ROCK REPORT

Mechanics & Tunnelling

Quarterly Newsletter of the Institute of Rock Mechanics and Tunnelling

01 Volume 4
April 2023

IRMT

NAWI Graz GEOZENTRUM

TU Graz Graz University of Technology

MLGT Machine Learning in Geotechnics

Content

Marcher's Column

When I started at the RMT in 2018 as head of the institute, I was promised the position of teaching and research coordinator for the start-up phase. This position was filled by Alexander Kluckner, who was already well established at the TU Graz and at the institute.

With his help, I was able to quickly settle into the processes of TU Graz in research and teaching as an "external" and "coming from practice".

I would like to take this opportunity to thank Alexander Kluckner, who has now completed his doctorate and is moving to the private sector. His support was extremely enriching and numerous teaching initiatives and research project proposals were also successfully launched thanks to his great commitment.

Thank you Alex! All the best for the future!

With this issue of the RockReport you will again get an insight into our institute life in Q1 2023 related to research, teaching and much more. Have fun reading!

Glück Auf!

Thomas Marcher

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Title Picture:
During the process of drilling blasting holes for tunnelling, a drilling jumbo is carrying out the drilling work. The machine is equipped with a measurement while drilling (MWD) system that sends data in real-time as the drilling is taking place. Picture: Alla Sapronova

April 11th, 2023 – published
Thomas Geisler – editor in chief
tunnel@tugraz.at – contact

Research Focus I

Learning from Drilling with the Help of Data Science

Measurement while drilling (MWD) data is a critical component in optimizing tunneling operations (cf. Rock Report 03/22) Jumbo drilling machines equipped with MWD systems can provide real-time data on drilling parameters such as penetration rate, drilling pressure, and drilling speed. This data can be analyzed to identify patterns and trends indicative of potential risks or fracture zones in tunneling. Utilizing this data in a decision support system can optimize the excavation strategy by, for example, predicting the over excavation volume or optimizing the volume of explosives.

The cooperative project between RMT and Taisei Corporation, Japan, started in 2022, is focused on MWD data analysis as part of the overall goal of building a decision support system for the excavation process. The first step in this process is developing, training, and validating data-driven models for MWD analysis. Post-excavation analysis of the data is essential in achieving this goal. The data is stored in a database, and statistical analysis and machine learning algorithms are used to identify patterns and trends that can be used to optimize drilling parameters for future excavation operations. For example, the analysis may reveal that a particular combination of drilling parameters produces better tunnel stability or reduces the likelihood of encountering fracture zones.

One way to utilize MWD data in a decision support system is to perform real-time monitoring of drilling parameters during excavation. This can help identiyfing potential issues that could impact the stability of the tunnel, such as excessive drilling pressure, deviations from the planned trajectory, or unexpected changes in rock characteristics. Detecting these issues early allows for corrective actions to be taken to prevent or mitigate potential problems, improving the safety and efficiency of tunneling operations.

The current project uses unsupervised and supervised machine learning methods in MWD data to predict the volume of explosive materials. The preliminary study showed that an ensemble model that combines unsupervised methods and correlation analyses can predict the volume of explosives with 90% accuracy. The study confirmed the importance of averaging the MWD data per borehole, as the accuracy of models trained on averaged data was always higher compared to the models trained on instant MWD data. An analysis of feature importance allowed for the reduction of the number of inputs for the machine learning model and, in combination with results from correlation analysis, helped to identify the optimal subset of input variables to train supervised machine learning models.

As the accuracy of machine learning models depends on the quality of the input data, it is vital to preprocess MWD data correctly. This includes removing duplicates, ensuring data consistency, correcting formats, and removing outliers. The outlier detection procedure can be performed together with the correlation analysis, making the preprocessing routine faster. This is essential for the foreseen real-time decision support system.

