ROCK REPORT

Mechanics & Tunnelling

Quarterly Newsletter of the Institute of Rock Mechanics and Tunnelling

03 Volume 4
October 2023

RMT

NAWI Graz
GEOZENTRUM

TU Graz
Graz University of Technology

MLGT
Machine Learning in Geotechnics

Content

Marcher's Column

A very active summer is coming to an end and with this RockReport we would like to give you an insight into our work over the last 3 months.

A milestone was the completion of the 6th edition of the 3-year-NATM-course for participants from all over the world. In the beginning, the course was affected by COVID-19. Nevertheless, we were able to run the course as planned; however, the attendance of the participants in Austria was limited to 2 of a total of 6 modules (the others had to be done online).

8 participants were able to complete their Master's theses in the last 6 months. The final touches were made in module 6 at the Graz University of Technology and the Montanuniversität Leoben in person. Great, practice-oriented theses were produced in the process. After the successful Master's examination, the graduation was duly celebrated last week, October 2nd, 2023.

We look forward to staying in touch with the graduates; after all, they are ambassadors of Austria's tunnelling art in the world! Of course there will be a continuation of the course, which, according to a new university law, will take place in a slightly modified form. We will probably be able to start the 7th course in winter semester 24/25.

Other highlights were the Summerschool TU Graz - FH OST, as well as numerous active contributions, session chairs and organisations of short courses in Würzburg, Cork and Trondheim, among others.

At the end, I would like to point out 2 events that we are organising:

On the one hand, the ATC² symposium December 1st followed by RMT's Barabara celebration. This year, the symposium's theme is "Shallow Tunnels, Subway constructions". Currently, this topic is of great importance, not only in Vienna but also other Austrian cities, such as Salzburg and Graz. We will commence the symposium with current information on the urban mobility transformation in the city of Graz. Afterwards, the symposium in the morning will focus on the S-Link, the underground railway line of in the city centre of Salzburg. Insights into major international underground projects from Gothenburg to Paris, Santiago de Chile, and Melbourne round off the programme in the afternoon.

Furthermore, on December 14th we have a highly interesting presentation at TU Graz about the Norwegian projects along the route E39 with deep-seated tunnel constructions, such as the ROGFAST project, as part of the Thursday lecture series.

Enjoy reading the current RockReport, Glückauf!

Thomas Marcher

Title Picture:
Tunnel Face in the iron-rich limestone at ZaB.
Picture: Paul Unterlass

thomas.marcher@tugraz.at

October, 2023 – published
Thomas Geisler – editor in chief
tunnel@tugraz.at – contact

Research Focus

Summer School TU Graz – OST successfully held in Switzerland

This brand-new format of cooperation between RMT and our partner OST - Ostschweizer Fachhochschule aims at sharing expert knowledge between the recognized institutions, complementing our student's curricula with specialized topics and communicating the state-of-science to practitioners. This event is designed as complement to the Winter School which was launched February 2023 and successfully at TU Graz.

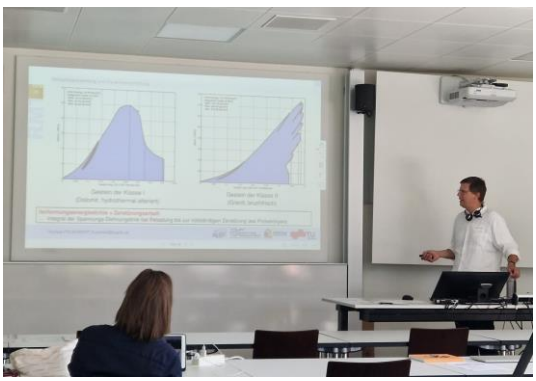
The first Summer School hosted by RMT and IBU Institut für Bau und Umwelt at OST – Ostschweizer Fachhochschule took place on September, 7th and 8th at the Rapperswil campus in Switzerland. Fascinating topics such as corrosion in retaining walls, laboratory testing in rock mechanics as well as the application of artificial intelligence in tunneling were covered.

On the first day M. Rebhan started with a presentation on testing and inspection of structures and buildings in geotechnics. He provided fundamental background knowledge as well as plenty of examples and case studies. His contribution was followed by a talk given by L. Bircher from ETH Zürich who introduced a novel method for underground corrosion inspection of concrete cantilever retaining walls. In the afternoon session T. Frühwirt took the audience along to lab testing of rock samples in uniaxial compression. Common pitfalls in the design and evaluation of these important group of rock tests were pointed out to the practitioners and best-practice examples were given to the audience.

The second day was dedicated to data science, data analysis and the application of artificial intelligence in geotechnics. A. Sapronova introduced the audience to the data life cycle, data acquisition, preprocessing, visualization and analysis. She concluded with a insight into the training and testing of predictive machine learning models and presented applications for real-time monitoring to detect abnormal behavior of tunnel boring machines.

There was enough room and time for lively discussions during and after each of the presentations so that the speakers could successfully pass their extensive knowledge to an audience of experts and students. The presentations were cleverly complemented by exercises and application examples, making the learning process extremely varied.

