Quarterly Newsletter of the Institute of Rock Mechanics and Tunnelling

ROCK

Mechanics & Tunnelling











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Marcher's Column

Happy New Year!

With the amazing RMT-team spirit, I am now looking forward to the new challenges in 2021!

2020 was a difficult year. This particular year - marked by the pandemic - taught us one thing above all: how important it is to focus on a specific challenge without losing sight of the big picture. Special skills were demanded of us in everyday life but especially also in teaching and research: to be flexible in time and space, to broaden perspectives, to look at solutions from different angles and to question points of view.

This issue of the Rock Report puts the focus on our research in anisotropy and the topic of Hard Soil – Soft Rock, where the 1. HSSR colloquium that was held last November is presented. As another special topic we present teaching strategies that we developed to deal with the COVID-19.

Let us think and act in an agile way to cope well with the still ongoing crisis. Let's move forward!

Glück Auf! And stay healthy.

Title Picture:

Validation of the generated excess pore pressures in the cross-anisotropic hyperelastic brick model under triaxial compression in various directions. M. Cudny, K. Kowalska & M. Winkler 2020 – Presentation at Geotechnical Conference Korbielow/Poland thomas.marcher@tugraz.at

14. January 2021 – published Georg H. Erharter – editor in chief <u>tunnel@tugraz.at</u> – contact

Research Focus Today

Anisotropy

"Anisotropy is Everywhere, to See, to Measure and to Model"

(Barton & Quadros, 2014)

It is justified by the formation history of rocks that many of them are naturally equipped with planar features which render the physical properties of the material to be orientationdependent (=inherent anisotropy) The well-established assumption of an isotropic material behaviour for simulations of tunnel excavation problems is therefore only valid, in case an excessive influence of these directional dependencies on the resulting deformations and stresses can be excluded. However, for rocks exhibiting high degrees of anisotropy, such as shales, slates or phyllites, the orientational characteristics of the material properties like strength and stiffness, must be taken into account to prevent dangerous misconceptions of the structure's safety and the need for overconservative design assumptions.

Some problems with commercially available anisotropic constitutive models are that these are subjected to major limitations especially when it comes to the simulation of soft anisotropic rocks. Such rocks display a high stress dependency together with a pronounced non-linearity, softening and anisotropic stress-states in the rock mass can alter the directional dependencies of the material (= stress-induced anisotropy). Standard constitutive models can capture neither of these features.

With the research topic of anisotropy our institute has launched its way towards the improvement of current approaches taken in anisotropic constitutive modelling. With putting another focus on experimental works we further want to enhance current laboratory techniques helping us to investigate the mechanical behaviour of anisotropic rocks in more detail.



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1. Hard Soil Soft Rock

Mini Symposium

November 27th 2020 was the last Friday prior to the day of Saint Barbara, who is the patroness of all tunnellers and miners. Traditionally, our institute combines this day with a conference during the day and a social event in form of a come-together and dinner in the evening. We have waited a long time and hoped that due to the low numbers of infections during the summer, the autumn and early winter 2020 would also be quiet. Eventually, we had to cancel the traditional celebration in the evening and transform the conference into an online event.

The online mini-symposium focused on the challenges of Hard Soil and Soft Rock (HSSR) materials in research and practice.

What is Hard Soil and Soft Rock? One characteristic is that such transition material can no longer be described with rock mechanical classification methods but usually also does not meet soil mechanical classifications. It is a challenge to characterise them and to determine characteristic geotechnical parameters based on in situ and lab test data.

What are typical examples for Hard Soil and Soft Rock? Clay-, marl-, sandstone, slate/schist or phyllite, tuffs and stiff clays. A well-known example is London Clay, one of the most studied materials in the world. In tunnelling in Austria, the so-called Schlier is a prominent HSSR candidate, which is a silty or fine sandy marl. Schlier was present in the construction of the new railway line from Vienna to Salzburg (the so-called western line). Another example is the quartz phyllite and green schist at the Brenner Base Tunnel project.

The Symposium 2020 allowed to identify possibilities and limits in the research and practice of HSSR. In the proceeding book, which you can order from us at the institute, you will find contributions on constitutive modelling and anisotropy, tunnelling in fault zones, characterization of and in situ-, site- and experimental investigations on HSSR materials.