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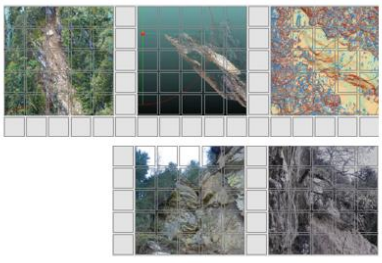
Research Focus II

STEIRIS (STEinschlagRISiko)

Project phase 1 of the STEIRIS (STEinschlagRISiko) project (cf. Rock Report 04/21) was concluded with the final presentation on March 20th 2022 at our project partner Regionalmanagement Liezen. Prof. T. Marcher and R. Kienreich presented the project process and the results to the decision-makers of the Liezen district. 29 mayors, members of the provincial, federal and national parliaments as well as approximately 10 administrative bodies were instructed on recommendations for action for practical prevention of rock fall hazards. The scientific results comprises six student's theses (five master's theses and one bachelor's thesis) and the conference proceedings of the rockfall symposium held in Schladming on 1st of December 2022 (cf. Rock Report 04/22). The developed recommendation offers the possibility of a process-oriented treatment of the topic with the core points of risk assessment and documentation

From a scientific point of view, the research topic is being continued by a Master's thesis on rock deconsolidation through thermo-mechanical processes as a result of freeze-thaw cycles (L. Kammerer, supervision: T. Frühwirt, R. Kienreich). In addition, the application for an INTERREG project with partner universities from Germany and Czech Republic is on its way.



STEINSCHLAGRISIKO

Handlungsempfehlung

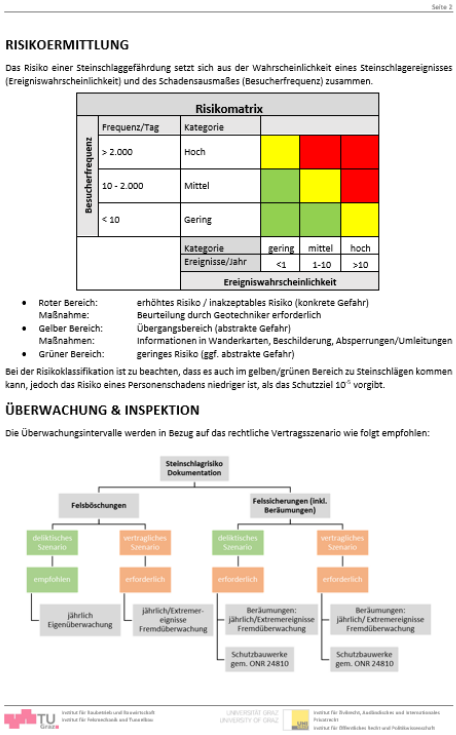
Kurzfassung

Die Handlungsempfehlung ist ein Ergebnis des Projektes STEIRIS (SteinschlagRisiko). Steinschlag ist eine häufige Naturgefahr und ein lückenloser Schutz ist unrealistisch. Das Risikomanagement ermöglicht es immerhin, die Haftung von Gemeinden oder Privaten zu reduzieren. In dieser Handlungsempfehlung wird ein transparenter Prozess für die präventive Beurteilung der Steinschlaggefahr, Klassifizierung, zugehörige Maßnahmen zur Haftungsreduktion und Dokumentation des Prozesses vorgestellt.

Geltungsbereich

Die Handlungsempfehlung ist für die Ermittlung des Steinschlagrisikos bei natürlichen Felsböschungen. Nicht umfasst sind andere Formen von Massenbewegungen, wie Rutschungen, Muren u.dgl. Dieses Papier ist eine Empfehlung für private und kommunale Erhalter und bezieht sich auf kommunale Wege, Wanderwege, Mountainbike Wege etc. im nicht hochalpinen Gelände.

Durch die Verfasser wird keinerlei Haftung übernommen.



Seite 2

RISIKOERMITTLUNG

Das Risiko einer Steinschlaggefährdung setzt sich aus der Wahrscheinlichkeit eines Steinschlagereignisses (Ereigniswahrscheinlichkeit) und des Schadensausmaßes (Besucherfrequenz) zusammen.