We are already looking forward to the biannual repetition of this event (summer- and winterschool) and to continuing our cooperation with OST - Ostschweizer Fachhochschule. This collaboration also opens up exciting opportunities for our students within the framework of the Erasmus agreement with our Swiss colleagues.



fruehwirt@tugraz.at

Site Visit

Unterangerberg Site Visit

RMT's research project ChaMod-HSSR (Characterization and Modelling of Hard Soil/Soft Rock considering Anisotropy and Swelling Potential) comprises, among other objectives, extensive rock mass observation and monitoring campaigns during the excavation of an exploratory tunnel. Tunnel excavation has started and the first meters were driven through the Unterangerberg formation. This argillaceous lithology comprises clayey marls with low thickness sandstone layers. In the course of the project, both in-situ and laboratory test campaigns are planned, serving as scientific basis for the subsequent geotechnical parameter determination. In the beginning of September, RMT was able to see the first excavated tunnel meters in the course of the on-site geotechnical meeting. Soon, our proposed testing program will be implemented in the tunnel and we are very much looking forward to getting data out of it.

ChaMod-HSSR
Characterization and Modeling of Hard Soil/Soft Rock considering Anisotropy and Swelling Capacity

Figure: First excavated meters of the Angath adit.

Publications & Presentations I

ISMLG 2023 Session Chair | Cork, Ireland

The Special Session "Data Quality Assurance and Pre-processing in Geoscience" at the 4th International Symposium on Machine Learning & Big Data in Geoscience, held at University College Cork in August 2023, provided a comprehensive overview of various critical aspects related to geotechnical data. The Session successfully facilitated a constructive discussion surrounding various challenges related to data quality assurance and pre-processing.

Chaired by Ass. Prof. Dr. Alla Sapronova, Dr. Thomas Dickmann, and Prof. Marlene Villeneuve, the session explored tools and techniques for enhancing geotechnical data quality while addressing specific challenges posed by sparse and imbalanced datasets.

The discussion was divided into several key areas: handling sparse and imbalanced datasets, improving the accuracy of machine learning models, specialized techniques for detecting rare events, and trade-offs involved in preprocessing with respect to noise reduction and outlier removal methods.

Prof. Villeneuve's presentation first addressed the challenges associated with preprocessing practices for MWD (measurement-while-drilling) data. Building on this foundation, Dr. Sapronova continued the discussion by illustrating the advantages that correlational analysis can provide in the context of MWD data preprocessing.

These presentations effectively laid the groundwork for a valuable and engaging dialogue on MWD data quality and preprocessing techniques, which saw active participation from representatives of institutions such as TU Graz, the University of Leoben, SCADA, and NGI.

Mr. Unterlass presented his findings regarding generating reliable synthetic data to address issues associated with imbalanced datasets or limited real-world information availability—a crucial aspect when working with geotechnical applications where obtaining sufficient samples may be challenging or costly (next page) .

Other contributions spanned a wide array of topics, including machine learning model accuracy improvement strategies, human perception's role during data labeling processes, and metrics suitable for assessing extremely sparse dataset quality.

Throughout this session, participants gained valuable knowledge about best practices for handling geotechnical datasets as well as understanding potential limitations associated with certain metrics used during assessments—contributing to the overall development of data quality assurance and preprocessing techniques within geoscience.

Publications & Presentations II

ISMLG 2023 conference talk | Cork, Ireland

Generating synthetic TBM operational data using generative adversarial networks (GANs)

Unterlass, P.U., Erharter, G.H.., Sapronova, A., Marcher, T. (oral presentation at 4th International Symposium on Machine Learning & Big Data in Geoscience 2023)

Our institutes research focus on machine learning applications in geotechnics, this time with a focus on the generation of synthetic data, was once again represented with a presentation at a pertinent symposium. Paul Unterlass, was given the chance to present and discuss his latest research with the talk titled "Generating synthetic TBM operational data using generative adversarial networks (GANs)".

With the third wave of machine learning within the last decade, data has proven to drive innovation and improve decision-making through countless industries, making it a more valuable resource then ever before. However, real world (geotechnical) data comes with its own challenges, that's why this talk was given within the "data quality assurance and pre-processing in geoscience" session, hosted by RMTs Dr. Alla Sapronova. This work presents a deep generative model approach to generate synthetic TBM operational data, to be used for existing dataset augmentation (e.g., balancing, oversampling, etc.).

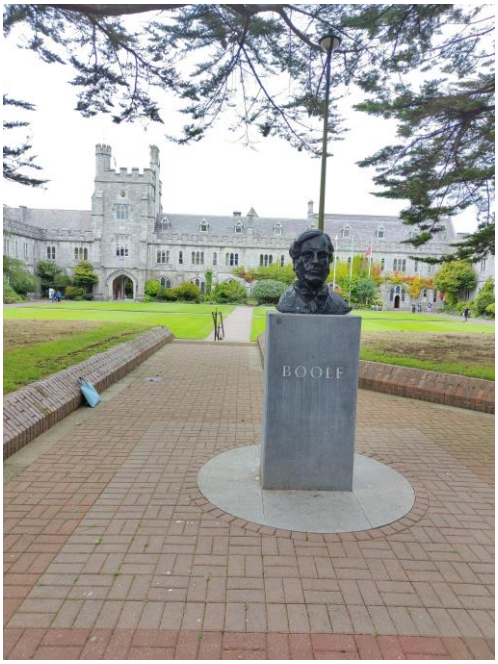


Figure: Statue of George Bool in front of the University College Cork. Bool is well known for his "Boolean Algebra", which is credited with laying the foundations for the computer technology.

Publications & Presentations III

Session Chair and Short Course IAMG Trondheim 1/2

The 22nd Annual Conference of the International Association for Mathematical Geosciences (IAMG) took place in Trondheim in 2023. The conference gathered experts from over 65 countries to focus on the growing importance of geodata. IAMG, a multidisciplinary society with 700-800 members, aims to advance math, statistics, and informatics in the geosciences. The key topics covered included mining geostatistics, machine learning, and uncertainty modeling, among others. The event served as a platform for scientific and social discussions around data exploitation and management.

