ROCK REPORT

Mechanics & Tunnelling

Quarterly Newsletter of the Institute of Rock Mechanics and Tunnelling

02 Volume 3
July 2022

RMT

NAWI Graz GEOZENTRUM

TU Graz Graz University of Technology

MLGT Machine Learning in Geotechnics

Content

Marcher's Column

Dear Friends of the Institute,

it is my conviction that a rethink must begin in the planning and realisation of tunnel constructions, but also in their rehabilitation/maintenance. Due to the increasingly evident multi-crises, which focus on climate change, price increases, energy shortages and the no longer functioning supply chains for products, we as tunnel builders are called upon to plan/build in a CO2-friendly way and to expand the benefits of tunnel structures. The coupling of the structure as a heat or cold storage facility would be an enormous step in this direction. The use of temporary tunnel lining (shotcrete shell in conventional tunnelling or excavation pit structures, e.g. in metro stations, for the dimensioning of the permanent/final lining, the use of characteristic geotechnical values "without braces and belts" and optimised (slim) components with monitoring by modern sensors would enable a considerable reduction of concrete masses including production and transport. The question also arises as to whether a 2-shell lining approach is always necessary in good rock conditions?

There are already pilot projects on all these questions. Owners of tunnels are called upon to support practical research in this regard. University teaching has the task of sensitising the next generation of young tunnel engineers on these issues.

Together we can add social value to tunnels and consume / construct significantly less carbon!

In this spirit I wish you a relaxing summer 2022. Enjoy our recent Rock Report!

Glück Auf!

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Title Picture:
Depiction of the Rock Mass Mapper -
A handheld mapping device from Canadian company „RockMass Technologies".
(see „Site Reports" section)

15. Juli 2022 – published
Manuel B. Winkler – editor in chief
tunnel@tugraz.at – contact

Research Focus 1/2

When hard rock meets powerful machinery – an insight into the life of an experimental rock mechanics engineer

Dear colleagues and friends,

my name is Thomas Frühwirt. I found my passion as a rock mechanics engineer with a distinct focus on experimental work. That's why my colleagues know that I would complete the introductory sentence above „when hard rock meets powerful machinery …" with „… I hope to have some supersensitive sensors at hand and will feel at home immediately". Consequently, I joined the team of the Institute of Rock Mechanics and Tunnelling at TU Graz on July, 1st. Currently, I hold the position of a senior scientist and deputy head of the rock mechanics laboratory.

Right after graduating from TU Vienna as a civil engineer with a focus on construction engineering I started my professional life in an engineering consultants office in Vienna. As an engineer I was contributing to several major building activities in structural engineering and infrastructure projects in Austria. However, during all this project work I felt the urge to not only work with man-made materials typically used in civil engineering such as concrete, steel or brickwork but to have a deeper look into what happens below the foundation level. Understanding that the material provided by earth and typically simply referred to as "subsoil" will decide at least on costs if not even on success or failure of a project I wanted to have a closer look on this subject.

Thus, I quit my job as a civil engineer and joined the rock mechanics group at the Institute of Geotechnics at TU Bergakademie Freiberg in Germany. There I found myself in a scientific community with experts in any facets of geo-related topics I could think of. I had the opportunity to cooperate with mineralogists

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working on the nano-scale to understand cleavage in minerals as well as with mining professionals looking at a regional scale when doing research on stability of mining layouts and induced subsidence. Learning from both of them – and many more colleagues from various geo-disciplines – I develop my own approach towards geo-related problems and soon it was clear to me that hard rock was going to be "my topic". For my PhD-thesis on rock support and bolting to ensure stability of the roof in potash and salt rock mining I was awarded several prices, among them the prestigious "Leopold Müller Preis" donated by the Austrian Society for Geomechanics (ÖGG). From 2009 I was heading the Rock Mechanical Laboratory at TU Bergakademie Freiberg. During this time the laboratory developed into one of the leading test institutions for hard rock in Germany with an excellent international reputation. As an academic I worked on numerous R&D-projects funded by official agencies or governmental authorities. In my research work I am focusing