Risikomatrix

Besucherfrequenz	Frequenz/Tag	Kategorie			
	> 2.000	Hoch			
	10 - 2.000	Mittel			
	< 10	Gering			
		Kategorie	gering	mittel	hoch
		Ereignisse/Jahr	<1	1-10	>10
		Ereigniswahrscheinlichkeit			

- Roter Bereich: erhöhtes Risiko / inakzeptables Risiko (konkrete Gefahr)
  Maßnahme: Beurteilung durch Geotechniker erforderlich
- Gelber Bereich: Übergangsbereich (abstrakte Gefahr)
  Maßnahmen: Informationen in Wanderkarten, Beschilderung, Absperrungen/Umleitungen
- Grüner Bereich: geringes Risiko (ggf. abstrakte Gefahr)

Bei der Risikoklassifikation ist zu beachten, dass es auch im gelben/grünen Bereich zu Steinschlägen kommen kann, jedoch das Risiko eines Personenschadens niedriger ist, als das Schutzziel 10^{-5} vorgibt.

ÜBERWACHUNG & INSPEKTION

Die Überwachungsintervalle werden in Bezug auf das rechtliche Vertragsszenario wie folgt empfohlen:

Mag. Rainer Kienreich

Rigorosum Kluckner

On February 27th 2023 our appreciated colleague DI Dr. Alexander Kluckner successfully defended his dissertation on the topic of “Tunnelling at greater depths: Study on the ground and system behavior when passing a stiff rock block in a weak zone”. With this big step in his career he caps of years of dedicated work and research. During his time at the Institute of Rock Mechanics and Tunnelling, Alexander made significant contributions to the success of our team. Besides bringing in his professional competence in teaching and research, his experience in project acquisition and meticulous approach to work proved to be extremely valuable for the development of our institute. Alexander was considerably involved in the growth of RMT’s inter-university network on both, national and international level, besides the expansion of our connections to industry.

Further, Alexander’s open attitude and his selfless efforts in supporting his colleagues in many different matters, underline the beneficial influence of his actions. Although he has left our institute with the completion of his doctoral studies, the positive effects of his work will still remain with us for a long time. We have no doubt that Alexander will continue to be an enrichment for his environment no matter where his journey will take him.

Dear Alex, thank you very much for the inspiration you have been to your colleagues throughout your time with us and your invaluable contributions you have made to our institute. We wish you all the best for your planned journey through South America, success for your future and hope to meet you soon again.

¡Nos vemos, amigo!

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Publications & Presentations I

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

On the Effect of Shield Friction in Hard Rock TBM Excavation
Georg H. Erharter, Robert Goliasch, Thomas Marcher (Published in Rock Mechanics and Rock Engineering 2023 – Open Access)

During hard rock tunnel boring machine (TBM) excavation, shields behind the cutterhead are in contact with the tunnel wall and therefore subjected to friction forces. To investigate the friction coefficient for the planning of TBM excavations, specialized shear tests were conducted where steel specimens were sheared against lithologically different rock specimens under realistic normal forces and shearing speeds. The tests were executed with and without the use of bentonite lubrication. The results show that there is a significant difference between different lithologies and also that bentonite does not lower the friction coefficient as expected. To elaborate on the effect of shield friction during construction, a framework for interpretation of TBM operational data based on experience from construction sites is provided. This study therefore provides the basis for theoretical and practical assessments of the effect of shield friction for the planning and construction phase of a tunnel. This becomes increasingly important in the light of new contractual developments that aim at differentiating “standard” from “special” advance in an objective and reproducible way