The special session "Rare Events Detection for Risk Management in Geoengineering" was a part of the IAMG 2023. Chaired by Dr. Alla Sapronova and Prof. Thomas Marcher, the session explored the challenges and methodologies associated with detecting rare yet high-impact events in geoengineering.

The session covered a wide range of topics, including data preprocessing, feature engineering, and rebalancing datasets. It aimed to offer a comprehensive understanding of current best practices for rare event detection while emphasizing its importance within risk management strategies in geoengineering.

One presentation focused on the application of unsupervised learning methods for predictive modeling in geoengineering projects. This discussion highlighted both the potential benefits and limitations associated with using unsupervised learning techniques to achieve accurate predictions.

Another key topic was dataset balancing through various machine-learning approaches. A thorough evaluation of different strategies allowed participants to gain insight into optimizing imbalanced datasets commonly found in geoengineering projects.

The use of Autoencoders as a novel tool for identifying rare but significant events was also explored during the session. Presenters demonstrated how this technique could enhance rare event detection capabilities within civil engineering applications.

Generative Adversarial Networks (GANs) were discussed as well, specifically their potential role in augmenting sparse geotechnical data using conditional WGAN-GP approaches.

Moreover, inventory data's utility as a decision support mechanism was examined - showcasing how it can be leveraged effectively within geoengineering projects to improve overall decision-making processes.

Lastly, presenters evaluated various metrics' effectiveness when assessing extremely sparse datasets' quality within geotechnics settings; this analysis helped identify which measurements are most suitable for evaluating dataset quality under specific circumstances.

The special session served as an all-encompassing platform that facilitated discussions about detecting rare events while highlighting the significance of improving data quality through computational techniques like machine learning algorithms and GANs. Such advancements ultimately contribute to better risk management practices within the field of geoengineering.

alla.sapronova@tugraz.at

Publications & Presentations IV

Session Chair and Short Course IAMG Trondheim 2/2

The course "From Data Preprocessing to Precision: Best Data Management Practices for Data-Driven Modeling in Geoengineering" took place as part of the IAMG 2023. Organized by Dr. Alla Sapronova, the course garnered considerable attention by a diverse group of participants. This included international students as well as staff members from the Norwegian University of Science and Technology (NTNU). The course was highly praised for its content and presentation style.

The course was designed for people with a background in civil engineering or geosciences, and it successfully bridged the gap between theoretical concepts and real-world applications, using actual datasets like data from cone penetration tests or tunnel boring machines.

The course was structured into multiple segments, each delving deep into the intersection of data science and geoengineering. It covered an introduction to Data Science and its relevance to Geoengineering and was followed by a detailed discussion on Data Quality, emphasizing the importance of data preprocessing, integration, and security.

After a lunch break, the course continued, with a focus on data-driven modeling and machine learning applications in geoengineering. The last segment of the course dealt with practical aspects like data preprocessing, feature engineering, and evaluation metrics tailored for geoengineering tasks. The course also had a special section devoted to the challenge of rare event detection.

The participants engaged actively during Q&A sessions, indicating a high level of interest. By the end of the course, attendees received the certificate of Course participation.

Overall, the course was a thorough exploration of how proper data management can drive success in geoengineering projects, and it was met with great interest from the attendees.

The main building of NTNU seen from the northwest. Photo: Eirik Refsdal, 2005 (CC-BY 2.0)

alla.sapronova@tugraz.at

Publications & Presentations V

Fachsektionstage Geotechnik 2023 Würzburg

Our institution actively participated in this year's Fachsektionstage Geotechnik 2023 organized by the Deutsche Gesellschaft für Geotechnik e.V. (DGGT). We contributed a series of papers focusing on practical aspects such as the application of machine learning techniques in geotechnics/tunneling, anisotropy in tunneling, and the geothermal utilization of drainage water in tunneling scenarios. Unfortunately, due to seasonal illnesses, not all accepted contributions could be presented, resulting in a partially attended event. However a presentation could be given by Thomas Geisler, who discussed the geothermal use of tunnel drainage water and the enhancement of the geothermal power.

The various sessions covering different geotechnical topics provided attendees with a broad overview of current developments, scientific advancements, and major projects in the field.

In addition to the technical insights, it's worth acknowledging the well-organized event and the pleasant atmosphere of Würzburg.

The thoughtful planning and execution of the Fachsektionstage created a conducive environment for knowledge exchange. The city's charm added to the overall experience, making it a perfect place of academic discussions and cultural appreciation. As we reflect on the gained knowledge and positive experiences, we look forward to future Fachsektionstage. Continued collaboration and exploration within the geotechnical community remain exciting prospects, and we anticipate further contributions and learning opportunities in the coming events.

The full papers can be found in the conference proceedings:

Anisotropie – ein Stiefkind der Felsmechanik im Tunnelbau? by *Marcher, T., Winkler, M.B., Metzler, I.*

Chancen und Risiken bei Anwendung von ML-Techniken in der Geotechnik/Tunnelbau by Unterlass, P.J., Sapronova, A., Marcher, T.

Thermisches Potential der Drainagewässer im tiefliegenden Tunnelbau by Marcher, T., Geisler, T.

Figure: Lecture hall at the congress center in Würzburg.

