ROCK REPORT

Mechanics & Tunnelling

Quarterly Newsletter of the Institute of Rock Mechanics and Tunnelling

03 Volume 5
September 2024

RMT

NAWI Graz
GEOZENTRUM

TU Graz
Graz University of Technology

MLGT
Machine Learning in Geotechnics

Content

Marcher's Column

In 2019 I had a very interesting discussion with Rainer Kienreich, which can be summarized as follows: In recent years, particularly during and after the pandemic, the use of the Alpine region for recreation has intensified, significantly impacting both summer and winter tourism. The distinction between the traditional peak seasons of winter and summer is becoming less pronounced, resulting in more evenly distributed tourism throughout the year. The rise in visitor numbers also brings heightened risks, particularly related to natural alpine hazards like rockfall. These hazards are becoming more dangerous due to the increased use of hiking and climbing trails, as well as other outdoor activities. Statistically, the growing number of visitors inevitably leads to a higher incidence of accidents involving injuries caused by falling rocks.

Based on this, Rainer started his PhD with the focus to investigate the issue of rockfall from a geological and rock mechanics perspective. Unlike previous studies, this research focuses on smaller but frequently occurring rockfall events on natural rock slopes. The objective is to refine the definition of 'alpine natural hazard' in relation to rockfall and make it quantifiable. In the course of his PhD at our institute he lead the organization of two symposia on this matter. The first one took place December 1st 2022 and covered a wide range of topics from geological/rock mechanical experiences, the influence of climate change and risk modelling. The success of the 2022 symposium has led us to organize a second symposium, taking place in late November 2024 in Schladming (see details p. 10). Meanwhile, Rainer Kienreich successfully defended his PhD (Rigorosum) on September 30th, 2024 (see p. 5). His work was truly outstanding, and we extend our heartfelt congratulations to Rainer on this significant achievement!

An additional point to highlight in this column: we have decided to reorganize the Saint Barbara's celebration with a renewed focus on our students. The students will now be at the heart, as they represent the future of our industry (see details p .17).

Dear friends of the Institute, enjoy reading the current issue. Glück Auf!

Thomas Marcher

Title Picture:
Parasitic folds in geologic structure at Folgefonna National Park, Norway.
Picture: Mario Wölflingseder

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October, 2024 – published
Ines Metzler – editor in chief
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Research Focus

Maintenance and Operation of Road and Rail Infrastructure subjected to Climate Change Effects (MORICE)

Large parts of Austria's transport infrastructure were built primarily between 1950 and 1980 and were planned based on the assumption of largely static environmental conditions. However, recent climate models show increasing variability in seasonal weather patterns, including more frequent extreme events such as heavy rainfall. These changes also affect the infrastructure, as it was not originally designed for such variations.

The FFG-funded project MORICE (Maintenance and Operation of Road and Rail Infrastructure subjected to Climate Change Effects) examines the impacts of climate change on road and rail infrastructure in Austria. The main goal of the project is to detect climate-related damage early and to adapt current inspection strategies accordingly. Project partners include the Institutes for Applied Geosciences and Soil Mechanics, Foundation Engineering and Computational Geotechnics as well as RMT, the Austrian Research Association for Road-Rail Transport (FSV), Vill Ziviltechniker GmbH, and recordIT GmbH.

A key component of the project is the use of modern mapping and modeling tools to assess structural and geotechnical impacts, as well as to identify risks and harmful processes caused by climate change. The Institute for Rock Mechanics and Tunneling focuses primarily on the rock mechanical aspects of the project. For example, the effects of climate change on unsecured rock slopes are under investigation. In this context, secured (netted) rock slopes are also considered, as they may be influenced by climatic changes, such as an increase in heavy rainfall events. Another key area of study is the increased frequency of freeze-thaw cycles due to climate change-induced temperature rises and their impact on the stability of rock slopes.

As part of MORICE, current maintenance practices and inspection methods are being reviewed to identify potential weaknesses in existing regulations. Digital processes are being integrated to systematically link damage scenarios with infrastructure classes. A major focus is on distinguishing between climate-related damage and extreme weather events, and expanding inspection strategies accordingly. The project also aims to develop new guidelines and working documents for Austria's road and rail infrastructure, to adjust inspections for future climate challenges. Overall, MORICE contributes to improving the safety and availability of infrastructure by promoting maintenance efficiency and sustainable repair concepts.

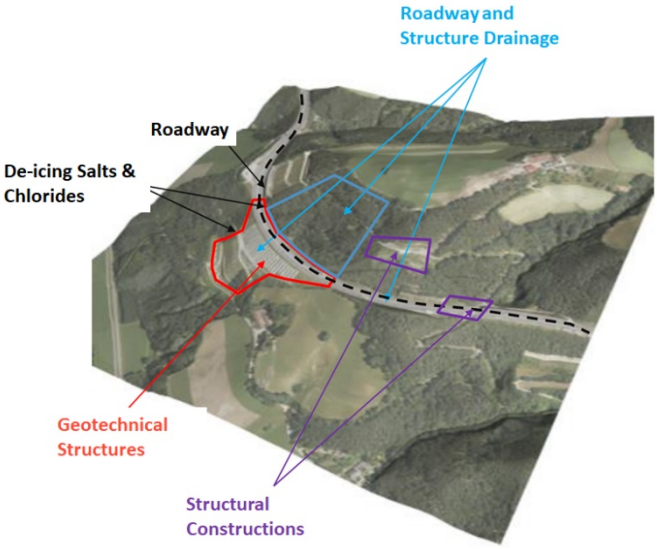


Figure: An overview of a typical Austrian highway section, which illustrates the diversity of structures within a small area. V. Reinprecht, 2024

Highlights I

Retirement Manfred Blümel

As we mark the retirement of Dr. Manfred Blümel, head of the rock mechanics laboratory at RMT, we reflect on his significant contributions to the field. Dr. Blümel has been a key figure at TU Graz for more than three decades, overseeing numerous critical projects in our lab. His expertise in laboratory rock mechanical testing, including his pioneering work on servo controlled shear tests, has made a lasting impact on the discipline. Under his guidance, the RMT laboratory became a vital hub for research and innovation, shaping new methods, and improving our understanding of rock behavior under various conditions.