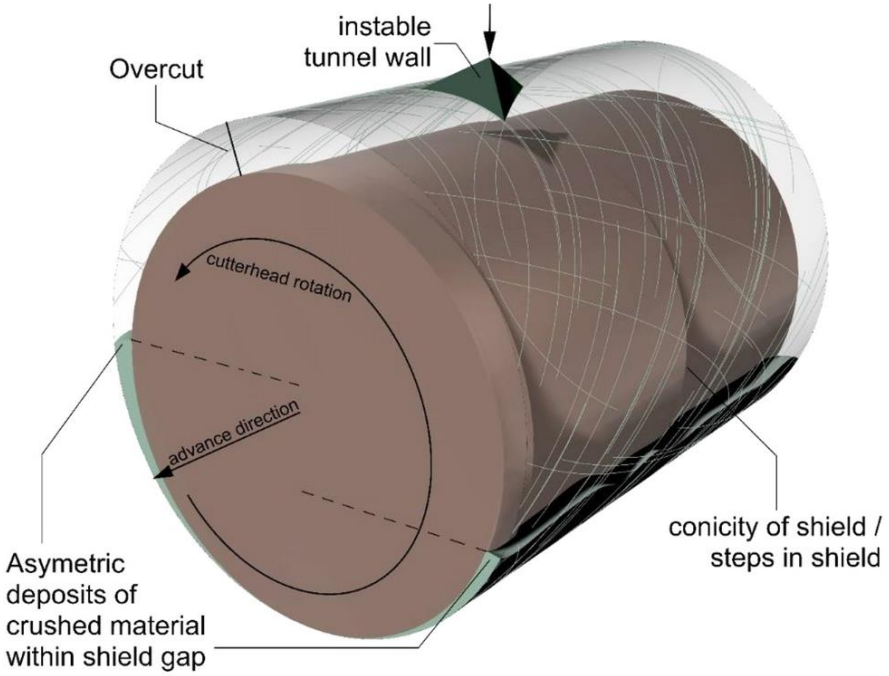

Figure: Influences on the effect of shield friction with the example of a single shield TBM

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Publications & Presentations II

Guest lecture RWTH Aachen

As part of the lecture series "Forum Geotechnik" at RWTH university Aachen (Germany), Prof. Marcher gave a lecture on innovative and sustainable aspects in the construction of deep tunnels through the Alps. In the course of the excavation of the various base tunnels in the European Alps, a large number of innovative solutions are being implemented: this begins with considerations on the sustainable single-shell tunnel lining of conventionally excavated areas, the systematicuse of sensor data from mechanically excavated tunnel section to the permanent thermal use of the drainage water for the heating system of urban environment. RMT would like to thank the Chair of Geotechnics in Civil Engineering (Institut für Geomechanik und Untergrundtechnik) for inviting us, especially the head of the institute Prof. Raul Fuentes and Akad. Dir. Martin Feinendegen.

Guest lecture China

Tao Xu, Professor at the School of Resources and Civil Engineering, Northeastern University, China, started a collaboration under the High Level Foreign Experts in China Programme. RMT has been accepted as a foreign expert in this programme, with a general focus/topic related to rock mechanics and rock engineering, such as rock mass deformation and stability.

In late 2022 and early 2023, it was still difficult to travel to China due to COVID-19 restrictions. Consequently, we have started with an online meeting. We look forward to a good cooperation in the future!

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Upcoming Special Sessions

Special session for ISMLG 2023 (Cork, Ireland)

RMT, Montan University Leoben, and Amberg Technology Group are organizing a special session on "Data Quality Assurance and Pre-processing in Geoscience" at the 4th International Symposium on Machine Learning & Big Data in Geoscience in Cork, Ireland from August 29 to September 1, 2023. The session will focus on discussing tools and methods to improve the quality of data used in geoscience, including handling sparse, imbalanced, and mislabeled datasets. The session will present methods for handling data imbalance, errors detection in data labeling, extraction of patterns in data, and assessing the quality of extreme sparse datasets.

Special session for IAMG 2023 (Trondheim, Norway)

RMT will hold a special session on "Rare Events Detection for Risk Management in Geoengineering" at the 22nd Annual Conference of the International Association for Mathematical Geosciences in Trondheim, Norway from August 5-12, 2023. The session will explore tools and methods for rare event detection in geosciences, with a particular focus on risk management and its application in geoengineering. The session will cover various topics, including data sparsity and uncertainty, new findings and techniques for rare events' detection, data preprocessing methods, data imbalance, perceptions and biases in data labeling, and risk modeling.