Research Focus 2/2

mainly on damage-induced alteration of rock mass properties and on the influence and behaviour of discontinuities in rock. I like to contribute to social relevant topics such as enhancing the potential for extraction of geothermal energy from the deep underground or the safe deposition of hazardous wastes in underground spaces. Beside my research in fundamental topics I love to do applied research on challenges industry is facing. Typically, my project partners have their background in civil and mining engineering and are affiliated to leading international companies. My credo in all these research works is that if you want to push the state-of-the-art you have to bring together fundamental research and practical application. My research typically has a strong experimental background and I usually work in the laboratory or at in situ sites. A well-equipped rock mechanics lab with powerful machinery and high-performance sensors helps me to duplicate in situ phenomena and understand characteristic behaviour of rock under certain boundary conditions. Discussing my scientific findings with national and international colleagues and transferring fundamental knowledge back into industry is one of the main motivations for my work.

Definitely, I will continue my scientific work at my new position at TU Graz. Here, with the mountains of the alps close by, I am especially looking forward to contributing to some of the most prestigious and most challenging tunnelling projects in the world. Therefore, doing the step beyond hard rock to soft rock and even expanding my expertise to hard soils is the logical consequence for me. For sure, this will not be successful without close cooperation with experts from adjacent scientific fields such as clay mineralogy, fluid dynamics and soil mechanics – just to mention a few. Having a strong background in geotechnics in mining I want to expand my applied research to mining activities in central and south-east Europe. On the long run it would be perfect to establish a long-term cooperation with one of the sites to do the step from the lab scale to mine scale and investigate relevant problems under in situ conditions. Research on latent geo-related hazards which may be triggered by extreme weather or changing climate conditions is a highly relevant topic especially for the alpine regions in Austria. Therefore, this is another topic I am looking forward to contribute to. With the “NAWI Graz Geocenter” (centre for geo-related natural sciences) TU Graz offers perfect possibilities for me not only by providing hardware, i.e. state-of-science testing facilities, but also by bringing together scientists from various fields as well as motivated students eager to learn and participate in our research activities.

I am really looking forward for the new opportunities here in Graz and want to encourage you to contact me if you are interested in a cooperation.

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Recent RMT Guests

Kajima visited Graz

To our surprise, because it was on short notice, a few weeks ago, Mr Yasuhiro Yokota (Ph.D.) paid Graz a visit. He is Senior Research Engineer at Kajima Technical Research Institute Singapore (KaTRIS).

Kajima is one of the oldest and largest construction companies in Japan (founded in 1840; > 18,000 employees worldwide). Having its own research departments, Kajima strives to uphold its reputation as a pioneer in construction technology.

In 2021, the International Society for Rock Mechanics and Rock Engineering (ISRM) awarded Mr Yokota with the Rocha Medal for his doctoral thesis titled "Experimental and computational study on rock bolt modelling and its application on a new type of energy-absorbing rock bolt". We were proud to have him in Graz.

It was a short stay: less than one day. Anyway, we made the best of it. First, we visited 3GSM. Mr Andreas Gaich (PhD; CEO) and Mr Markus Pötsch (PhD) showcased what their products are capable of. After introducing some of Kajima's innovations, both Mr Yokota and the 3GSM experts soon created ideas for a collaboration. The next place to be was the Institute of Engineering Geodesy and Measurement Systems (head: Prof. Werner Lienhart). Another three experts welcomed us kindly: Ms Madeleine Winkler (MSc), Mr Slaven Kalenjuk (MSc), and Mr Christoph Monsberger (MSc; former staff member of the institute, now CEO of ACI Monitoring GmbH). Madeleine gave a brief tour through the institute's laboratory. Slaven gave us an insight into some research fields he and his colleagues are working on (including the research with image-assisted total stations). And, finally, in ACI's office, Christoph showed us projects where he successfully installed and ran distributed fibre optic sensing systems. After some Q&A's from all sides, the lunch break was due. Strengthened with traditional Styrian food (Backhendlsalat), the head of our laboratory, Mr Manfred Blümel (PhD), showed the rock mechanics laboratory to Mr Yokota. They soon found a common ground for discussion as both Manfred and Mr Yokota dealt with rock bolts in their thesis. That followed an introduction of our institute by Prof. Marcher and some of his PhD students. At 3 pm (CET), Mr Yokota already had to leave us rushing to the airport.

We thank all who helped us to arrange this day in Graz for Mr Yokota. He liked it a lot.

Based on the discussions, we look forward to collaborations with Kajima.