Dr. Blümel's dedication to advancing both academic research and practical applications in geotechnics has been inspirational to colleagues and students alike. His career, filled with countless collaborative projects and publications, has set a high standard for the future of rock mechanics at TU Graz.

We wish him a well-deserved retirement and thank him for all his years of service and leadership.

Figure: Dr. Blümel at his fare-well party.

Figure: Wolfgang Hohl and Manfred Blümel.

Highlights II

Rigorosum Rainer Kienreich

On the 30st of September 2024, Mag. Dr. Rainer Kienreich successfully defended his dissertation titled “Steinschlagrisiko - Ein modulares Prozessmodell zur präventiven Gefahrenabschätzung”. His research tackled the increasingly important issue of rockfall risks in alpine regions, where outdoor leisure activities are growing in popularity. In consequence, path keepers, municipalities and tourism associations are increasingly confronted with liability issues arising from such hazardous events and questions regarding the required implementation of preventive safety measures. An answer to these questions demands an objective and systematic approach for the evaluation of the risks associated with rock falls for which Dr. Kienreich’s work offers an innovative and yet easily applicable solution.

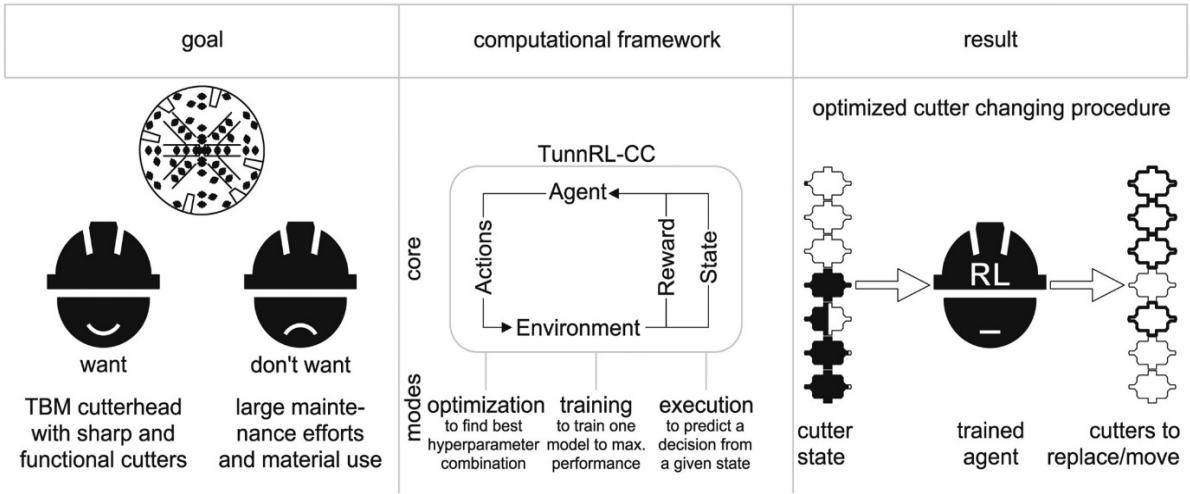
We congratulate Dr. Kienreich on this remarkable achievement and look forward to seeing the continued impact of his work in ensuring a safer use of mountainous landscapes.

Figure: F.l.t.r. Prof. Marcher, Dr. Kienreich, Prof. Winkler & Prof. Marte.

Publications and Presentations I

Towards reinforcement learning - driven TBM cutter changing policies

Together with colleagues from the Norwegian Geotechnical Institute (NGI) we developed a state of the art machine learning framework to optimize tunnel boring machine (TBM) cutter changing policies. Optimizing the cutter changing process for TBMs is crucial for minimizing maintenance costs and maximizing excavation efficiency. This paper introduces TunnRL-CC, a computational framework that utilizes reinforcement learning to autonomously determine cutter-changing strategies. TunnRL-CC's realistic simulation models cutter wear under varying rock conditions, including hard rock and blockyness. A reinforcement learning agent is trained to learn optimal cutter-changing policies based on a reward function that balances cutter conditions and operational costs. The agent demonstrates innovative decision-making, adapting to changing excavation conditions. TunnRL-CC's proposed methodology significantly differs from traditional cutter changing practices, which rely heavily on operator experience. Although TunnRL-CC has not been applied in practical projects, its theoretical basis and comprehensive computational experiments demonstrate its capability to significantly improve TBM cutter maintenance procedures.



Find the full open access paper here: https://doi.org/10.1016/j.autcon.2024.105505

Publications and Presentations II

9th International Conference on Geotechnical Research and Engineering (ICGRE 2024)

Dr. Sapronova, together with Prof. Marcher and F. Klein presented the research at the 9th International Conference on Geotechnical Research and Engineering (ICGRE 2024), held on April 14-16, 2024, in London, United Kingdom.

The paper "MWD Data Analysis for Risk Assessment and Process Optimization in Tunneling" focuses on using Measure While Drilling (MWD) data to train a machine learning (ML) model that enhances tunneling operations by predicting overbreak volumes, which is critical for ensuring safety and controlling costs in tunneling projects. While showing how advanced analysis of MWD data with ML models can help to improve real-time risk assessments, optimize excavation processes, and increase cost efficiency, the study highlighted the importance of data preprocessing and feature engineering in preparing MWD data for predictive models.

