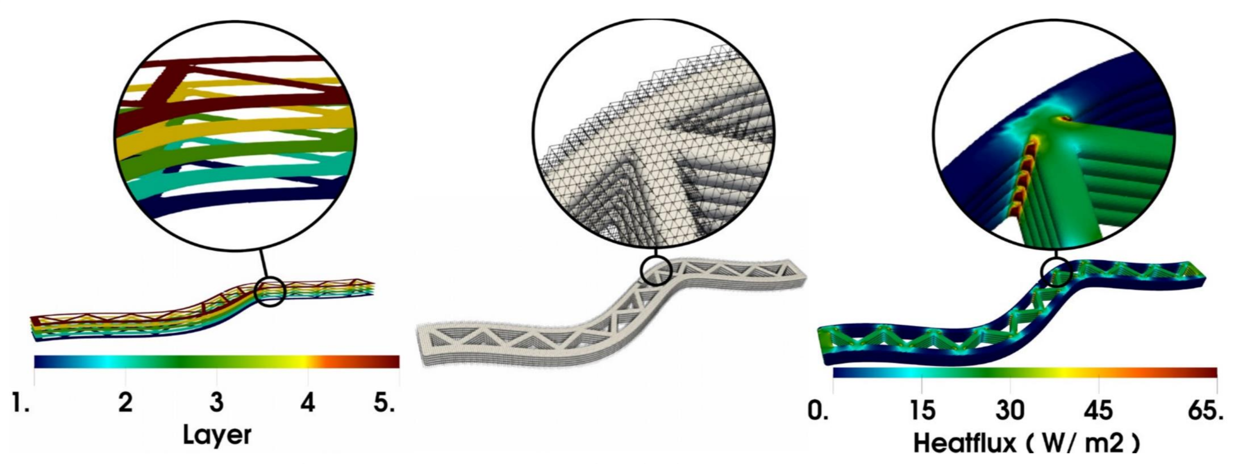


Fig 3: Models and workflow a) the print-path model (left) b) computational grid around the generated volumetric model (middle) c) heatflux shown for numerical analysis model

Virtual experiments
It was demonstrated, that the virtual experiments deliver accurate results, as validated by physical experiments. To this end, new numerical techniques were required to recover precise fluxes where Dirichlet boundary conditions are applied.