ロッキーのご挨拶
(Rocky greetings)

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Teaching Highlights I

Résumé of 1st "Applied Data Science for Geotechnics" Lecture

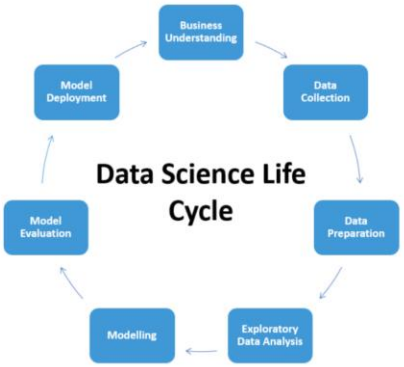
During past June, the "Applied Data Science for Geotechnics" lecture was held for the first time as a regular lecture after two years of offering it as a pilot course. About 30 students, some of them joining from external universities, took the chance to increase their knowledge in the principal parts of data science (theory part) and coding with python for data processing and analysis (practical part).

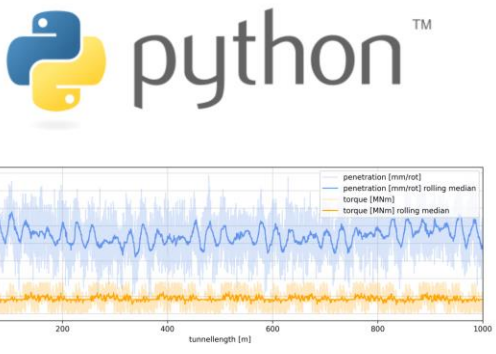
The practical part started out with an introduction to coding with python, emerging to sophisticated geotechnical data processing and analysis techniques during the course of the lecture. In-class exercises were followed by home assignments to ensure every student gained sufficient knowledge and developed an understanding and the necessary skills to use python for geotechnical data processing.

During the theoretical part, the principles of data science were presented. Including:

- Introduction to data management
- Data pre-processing and cleaning techniques
- Principles of data driven modelling and knowledge discovery
- Data engineering and transformation
- Assessment and validation of results

All the topics of the theoretical part were accompanied by practical examples from the geosciences, to breach the gap between theory and practice. Special attention has been given to the topic of how to deal with the limitations (i.e., sparsity and incompleteness) geotechnical datasets come with.





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Teaching Highlights II 1/2

Field Trip “Geotechnics and Hydraulic Engineering”

From the 16th to 19th of May the biannual „Geotechnics and Hydraulic Engineering“ excursion took place again after it had to be postponed in 2021 due to corona restrictions. Up to 40 master’s students were given the chance to visit interesting and unique field trip destinations with a connection to geotechnical and hydraulic engineering.

Our first excursion point led us into the city of Salzburg where we visited an excavation pit with surrounding sheet pile wall support in “Salzburger Seeton”. In this case, the focus was put on discussing the geotechnical problem of hydraulic ground failure that was encountered during ground excavation and potential solutions for remediation works.

After spending the night in Röthis (Vorarlberg), our next stop was at the model testing hall Dornbirn, were we could get a practical insight into the plans for the major Rhein renaturation project (RHESI) as an international collaboration between Austria and Switzerland. Towards the plans of increasing the region’s flood resilience, a hundred-meter-long high-tech model at the testing hall in the scale of 1:50 served as a basis for the investigation of the effects of river renaturation, including the study on debris transport and sedimentation.

Next, we drove to the village “Oberlech am Arlberg” to learn about the challenges that are connected with confined building pit excavations in steep alpine terrain. Under this specific environment, besides complex ground conditions, the completion of individual construction projects are additionally complicated by difficult logistical boundary conditions and long-lasting annual construction bans during touristic periods.

Staying in Voralberg, we started the third day with a bus ride to the village of Doren (Vorarlberg), known for its famous deep landslide. This landslide has gained attention in the geological and geotechnical community due to its large extension, its complexity and the major threat it imposes upon some residential buildings of Doren. Some of these buildings are located only 30 m away from the edge of the landslide, which is approaching the village with a speed of around 1 m/year.

As the second program item of the day, we visited the construction site of the new rock fall protection gallery for the “L 76 Landecker Straße” in Tyrol. This excursion point was specifically interesting from a rock mechanical point of view considering the extensive rock removal works and rock fall protection measures that were required in advance to starting with the construction works for the gallery.