In paper it is stated that data preparation stage plays a crucial role during data driven modeling and data analysis. At this stage, the irrelevant information in raw data shall be removed and the relevance of the input variables towards predicting target outcomes shall be refined. The goal of the data preparation is to create more meaningful representations of the process with the data, aiming at the identification of underlying patterns essential for predictive models' training.

It is stressed that correlation analysis of input variables is an essential tool that can be used during data preprocessing and feature engineering stages. Analysis of the correlation between variables helps to identify significant relationships between variables that may be vital for accurate prediction tasks. By employing correlation analysis, the role of various MWD parameters on rock mass conditions and excavation volume predictions can be better identified.

Figure 1 illustrates how the results from the correlation analysis can be utilized to identify patterns in MWD data. The assumption is that similar correlation matrices represent similar drilling regimes, which are influenced by similar rock mass conditions. The correlation coefficients for data collected from a single borehole offering a more concise overview of the process: instead of analyzing timeseries for every parameter for each borehole, the ML model can be trained to measure the similarity between correlation matrices. By automatically creating several classes of the most distinct correlation matrices and associating each class with target variables, such as overbreak, the ML model can then predict the target variable for new boreholes by assigning the new correlation matrix to one of the predefined classes based on a similarity metric.

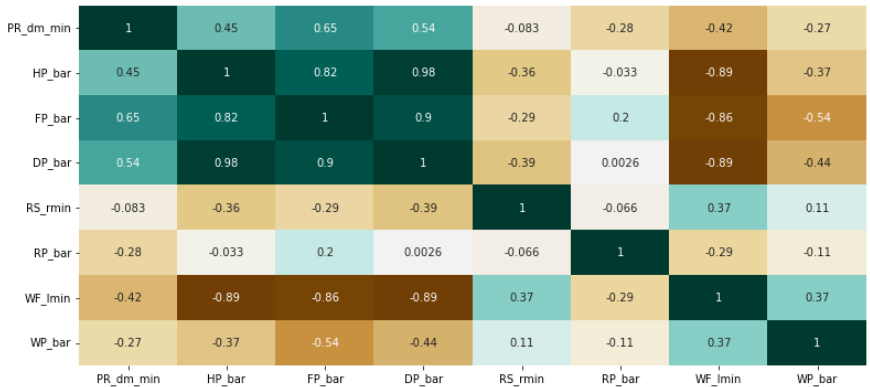


Figure: The correlation matrix (shown as a heatmap) representing the strength of relationships between different drilling parameters for a single borehole.

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Publications and Presentations III

Using Physics-Informed Neural Networks (PINNs) in Geotechnical Engineering

In many areas of engineering, solving complex problems requires the use of data. However, in fields like geo-mechanics, there is often limited data available, especially when studying processes in geological materials such as soils and rocks. Traditional data-driven models may struggle to provide accurate predictions when faced with such limited data. This is where **Physics-Informed Neural Networks (PINNs)** come into play.

PINNs are designed to overcome the challenge of limited data by integrating physical laws directly into the neural network. They do this by incorporating partial differential equations (PDEs), which describe the physics of the problem, into the network's training process. By using initial and boundary conditions from these PDEs, PINNs can effectively "learn" how to solve complex engineering problems, even with small datasets.

PINNs have been successfully applied in a variety of fields, such as computational fluid dynamics to model turbulent flows, material science to predict material properties, and finance for modelling economic systems. In geo-mechanics, they are being explored to model complex physical processes in geological media, such as the behaviour of soils and rocks.

Currently, the application of PINNs in geotechnical engineering is an evolving field. While PINNs offer great potential, there are still hurdles to overcome, particularly in accurately representing the complexity of subsurface conditions. Geological formations are highly heterogeneous, making it difficult to define precise boundary conditions. This challenge is compounded by the fact that geotechnical processes, such as soil-structure interactions and rock mechanics, are often governed by non-linear behaviours that are hard to capture with simplified PDEs.

Despite these challenges, recent advances in PINNs are promising. Researchers are exploring hybrid approaches that combine traditional numerical methods, such as the finite element method (FEM), with PINNs to improve the accuracy of predictions in geotechnical applications. By merging physics-based models with machine learning, these hybrid approaches aim to better handle the uncertainties and complexities of real-world geotechnical problems.

Recently, PINNs have been integrated with various types of field data, such as sensor data from tunnels and construction sites, which could significantly improve predictive capabilities. This is especially relevant in applications like tunnel boring and excavation, where real-time monitoring and prediction are essential for safe and efficient operations.

In September 2024 Ass. Prof. Alla Sapronova took part in the 19th Nordic Geotechnical Next Generation Meeting in Göteborg, Sweden, where PINNs application to the geotechnical problems were in focus at the "Digitalization/Visualization" session, with several examples of PINNs demonstrated. At the followed-up meetings with researchers from NTNU and SINTEF, Norway it was confirmed that PINNs could refine data-driven models by incorporating field data with physical properties of the process.

In the context of tunnelling, *Measured While Drilling (MWD)* data can provide valuable insights into the excavation process. As part of PhD research topic at RMT the feasibility of using PINNs with MWD data will be investigated by Mr. Soliman. The goal of his research is to accurately predict over- or under-excavation quantities resulting from blasting activities in tunnels. By combining physics-based equations with data, PINNs could offer more accurate predictions for tunnelling operations.

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Upcoming special session / issues I

1st international Rock Mass Classification Conference (RMCC)

Oslo, Norway (2024/10/30&31)

The RMCC will provide an arena for international rock mechanics experts from academia and practice. The conference stands under the paradigm "Rock Mass Classification meets the Challenges of the 21st Century" and will be organized by the Norwegian Geotechnical Institute. RMT's Georg Erharter will be chairman at the conference and Prof. T. Marcher has joined the scientific committee. LINK

Save the date!

