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The ITA Young Members' Magazine

Issue 7 2021

YM

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Welcome to 'Breakthrough'

Dear readers,

Welcome to the seventh issue of *Breakthrough*, the official magazine of the International Tunnelling & Underground Space Association's (ITA) Young Member's group (ITAym). It's a great pleasure to give you an insight into the world of tunnelling and the work of young tunnelling professionals in this industry. In the 2021 edition, we focus on 'Challenges'.

Life is full of challenges and this is true of the tunnelling industry as well. The underground never ceases to challenge us with unpredicted geological 'surprises'; right-of-way and boundary conditions get tighter and tighter with the increasing density of infrastructure in urban areas; working in multidisciplinary teams demands a lot from us; and, last but not least, time and money is always an issue. But don't the challenges make it interesting? And challenges can also be opportunities in every respect! To be honest, this is one of the reasons I chose a career in tunnelling.

I don't know if you're holding this magazine in your hands or if you're studying the digital version. Over the last year, a big portion of our daily life has taken place in the digital world, due to the worldwide COVID-19 pandemic. The reduction of physical meetings has been a challenge for many of us. How do we run a construction site under these restrictions? How do we work as a team? What about our social lives? Questions and problems that demand solutions. There are and will be changes once the impact of COVID-19 diminishes, new ways to work, to collaborate, to make use of digital tools and so on. Challenges drive us forward!

It has now been two years without a 'physical' ITA World Tunnel Congress (WTC) – WTC 2020 was virtual; WTC 2021 was postponed to 2022 – so, we are very much looking forward to meeting again at the World Tunnel Congress 2022, in Copenhagen, Denmark (wtc2022.dk).

Until then, we strive to keep you updated on the activities of the ITAym Steering Board and the Young Member groups of the ITA Member Nations and stay in touch with you all. Follow us on LinkedIn, sign-up for our email newsletter and check out our Youtube channel for updates (e.g. the amazing celebration videos from World Tunnel Day 2020)!

Stay safe and let's break through!

Jasmin Amberg, ITAYym Chair

Front Cover
Mathieson Stosic, a Tunnel Engineer for CPB Contractors (CPB) – part of the CPB, BAM, Ghella and UGL Joint Venture (CBGU JV), at work on his first project in the tunnelling industry, the AUS$5.4bn Cross River Rail Project, in Brisbane, Australia (see p34).

Brought to you by the publishers of:

Tunnelling Journal

TGS Media Ltd. The Old Library, Webster House
Dudley Road, Tunbridge Wells, Kent, TN1 1LE United Kingdom
Tel: +44 (0) 1892 522585 www.tunnellingjournal.com

Contributing to Breakthrough

If you would like to get involved in Breakthrough magazine by contributing an article, or suggesting potential content for future editions, we would be delighted to hear from you! Please feel free to contact Breakthrough's editorial team or the ITAYM Young Members Committee (details below).

Note to YM Member Nations

All national Young Member (YM) groups are encouraged to get involved in Breakthrough magazine – we rely on your input. Please remember to document your country's YM activities and take plenty of good quality photos at any YM events throughout the year so we can make the most of your reports in the next edition!

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ITA AITES

Meet the ITAYM Board

The governing structure of the International Tunnelling & Underground Space Association's (ITA) Young Members group (ITAYM) is a Steering Board made up of Chair, Vice-Chair, and a number of representatives selected by members of the Group. Steering Board members are elected for alternating periods to ensure continuity. The mandate is for two years.

Jasmin Amberg

Jasmin first visited a tunnel construction site when she was six years old. Although she didn't understand much at the time, she got the bug. In 2013, Jasmin did her Masters in Civil Engineering at the ETH Zurich in Switzerland and works now as a Project Manager at Amberg Engineering AG, where she is involved in several tunnelling projects at different stages. Jasmin is the Founder and Chair of the Swiss Tunnelling Society Young Members group (STSym). Outside of work, she likes cooking and spending time with her family and friends, when she's not busy acting as a basketball coach and referee.