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Teaching Highlights II 2/2

We spent the last night of our field trip in Innsbruck, from where we started the last day of our excursion heading towards the region of Zell am See (Salzburg) to visit the construction sites for the hydro power plant projects “Tauernmoos” and “Limberg III”. These sites comprised all interesting aspects of underground works, from ongoing TBM and conventional excavations, cavern constructions, site logistics and excavation landfills, making it the perfect finishing point of our excursion.

Thanks to our colleagues from the soil mechanics institute, who perfectly organized the field trip this year, our students could enjoy the four-day excursion to the fullest, with a lot of interesting destinations we visited and culinary highlights included, such as the tasting of the original “Vorarlberger Käsknöpfle”.

Thank you all, for this great excursion!

Figure: Impressions of the excursion from various field destinations

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NATM University Course 1/3

Module 4 - Excursion

For the first time since the launch of the current NATM university program in 2020, our participants from all over the world were able to visit Austria with the aim of getting to know construction sites in Austria, Italy and Germany.

Therefore, on the 7th of June we started into our two-week excursion, which led us from the west of Austria to the federal capital Vienna.

Our first stop was at the TU Graz, more precisely in the rock mechanics laboratory. There, the participants were introduced to the state of the art procedures for rock mechanical tests by Dr. Blümel. Subsequently, we boarded the buses and headed in direction of the city of Innsbruck, where we spent the next day visiting two different construction lots of the Brenner Base Tunnel. In the morning we went to South Tyrol (Italy) to see the Eisack undercrossing with special measures undertaken like ground freezing. In the afternoon, we drove back to Tyrol, where we entered the Austrian part of the tunnel through the access tunnel Wolf. Here, we were guided through the tunnel system, where we got interesting insides into the existing joint pattern and fault system. The last stop of the day was the area of the landfills.

After spending the night in Innsbruck, we travelled high up into the mountains to the village of Kühtai, where the existing hydroelectric power plant is currently being expanded. The project envisages the construction of a third reservoir in Längental ("Kühtai Reservoir"; 31 million m^3) as well as an underground pumped storage power plant ("Kühtai Power Plant 2"; capacity: 130 MW in turbine operation, 140 MW in pumped operation) between the Finstertal and Kühtai reservoirs.

Figure: Group picture with the NATM University Course participants at Kühtai

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NATM University Course 2/3

Module 4 - Excursion

As a last program point of the first week, we drove to the Bavarian capital of Munich (Germany), where currently the second trunk line of the Munich „S-Bahn“ is beeing build, with an construction lot right behind the city hall. The project covers a length of 11 km, of which about 7 km are tunnels with an average overburden of about 48 m.

After a first exhausting week, the participants spent the weekend in the provincial capital Salzburg with some sightseeing, where also the New Austrian Tunneling Method was developed in the mid-50s.

The second week began with a visit to the one-to-one scale research facility Zentrum am Berg, in Eisenerz, which consists of two parallel road tunnels and two parallel railway tunnels, which are connected by cross passages and galleries. In total, the entire facility offers about 4 km of underground testing and training areas.

The following day took us to Linz, where we visited the A26 urban highway, which is intended to improve the traffic situation in Linz in the future. 85 percent, about four kilometers of the total route, run underground in tunnels. Additional two bridges will be built to cross the Danube and the railway lines.

Figure: RMT delegation at the NATM excursion in Linz (left: Thomas Geisler, right: Manuel Winkler)

Of course, the 27.3 km long Semmering Base Tunnel could not be missed out on our trip, which is why we visited construction lot 1.1 Gloggnitz the next day. The Gloggnitz construction lot, covers an over seven kilometers long tunnel section and is located in federal state of Lower Austria. The construction works in this section started in the summer of 2015 and might last until 2025. Tunneling is carried out by drilling and blasting. Since the construction lot also covers a complex geological zone, the participants were able to see impressively how challenging tunnel driving can be under such difficult conditions.