Contact: georg.erharter@ngi.no, thomas.marcher@tugraz.at

Civil Engineering Design - CEND

CALL FOR PAPERS

Prof. Thomas Marcher and Prof. Wang Xiangyu (Curtin University) currently serve as guest editors for a special issue (SI) of CEND. Civil Engineering Design journal with a focus on “Advancing Infrastructure through Digital Innovation”. LINK
The December 2024 issue will be a special issue regarding Data Analytics, Machine Learning (ML) and Artificial Intelligence (AI).
Contribute your latest research and insights to the expanding landscape of Data Analytics, Machine Learning (ML), and Artificial Intelligence (AI). We welcome scholarly submissions showcasing innovative applications, advancements, and practical implementations of these technologies in the infrastructure field. Share your valuable contributions to enrich the discourse and advance the collective understanding of the transformative role played by intelligent data analytics and Machine Learning in diverse domains.
Deadlines will follow soon.

Upcoming special session / issues II

2. Steinschlagsymposium 2024 | 2nd Rockfall Symposium

Schladming, Austria (2024/11/28)

In Fortsetzung zu dem sehr erfolgreichen 1. Steinschlagsymposium 2022, soll das 2. Steinschlagsymposium 2024 eine Verbindung von Wissenschaft und Praxis für kommunale Verantwortliche, Verwaltung, Planer und Sachverständigen ermöglichen. Der Bogen wird von rechtlichen Themen über das Risikomanagement, Messtechnik, Geologie und Geotechnik bis hin zu Erfahrungsberichten gespannt werden. Im Rahmen einer Podiumsdiskussion werden Erwartungen aus der Verwaltung, Wegehalter, Tourismusverbänden und Versicherungen diskutiert. LINK zum Anmeldeformular.

Following on from the very successful 1st Rockfall Symposium 2022, the 2nd Rockfall Symposium 2024 will provide a link between science and practice for local authorities, administrators, planners and experts. The topics will range from legal issues, risk management, measurement technology, geology and geotechnics to field reports. Expectations from the administration, trail owners, tourism associations and insurance companies will be discussed in a panel discussion.

Save the date!

Contact: rainer.kienreich@tugraz.at, thomas.marcher@tugraz.at

Steinschlag – Risikoeinschätzung und Maßnahmen aus der Sicht kommunaler Entscheidungsträger

TU Graz

Programm

Begrüßung

09:00 **Begrüßung durch den Bürgermeister der Stadtgemeinde Schladming**
Bürgermeister Dipl.-Ing. Hermann Trinker
(Stadtgemeinde Schladming)

09:10 **Eröffnung**
Univ.-Prof. Dipl.-Ing. Dr.-Ing. Thomas Marcher
(Vorstand des Instituts für Felsmechanik und Tunnelbau, Technische Universität Graz)

09:20 **Umgang mit Steinschlagrisiko an natürlichen Felsböschungen**
Mag. Rainer Kienreich
(Institut für Felsmechanik und Tunnelbau, Technische Universität Graz)

Block I – Moderation Univ.-Prof. Dr.-Ing. T. Marcher

09:40 **Probabilistische Methoden zur Bewertung von Risiken**
Kevin Lundberg
Univ.-Prof. Dipl.-Ing. Dr. techn. Philip Sander
(RiskConsult GmbH, Innsbruck; Institut für Projektmanagement und Bauwirtschaft, Universität der Bundeswehr, München)

10:10 **AlpSenseRely – Multi-Methoden-Monitoring zur Vorhersage klima-induzierter Naturgefahren**
Leinauer Johannes, Msc.
Univ.-Prof. Dr. Michael Krautblatter
(Lehrstuhl für Hangbewegungen, Technische Universität München)

10:40 **Erfassung von Hangbewegungen und Steinschlägen mit geodätischen und faseroptischen Sensoren**
Univ.-Prof. Dr. Werner Lienhart
(Institut für Ingenieurgeodäsie und Messsysteme, Technische Universität Graz)

Block II – Moderation Mag. J. Leitner

11:10 **Alpine Infrastrukturen, Herausforderungen und Zukunftsperspektiven**
Dipl.-Ing. Clemens Matt, Msc.
(Generalsekretär des Österreichischen Alpenvereines)

11:40 **Auswirkungen des Klimawandels auf gravitative Prozesse: Welche Veränderungen der Klimaparameter erkennen wir?**
Mag. Dr. Michael Avian (Department für Klima-Folgen-Forschung, GeoSphere Austria, Wien)

12:10 **Die Schutzfunktion des Waldes vor geogenen Naturgefahren in der Schutzwald-Hinweiskarte im Waldatlas**
Dipl.-Ing. Frank Perzl
(Bundesforschungszentrum für Wald, Institut für Naturgefahren, Innsbruck)

12:40 – 13:40 Mittagspause

Block III – Moderation Mag. G. Valentin

13:40 **Steinschlaggefahr auf Infrastruktur und Siedlungsräume: Erfahrung aus der öffentlichen Verwaltung**
Dr. Volkmar Mair (Amt für Geologie und Baustoffprüfung, Bozen, I)

14:10 **Steinschlaggefahrenmanagement in Kärnten – Erfahrungen mit der Gefahrenhinweiskarte und bei Steinschlagereignissen**
Mag. Franz Goldschmidt
(Amt der Kärntner Landesregierung, Abteilung 8 - Geologie und Gewässermonitoring, Klagenfurt)

