DFG Collaborative Research Centre SFB 837 "Interaction Modeling in Mechanized Tunneling" at Ruhr University Bochum

Mechanized tunneling is an established flexible and efficient technology for the construction of underground infrastructure. It is characterized by a dynamic advancement of tunnel boring technologies, increasing TBM diameters and a broadening range of applicability. This rapid development in association with the inherent heterogeneity of the underground and the uncertainty of ground parameters, poses new challenges to reliable prognosis models. Such models are indispensable for the limitation of tunneling risks in the design and construction phases, particularly for difficult conditions in terms of geology or tunneling have to be considered.
Considering this background, the subject of the new Collaborative Research Centre SFB 837 "Interaction models for mechanized tunneling" installed at the Ruhr University Bochum is the research and development of models, methods and design concepts, which, when adequately interlinked, can deal with the manifold complex interactions of the components (ground, shield machine, support measures, tunnel lining, existing buildings) and processes (advancing and excavation process, construction operation) involved in mechanical tunneling. This research centre was set up by a decision of the German Research Foundation (DFG) on 18 May 2010 and will start at 1 July 2010. Collaborative Research Centres (SFBs) are scientific competence centres where cooperative research, often in an interdisciplinary context, is supported by the DFG for periods of up to twelve years. The SFBs are evaluated every four years by a 10- to 15-person expert committee.

Objectives and research perspectives of the Collaborative Research Centre

The objective of the SFB 837 is the determination of the essential interactions between the tunnel excavation, the ground, the tunnel lining and existing structures through scientifically secured computational models and methods as well as laboratory tests. The individual partial objectives of the research project, for which four project areas have been set up (Fig. 1), are:

- To increase the reliability of the interpretation of advance investigation measures, and determine the ground properties and face stability by means of new methods and models (Project section A),
- Model-based concepts for tunnel linings and the support of the annular gap (Project section B),
- Holistic and realistic computational simulation of the excavation and tunneling processes for various geotechnical and machine-related constraints (Project section C),
- Modelling of the risk of damage to existing buildings and ensuring of the interoperability of all partial models through a consistent integration level (Project section D).

The developed computer models are highly interlinked so that, in addition to supporting the design work for a tunnel project, they will also permit real-time forecasts during construction and allow for a continuous support of the shield supported excavation process. The provision of efficient design and tunneling strategies in mechanized tunneling, and, particularly, to comply with the high quality requirements placed on the construction process and the tunnel structure, require the following:

- Realistic modelling and the integration of all relevant system components (ground, advance, lining, surroundings) for various design variants including the multitude of interactions during the tunneling process, considering variable geological conditions,
- measurements and advance investigations during tunneling and
- continuous updating of the computational models and partial models, respectively, to take into account the local conditions and constraints as they become known during tunneling.

In the SFB 837, all the essential components of mechanized tunneling in the planning, design, and construction phases are taken into account. Also considered are the ground including the advance investigations during tunneling, the tunnel boring machine, the tunnel lining including the grouting of the annular gap and the effects of tunneling work on existing structures. The associated processes (excavation, tunneling and logistics) are also depicted by

numerical models and integrated into an overall information management system. These computer-supported interaction models are related to the design phase and also to the construction phase, with aspects of operation and lifetime also being partially considered. The maintenance and repair of tunnel structures, however, is not directly part of the current project.

Description of the research programme

The altogether four project sections of the collaborative research project are derived from the categorisation of the tunneling process into three sections, "Ground and Tunneling Machine", "Lining and Support Materials", and "Process Modelling" and contain, with the project section D "Information Management and Risk Modelling", a linking, inter-SFB methodical element that ensures the consideration of reliability and risk models as well as the integration of all partial models into a consistent system of information management.
The SFB 873 includes in the first phase 14 sub-projects (Table 1), which are managed by 15 scientists at the Faculty of Civil and Environmental Engineering Sciences and the Faculty of Geosciences at the Ruhr University Bochum. The overall coordination of the Collaborative Research Centre is the responsibility of Prof. Günther Meschke, Head of the Chair of Structural Mechanics at the Ruhr University Bochum, who is supported by the members of the Executive Board (Prof. R. Breitenbücher, Prof. D. Hartmann, Prof. T. Schanz, Prof. M. Thewes). The available project budget for the first project phase is about 8 million €.

Prof. Dr. Günther Meschke
Coordinator SFB 837 “Interaction Modeling for Mechanized Tunneling‘‘
Institute for Structural Mechanics, Ruhr University Bochum
Universitätsstraße 150, D-44801 Bochum
www.rub.de/sfb837

Table 1. Sub-projects in the first phase of the Collaborative Research Centre SFB 837

No.	Description	Project Leaders
1	Ground investigation through the analysis of TBM data	Prof. M. Alber Prof. M. Thewes
2	Advance investigation concepts using acoustic methods	Prof. K. Hackl Prof. W. Friederich Prof. T. Nestorovic
3	Investigation of face stability	Prof. M. Thewes Prof. H. Steeb
4	Material models for the description of destructuredsoil behaviour	Prof. T. Schanz
5	Optimized structural segments for durable and robust tunnel lining systems	Prof. R. Breitenbücher Prof. P. Mark
6	Damage analyses and concepts for damage-tolerant tunnel linings	Prof. G. Meschke
7	Development of annular gap grout considering the interactions with the surrounding ground	Prof. R. Breitenbücher
8	Multi-scale infiltration models for the annular gap grout	Prof. H. Steeb
9	Process-oriented simulation models for mechanized tunneling	Prof. G. Meschke
10	System identification methods for the adaptation of numerical simulation models	Prof. T. Schanz Prof. D. Hartmann Dr. M. Baitsch
11	Model- and monitoring-based optimisation and quality assurance of the tunneling process	Prof. M. König Prof. M. Thewes
12	Simulation models for the cutterhead-ground interaction	Prof. K. Hackl Prof. G. Meschke
13	Software engineering for system integration and process interoperability	Prof. D. Hartmann Prof. M. König
14	Model-based risk analysis for heterogeneous existing structures	Prof. P. Mark