C01 Bridging Scales - From Geometric Part Details to Construction Elements

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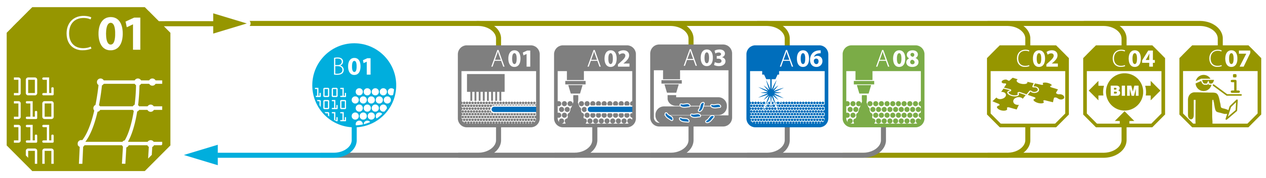
Summary



Digital models for AM involve many different geometric scales. These scales start from micrometres for metal- or concrete-based processes. AM product scales, which are in the centre of this project, characterise parts as well as entire constructions and range up to tens of metres. This project has closely connected central goals: The first one is to develop a consistent description for the relevant geometric models. The second focusses on efficient simulation methods for AM products in construction, based on the multi-scale geometric models. Finally, special emphasis is placed on validation of the developed techniques.

Research Questions

The geometric freedom offered by Additive Manufacturing in construction challenges established processes of design and analysis:

- How can different levels of geometric detail of AM in construction be described?
- How are these scales consistently considered in a structural analysis?
- How can models for individualised construction parts be efficiently integrated in a global structural analysis and design?
- How must traditional workflows be modified?
- How can innovative simulation methods support this workflow better than classical CAD-systems and Finite Element programs?

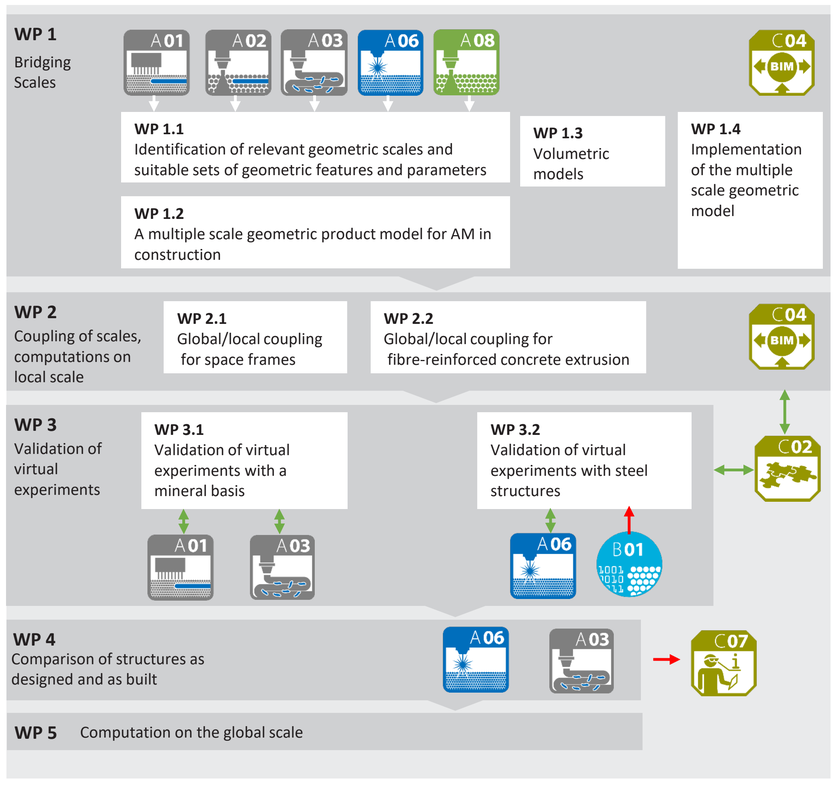
Space frame on a NURBS surface.

Three nodes, with different topology and geometry.

Methods

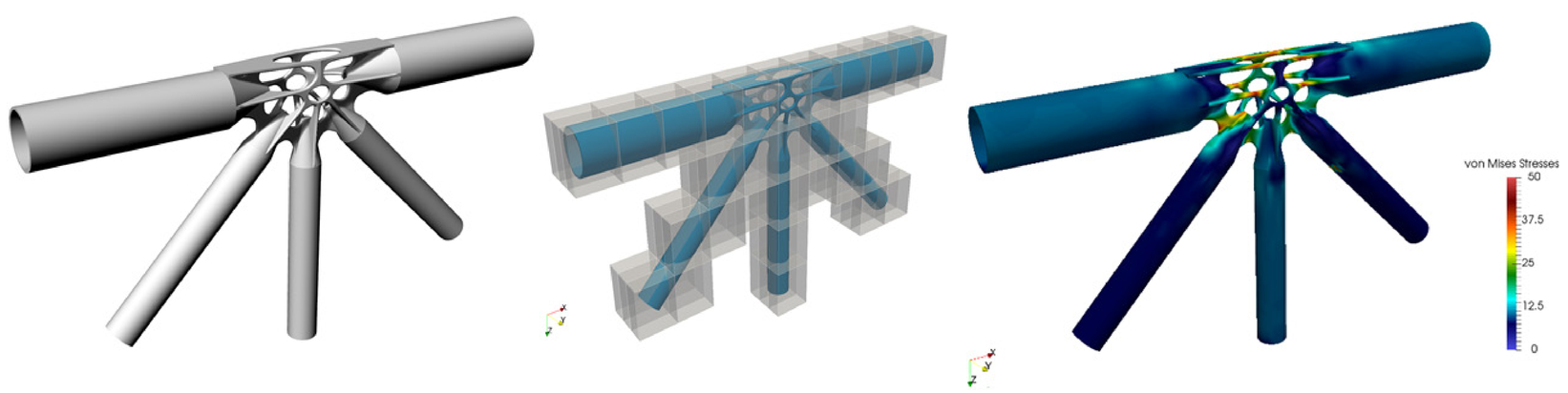
- Development of a multi-scale geometric model for AM in construction (with C04).
- Scales-bridging workflow with automated computation on part level.
- Further development of the Finite Cell Method (FCM) for efficient, robust and automated computation on part level.
- Validation of part level computations through experiments of A-projects.
- System integration with global-scale computations.

Concrete extrusion example made by the Chair of Timber Structures and Building Construction at TUM (A03).



Preliminary Work

- Long experience in seamless integration of geometric design and numerical analysis.
- Introduction of the FCM (Ernst Rank et al., 2007) initiated broad worldwide research on immersed boundary methods.
- Intense collaboration with NIST and other leading institutions on verification and validation of numerical simulation for SLM processes (Stefan Kollmannsberger).



Left: Geometric Model.
Centre: FCM model submerged into a non-boundary-conforming computational grid.
Right: Computation of corresponding Von Mises stresses using the FCM model.