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Lab News

Triaxial Testing Facility for HSSR material

Since autumn 2020, our institute is operating a new triaxial testing facility which is designed for transition rocks (HSSR). With special laboratory equipment, we can now investigate the behaviour of such materials in the pre-peak- and post-peak-range.

Detailed knowledge about the material's strength and stiffness is essential for economic constructions. In the upcoming years, we will study the effect of different stress regimes, cyclic loadings, and thermal fluctuations on the material behaviour and the development of the pore water pressure.

Please refer to this <u>Planet Research article</u> for more details.



01/2021

Teaching Highlights

Partial presence mode

The COVID-19 pandemic is still gripping global affairs. The Graz University of Technology has therefore introduced a COVID 19 traffic light system to which all processes, such as teaching activities, must be oriented. Due to the restriction of persons resulting from the given traffic light status, it is no longer possible to allow the full number of students into the teaching rooms.

The RMT has also adapted to these regulations and introduced the partial presence mode. This provides optimal protection for high-risk students in particular, while at the same time allowing them to participate fully in the lecture.

Here, a direct stream is made available from the lecture hall to the students' private living area. Due to the direct stream from the lecture hall into the private area of the students, it is thus possible for the full number of registered students to participate in the lecture. While other nonat-risk students can follow the lecture directly on site.

Thanks to the hardware and software provided by Graz University of Technology, it is now possible to bring university teaching directly to the student's desk at home. Due to the high functionality of the software, the lecturer as well as the students can ask questions and comment on the discussed topic at any time.

The bottleneck with internet-based communication is often the internet connection or the bandwidth supplied by the network provider. In this area, there may be a reduction in transmission quality in rare cases, but this is within reasonable limits and in no way reduces the quality of teaching.

Despite the many benefits of this teaching method, the lecturers of the RMT team are looking forward to welcoming the students back to the lecture halls in full and risk-free attendance.

A COVID ready classroom: special camera set up to record lectures; green dots mark the chairs where students can sit with sufficient distance to others; sanitizing equipment in the back.



Site Reports

DDSM column testing and in situ investigations on improved ground

In 2020 a cooperation was started with KELLER Grundbau aiming to enhance testing techniques on grouted soil columns called Deep Dry Soil Mixing (DDSM) which is a common technique to improve the ground especially in Scandinavia.

Due to the partially high requirements regarding the shear strength of DDSM columns in Scandinavia the improved soil conditions are categorized as Hard Soil – Soft Rock. Therefore, in situ investigations on these columns are of great interest for the Institute of Rock Mechanics and Tunnelling. The standard testing methods on DDSM improved soils are per definition limited to approx. 350 kPa. Since there were and are problems considering the high column shear strength while testing, the research will evaluate the correlations, advantages and disadvantages of different testing methods on strong DDSM columns.

At the end of 2020 a visit at several construction sites in Gothenburg (Sweden) and Moss (Norway) was conducted to learn more about the procedure and see the mixing equipment in action. These investigations in Scandinavia should improve the testing procedure itself and will form the basis for ground parameter determination based on rotary drillings in the future due the possibility to test very homogenous stiff "soil" with known ground parameter.



FOPS, "pull out test" (Keller, Norway)



FOPS, "drill & push down test" (Keller, Norway)

Publications & Presentations

All publications of the institute are listed chronologically on our <u>homepage</u>. Selected papers and presentations are presented here.

On the pointlessness of machine learning based time delayed prediction of TBM operational data

Erharter, G.H.; Marcher, T. (Automation in Construction) Open Access

https://doi.org/10.1016/j.autcon.2020.103443

In tunneling, predictions of the rockmass conditions ahead of the face are of great interest to be able to take appropriate countermeasures at the right time. Besides investigations like drilling or geophysics, new approaches in mechanized tunneling aim at forecasting the geology ahead via Machine Learning models. These models are trained to forecast tunnel boring machine data by learning from recorded data in already excavated parts of the tunnel. Simply judging from high accuracies, these results may look promising at the first sight, but forecasts like this are mostly just delayed and slightly altered versions of the input data and no predictive value can result from them. This paper shows deficits in the current practice of data driven forecasts ahead of the tunnel face and raises impetus for further research in this particular field and TBM data analysis in general.



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HSSR - Ein Versuch der Einordnung und Abgrenzung des Materials

HSSR - An attempt to define and categorise this material

Marcher, T.; Stauder, S.; Winkler, M.