Publications & Presentations VI

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

Anisotropie – ein Stiefkind der Felsmechanik im Tunnelbau? (Anisotropy - a stepchild of rock mechanics in tunnelling?)

Marcher, T., Winkler, M.B., Metzler, I. (Proceedings of the „Fachsektionstage Geotechnik 2023“ – in german)

The assumption of an isotropic material behavior is still common practice for tunnelling simulations. Strictly speaking, this assumption is only valid if the influence of directional dependencies on the resulting deformations and stresses is subordinate. In lithologies with a high degree of anisotropy, such as shales and phyllites, the orientation properties of material properties such as strength and stiffness should be taken into account in order to avoid serious misjudgements of the load-bearing capacity and serviceability of the surrounding rock and the tunnel lining.

Examples of completed projects are used to highlight gaps in modelling and simulation techniques. Furthermore, the use of common modelling approaches is presented. The challenge of deriving meaningful material constants from laboratory experiments is addressed. The main focus is on the careful selection of suitable test methods, as well as on the correct procedure for the evaluation of results. The focus of the paper is on the improvement of current approaches to anisotropic constitutive modelling.

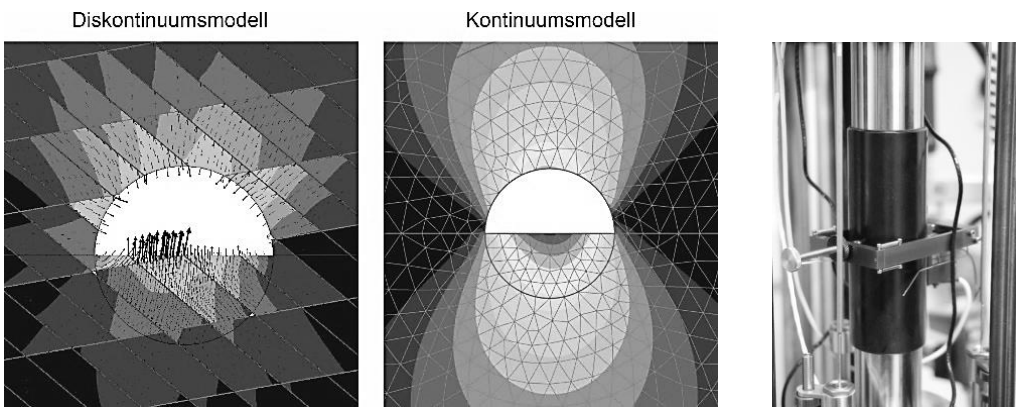


Figure: Left: Comparison between discontinuum and continuum modelling of anisotropic rock masses. Right: Measurement of lateral deformation using diametral strain extensometer.

Publications & Presentations VII

Discussion on the paper "Success and challenges in predicting TBM penetration rate using recurrent neural networks" by Feng Shan, Xuzhen He, Danial Jahed Armaghani, Pin Zhang, Daichao Sheng

Erharter, G.H., Marcher, T. (Published in Tunnelling and Underground Space Technology 2023 – Open Access)

After writing a first critical paper about machine learning (ML) based time delayed prediction (TDP) in TBM tunnelling in 2021, Dr. Erharter and Prof. Marcher now wrote another short discussion on this topic. The paper discusses using ML to forecast TBM operational data, specifically predicting the TBM's penetration rate ahead of its current position. Despite seemingly good error metrics, past attempts in various fields have shown that TDP often fails to provide accurate forecasts and Erharter and Marcher (2021) caution researchers about these limitations. The discussion paper again highlights the recurring issue of misleading error metrics in ML applied to geotechnics and emphasizes the need to evaluate ML results from a practical engineering perspective, not just based on model validation, to ensure ML's usefulness in geotechnical engineering.

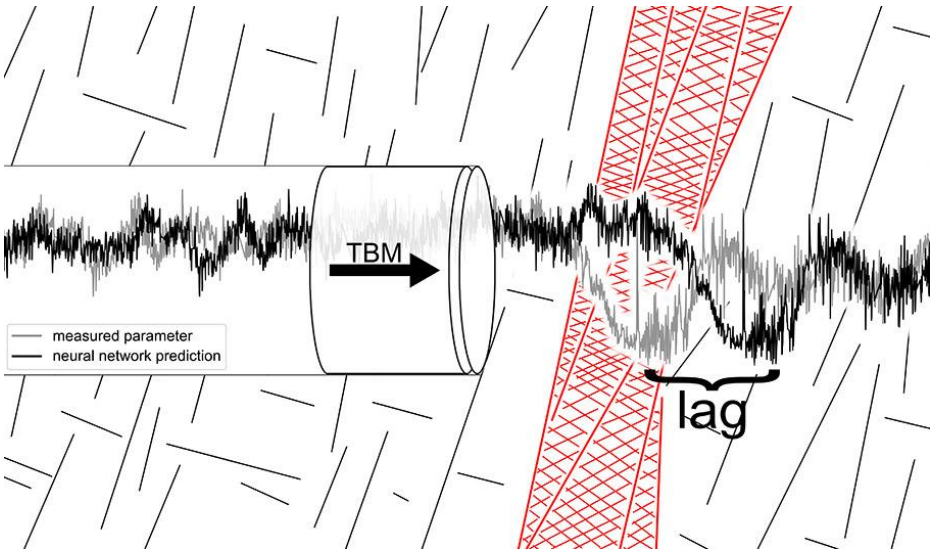


Figure: Graphical Abstract from Erharter and Marcher (2021).