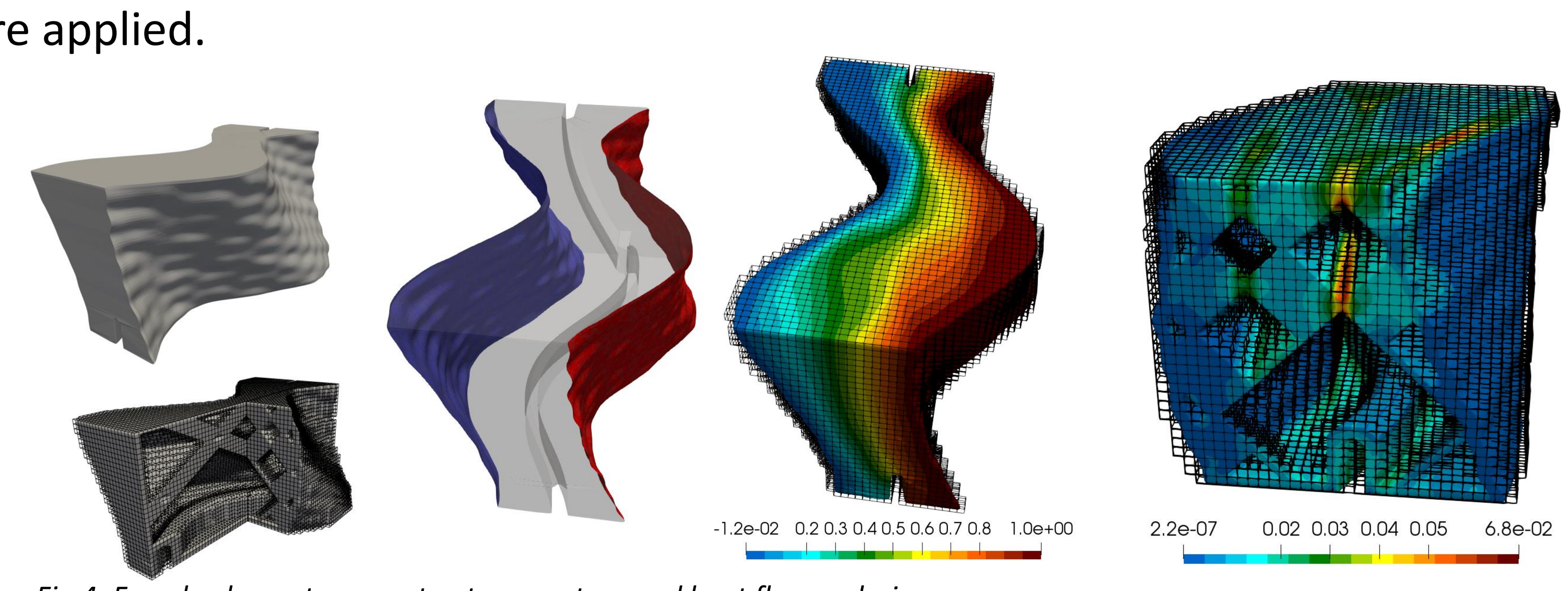


Fig 4: Façade element: geometry, temperature and heat flux analysis

Comparison of as-designed and as-built structures
It was found to be essential to compute on as-built structures.

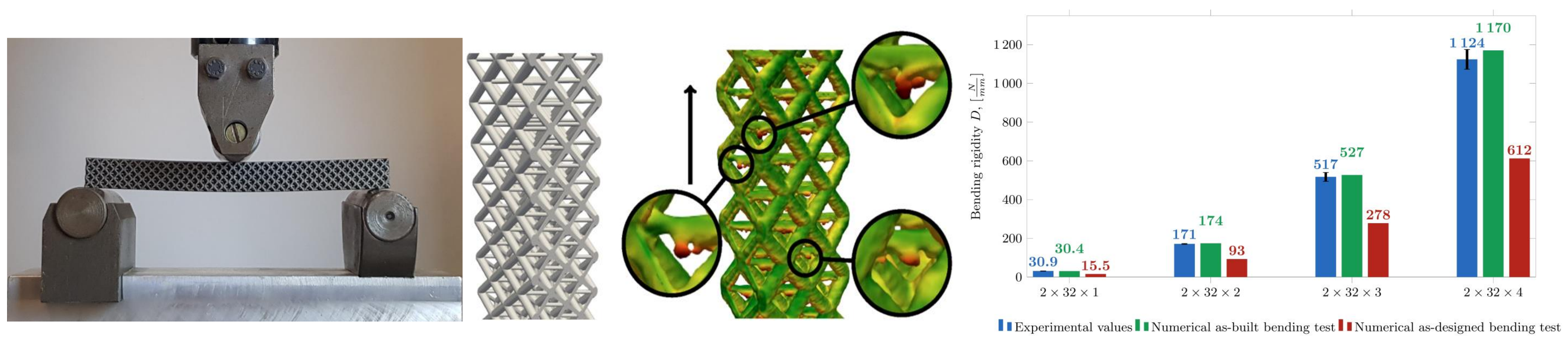


Fig 5: Bending rigidity of as-built versus as-designed octet lattice structures: experiment, geometric models, results

Large Scale Demonstrator

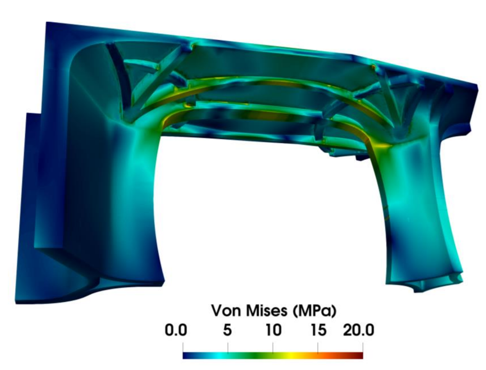


Fig 6: Linear elastic analysis on an early design Shelltonics model

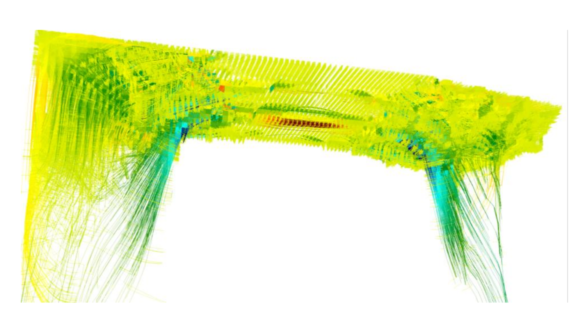


Fig 7: Principal stress trajectories of an early Shelltonics model under compressive load

Shelltonics
- 3D visualization of principal stress lines
- Support A04 with the placement of the reinforcement based on numerical analysis.

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