Chrysothemis Paraskevopoulou

Chrysothemis is a Tunnel/Mining/Geological Engineer (MEng) with post-graduate studies (MSc) in Tunnelling from NTUA (Greece). In 2016, she completed her PhD, which involved working on a joint Research Project between Queen's University and ETH Zurich. She has completed an MBA at LUBS. In 2017, she was appointed Assistant Professor at the University of Leeds (UK). She also works as an Independent Consultant and, in the past, as a Tunnel Engineer. She is an active member in the Greek and British Tunnelling Society Young Members groups and the ITA's ITACUS and ITACET committees. When Chrysothemis is not working, you will find her spending time with friends and family at her Eden, a magical place in Southern Greece.

Sandeep Singh Nirmal

Sandeep holds a Masters in Tunnelling & Underground Space from the University of Warwick, UK, and was a recipient of the ITA's ITA-CET scholarship in 2015. He was a finalist for the ITA's Young Tunneller of the Year award in 2020 and voted Young Tunneller of the Year in 2019 by the Tunnelling Association of India (TAI). He has 9.5 years' experience working in the UK and India with active engagements with professional development organisations such as the British Tunnelling Society, Institution of Civil Engineers and TAI. He co-founded the TAI Young Members (TAIym) group in 2018 and is currently Chair. He co-founded the annual Symposium of Young Tunnellers of Asia (SYTA). Sandeep also enjoys long distance running and photography in his spare time.

Bartlomiej Dziuban

Bartłomiej did his undergraduate studies in Poland and Spain and graduated from Columbia University in New York with a Masters focusing on Tunnel Design and Construction. He works as TBM Site Engineer for Gulermak, in Poland, on the construction of Warsaw's Metro Line II Extension Project. His professional goal is to increase efficiency in tunnelling allowing faster rates of construction. He is passionate about promoting tunnelling as career path among young engineers in Poland where the industry is on a rise. Bartlomiej is also involved in academia giving guest lectures at universities in the US and Poland. He has served on the ITAym Steering Board committee since 2020.

Eyðbjørg Amanda Petersen

Eyðbjørg holds a MSc in Civil Engineering from the Technical University of Denmark and is currently working as a tunnel engineer at Ramboll. With a flair for the interaction between man-made structures and untamed ground, she started diving into the field of tunnelling after a brief visit to a tunnel construction site in Iceland with rapidly changing geology along the alignment and rare rock formations. She is a board member of the Danish Tunnelling Society Young Members. Eyðbjørg is always up for some fun on the water in her spare time, be it fishing (not necessarily catching anything), swimming, dragon boat racing (or just rowing).

Alex Nowak La Flor

Alex is a Civil Engineering graduate from the Federal University of Rio Grande do Sul, currently working as a pipe jacking engineer at ServBrax and pursuing a postgraduate degree in Mechanised Tunnelling at the University of São Paulo, Brazil. Passionate about the use of tunnels and underground space, he has been part of the Brazilian Tunnelling Committee Young Members (CBTym) board since 2018; initially as Vice President, and since 2021, as President. Alex's responsibilities involve helping both CBT and CBTym organise a wide array of events and has been instrumental in delivering YouTube webinars over the past year. In his spare time, Alex enjoys travelling and watching football.

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CONTENTS...

YM MEMBER NATION NEWS

ATSym Guides the Way

By Brodie Aitchison

Despite the difficulties with borders and lock-downs during 2021, it has been a busy year so far for the Australasian Tunnelling Society's Young Members (ATSym). During the ATS 2020+1 Conference, in May, an ATSym meeting was held at the General Assembly.

The event was sponsored by Mott MacDonald with more than 150 people in attendance. Brodie Aitchison was introduced as the new ATSym representative and gave a short overview of the 2021 programme. The primary focus is on promoting and raising awareness of the new ATS Tunnel Design Guide, which was completed in late 2020 [see further details on p45].

Recognition was also given to Joshua Barry who was awarded the ITA's Young Tunneller of the Year Award in 2020 [see p27]. Josh was present on the evening and his key message to the young tunnellers in the room was to believe in yourself and take new opportunities as they arise. The evening continued with food, beverages, and lots of networking. It was great to get back together, meet old friends and make some new friends after a challenging 2020.