Publications & Presentations VIII

Upcoming RMT contributions at ISRM Congress 2023

The ISRM Congress in Salzburg is scheduled from October 9 to October 14, 2023. Our institute is actively engaging in the event with diverse contributions, including:

- **A guidance for the optimal site location of Cavern Thermal Energy Storage (CTES)**
  S. Zelzer, T. Geisler, T. Marcher
  T16 ; Presentation, Wednesday, October 11, 17:45, Doppler Hall (4th upper floor)

- **Evaluation of trends in tunnel lining utilization with regards to the moment of ring closure**
  V. Shringi, M. B. Winkler, A. Kluckner, T. Marcher
  T13; Poster Session, Thursday, October 12, 12:15, Papageno Hall (ground floor)

- **Towards the development of a harmonized inventory database for decision support: automatized information extraction**
  A. Sapronova, P. J . Unterlass, V. Shringi, T. Marcher
  T05; Poster Session, Thursday, October 12, 15:45, Doppler Hall (4th upper floor)

- **A theoretical framework for calibrating the transversely isotropic elastic rock parameters from UCS tests on cylindrical specimens using circumferential strain measurements**
  M. B. Winkler, T. Frühwirt, T. Marcher
  T15; Presentation, Thursday, October 12, 17:30, Mozart Hall (ground floor)

- **MWD data analysis for optimization of tunnel excavation**
  A. Sapronova, P. J. Unterlass, K. Sakai, S. Miyanaga, A.A. Soliman, T. Marcher
  T05; Presentation, Thursday, October 12, 17:30, Doppler Hall (4th upper floor)

- **Rock Fall Risk - Modular Risk Management**
  R. Kienreich, A. Kluckner, T. Marcher
  T07; Poster Session, Thursday, October 12, 17:45, Trakl Hall (3rd upper floor)

- **A 2023 perspective on Rock Mass Classification Systems**
  G. H. Erharter, T. F. Hansen, S. Qi, N. Bar, T. Marcher
  T06; Poster Session, Thursday, October 12, 17:45, Europa Hall (2nd upper floor)

- **Comparison of analytical and numerical solutions for stresses and displacements around unlined tunnels with arbitrary cross sections inside anisotropic rock masses**
  M. B. Winkler, A. Yaz, T. Marcher
  T16; Presentation, Friday, October 13, 09:45, Doppler Hall (4th upper floor)

- **An iterative scheme for the determination of the conformal mapping coefficients used in closed form solutions for tunnels with arbitrary geometry**
  M. B. Winkler, T. Marcher, A. Yaz
  T13; Poster Session, Friday, October 13, 10:00, Doppler Hall (4th upper floor)

Upcoming special issues

Geosciences Special Issue "Benchmarks of AI in Geotechnics and Tunnelling"

Driven by a global trend for digitalization, we have seen an explosion of contributions on artificial intelligence (AI) technologies for geotechnics and engineering geology in the past years. In 2018 we – the editors – founded a working group on “Machine Learning in Geotechnics” at the Graz University of Technology, which continues to closely collaborate with the Norwegian Geotechnical Institute up to the present day. While the developments of AI in geotechnics are in line with global trends, we also see deficits that hinder the general advancement of AI technology in our field. An overwhelming number of contributions can be attributed to the field of supervised machine learning, where algorithms learn input-output relationships based on predefined examples though other fields of AI are underrepresented. Furthermore, there is a significant number of studies that are partly or fully irreproducible due to lacking source code and original data.

With this Special Issue, we wish to provide a platform for high-quality contributions from all fields of AI, including but not limited to supervised machine learning (ML), unsupervised ML, self-supervised ML, reinforcement learning, evolutionary computation, and swarm intelligence. The applied geoscientific context of the contributions is set to be very wide, ranging from fields of geotechnics such as slope stability, constitutive modelling, or tunnelling to all applications of engineering geology such as ground investigations, mapping, or geological modelling.

A requirement of contributions is that the associated source code as well as the original training data or representative substitute data are provided such that the presented approaches are reproducible to the highest possible degree. By gathering the best contributions of AI for geotechnics and engineering geology, this Special Issue will serve as a benchmark for many future developments in this field and further push the state of the art.

Guest editors: Franz Tschuchnigg, Georg H. Erharter, Thomas Marcher

More information can be found on the website of the SI.

erharter@tugraz.at; thomas.marcher@tugraz.at; franz.tschuchnigg@tugraz.at

Teaching I

NATM University Programm|Module 6 | 1/2

After three years, the time had come for eight of the ten NATM participants to end their NATM university course journey - in a gratifying way. We can therefore proudly announce that the NATM course could be completed and the final documents could be handed over. But one by one. After the participants had passed all exams positively, the last step followed - the master thesis. The students worked diligently for the last half year on their master's theses on various tunneling-related topics from home. Periodic feedback from the course directors guided them, allowing the students to travel to Austria for the last module with almost completed theses.

Arrived in Austria, the students set up camp in Graz and Leoben to improve the final details of their master thesis and to prepare for their final exam and the defense of their master thesis. On September 28th, the final exam followed, which each student mastered with flying colors. The examination board consisted of Prof. Thomas Marcher, Prof. Galler and Dr. Thomas Frühwirt. After the students had completed this - justifiably exciting - day, a celebration was held, where the course directors, the students, the lecturers and other involved persons had dinner together at the Brandhof and toasted the graduates.