14:40 **Und dann kam Zacharias! Katastrophenereignis in der Steiermark Resümee und Ausblick**
Mag. Karin Schmölzer, Mag. Martin Schröttner
(Amt der Steiermärkischen Landesregierung, Abteilung 15, Graz)

15:00 **„Trockene" Felsstürze versus Bergsturz: Auswirkungen der Rheologie der Sturzmasse auf die Abschätzung von Wirkungsbereichen mit Simulations-Modellen**
Mag. Michael Mölk
(Fachbereich Geologie, Wildbach- und Lawinenverbauung, Innsbruck)

Block IV – Moderation Univ.-Prof. Dr. T. Marcher

15:30 **Steinschlag und Haftung**
Univ.-Prof. Dr. Walter Doralt
Ass.-Prof. Dr. Peter Schwarzenegger
(Institut für Zivilrecht, Ausländisches und Internationales Privatrecht, Universität Graz)

16:00 **Podiumsdiskussion**
Moderation: Univ.-Prof. Dr. Walter Doralt & Univ.-Prof. Dr. Thomas Marcher

Bezirkshauptmann Mag. Nico Groger
(Land Steiermark, Bezirkshauptmannschaft Liezen)

Dr. Volkmar Mair (Amt für Baustoffprüfung und Geologie, Bozen, I.)

Stadtamtsdirektor Mag. Johannes Leitner
(Stadtgemeinde Schladming)

Geschäftsführer Mag. (FH) Mathias Schattleitner
(Tourismusverband Schladming-Dachstein)

Mag. Helmut Sitter
(UNIQA Versicherung AG)

HR Mag. Gerald Valentin
(Land Salzburg, Geologischer Dienst)

17:00 Abschluss und Verabschiedung

Es kann, in Abhängigkeit des Umfangs der Diskussionsrunden, zu zeitlichen Verschiebungen kommen.

Änderungen vorbehalten

28. November 2024

Teaching I

Recent master graduate at RMT

Stefan Zelzer

Supervision: Marcher T., Geisler T.

"Location guideline and thermal performance assessment for energy storage in underground engineered caverns and shafts" was the title of DI Stefan Zelzer's master's thesis, which he defended on the 23rd of September. After his excellent presentation he thoroughly answered the questions of the examination committee, which led to him graduating with distinction. His research addresses guidelines for identifying suitable storage sites and analyzes the thermal performance of these structures over a 50-year period. Horizontal and vertical storage designs were evaluated as potential alternatives for long-term water storage, particularly for district heating and cooling applications. He focused on the specific conditions required for making underground thermal energy storage economically feasible, with an emphasis on the thermal properties of the surrounding rock. These properties are crucial for the cost-effective operation of storage systems. The main findings of his study were that single storage tanks offer better thermal efficiency compared to multiple storage configurations, while higher overburden structures transfer less heat to the surrounding rock, due to the temperature gradient in the earth crust, making them more favorable. This is outlined in the figure below.

Congratulations on the great work Stefan! Wishing you all the best in your future endeavors!

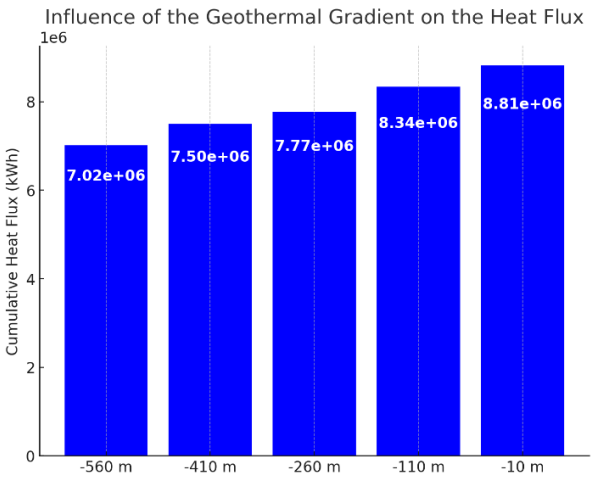

Figure: Influence of the geothermal gradient on the cumulative heat fluxes over time.

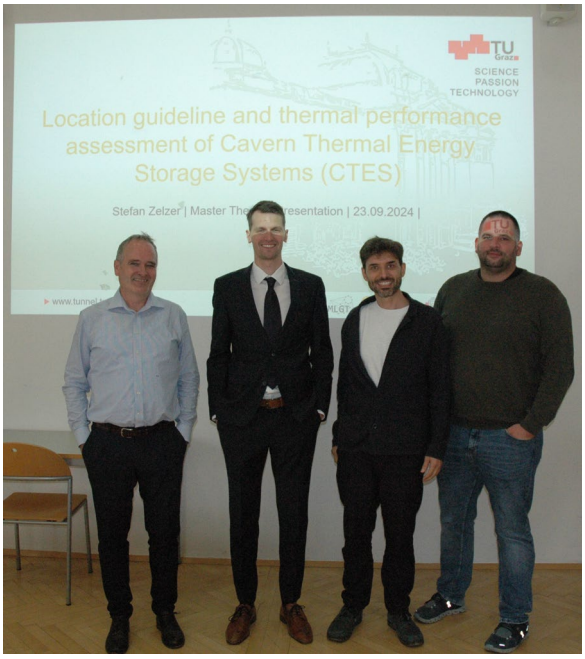

Figure: F.l.t.r. Prof. Marcher, Stefan Zelzer, Dr. Richter and Dr. Rebhan.

Teaching II

Lecture Alert: NTNU Joint Course

In May 2024 Graz University of Technology approved an application for a joint online course that will be jointly hosted by RMT and the Department of Geoscience and Petroleum, Norwegian University of Science and Technology (NTNU), Norway.