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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.

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RMT Insitute Outing

Skiing in Carinthia: A Memorable Institute Outing

During the last days of January, the members of our institute decided to organize an outing to the beautiful mountain village Bad Kleinkirchheim in Carinthia for a skiing adventure. The trip turned out to be a memorable experience, filled with fun, adventure, and new experiences.

Carinthia is known for its stunning natural beauty and skiing facilities, making it the perfect destination for a winter getaway. Luck was also on our side, as in the week before our outing the mountainsides of southern Austria were covered in white by heavy snowfalls.

Upon reaching our destination, we were greeted by a bustling ski resort, complete with ski lifts, rental shops, thermal spas and traditional restaurants. The resort had something to offer for skiers of all levels, from beginners to advanced skiers, and we were eager to hit the slopes and try our hand at skiing.

For those of us who were new to skiing, the resort offered beginner slopes, and thanks to one of our student assistants, who is a ski instructor himself, the beginners got a full experience from putting on their skis to mastering their first movements on the slopes. The more experienced skiers in our group wasted no time in exploring the vast expanse of ski trails that Bad Kleinkirchheim had to offer. The ski trails ranged from gentle slopes to challenging black race tracks (Franz Klammer downhill piste), providing an exciting challenge for everyone.

Skiing was not the only activity on our itinerary, though. During our downtime, we had fun evenings and paid a visit to the local thermal spas. We also indulged in traditional Austrian cuisine, from hearty stews to warm apple strudel, which helped us refuel and re-energize for our skiing adventures. As our trip came to an end, we returned home with a sense of fulfillment and a renewed appreciation for the great outdoors. The institute outing to Carinthia was not only a great opportunity to bond with our colleagues outside of work, but it also allowed us to challenge ourselves and try new experiences.

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Guests & Visits

Guest lecture Mag. Goldschmidt

On Thursday, January 26th, 2023, the Institute of Rock Mechanics and Tunnelling hosted a lecture by Mag. Franz Goldschmidt, a geologist in charge for the Carinthian county, who currently works at the “Amt der Kärntner Landesregierung, Abteilung 8 - Umwelt, Energie und Naturschutz, Unterabteilung GGM - Geologie und Gewässermonitoring“. The focus of his talk was on the challenges that the Provincial Geological Survey encounters in their line of work, with specific case studies derived from Carinthia.

Throughout his presentation, Mr. Goldschmidt expertly utilized numerous examples to provide insight into how the survey deals with potential hazards and the invaluable role of experience. Attendees of the lecture included a significant number of students, as well as many colleagues from both Graz University of Technology and the business sector.

As the lecture drew to a close, the floor was opened up to a lively question and answer session, allowing attendees to dive further into the practicalities of everyday work within the field. We would like to thank Mag. Goldschmidt for sharing his wealth of knowledge and providing such interessting insights into this complex and fascinating practical work.

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Research exchange at University of Innsbruck Campus Technology

On February 6th, 2023, a delegation from RMT visited the working groups of "Strength of Materials and Structural Analysis" and "Computational and Experimental Soil Mechanics" at the University of Innsbruck Campus Technology. The delegation was led by Prof. Thomas Marcher, and consisted of 4 RMT team members.

The main objective of the visit was to introduce ourselves to the groups around the esteemed professors, Prof. Günter Hofstetter and Prof. Barbara Schneider-Muntau, and to gain insights into their respective research areas. Through discussions with the working groups, we were trying to identify potential areas of collaboration and overlapping research interests, which could lead to fruitful research partnerships in the future.

Overall, we perceive our visit as very enriching and we look forward to maintaining ongoing communication with our colleagues from the University of Innsbruck. We hope that this visit will serve as a starting point for future collaborations, and we are excited to see what the future holds for our respective institutions.