The highlight of the entire journey was the graduation ceremony in the auditorium of Graz University of Technology on Monday, October 2nd. At 9:00 a.m., Johann Sebastian Bach's Festive March, played by the Frohnleitner String Quartet, set the tone as Prof. Dipl.-Ing. Dr. Stefan Vorbach and course directors Prof. Thomas Marcher & Prof. Robert Galler entered the auditorium.


©Nikola Milatovic

Teaching I

NATM University Programm|Module 6 | 2/2

After their speeches, the certificates were handed over, the individual students were congratulated and “Gaudeamus igitur” was sung together. The ceremony was concluded by the speech of the head of Life Long Dr. Ernst Kreuzer. After all the souvenir photos had been snapped, the ceremony ended with a buffet and the students headed back home in various directions.

We would like to take this opportunity to first of all thank the students who have worked diligently and determinedly. Not even a pandemic could prevent you from finishing. We would also like to thank the team from Life Long Learning, who were always there to support us during the whole time. Of course, the many external teachers should not be forgotten. Through their expertise in the most diverse topics in the field of tunnelling, it was possible to convey profound knowledge to the students and prepare them for the challenges of everyday professional life.

Last but not least, we would like to thank the Montanuniversität Leoben for the excellent cooperation in this jointly organised course!

We wish the graduates all the best for the future and would like to take the opportunity to mention them and their thesis in the Faces section. Further we share photos of the festive graduation ceremony on the next pages.

Teaching III

NATM University Programme | Graduation Ceremony

Teaching IV

NATM University Programme | Graduation Ceremony

Teaching V

NATM University Programme | Graduation Ceremony

Teaching VI

NATM University Programme | Graduation Ceremony

Teaching VII

NATM University Programme | Graduation Ceremony

geisler@tugraz.at

Teaching VIII

NATM University Programme | Graduation Ceremony

Faces

… in this issue we want to highlight our NATM course graduates, which have done a fantastic job. Hence, we aim to acknowledge each participant by name and highlight their master thesis title. The NATM course consistently attracts a diverse international cohort, and this round was no exception. This diversity allows for a comprehensive understanding of various tunnel construction methodologies across different nations, as well as to get to know the beauties of the individual countries.

- **Promneewat Khomchan (Thailand)**

Comparison between FEM and DEM at Zentrum am Berg (ZaB)

- **Sanyal Sanjoy (India)**

Design of 3+1 Lane Twin Tunnel at Kota, Rajasthan, India

- **Gonzales Jorge (Mexico)**

Support Elements in Tunneling and current developments

- **Gupta Akshay (India)**

Shinkun la Tunnel - Design of excavation and primary support

- **Priesack Tobias (Germany)**

Innovative use of thermal imaging sensors in NATM and TBM tunnelling

- **Arif Muhammad (Pakistan)**

Design Optimization of Road Tunnel in Pakistan

- **Herrera Caicedo Juan David (Columbia)**

Unforeseen operation conditions in underground hydropower complex - Effects on the rock mass and stabilization measures

- **Viduya Sonny (Singapore)**

Effects of Excavation on Diaphragm Wall Structure by Modelling Using FEA in Chittagong Soft Soil

Figure f.l.t.r.: Dr. Ernst Kreuzer, Prof. Stefan Vorbach, Thomas Geisler, Akshay Gupta, Juan David Herrera Caicedo, Sanjoy Sanyal, Priesack Tobias, Promneewat Khomchan, Sonny Viduya, Jorge Gonzales, Prof. Robert Galler, Prof. Thomas Marcher.

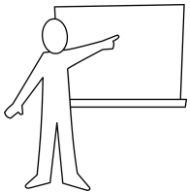
Diary of Events I

> ATC²-Symposium 2023 RMT followed by "Barbarafeier"
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 and on the subsequent page.
After the ATC²-Symposium our yearly "Barbarafeier" will take place.

If you are interested in sponsoring or advertising opportunities at both events, please get in contact with Ms. Ines Metzler MSc (metzler@tugraz.at). Regular updates are published via the event's homepage: http://austrian-tunnel-competence-center.at

> Thursday lecture series by Anne Merete Gilje
Graz, Austria (2023/12/14, 17:15 CET)



Lecture entitled "E39 Rogfast – The world`s longest and deepest sub sea road tunnel. It will be built in Rogaland Norway in the time window 2021 – 2033 with the Norwegian Method of Tunnelling (NMT)" by Anne Merete Giljem, an assistant project manager of the NPRA. The lecture will be in English and will take place in the lecture Room HS L (Lessingstraße 25/1, 8010 Graz). Registration via email addressed to tunnel@tugraz.at .

> 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.

Save the date!

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

>"Barbarafeier" 2024
Graz, Austria (2024/11/29)
More information will follow. Save the date.