The course “Application of AI in Geotechnical Engineering: Data Science & Geotechnical Engineering” will start in Fall 2024 and will be taught by Prof. Thomas Marcher and Ass. Prof. Alla Sapronova, both RMT and from NTNU Prof. Kristin Hilde Holmøy and Prof. Hakan Basarir. The course aims to teach master students majoring in engineering the power of data, focusing on data pre-processing and data-driven modelling. Practical examples provided by NTNU and RMT will demonstrate the applications and limitations of data-driven methods.

Course Description

With the boom in digital transformation and automation, data's power in civil engineering is rising. Data-driven modelling is now used for proactive management, process optimization, decision support, and risk analysis in engineering projects. Despite large amounts of available data, quality constraints often limit its direct use in analysis. Data-driven modelling processes must include data quality check, model evaluation and shall comply with engineering principles to ensure robustness and reliability of model’s outputs.

This course will guides students through the data-driven project life-cycle: from data acquisition and pre-processing to analysis and result presentation. The course also covers an introduction to generative AI and co-pilot-enabling solutions.

A key component of this course is a hands-on data-driven project, based on a real dataset. Students will apply learned data science principles to tackle real-life geoengineering challenges.

The course is comprised of seven lectures and five hands-on exercises (two workshops, a hackathon, and two guided group projects).

There are still places available, you’d better be quick!

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Teaching III

Winter school

The **Second Winter School on Sustainable Innovations in Geotechnical Engineering** is organized by RMT and IBU (Institut für Bau und Umwelt). The event is scheduled to take place in February 2025 at the OST campus in Rapperswil. The program will cover topics such as sustainable construction materials, geothermal energy systems, data-driven modeling, and the application of generative artificial intelligence (AI) in geotechnics.

Participants will first explore recent advancements in sustainable materials, focusing on hart materials for construction—eco-friendly and resilient solutions that are critical to modern construction. Following that, the latest strategies in geothermal energy systems and their application in energy storage will be presented, providing insights into alternative energy sources, as the geotechnical engineering field shifts toward sustainability.

The program will also demonstrate how the analysis of Measure-While-Drilling (MWD) data can be applied in geotechnical engineering to develop modern decision support systems. Additionally, state-of-the-art AI tools, such as GPT, will be showcased to illustrate how generative AI is transforming geotechnical data analysis.

The Winter School combines lectures and interactive sessions designed to enhance knowledge-sharing and discussion. Remote participation is available, making it accessible to a wider audience.

This event offers an excellent opportunity to stay at the forefront of developments in sustainable solutions and AI-driven innovations in geotechnics.

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Teaching IV

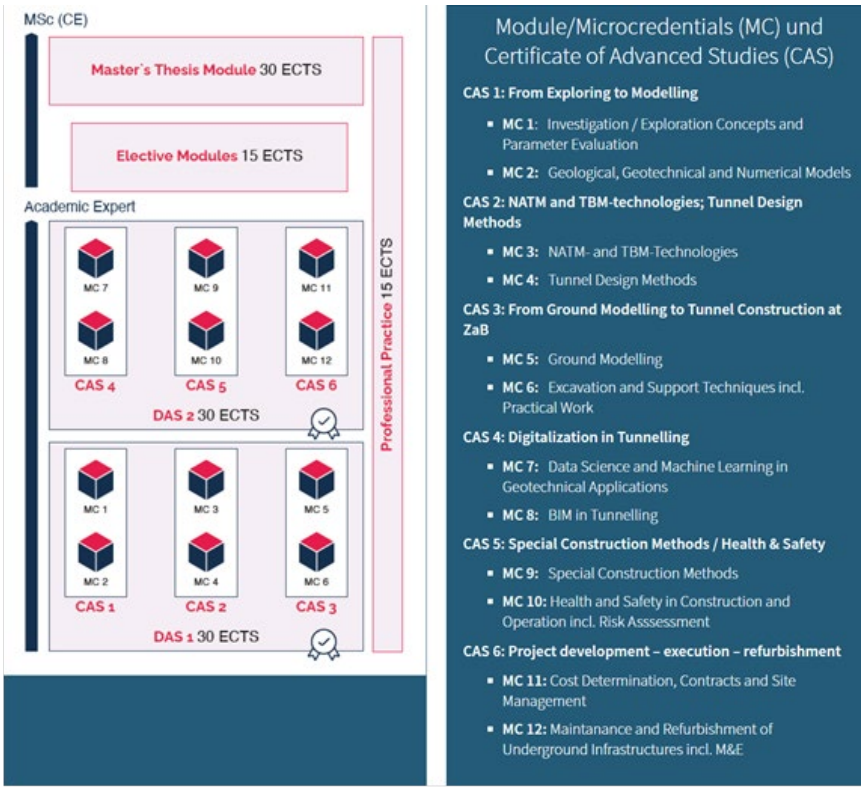
New Edition: "Joint NATM Master of Science: Construction, Rehabilitation, and Operation of NATM and TBM Tunnels"

The university programme in NATM Engineering is a collaboration between the Institute of Rock Mechanics and Tunnelling at TU Graz and the Institute for Subsurface Engineering at Montanuniversität Leoben. The 7th edition introduces a new modular structure to enhance flexibility and customization.

This programme is designed for engineers with a background in civil engineering or mining technology, as well as geotechnical engineers and engineering geologists seeking to specialise in tunnelling, particularly using the New Austrian Tunnelling Method (NATM).

In this unique Master's programme, offered globally, participants will deepen their expertise in tunnelling with a focus on NATM and tunnel boring machines (TBM). The modular structure allows participants to progress in stages or choose individual modules relevant to their interests.

The Master's programme offers flexible learning pathways, including completing the entire programme for a Master's degree, or selecting individual modules for microcredentials. Additional degree options include 'Certificate of Advanced Studies (CAS)', 'Diploma of Advanced Studies (DAS)', and 'Academic Expert (AE)' based on defined module combinations.