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Teaching I

Cooperation of Ostschweizer Fachhochschule and TU Graz: Winter School #1

On February 2nd & 3rd 2023, the cooperation between the Ostschweizer Fachhochschule and Graz University of Technology (the latter represented by three institutes: RMT in collaboration with the Institute of Soil Mechanics, Foundation Engineering and Computational Geotechnics and the Institute of Geodesy) hosted its first Winter School in Graz. Five experts from FH Ost and backgrounds in the fields of civil engineering and geodesy prepared two days packed with sessions on the topics of structural preservation of reinforced concrete structures as well as on fiber optics strain sensing to be presented to interested students from TU Graz in the form of an interactive workshop. Apart from theoretical input, the participants had the opportunity to work on real-life examples, gaining hands-on understanding of these crucial subjects.

We want to thank our Swiss colleagues for their engaging and thought-provoking workshop program and would like to announce the continuation of our cooperation, namely the upcoming Summer School in September 2023, taking place at FH Ost Rapperswil (CH). Those interested will also be able to participate online. To register for the Summer School, simply send an email to metzler@tugraz.at.

metzler@tugraz.at

Teaching II

Field Excursion “Tunnelling Technology with TBMs’”

As part of the course “Tunnelling Technology with Tunnel Boring Machines”, on January 26th 2023, interested course participants had the chance to visit the alpine project area of the extension of the Kühtai pumped storage power plant in the Tyrolean Sellrain Valley in the Stubai Alps, and to also gain some first hands-on experience by seeing a small diameter, open-gripper TBM in action. After getting an extensive technical insight into the project via a presentation held by the TBM construction manager DI Christoph Sinkovec and Jäger Bau managing director DI Wolfgang Weber, the students were able to visit all construction site highlights, namely the large cavern constructed for the power house and turbine of the power plant, the segment factory, the earth fill dam construction site, the impressive fleet of construction vehicles, and last but not least: the TBM excavation. After an informative site visit, everyone was treated to lunch at the site canteen before heading back to Graz.

Thanks to Wolfgang Weber and the team at Kühtai, who explained and showed us all the technical peculiarities of this alpine construction site for a day and answered so many questions about it, we all enjoyed it a lot!

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Teaching III

Start of NATM Course 7th round

Did you know that some of the world's most iconic subway systems, such as those in Washington, São Paulo, Seoul, Athens, Munich and Vienna, were constructed using the innovative New Austrian Tunneling Method (NATM)? Indeed, the widespread use of this tunnelling method highlights its significance and underscores the need for tunneling engineers to have a solid grasp of its principles and practices.

That's why we're thrilled to announce that the Institute of Rock Mechanics and Tunnelling at TU Graz, in collaboration with Montanuniversität Leoben, will be offering the NATM Engineering university program for the seventh time, starting in September 2023. This comprehensive program provides students with an in-depth understanding of NATM principles, techniques, and applications, equipping them with the knowledge and skills required to succeed as tunneling engineers in the present and the future.

If you're interested in learning more about this exciting opportunity to expand your knowledge and expertise in NATM engineering, please visit www.natm.at or send an email to natm@tugraz.at at any time to obtain further information.

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Teaching IV

Recent master graduates at RMT

We are delighted to announce the successful completion of two master's theses at our institute in the first quarter of 2023.

Mr. John Martin

The first of these works was written by Mr. John Martin, who defended his master thesis with great success during an online examination held on the 26th of January 2023. Entitled "Back-analysis of rock mass parameters at the Semmering Base Tunnel based on the convergence confinement method," Mr. Martin's thesis was supervised by Prof. Thomas Marcher, Dr. Alexander Kluckner, and Dipl.-Ing. Gerold Lenz. The thesis offers a thorough and insightful exploration of this important topic and is sure to make a significant contribution to the field. The RMT team congratulates Mr. Martin on his achievement and wishes him all the best as he pursues his future career.