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NATM University Course 3/3

Module 4 - Excursion

The next-to-last stop took us back to Salzburg, more precisely to the municipality of Uttendorf. Here, as in Kühtai, the Tauernmoos hydropower plant is currently being expanded. Already in the first half of the last century, two reservoirs „Tauernmoos“ and „Weißsee“ were built in the Stubach valley (municipality of Uttendorf) in the Hohe Tauern National Park. Since then, the Tauernmoossee has been used for power generation with another power plant (capacity 80 MW). Lake Weißsee, which is 220 meters higher, still serves only as a pre-storage reservoir. The head between Weißsee and Tauernmoossee was still unused with regard to power generation. Thanks to the new pumped storage plant under construction, this difference in elevation of the reservoirs can be utilized in future.

The final stop of our excursion was the expansion of the subway lines U2 and U5 in Vienna. The U2/U5 line intersection is an expansion project that is currently under construction. It includes eleven new stations, 9 km of track and the creation of a new U5 subway line. The project is to be realized in two expansion stages until 2035. There, various methods of tunnel construction are being applied and will relieve public transport in the city of Vienna in the future.

In summary, the participants were introduced to the Austrian practice in tunneling, the differences were pointed out and furthermore it was shown how to deal with and overcome some major difficulties in tunneling in Austria. Despite the tight schedule, the social interaction and direct exchange among the participants did not come off short.

For us it was a great time and we look forward to welcoming the NATM participants back to Austria in Module 6.

Figure: “Liebe Grüße vom Semmering-Basistunnel!”

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Site Report 1/2

Hands-on the Rock Mass Mapper: A Canadian based hand-held tool meant to revolutionize the future of underground mapping

Thanks to our guest researcher Josephine Morgenroth (introduced in Issue 1 Vol.3 of our Rock Report series), who is also the Research and Technical Partnerships Manager at the Canadian tech company “RockMass Technologies”, members of our institute had the chance to get hands-on experience with one of the company’s products, the “RockMass Mapper”.

The “RockMass Mapper” is a handheld hardware-software tool that is able to digitally collect geotechnical data, such as structural orientations of rock face features and point clouds, underground and within seconds. The Mapper automatically calculates joint set orientations underground using a flash LiDAR, an inertial measurement unit, and a custom built software platform. The Mapper’s digital interface provides an intuitive platform for geological and geotechnical mapping, documenting RMR, Q, and geotechnical observations, recording sample locations, and automated trace feature mapping. All collected data for scanned locations is output as HD images, an RGB point cloud, a tabulated database of all geological and geotechnical features mapped, a georeferenced point cloud and .dxf files, and customized integration files for industry standard post-processing software. All these data are synced to RockMass’ cloud database, called Stratus, for easy viewing and management.

Figure: View of the RockMass Mapper and it’s graphical interface
© RockMass Technologies Inc

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Site Report 2/2

On May 10th, we made our way towards one of the tunnel galleries within the “Grazer Schlossberg”, where we got the chance to test the ease of use and the reliability of the Mapper for ourselves. Due to the simple and self-explanatory graphical interface, even non-experienced users are able to operate the mapping tool within minutes. Implemented algorithms combined with on-device processing enable the real-time depiction of feature orientations within stereo-plots. The user may detect and save individual features separately and directly assign it with additional information, such as input properties required for rock mass classification. Ultimately, all of the collected information can be transferred to a computer system after finishing the mapping works for post-processing, e.g. to create 3D - models of the mapped areas.

To conclude our little excursion: The “RockMass Mapper” is a great and innovative tool that uses state-of-the-art technologies and rethinks the way we map our underground environment today. We are definitely excited about upcoming innovations by “RockMass Technologies” and would like to wish the company all the best.

Figure: Prof. Marcher and Thomas Geisler testing the RockMass Mapper device

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Internship Report

A report by IAESTE trainee Vaibhav Shringi

Hi everyone,

© Vaibhab Shringi

I am Vaibhav Shringi. I have recently graduated with a Bachelor's degree in Civil Engineering from BITS Pilani, India. During my final semester, I had a remarkable experience, working and learning at the Institute of Rock Mechanics and Tunnelling (RMT). From January to June 2022, I completed my off-campus bachelor's thesis whilst working as an IAESTE intern there.

Under the close supervision of Mr Manuel Winkler and Mr Alexander Kluckner, I got great exposure to using the FEM tool 'PLAXIS' for simulating conventional tunnel excavations and study the effect of tunnel ring closure. I also got introduced to the programming language Python to be used in Plaxis via the remote scripting interface. Starting as a newbie in the usage of Python, the resources provided helped me pick up the required proficiency step by step. Further, I could greatly improve my report writing skills and was able to develop an efficient workflow with regard to literature research and citation management.