All details: www.natm.at

Faces

...today‘s with our new secretary and one of our student assistants working in the lab.

Irene Preitler

Hello everyone, my name is Irene Preitler and I took up the position of institute secretary at RMT in September 2024.

After successfully completing the BD Benko Business School in Graz, I was finally able to take my office skills out into the world. After working in the same company for over 10 years, it was time for a change at the beginning of 2020 and for the next two years I worked as a secretary in two different companies until the best part of my life so far began, I welcomed my daughter into this world and from then on we explored the world together.

Before my maternity leave ended, I began to ask myself where my career would take me and three months later I found myself here at RMT where I was warmly welcomed by the whole team. I am looking forward to supporting the institute with my skills, developing myself further and gaining new impressions and experiences.

Paul Dax

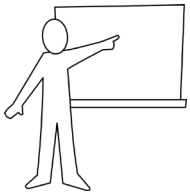
Dear interested readers, my name is Paul Dax, and I’m currently studying for my bachelor's degree in Civil Engineering at TU Graz. Besides my studies, I have been working at the Rock Mechanics and Tunneling (RMT) Institute for a few months now. In the third semester of my bachelor’s degree, I had the chance to get my first look at rock mechanics. At that time, I didn’t fully understand what this field was about, but this first experience sparked my interest and made me want to learn more about the fascinating and complex aspects of rock mechanics.

What fascinates me most is the diverse and interdisciplinary nature of rock mechanics. I find it very exciting to understand how rocks behave under different conditions and to develop solutions for real engineering problems. It’s also rewarding for me to gain a better understanding of nature through this work.

I’m looking forward to learning much more from my supervisors and colleagues and deepening my knowledge.

Diary of Events

> Thursday Lecture Series by Dipl.-Ing. Gerhard Gobiet
Graz, Austria (2024/10/24, 17:15 CET)



Lecture entitled “Semmering-Basistunnel: Herausforderungen eines Großprojekts von Start bis Ende”. by Gerhard Gobiet, Project Manager of the Semmering-Basetunnel project, ÖBB-Infrastruktur AG. The lecture will take place in the lecture room HS L (Lessingstraße 25/1, 8010 Graz).

> VÖBU Seminar “Forschung in der Geotechnik”
Graz, Austria (2024/11/21, 09:00 CET)

Die Komplexität der Herausforderungen bei geotechnischen Fragestellungen hat in den letzten Jahren ständig zugenommen. Da Universitäten eine Schlüsselrolle in Forschung und Entwicklung im Bereich der Geotechnik einnehmen, ist es das Ziel dieses Seminars den Wissensaustausch mit PraktikerInnen und Interessierten zu forcieren. Das Seminar wird im Hörsaal VI an der TU Graz (Rechbauerstraße 12, 8010 Graz) stattfinden.

LINK zum Programm. LINK zur Anmeldung.

> 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. https://atc2-symposium.eu/

ATC²
AT Austrian Tunnel Competence Center
Graz University of Technology | Montanuniversität Leoben

> 2nd Mini-Symposium “Rockfall”
Schladming, Austria (2024/11/28)

The second edition of the Rockfall Symposium in Schladming will again shed light on experiences and approaches to this topic from various disciplines. Save the date and stay tuned for further updates.

LINK to the program. LINK to the registration.

>“Barbarafeier” 2024 – reloaded
Graz, Austria (2024/11/29)

RMT’s “Barbarafeier” will be reloaded in a sense that our students will be in the focus. Students achievements and a guest lecture by a “non-profit” organization will kick off the event, followed by drinks and snacks in a relaxed atmosphere. All our friends are welcome to join.
More Information on the new format can be found on the next page.

> 6th International Conference on Information Technology in Geo Engineering (ICITG)
Oslo, Norway (2026/10/13-16)

The 6th International Conference on Information Technology in Geo-Engineering (6th ICITG) will be an arena to discuss all topics related to the ongoing digital transformation in Geo-Engineering. Case studies of IT in Geo-Engineering, integration of digital systems (Scan2BIM, BIM2FEM, etc.), benchmark datasets, information modelling, monitoring technology and artificial intelligence are some of the key topics of the 6th ICITG. It is organized under the auspices of the Joint Technical Committee 2 (JTC2) on “Representation of Geo-Engineering Data” of the Federation of International Geo-Engineering Societies (FedIGS).

Diary of Events

Barbarafeier 2024

The traditional Saint Barbara's celebration at our institute usually takes place on the Friday before St. Barbara's Day, which falls on December 4th. This event has long been a valued opportunity for bringing together sponsors from the tunnelling sector, their guests, and our partner institutes in a spirit of community and collaboration. However, recent challenges, including rising catering costs and mergers among our sponsoring companies, have made it increasingly difficult to maintain a cost-neutral event under the previous format.

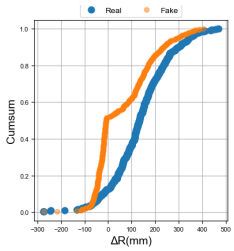
To address these challenges and enhance the event's impact, we have decided to reorganise the celebration with a renewed focus on three key aspects. First and foremost, our students will now be at the core of the celebration, as they represent the future of our industry. Secondly, we have invited a business partner to participate as a sponsor, providing a bridge between industry and academia that will offer our students insights into real-world applications. Lastly, we have involved an NGO closely connected to our field, adding a meaningful social aspect to the event. This year, we are proud to collaborate with Engineers Without Borders and Implenia Austria, whose work embodies the positive impact that engineering can have on society.