Mr. Stefan Leiner

The second thesis was authored by Mr. Stefan Leiner, who recently concluded his master thesis entitled "Machine Learning Assisted Analysis of Tunnel Seismic Prediction Data" with the final exam taken on the 30th of January 2023. His thesis was supervised by Prof. Thomas Marcher and Paul Unterlaß and was inspired by an ongoing research collaboration with the Geophysics Department of Amberg Technologies AG. This work represents a significant step forward in the application of machine learning to the analysis of seismic prediction data and is sure to generate interest and excitement in the field. RMT extends its congratulations to Mr. Leiner and wishes him every success in his future endeavors

Picture: Mr. John Martin

Picture: Examination board with “newly baked” graduate student, f.l.t.r. Prof. Qian Liu, Prof. Thomas Marcher, Stefan Leiner, Prof. Steffen Birk

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Faces

… today's student of the Institute of Rock Mechanics and Tunnelling

Timna Plöchl (student)

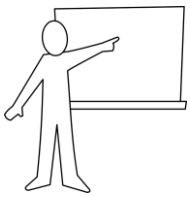
While studying civil engineering, the rock mechanics and tunneling basic course immediately attracted my attention. The interesting mixture of geology and engineering convinced me of writing my bachelor´s thesis on ´Geothermal potential of Austrian tunnels´ at RMT institute. The main task was to sum up methods for thermal activation and influential parameters, followed by collecting some data for 20 Austrian tunnels. It was not only fascinating to find out more about the topic itself but also showed me that research in some fields of RMT is not very advanced yet. Knowing there is still a lot of room for new concepts and ideas for improvement, makes me really looking forward to my future job.

After some months of working with the RMT institute on my bachelor´s thesis they offered me a job as student assistant. It gives me the opportunity to get a deeper insight in various topics of RMT and allows me to take part in interesting events like the rock fall symposium we visited some weeks ago.

Simultaneously to finishing my bachelor, I started taking courses from the hydraulic and geotechnical engineering master´s program this year. Since that proved again that my interests match the most with courses in Geology and RMT, I will specialize in those fields during the next years of my studies. Next semester I am going to take a little break studying in Alaska, but I will be happy to come back to TU Graz and my job at RMT institute afterwards.

Diary of Events I

> Thursday lecture series by Dipl.- Ing. Bernd Raderbauer
Graz, Austria (2023/04/27, 17:15 CET)



Lecture entitled Grossprojekt im Energiesektor, Kraftwerk Linth-Limmern
Bau eines 1'000 Megawatt Pumpspeicherkraftwerkes im Schweizer Hochgebirge
Leistungsstarke Logistikkonzepte und nachhaltige Materialbewirtschaftungon by Dipl.- Ing. Bernd Raderbauer EMBA of the Marti Tunnel AG. The lecture will be in German and will take place in the lecture Room HS L (Lessingstraße 25/1, 8010 Graz). Registration via email addressed to tunnel@tugraz.at .

> ATC²-Symposium 2023 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

> 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”

TU Graz IRMT ZaB ZENTRUM am BERG

ATC²
Austrian Tunnel Competence Center

“Shallow tunnels, subway construction“

Pre-Announcement - Detailed programme to follow

December 1st, 2023

Graz University of Technology
Rechbauerstraße 12, 8010 Graz

Organizers

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

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Following the symposium, we would like to cordially invite you to our annual Barbarafeier taking place in the same premises.

TU Graz IRMT ZaB ZENTRUM am BERG

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- Jedlitschka, G. (Geoconsult); Kohlböck B. (IGT); Eder, M. (Laabmayr); Greinmeister, A. (S-LINK)

Focus Tunnelling Specifics of Metro/Subways

- Schweiger, H. (Wiener Linien); Wäger, R. (Strabag) - Line Intersection U2xU5, Vienna
- Massimo-Kaiser, I.; Salzgeber, H.; Flora, M. (University of Innsbruck) - Model-based prediction reliability
- Classen, J. (Implenia); Listl, R. (DB Netz) - Marienhof Station, Munich