Because of increasing scarcity of usable building land, project planners are confronted with having to relocate a large part of critical infrastructure underground. Limited subsoil suitable for buildings makes the situation even more problematic. Hence, we have to manage complex subsoil conditions, including the special behaviour of transitional rocks also described as Hard Soil / Soft Rock (HSSR). This material often cannot be handled by conventional soil or rock classification methods. It is not only difficult to describe and to characterise, but also problematic when it comes to the derivation of computational parameters based on test data (in situ and laboratory) and to modelling the material's behaviour. This paper provides an overview of the most important characteristics of HSSR material from a geological/geotechnical perspective and identifies the existing research gaps.

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Faces

... today's students and alumni of the Institute of Rock Mechanics and Tunnelling

Johannes Leo

After my school education and completion of my A-level at an engineering specialized high school, I decided to move to Graz to take on my bachelor studies in Civil Engineering at Graz University of Technology in 2017. From beginning on my interest was lying on the geotechnical and rock mechanic lectures. My fascination for geotechnics and especially for tunnelling increased rapidly during an internship on a big hydropower plant construction site where I was working as a technical and hydraulic engineering. I am excited to learn more about and increase my understanding in the field of geotechnical engineering every day. Right now, I am working on a project dealing with the problems using the "Remote scripting" interface in Plaxis. I try to soak up every input we get within our studies at Graz University of Technology and I am looking forward to start working in the field of geotechnical engineering after I have finished my master studies.





Johanna Spitzer

I finished my bachelor's degree in Geoscience at the University of Potsdam. The program was very interesting, and research based. To learn more about the applied fields of geology was one of the reasons why I chose the master's program Geoscience in Graz, with the possibility to specialise myself in Engineering Geology. Currently I'm finishing my master thesis at the institute of Rock Mechanics and Tunneling with the topic "Geological and Geomechanical analyses of a rock slope at the Ödenwinkelkees". As a part of the thesis I did a few days of field work at the rock slope. I characterised the discontinuity network and assessed how glacier retreat affects the slope stability. During the work in the mountains I cannot think of a better job and I'm looking forward to apply my knowledge soon.

Diary of Events

AI in drill & blast tunnelling - focusing on rock mass classification and drillplan optimization Graz, Austria (2021/01/21; 5:15 p.m. CET)

Lecture by Tom Frode Hansen who is an experienced rock engineer from the Norwegian Geotechnical Institute about modern applications of Machine Learning for rock mass characterization. Registration via email addressed to <u>tunnel@tugraz.at</u>.

35. Christian Veder Kolloquium 2021

Exhibition hall of the city of Graz, Austria (June 24th-25th, 2021)

Annual conference hosted by the Institute of Soil Mechanics with this year's special topic "Inner-City Underground Engineering – Design and Construction". Conference is held in German without simultaneous translation. For further information see: <u>https://www.tugraz.at/institute/ibg/events/christian-veder-kolloquium/</u>

Barbarafeier

Graz, Austria (2021/11/26)

Annual institute's celebration of the feast day of St. Barbara together with friends from all over the world. After the HSSR-Workshop. Everybody is welcome. We normally start at 7 p.m. Registration via email addressed to <u>tunnel@tugraz.at</u>.

2nd ATC2-Symposium 2021

Leoben, Austria (2021/12/02)

Symposium by the Austrian platform ATC2 (Austrian Tunnel Competence Center), a collaboration of Graz University of Technology and Montanuniversität Leoben. The aim of the symposium is to transfer innovative ideas and know-how in tunnelling. In German. Abstract submission possible until 31.01.2021. Registration and further information: http://austrian-tunnel-competence-center.at

In 2021 the ATC2 Symposium will be held directly after the Tunnel Boring in Difficult Grounds (TBMDiGs) conference, and it will be possible to register for both events at a reduced combination registration price. More information about the TBMDiGs can be found here: https://www.tbmdigs2021.org/en/

The Long Night of Research at TU Graz

Graz, Austria (2022)

Researchers all around Austria will allow a unique look behind the scenes and bring their research to life for one night. Our team will show some exciting tests in the rock mechanics laboratory. The first tour will start at 5 p.m. Registration via email addressed to tunnel@tugraz.at.

[additional information]

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Geotechnical

Lectures







Have a look at our Master's Theses

The institute has different research areas and offers numerous topics for a master thesis.