As part of my continuing education, I also attended some classes from the Geotechnical and Hydraulic Engineering master, though the most fun were the German language courses. I believe to have reached the A2 level: “Aber Deutsche Sprache, schwere Sprache.”

I also got the chance to visit the Brenner Base Tunnel in March. Travelling through the Alps in Austria, Germany and Italy, the two-day excursion was my first on-site experience. The vast machinery and deep excavations fascinated me. We also visited a small tunnel within the “Grazer Schlossberg”, testing and playing around with a GPS-enabled automated RockMass Mapper. I am proud to say that I gained valuable academic lessons and essential connections during my internship.

Throughout my entire free time in Austria, I was kept busy by TU Graz Welcome Centre, Erasmus Student Network and IAESTE. They organized various events, hikes and “Stammtische”. Every weekend, I had a chance to make new friends and enjoy Austria's beautiful and adventurous nature.

Undoubtedly, the past six months were the best time in my life. I again thank IAESTE, Prof. Thomas Marcher and RMT for providing me with this great opportunity.

Publications & Presentations I

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

Geothermal Potential of the Brenner Base Tunnel – Initial Evaluations
Thomas Geisler, Klaus Voit, Ulrich Burger, Tobias Cordes, Florian Lehner, Gregor Götzl, Magdalena Wolf and Thomas Marcher (Published in Processes 2022)

Increasing demands on mobility and transport, but limited space above ground, lead to new traffic routes being built, even more underground in the form of tunnels. In addition to improving the traffic situation, tunnels offer the possibility of contributing to climate-friendly heating by indirectly serving as geothermal power plants. In this study, the geothermal potential of the future longest railway tunnel in the world, the Brenner Base Tunnel, was evaluated. At the Brenner Base Tunnel, warm water naturally flows from the apex of the tunnel towards the city of Innsbruck, Austria. In order to estimate its geothermal potential, hydrological data of discharge rates and temperatures were investigated and analyzed. The investigations indicated the highest geothermal potential in the summertime, while the lowest occurs during winter. It could be shown that these variations were a result of cooling during discharge through areas of low overburden (mid mountain range), where the tunnel atmosphere is increasingly influenced by the air temperatures outside the tunnel. Nevertheless, the calculations showed that there will be a usable potential after completion of the tunnel.

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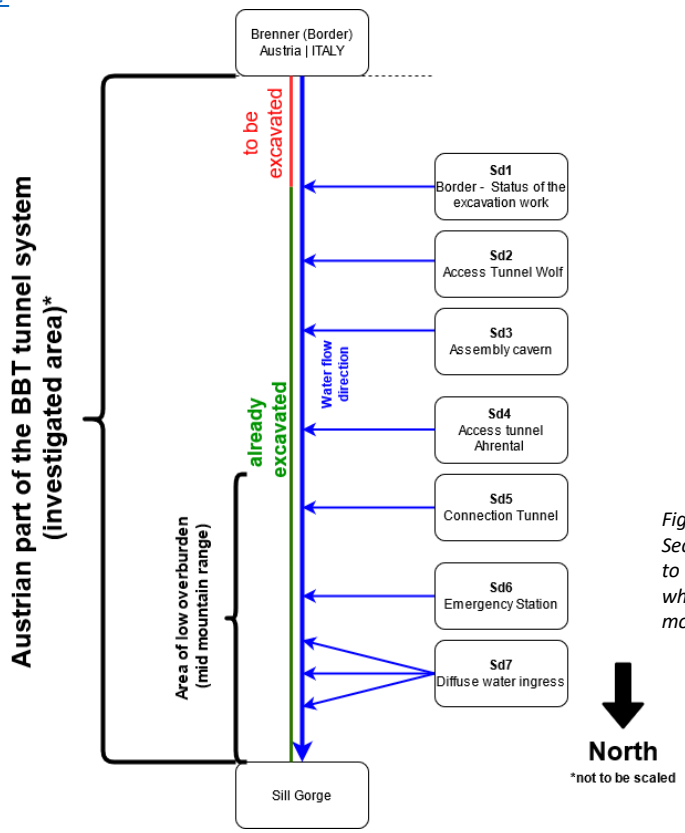

Figure:
Sectional discharges contributing to the total tunnel discharge, which have been investigated in more detail within the paper.

