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Automatic web-based numerical modelling of shield tunnelling

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ABSTRACT

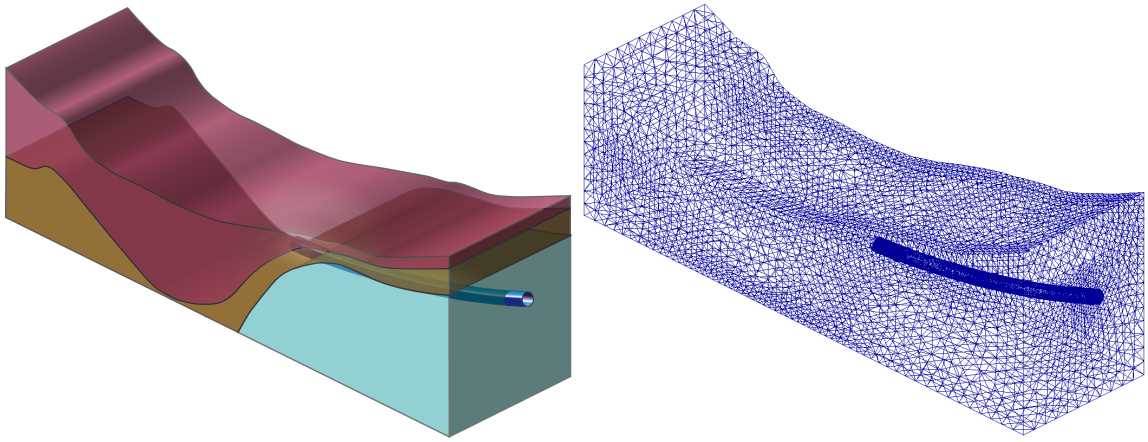
In this contribution an automatic model generator for numerical simulations in shield tunnelling is presented. It covers the complete workflow starting from an existing geological model and tunnel specifications to a ready-to-use Finite Element model for the simulation. This includes the generation of the ground and tunnel topology, the modelling of support measures, the modelling of the shield machine and the application of boundary conditions.

Numerical simulation of the excavation of shield driven tunnels is characterised by a high degree of complexity and requires efficient and highly sophisticated numerical techniques. It requires the consideration of all relevant components of a tunnel, such as the shield machine, the tunnel lining, the support measures, the geological conditions and the ground properties, as well as their interactions. The various stages of the excavation process have to be accounted for as well. This complexity in modelling requires a very large effort in the generation of a suitable model and its process-dependent temporal change. This effort may impose an obstacle against the use of ambitious Finite Element modelling in the design phase of a tunnelling project, in particular if a number of different design variants are to be examined.

The proposed automatic web-based modeller is part of a design support tool, developed within the European Integrated Project TUNCONSTRUCT [1], intended to guide the user through the complete design process and to store all relevant design data in a unified structure. In this context, a maximum degree of automation in the generation of numerical models is needed. In order to provide the user with maximum flexibility, the design support tool is projected in a distributed software architecture. This allows for a lightweight software client on the user's computer while numerically demanding calculations are performed by dedicated, highly performant servers. This implies the need for a web-based solution for the presented modeller.

The modeller can be invoked automatically by software agents, such as the design support tool, via web services [2]. As input, it requires a complete specification of a given design (alignment, diameter, support measures, lining specifications and machine specifications), stored in terms of a unified data model as well as a three-dimensional geological model of the tunnel site. The input specifications are retrieved on demand and processed by the modeller. Thus it is ensured, that only little data has to be transferred via networks while large amounts of data are kept where they are processed.

The workflow of the modeller covers several steps of geometrical and numerical modelling, starting from the treatment of the geological model by means of geostatistical methods [3]. The geometrical model of the tunnel is created according to its specification in a Python [4] program that creates a semantically complete geometrical description of the model. This semantic model is then processed by an external pre-processor in order to generate a Finite Element mesh. The material definitions and boundary conditions are applied to the mesh by the pre-processor. An example for an automatically generated Finite Element model of a tunnel is shown in Figure 1.



(a) Topology (b) Mesh

Figure 1: Automatically generated model of a tunnel: a) geometrical model; b) Finite Element mesh

The contribution gives an overview of the modeller and its workflow and will present in detail the geometrical modelling of the ground and the tunnel. Special focus is put on the web interface of the modeller, which allows for a seamless integration in the client software. Thus it combines the computational power of a large multi-processor server with the convenience of a local client software.

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