The ATSym also held a technical session at the ATS 2020+1 conference, comprising four presentations on topics ranging from segmental lining design to large span caverns. In addition, there were many other young members presenting in the technical streams throughout the conference, which showcased the depth of young talent within the industry

In Brisbane, this May, the ATSym hosted a 'Tunnelling Heroes' networking event at the Milton Common craft brewery. The event featured a Q&A session with three eminent tunnellers; Matt Lennon (Tunnel Construction Director), Ulrike Pelz (Project Design Director), and Adrian Smith (PSM Design Director) and provided an invaluable opportunity to ask questions and hear advice from three experienced tunnel engineers.

In September, the ATSym held a site visit to the Cross River Rail Project, in Brisbane. The event sold out quickly and there was a great mix of young members in attendance along with a strong representation of students and young engineers who had not been involved in much tunnelling and were keen to see what the hype is about!

The site visit kicked off with presentations from Alena Conrads (Project Engineer with the TBM Tunnels) and Mathieson Stosic (Site Engineer with the Mined Tunnels [see Cover and p34]) who gave an overview of the project and the technical details involved with constructing the station box, mined tunnels and TBM tunnels.

Attendees were then given tours of different aspects of the site, with engineers from CBGU JV leading each group and talking through all the project details as they went. After getting our boots dirty for two hours we resurfaced, debriefed and then headed to Easy Times Brewing for some socializing before heading to the River Fire festival and the AFL Grand Final.

Hearing conversations afterwards, it was clear the site visit was a huge success, sparking a lot of interest and thought from the next generation. A special thanks goes out to CBGU JV and the CRR Delivery Authority for supporting the event and making us feel very welcome!

Permanent lining works on the Cross River Rail Project

The ATSym event at the ATS 2020+1 Conference, in May

ATSym members, young engineers and students on one of the Cross River Rail tunnel tours, in September

Silver Linings and New International Ties

By Vojtech Ernst Gall

The UCA Young Members is a standing committee of the Underground Construction Association of the Society for Mining, Metallurgy, and Exploration (UCA of SME). Founded in June 2014, our primary goals are to support professional development, provide networking opportunities to our members and create close links with universities to recruit new talent. This has been the status quo for seven years now, but, as everyone knows, 2020 was a year unlike any other.

Due to the pressures of the COVID-19 pandemic, many parts of the country went into lockdown or partial shutdowns from the early spring onwards. The first major impact this had on our community is that the in-person North American Tunneling Conference (NAT), which, in most years is one of the few chances we get to see each other face-to-face, was cancelled. Similarly, all other major in-person events were postponed or cancelled entirely. Nevertheless, as with all of our international colleagues, we soldiered on! NAT, as with the Cutting Edge conference last November, were held virtually for the first time in their history. It was in this way, as with so many others, that the pandemic has presented challenges. But it has also presented opportunities.

Online meetings with "flair:" The UCA of SME Young Members playing around with MS Teams settings. From left to right: Ritika Kundu, Anvesha Dogra, Sean McDonald, Aswathy Sivaram, Jes Barron, Vojtech Ernst Gall, Luis Avila and Rajat Gangrade.

North America is a large continent with relatively few countries, so in many ways going virtual helped us overcome barriers that travelling normally imposes. We at the UCA of SME Young Members have therefore continued our webinar speaker series and increased the frequency of meetings. Similarly, we have continued to support the UCA of SME's Down for That! initiative (https://undergroundcareers.org/), which we continue to improve with new stories and personalities from all aspects of the mining and engineering community. As always, we publish the latest updates on our LinkedIn page (www.linkedin.com/groups/8338122/).

To supplement our webinar series, we are also developing a new "round-table" concept, in which we will open up our virtual meeting room to young engineers to share their experiences and stories about the underground community.