Publications & Presentations II

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

Chair of the Minisymposium MS-2 at the EURO:TUN 2022
Marcher, T., 22-24 June 2022, Ruhr University, Bochum

From June 22nd to 24th the EURO:TUN 2022 conference on computational methods and information models in tunnelling took place at Ruhr University Bochum. Central topics of the conference include computational methods, information models, methods of machine learning and big data analytics which have experienced increasing application in the design and construction of underground infrastructure. Prof. Marcher chaired one of several minisymposia, namely – MS-2, data driven models and machine learning in subsurface engineering – comprising eight talks on promising machine learning applications contributing to the ongoing digitalisation in tunnelling.

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Conference talks at EURO:TUN 2022
Paul Unterlass & Georg Erharter., 22-24 June 2022, Ruhr University, Bochum

Aside from Prof. Marcher chairing one of the minisymposia at EURO:TUN 2022, our institutes research focus on machine learning in geotechnics was represented by two conference talks. Georg Erharter and Paul Unterlass, both members of the machine learning in geotechnics (MLGT) workgroup at TU Graz, were given the chance to present and discuss their latest research amongst a highly qualified audience of scientists, developers and engineers. Mr. Georg Erharter held an innovative talk on the introduction of reinforcement learning to tunnelling, showing the potential of reinforcement learning for developing new strategies in conventional tunnelling. Mr. Paul Unterlass' talk dealt with the problem of subjective labelling in geotechnical datasets, introducing a new approach to eliminate such, resulting in improved accuracy in geological predictions. This work represents one of the research outcomes from a recent project with the geophysical department of Amberg Technologies, focusing on introducing machine learning into their tunnel seismic prediction (TSP) system.

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Faces

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

Stefan Zelzer

After finishing my bachelor's program in civil engineering here at Graz University of Technology, I decided to deepen my interest in geotechnical and hydraulic engineering. Since the end of April 2022, I am working as a project assistant at the Institute of Rock Mechanics and Tunneling dealing with numerical modelling of large underground thermal storages.

Thermal storage with the medium water in large underground shafts, caverns and other geometries is a promising way to provide a seasonal energy supply in urban regions. In cooperation with FH Wels, the projects targets an economical design of the underground geometry for the storage of hot water. In line with the geological and geotechnical aspects of the project area, which is close to the city of Salzburg, tunnel and shaft geometries with different depths and diameters are scope of the study. Numerical modelling with PLAXIS 2D and 3D gathers information on the behavior during excavation with respect to the chosen excavation method.

I can say that I am glad to work on such promising projects, alongside my motivated colleagues throughout my whole career at the University.

Anna Kofler

In 2015 I started studying Civil Engineering at Graz University of Technology. After an internship at a geotechnical engineering company and a high interest in the rock mechanics lectures in the Bachelor's programme the decision of taking the "Geotechnical and Hydraulic Engineering" Master's programme with focus on rock mechanics and tunnelling was clear. This summer I will start my master's thesis on the topic of "The numerical derivation of rock mass parameters" at the Institute of Rock Mechanics and Tunnelling. First, I will work out the deficiencies of the different standard methods for rock mass characterization based on a literature study. After that, I will work with 3DEC and perform numerical lab tests on the digital rock mass. I am really looking forward to focus on this topic in the upcoming months.

Diary of Events

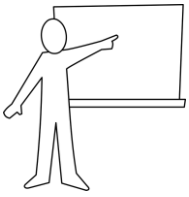
> Mini-Symposium “Rockfall Risk”
Schladming, Austria, (2022/12/01)

The symposium "Rockfall" will shed light on experiences and approaches to this topic from various disciplines. The spectrum ranges from engineering geology and rock mechanics to influences related to climate change, modern processing methods, possible further developments with the help of artificial intelligence, and legal liability issues. National and international experts will provide technical contributions and institutions will present their approaches (Further information - Link).

> 30th Anniversary Celebration of RMT followed by “Barbarafeier”
Graz, Austria (2022/12/02)

It has been 30 years since the Institute of Rock Mechanics and Tunnelling was founded in the year 1992. This must be celebrated and therefore a 30th anniversary celebration will take place at TU Graz on 2nd December 2022 (Start: 17:00 o’clock). After the anniversary celebration our yearly Barbarafeier will take place starting at 19:00 o’clock. Hope to see you there. Further information regarding the program and registration will follow on our website - Link.