Diary of Events II

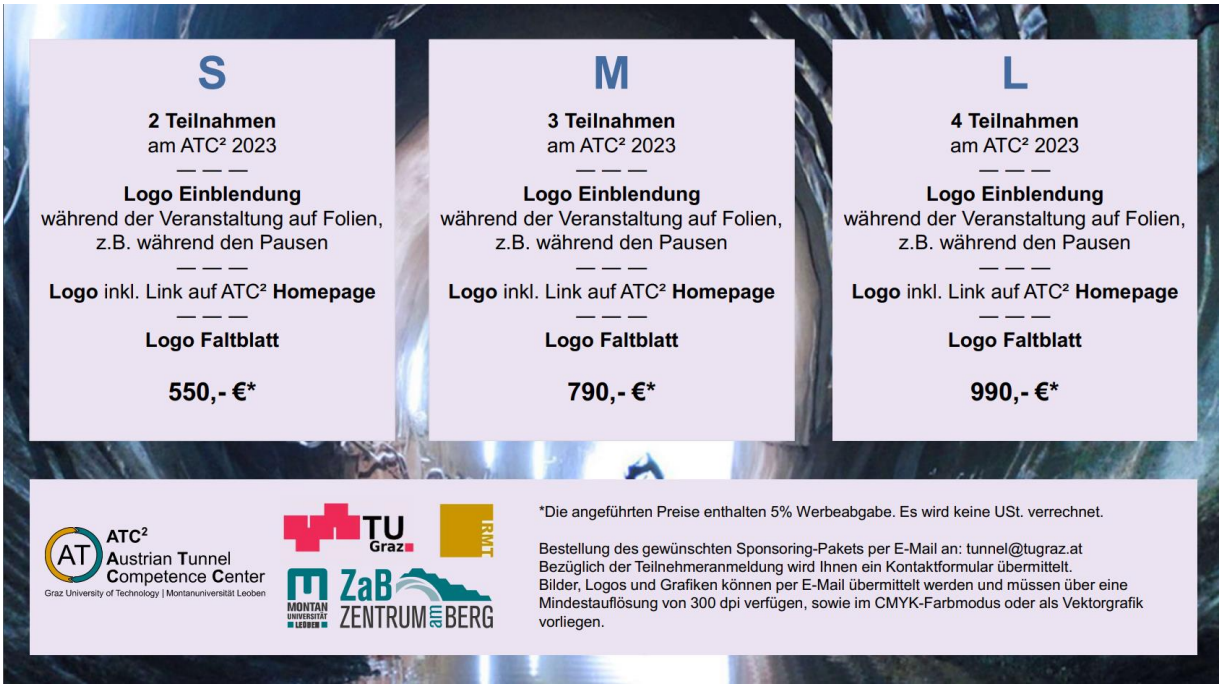
ATC² - “Shallow tunnels, subway construction”

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. The contributions to the ATC² will be printed in issue 6/23 of the Geomechanics and Tunnelling and will readily distributed at the STUVA Conference in November 2023, Munich.

The conference program including the presentation titles and speakers can be found on the ATC² homepage and on the subsequent pages.
After the ATC²-Symposium our yearly “Barbarafeier” will take place.

If you are interested in sponsoring or advertising opportunities at both events, see below and please get in contact with Ms. Ines Metzler MSc (metzler@tugraz.at).

Registration is now open via the event’s homepage austrian-tunnel-competence-center.at or via mail to tunnel@tugraz.at. Please register to the ATC² conference and the Barbarafeier separately. This facilitates the organisation for both events for us.



Diary of Events III

ATC² - “Shallow tunnels, subway construction” – Schedule 1/2

ORGANISATION

■ ORGANISERS

Univ.-Prof. Dipl.-Ing. Dr.-Ing. Thomas Marcher
Institute of Rock Mechanics and Tunnelling
Graz University of Technology

Univ.-Prof. Dipl.-Ing. Dr.mont. Robert Galler
Chair of Subsurface Engineering
Montanuniversität Leoben

■ LOCATION

Graz University of Technology
Rechbauerstraße 12, 8010 Graz
HS I, on basement floor

■ CONTACT

Ines Metzler, MSc
Institute of Rock Mechanics and Tunnelling
Graz University of Technology
Rechbauerstraße 12, 8010 Graz
Tel.: +43 316 873 8114
E-Mail: metzler@tugraz.at
Web.: www.austrian-tunnel-competence-center.at

■ PARTICIPATION FEES

Early-Bird (until incl. 31st October 2023):	€ 240,-
Regular:	€ 280,-
Student*:	€ 49,-
Barbarafeier**:	free

The participation fees include the participation in the symposium, the conference documents, coffee, and lunch. The registration is only valid after payment of the participation fee. A refund of paid contributions is no longer possible, but a substitute participant can be named if desired.

*Only persons under 26 years of age who do not have a regular taxable income are considered "students" - no doctoral students. Proof of study must be enclosed with the registration.

**Separate registration via tunnel@tugraz.at required.

■ REGISTRATION

We ask for registration at:
www.austrian-tunnel-competence-center.at/registration-prices

■ SPONSORING

If you are interested in one of our sponsorship packages, please contact us by email or telephone.

■ HOTEL RESERVATION

Participants are asked to book a hotel room themselves or through the Tourist Office Graz as early as possible.
Further information at:
Web: www.graztourismus.at
Tel.: +43 316 8075 0
E-Mail: info@graztourismus.at

■ MAP

Your Advertisement Opportunity

ATC² stands for Austrian Tunnel Competence Center and represents a platform for innovation and know-how transfer in the field of tunnel construction. Besides developments in the field of the traditional sequential excavation method NATM, continuous tunnelling as well as special underground construction measures are also dealt with. Special challenges and innovations from deep-lying rock tunneling to urban (shallow) loose rock tunneling are considered.