We are also reaching beyond our borders, as it were, and have used our new virtual platforms to connect with our international colleagues. We proudly took part in the World Tunnel Day, hosted by the ITA YM, last December and felt a spark of inspiration to expand our own international connections. Following the event, we reached out to our colleagues at the TAC YM, in Canada, and the AMITOS YM's in Mexico, together we are planning to host a "pan-North American" meeting this year. With this in mind, we look forward to strengthening our international connections and to continue to support the worldwide community of young tunnellers!

Lastly, and on a more personal note, we have managed a changing of the guard in our organizational structure. We would like to welcome our new members, Rajat Gangrade, Anvesha Dogra, and Sean McDonald to the team!

Luckily not all of us were kept off the field: Sean McDonald, one the UCA YM's Executive Committee members, standing in front of a TBM ready to be put to use for the new I-75 tunnel in Detroit, Michigan.

YM MEMBER NATION NEWS

Special Times Call for Special Activities

By Joakim Navestad Hansen

Like everyone else, Norwegians have been living with strict rules to avoid the spread of the COVID-19 pandemic and most indoor gatherings were banned in March 2020. The Norwegian Tunnelling Society (NFF) has, nevertheless, continued to display a good level of activity, with a number of webinars and virtual conferences on several different topics held throughout the last year.

However, a particular highlight was the geological bike ride we arranged in Oslo, as outdoor gatherings were still allowed in Norway.

Oslo, like most capital cities, has a lot of subsurface infrastructure, but not all cities are located in such difficult geology. Without going into all the details, the Oslo field is known for its mix of volcanic rock and marine sediment, which results in quick clay and Alum Shale to mention but a few of the challenges.

Professor of palaeontology at the Natural History Museum, University of Oslo, Hans Arne Nakrem, put together an interesting tour that covered the special geology of the city and the use of national and international rock in different buildings and structures.

The Young Members of the NFF have previously arranged a geological walk and the next idea is to use the water. Maybe we can invite other YM groups to the next one? A geological kayaking trip around the islands of the city.

Professor Hans Arne Nakrem, of the University of Oslo, is an award winning geologist who has contributed significantly to the popularisation of scientific research in Norway

Forging New Links and Spreading Awareness

By Paola Castillo

Founded in 2017, the Young Members group (New Generation of Tunnellers or NGT) of ACTOS (the Colombian Tunnelling and Underground Works Association) expands every year and now has more than 120 members.

Yearly, ACTOS-NGT organise and participate in several events in Colombia and internationally with fellow Young Member societies, such as the Youth Commission of the Colombian Society of Engineers (SCI), the ITAym Group and the Brazilian Tunnels Committee's Young Members (CBTym).

A noteworthy event in 2021 was the ENJI National Young Engineers Conference, where young civil engineering professionals came together to discuss sustainability, innovation and a holistic vision of engineering. The event took place virtually on August 3-6, and showcased young talented engineers in keynote speeches, lectures, discussions, mini-courses and forums.

Young engineers at the ENJI Conference

CBTym Talk #15 can be viewed on CBTym's YouTube channel

ACTOS-NGT also participated in the World Tunnel Day 24hr Zoom Meet-Up organised by the ITAym Steering Board on December 4, 2020 [see p15]. During the difficult times of the pandemic, it provided a key platform for young tunnellers from all around the world to learn, exchange, and make new connections.

Another noteworthy event was the CBTym Talk #15, which was a presentation led by CBTym with ACTOS-NGT as a special guest to share reflections on underground engineering from the point of view of young engineers (youtube.com/watch?v=IcjfTAmR548).

Among future plans, ACTOS-NGT seeks to raise awareness about the importance of sustainability, ethics and morality in Colombian underground works; through a national tour of universities and other forums. NGT also aims to remain internationally proactive by supporting and promoting the ITAym group and its fellow YM associations.

YM MEMBER NATION NEWS

Joint visit to CERN

By Arnaud Taillandier, AFTES-ym

In February 2020, shortly before the pandemic shut down Europe, the Young Member groups of Switzerland and France's tunnelling associations (STSym and AFTES-ym, respectively) came together to organise a joint technical and networking event. Specifically, the European Organization for Nuclear Research, CERN, drew our attention.