> Lecture „Die Herausforderungen an den landesgeologischen Dienst - Fallbeispiele aus Kärnten“ (in German)
Graz, Austria (2023/01/26, 17:15 CET)



Lecture by the federal geologist of the province of Carinthia Mag. Franz Goldschmidt. The lecture will be in German and will take place in the lecture Room HS L (Lessingstraße 25/1, 8010 Graz) . Registration via email addressed to tunnel@tugraz.at .

> ATC²-Symposium 2023
Graz, Austria (2023/12/01)

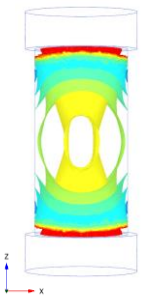
Symposium by the Austrian platform ATC² (Austrian Tunnel Competence Center), a collaboration of Graz University of Technology and Montanuniversität Leoben. The aim of the symposium is to transfer innovative ideas and know-how in tunnelling. In English. The topics of the upcoming events are: Shallow Tunnelling, Urban Tunnelling incl. Metro Tunnels and Stations. Further information can be found on the ATC² homepage (update in progress).
http://austrian-tunnel-competence-center.at

> ATC²-Symposium 2024
Innsbruck, Austria (2024/11/14)

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 English. In 2024, ATC² will be hosted at the guest location in the City of Innsbruck. Information on the topics of this event will follow. http://austrian-tunnel-competence-center.at

Have a look at our Master‘s Theses I

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

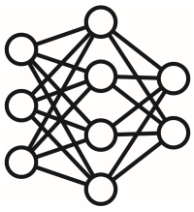


- **Numerical and experimental investigation of rock anisotropy**

(supervisors: T. Frühwirt, M. Winkler)

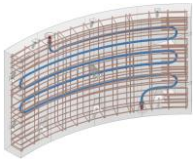
Rock is a complicated material, for example it is very often anisotropic making its’ deformational and strength characteristics dependent on the loading direction. To learn more about this phenomenon, numerical and experimental studies need to be carried out.

- **Machine Learning (supervisor: G. Erharter, P. Unterlass)**



An exciting area of research is being led by the newly founded Machine Learning 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 high resolution landslide monitoring data and another with the analysis and evaluation of geophysical data from Tunnel Seismic Points (TSP).

- **Tunnel-thermal energy (supervisor: T. Geisler)**



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

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.

- **Significance of thermomechanical processes on rockfall hazards (supervisor: R. Kienreich)**

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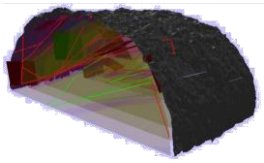
Thermomechanical processes, along with interface structure and mountain water conditions, are considered primary triggers of rockfall phenomena. The rock mechanical hypothesis is that numerous microcracks form more or less statistically distributed cavities. In the precipitation-intensive period in the following fall, this causes intensive water input, which leads to an increased exceeding of the stability, i.e. rockfall. In order to get a better understanding of the phenomenon, the field data - precipitation in combination with the temperature course of the accumulation of rockfall events should be compared. The different material behavior of carbonate and crystalline rocks is to be described from literature data or possibly laboratory tests.

Have a look at our Master‘s Theses II

- **Data Science in Geotechnics** (supervisor: **A. Sapronova**)

Advances in engineering equipment that is now capable to delivers massive in-situ data at runtime, open the possibility of employing data analysis and data-driven modeling to ensure proactive risk management and optimize the work. Although a large number of features characterize the geotechnical data, its extreme volumes and sparsity place special constraints on the applications of the data science methods in geoengineering and the special focus shall be placed on the data quality assessment, pre-processing routines, and integration of the data from various sources.



- **Digital Face (supervisor: A. Sapronova)**

Various data near and at the tunnel face is available during the underground construction: from hand-made technical sketches made by geologists to the 3D point-cloud datasets from seismic surveys. Integration of such information into a harmonized database that will help to forecast the geological conditions and ensure safe tunneling. Ongoing research aims to find methods for the information extraction and integration to move further from the survey data to the dynamically updated visual and digital representation of a tunnel face.

Cooperation

… please contact us in case we forgot you here