Focus International Projects

- Larsson-Gruber, B. (Trafikverket) - Metro Station Odenplan, Stockholm
- Raja, S. U.; Landergren, H.; Thurner, R. (Keller Grundläggning) - WestLink project, Gothenburg
- Cavagnet, S.; Mancinelli, L.; Midali, E.; Diallo, I. (Lombardi) - Grand Paris Express
- Lagger, H. (ARUP); Sainsbury, D. (Geotechnica); Sainsbury, B.-A. (Deakin Uni); Storry, R. (Bouygues) - Melbourne MetroTunnel
- Toledo, M.; Cárcamo, V.; Silva, D. (Skava Consulting SA) - Metro Review AVO II, Santiago de Chile

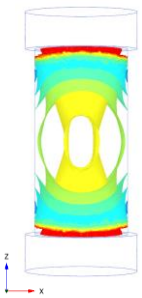
Advertising opportunities

Description	Cost per unit*
Poster [1) 2)]	€ 250,-
Roll-Up [1) 2)]	€ 300,-
Advertising material as an insert in the conference bag [2)]	€ 360,-
Company logo on conference bag	€ 600,-
Banner in the lecture hall [2)]	€ 900,-

* excl. any taxes and advertising fees
1) Information on possible positions in the event area on request
2) Information on possible dimensions on request

Have a look at our Master‘s Theses I

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

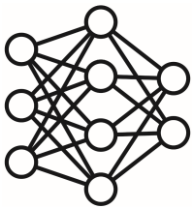


- **Numerical and experimental investigation of rock anisotropy**

(supervisors: T. Frühwirt, M. Winkler)

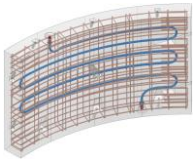
Rock is a complicated material, for example it is very often anisotropic making its’ deformational and strength characteristics dependent on the loading direction. To learn more about this phenomenon, numerical and experimental studies need to be carried out.

- **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)**

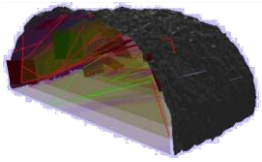
The ChaMod-HSSR project (cf. Rock Report 03/3) aims at an extensive characterization of transitional material excavated with the construction of the Angath adit in Tyrol, Austria. The local Unterangerberg formation comprises hard soil/soft rock (HSSR) with strong anisotropic tendencies as well as a certain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

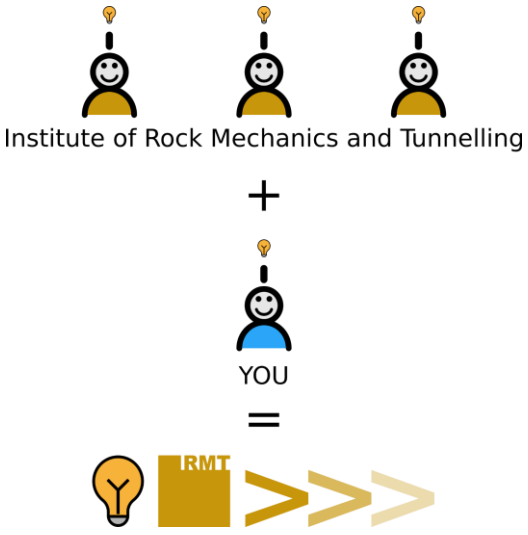


Various data near and at the tunnel face is available during the underground construction: from hand-made technical sketches made by geologists to the 3D point-cloud datasets from seismic surveys. Integration of such information into a harmonized database that will help to forecast the geological conditions 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.

Positions at RMT



Open Positions

- We are looking for a technician with interest in mechanical and electrical engineering to support our laboratory team. The job offers plenty of variety as it includes diverse tasks ranging from operating high-end measuring equipment to skilled manual work such as drilling and sawing of rock cores. A special focus will be on mechatronic and electrical engineering to set-up, retrofit and further develop our laboratory testing equipment. This challenging full-time job may be started before the end of this year, the sooner the better. For more information just send us your contact details via tunnel@tugraz.at.

JOIN RMT – we'd love to welcome you.

Cooperation

… please contact us in case we forgot you here

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