CERN is the largest particle physics laboratory in the world and is the site of the Large Hadron Collider (LHC), the world's largest and highest-energy particle collider. The CERN facility spans a wide area, straddling the Franco-Swiss border, and includes a large complex of underground caverns and accelerator tunnels to house experiments, which have been expanded on several occasions in recent decades. In October 2019, underground construction began on a planned upgrade to the LHC's luminosity (known as the High Luminosity LHC or HL-LHC), which will ultimately provide a better chance to see rare processes and improve marginal measurements during LHC experiments.

We were ambitious enough to organize a two-day event, including one full technical tour day and one networking and cultural day (as per STSym's usual gatherings). This time, we planned to go big (20 to 40 attending participants, a first-class programme and international guests). Invitations started with Swiss and French young members and then extended to several European countries. In the end, we had 37 participants from Austria, France, Germany, Italy, Portugal and Switzerland!

The event began on a Friday morning with a working visit to the CERN HL-LHC Point 1. The visit was hosted by Swiss-based international contractor Marti and French-based engineering firm SETEC. They prepared a great visit including a tunnel tour, surface tour and technical presentations. The tour was even carried out in English, German and French to cater to all our participants.

The current expansion for the High Luminosity Large Hadron Collider (HL-LHC) includes: An 80m deep shaft; An underground service hall cavern that will house cryogenics equipment; A 300m-long tunnel for electrical equipment (power converters); Four tunnels measuring around 50m in length, connecting the new structures to the existing accelerator tunnel. These will house specific hardware, such as radiofrequency equipment; and five new surface buildings, totalling 2,800m², that will house cooling, ventilation and electrical equipment. The noise and vibration created during construction disturbs the measurements of CERN's scientists (their precision scale is an atom…). Therefore, works can only be carried out during a planned shutdown of the LHC, between April 2018 and 2021.

In February, 37 young members from six nations came together to visit the CERN HL-LHC expansion works on the Franco-Swiss border

In the afternoon we had two possibilities, visit CERN itself on a guided tour or view the permanent exhibition. The guided tour started with a high-level physics lecture, where English undergraduate students shamed us all with their knowledge (I got lost between "Boson" and "Muons"…). This was followed by visit to different technical installations, all informative and interactive, where we could ask so many practical questions! The other group had also the chance to explore the world of contemporary physics and learn about the origins of the universe in the different CERN exhibitions.

The day ended in a bar sharing our experiences while sampling Geneva's food and hospitality.

The programme on Saturday also focused on networking. Survivors of Friday night enjoyed a sunny day's visit to Geneva while trying to solve a robbery mystery in a city game (yes, we finally did it!).

We are looking forward to future events where we hope many other national ym-groups will be able to join us; until then stay safe!

A special thanks to the young tunnel engineers who came from all over Europe by car, train and airplane to attend the event at short notice; the kind support of the STS and AFTES associations; and last, but not least, SETEC and Marti for their generous hospitality.

CERN's Globe of Science & Innovation

Young members on the tunnel tour

Socialising after a long day at CERN

Danish Young Members Gear Up for WTC '22

By Eyðbjørg Amanda Petersen

The Danish Society for Tunnelling and Underground Activities (DFTU) is currently focused on the final sprint of preparations for the upcoming ITA World Tunnel Congress (WTC), on 22-18 April 2022, in Copenhagen, with Early Bird delegate registration now open. The overall theme of the congress is "Underground Solutions for a World in Change", touching on climate resilience, innovative solutions for a sustainable society, subsurface planning and sustainable underground structures.

Two rounds of paper reviews have been performed. The acceptance process of the first round is just around the corner and letters will be sent to authors in late October. The schedule for the second round is available on the conference homepage and all final papers are expected by mid-December. Planning of the opening ceremony is well underway, and invitations have been sent to the European Union for a keynote speaker from the commission.

The idea of a dedicated Young Members session has been proposed and is currently being developed between the ITAYM and the WTC Organising Committee. This is in addition to the ITACET training session, which will be held in advance of the WTC. A preliminary programme for the training session has been developed and more details of the exciting content will be available very soon! Follow updates on the web site for more information.