The event will begin at 16:00 with short introductory speeches from our institute, our business partner Implenia Austria, and Engineers Without Borders. Following the formalities, guests are invited to enjoy drinks and snacks in a relaxed and informal atmosphere, providing ample opportunity for networking and conversations among students, industry professionals, and academics.

We very much hope that you enjoy this new format to the celebration, and we look forward to welcoming you to an event that highlights the importance of education, industry partnership, and social responsibility in our field.

Have a look at our Master‘s Theses I

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



- **Improving the quality of synthetic measurement while drilling (MWD) data generated from SMOTE technique. (supervisor: A. Soliman)**

The project aims to use feature engineering and data pre-processing techniques to improve the quality of synthetic (fake) MWD data that generated from SMOTE algorithm and it’s extensions. E.g., borderline SMOTE. So that, the synthetic data will be more following the real data e.g., in terms of the cumulative distribution.

- **Aspects of steel – rock contacts in TBM tunneling (supervisor: G. Erharter)**

New contractual developments set a focus on the effect of shield friction in hardrock TBM tunneling. Low speed and low stress contacts between steel and rock have not been explored a lot so far and the goal of this study is to focus on geometrical and mineralogical aspects of contact points between tunnel boring machine (TBM) shields and the tunnel wall. Research questions that need to be answered are for example: What are the contact points between a TBM shield and the tunnel wall in slanting and curved driving conditions? Which mode of TBM driving is most unfavorable in terms of expected frictional resistance? Are there correlations to standard abrasivity tests such as the Cerchar abrasivity? Methodologically the thesis should contain theoretical work, analog models, and geotechnical laboratory work (abrasivity tests). The master thesis is part of a currently ongoing bigger research endeavor on this matter.

- **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.

Have a look at our Master's Theses II

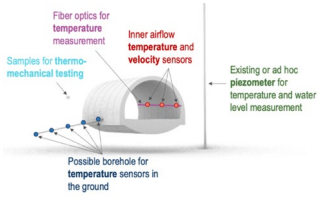
- **Characterization and Modeling of Hard Soil/Soft Rock considering Anisotropy and Swelling Capacity (supervisor: I. Metzler)**

The ChaMod-HSSR project (cf. Rock Report 03/23) aims at an extensive characterization of transitional material excavated with the construction of the Angath adit in Tyrol, Austria. The local Unterangerberg formation comprises hard soil/soft rock (HSSR) with strong anisotropic tendencies as well as a certain swelling capacity due to the clay minerals present within the rock mass. To achieve a comprehensive rock mass characterization, the project objectives are the creation of a reliable and precise database of geological and geotechnical parameters to be achieved via in-situ and laboratory tests, and are to be implemented in numerical models in the third step. The latter aim at predicting relevant, possibly extraordinary material behavior on both, small- and large-scale models. Master's theses may be assigned for selected parts of the project depending on the student's interests as well as the current project and construction progress.

- **Definition of discontinuities in case of foliated rock (foliation) (supervisor: T. Marcher)**

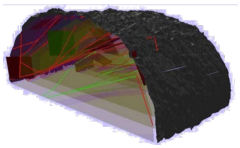
Determination of the mechanical properties of the discontinuities using selected examples of Phyllites in the Central Alps (Switzerland and Austria). Backcalculation on the influence of the schistosity on the tunnel stability. Determining the influence of tunnelling on the activation of potential discontinuities.

- **REuse for ENergy Exploitation and Storage of Existing Urban Tunnels in Europe (supervisor: G. Kaml)**



The project REGENERATE focuses on the thermal use of existing tunnel structures. The goal is to harness thermal energy for heating and cooling in urban areas. Existing tunnels will be converted, for example, as heat exchangers and energy storage systems. The project is being carried out in cooperation with the Polytechnic University of Turin (Italy), the Technical University of Cluj-Napoca (Romania), and the Technical University of Darmstadt (Germany), among others. These partnerships enable the consideration of different climate zones, urban areas, and energy demands. The main objective of the project is to contribute to the decarbonization of urban areas. To this end, various types of tunnels are being examined to identify suitable structures for energy adaptation. Their potential is being evaluated through pilot monitoring and numerical modeling. For interested students, master's theses on selected topics will be offered, depending on the progress of the project.

Have a look at our Master‘s Theses III

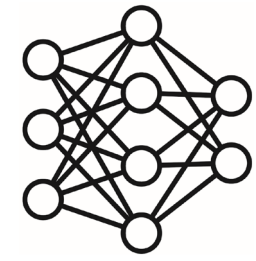


- **Digital Face (supervisor: A. Sapronova)**

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 tunnelling. 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.

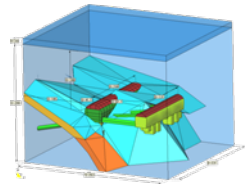
- **Experiences gained with regard to explorations of long, deep-seated tunnels (supervisor: T. Marcher)**

How many exploratory boreholes are necessary in the course of long, deep seated (base-)tunnels? Which insitu and laboratory tests are carried out as standard? How are the explorations distributed between the different project phases? The work focuses on the collection of data based on the experience gained in the construction of deep-seated tunnels in the Alpine region. The data will be systematically analyzed and the results of the different tunnel constructions will be compared.



- **Machine Learning (supervisor: P. Unterlass)**

An exciting area of research is being led by the 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 anomaly detection in multivariate tunnel boring machine operational data and another with automatized information extraction from archived civil-engineering reports.



- **A case study: Cavern Stability Analysis (supervisor: T. Marcher)**

In the course of excavating a cavern, difficult tunnelling conditions were encountered in an executed project. The aim of the thesis is to numerically backcalculate the observed behaviour. The involved company offers a position as a trainee and practice-oriented supervision.

Cooperation

… please contact us in case we forgot you here