Mission to the Mars (supervisors: G. Erharter, G. Grömer (OeWF))

A rather extra-terrestrial research topic looks at the Earth's neighbour Mars. The lava tubes on the red planet are perfect locations for establishing bases for manned missions. In order to use them, the geotechnical instruments must be adapted to the Mars environment, as must the methods for using Earth's stability analysis.

Strates Strates

Artificial Rock Samples / Anisotropy (supervisor: M. Winkler)

Rock is a complicated material, for example it is very often anisotropic, i.e. its properties are dependent on certain directions. To learn more about this property and to develop a constitutive model for it, numerical simulations are carried out and artificially anisotropic rock samples are tested in the laboratory.

Hard Soil Soft Rock (supervisor: S. Stauder)



Have you ever wondered what the difference between a stone and soil is? This question is more difficult to answer than expected and is the focus of the research field Hard Soil-Soft Rock (HSSR). The topic of a master thesis in this area is the harmonisation of the nomenclature used in earthworks in connection with hard and soft rock.

Another proposed thesis should focus on the calibration and testing of the Hoek Brown Softening (HBS) model with respect to hard soils or soft rocks and includes numerical simulations, a case study and a comparison of the HBS to other constitutive laws.

An exciting area of research is being led by the newly founded Machine Learning

Machine Learning (supervisor: G. Erharter)



in Geotechnics (MLGT) Group. The research of this group focuses on machine learning, but the research topics are quite diverse, as one thesis deals with the application of Artificial Neural Networks (ANN) for the prediction of highresolution landslide monitoring data and another with the analysis and evaluation of geophysical data from Tunnel Seismic Points (TSP).

Tunnel-thermal energy (supervisor: T. Geisler)

You are interested in geology, tunnel construction and alternative forms of energy production? If so, this topic could be interesting for you. The main goal is the extraction of geothermal energy, by using (infrastructure) constructions, with the focus on deep-seated tunnels, so called "tunnel thermal energy". This requires a symbiosis of geology, technical implementation possibilities and tunnel construction.

In addition to these main research areas, further master theses are supervised, which can be found on the website. These include a numerical approach to classifying rock masses, a study of Building Information Modelling (BIM) in conventional tunnelling with respect to the tunnel face. [overview of master's theses]



Moormann, C. (2010). GeoTU6 – a geothermal Research Project for Tunnels. Tunnel. 29. 14-21

Positions at RMT

Newcomers



Marko Verient

Hello, I am Marko Verient and I originally come from upper Styria, a small village named Lassing, which became highly publicised in 1998 due a mining accident. Now I live with my wife in Graz in a little house on the Plabutsch.

A few key data about my professional career. After visiting the HTL in Zeltweg, I studied civil engineering with a focus on geotechnical engineering at the University of Technology in Graz. I have already written my master's thesis at the RMT-laboratory, where I have already had the opportunity to work with some of you. The topic of my thesis was "Investigations on telescope yielding elements with porous filling". After graduation 2014, I have been working as a geotechnical engineer for GeoConsult ZT at the Koralmtunnel. During these interesting four years, I have experienced several challenging geotechnical situations. Those provided me with the opportunity to learn how to apply the theory of rock mechanics and failure mechanisms, which I gained during my studies, and they have helped me to deepen my understanding of both.

As a geotechnical engineer, I was also interested in the fundamental principles of soil mechanics and their failure mechanisms. To gain more integral knowledge in this field, I left tunnel engineering to start developing experience in special foundation engineering. So I started working for Keller Grundbau from 2019 to the end of 2020, where I support my team, for two years, as a geotechnical design engineer for projects in South-East Europe and Scandinavia.

Now I have been given the great opportunity to support the team in the RMT-lab and become part of the RMT-family. I am looking forward to the new interesting challenge and to working with you guys.

Open Positions

- A civil engineer with experience in inspection and maintenance of tunnels interested in writing a PhD thesis. Many research questions exist and wait to be answered by you. Funding possibilities depend on your current employment situation. Tell us your interest any time and we will find a funding.
- A PhD candidate who is interested in the real-time evaluation of the state and utilization of tunnel linings using wireless sensor technology. This task is part of a national and a transnational project at which several companies, public authorities and universities will cooperate. The project start is planned for spring 2021.

Cooperation



... please contact us in case we forgot you here

01/2021

... moving forward

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