Topic:
Shallow Tunnels, Subway Construction

December 1st, 2023

Graz University of Technology
Rechbauerstraße 12, 8010 Graz

ATC²
Austrian Tunnel
Competence Center

Diary of Events IV

ATC² - “Shallow tunnels, subway construction” – Schedule 2/2

SCHEDULE

FRIDAY, 01.12.2023

REGISTRATION & OPENING

- 08:00 Registration
- 09:00 Introduction to the symposium
- 09:15 Opening lecture: Above, below and beyond the mobility transformation in Graz
  Fallast, K.
  PLANUM Fallast & Partner

S-LINK SALZBURG

- 09:55 S-LINK Salzburg gains momentum
  Greinmeister, A.
  S-LINK
- 10:20 The soil investigations and soil mechanics insights for the underground construction of the S-LINK
  Saurer, E.; Greinmeister, A.
  Skava; S-LINK
- 10:45 S-LINK - tunnel construction in the city centre of Salzburg, challenges and solutions
  Jeditschka, G.; Kohlböck, B.; Eder, M.; Greinmeister, A.
  S-LINK
- 11:10 Coffee break

INTERNATIONAL PROJECTS I

- 11:40 Using various geotechnical techniques for challenging conditions at the WestLink project
  Raja, S. U.; Landergren, H.; Thurner, R.
  Keller Grundläggning AB
- 12:05 Grand Paris Express - a shallow urban tunnel with conventional method - a case study from Line 15 South
  Cavagnet, S.; Mancinelli, L.; Midali, E.; Diallo, I.
  Lombardi Ingegneria S.r.l.
- 12:30 Use of fiber-reinforced segments and cement-reduced annular gap mortar on the Grand Paris Express project
  Khatchadourian, A.; Heim, A.
  Implenia
- 12:55 Lunch break

TUNNELLING SPECIFICS OF METROS/SUBWAYS

- 14:25 Model-based representation of geological prognosis (un)reliability for shallow tunnels
  Massimo-Kaiser, I.; Salzgeber, H.; Flora, M.
  University of Innsbruck
- 14:50 Line crossing U2xU5 construction sections U2/17 to U2/21 - experience gained to date from tunnel excavation works
  Schweiger, H.; Wäger R.
  Wiener Linien
- 15:15 Coffee break

INTERNATIONAL PROJECTS II

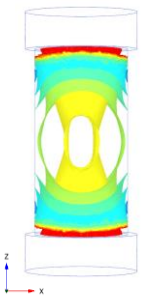
- 15:45 Assessing potential building damage caused by leakage to urban tunnels
  Langford, J.; Ritter, S.; Lysdahl, A. K.; Anes, E. W.; Piciullo, L.
  NGI
- 16:10 Large highway tunnels under operating metro lines in the soils of Santiago - design and control approach
  Toledo, M.; Cárcamo, V.; Silva, D.
  Skava Consulting SA
- 16:35 Melbourne Metro Tunnel Project - novel design and construction approach for major station caverns
  Lagger, H.; Sainsbury, D.; Sainsbury, B.-A.; Storry, R.
  ARUP
- 17:00 Closing words

BARBARA CELEBRATION

- 19:00 Start
  All participants of the ATC² are warmly invited to join the barbara celebration of the Institute of Rock Mechanics and Tunnelling.
  A separate registration at www.tugraz.at/institute/fmt/events-1/barbarafeier-2023 is kindly requested for organisational reasons.

Have a look at our Master‘s Theses I

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

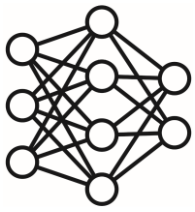


- **Numerical and experimental investigation of rock anisotropy**

(supervisors: T. Frühwirt, M. Winkler)

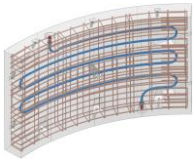
Rock is a complicated material, for example it is very often anisotropic making its’ deformational and strength characteristics dependent on the loading direction. To learn more about this phenomenon, numerical and experimental studies need to be carried out.

- **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.

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

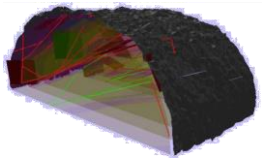
The ChaMod-HSSR project (cf. Rock Report 03/3) aims at an extensive characterization of transitional material excavated with the construction of the Angath adit in Tyrol, Austria. The local Unterangerberg formation comprises hard soil/soft rock (HSSR) with strong anisotropic tendencies as well as a certain 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.

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.

- **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 bigge rresearch endeavor on this matter.

Have a look at our Master‘s Theses III

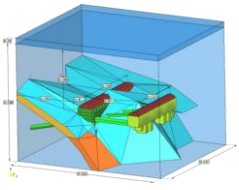
- **Application of an existing testing device to check successful pea-gravel bedding of segmental linings** (**supervisor:** T. Marcher)

The goal of the thesis is to apply an existing testing device (prototype) to real conditions at the construction site. The thesis shall focus on the application limits and optimization proposals for a regular use during the segmental lining installation. The involved company offers a position as a trainee and practice-oriented supervision.

- **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.

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

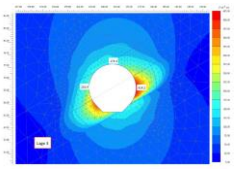


In the course of excavating a cavern, difficult tunnelling conditions were encountered in an executed project. The aim of the thesis is to numerically backcalculate the observed behaviour. The involved company offers a position as a trainee and practice-oriented supervision.

- **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.

- **A case study: back-calculation of shallow tunnel highly sensitive to surface settlements in urban environment (supervisor:** T. Marcher**)**



Numerical study. The tunnel has been excavated with side drifts (Ulmenstollen). The focus of the work is on the prediction of the tunnel stability and surface settlements. Numerical analysis shall be performed of which settlements can be expected if a different excavation concept is chosen. The surrounding ground consists of sand. The influence of improving the ground prior to excavation shall be considered as well..

Cooperation

… please contact us in case we forgot you here