STUVA-YEP's launch Digital Workshop Series

By Christian Rhein

As planned excursions, workshops and get-togethers could not take place in 2020, STUVA-YEP (Germany's young members group) decided to launch a digital workshop series, called "STUVA-YEP goes digi". These online workshops last about 90 minutes and include two presentations. In between, participants have the opportunity to get in touch with each other in breakout sessions, to exchange ideas and catch-up. In addition to the professional exchange, the overall goal of these workshops is to maintain contacts and to further expand networks.

The first workshop, which took place in November 2020, was a great success! Around 50 young tunnel engineers attended presentations about geotechnical computing and urban rail tunnel construction. Due to the positive feedback, STUVA-YEP organised a second workshop at short notice., which took place on 10 December as a Christmas special. With cookies and mulled wine, around 35 interested participants met in front of their screens and listened to presentations on a current highway tunnel project and risk analysis for road tunnels in operation.

Young tunnellers from abroad also became aware of our digital series. Thus, engineers from Austria, Switzerland, France, the Czech Republic and America also took part in the second workshop. As this new format is enjoying such popularity, the workshops will now be offered every three months, starting March 2021.

Czech YM Group Established!

By Simona Zetkova

A Czech young members group (CzTA_ym) was established in November 2020 as a working group within the Czech Tunnelling Association. Since then, the group has gained 35 participants. Due to COVID-19, the first meeting took place online. During the meeting, presentations dealing with BIM, a construction site progress and an overview of upcoming railway tunnel projects were held. To provide a non-formal interaction opportunity between participants, the group asked attendees to present themselves in the form of "Wanted" posters. We are looking forward to organising our first face-to-face meeting of the group in 2021. Moreover, CzTa_ym are open to future collaboration with groups from other countries!

CzTA ym

YM MEMBER NATION NEWS

Italian YM's Celebrate 5th Anniversary

By Diego Sebastiani, Daniele Martinelli, Agostino Viglione, Stefania Fabozzi, Luca Perazzoni and Luigi D'Angelo

In 2016, the Italian Tunnelling Society (SIG) formed a Young Members group to pro-actively support its activities, connect young professionals in the industry with universities and to establish fruitful collaboration with other ITA Member Nation YM groups. Five years on, the SIG YM group is now coordinated by a Board and has more than 270 members including junior members (comprising 34% of the overall members of the Italian Tunnelling Society).

Since its foundation, the YM group has focused its energies on finding ways to promote the activities of the group, and the Italian underground industry, among young professionals. Over the last five years SIG YM has been involved in the promotion of many conferences and events through its official channels (email, social network and website), such as the 2019 World Tunnel Congress (WTC), in Naples. As YM's chief of communication, Agostino Viglione, is periodically in contact with young professionals and members of our community to relay YM group activities and invite them to join in.

We strongly believe that communication represents the pillar on which the tunnelling and underground industry should be founded, to develop its potential and spread its benefits in terms of social impact, environmental sustainability and infrastructure development. As a YM group we are in charge of the next generation's future, building on the experience of our senior members and international colleagues to enhance our potential and help shape a better world.

As YMs we also support ITA Working Groups, technical visits and at national and international conferences. In October 2020, SIG's YMs organised the 2nd SIG-YM Conference, in Bologna, "Tunnelling 4.0: New Technologies and Future Perspectives for Maintenance, Upgrading and Refurbishment of Tunnels". The conference explored the latest advances and future challenges in maintenance, monitoring and prediction technologies and the automation of Tunnel and Underground Space inspection. More than 20 infrastructure owners and managers presented innovations in monitoring techniques, as well as interesting case studies. The organisation of the conference, considering the COVID-19 pandemic, required particularly heightened security protocols in order to guarantee the safety of participants.

(From left) Diego Sebastiani, Stefania Fabozzi, Luigi D'Angelo and Agostino Viglione with Andrea Pigorini, President of the SIG

In 2020, the SIG Board decided to renew its website, in terms of appearance (with a more attractive design), in content (with new sections) and making it more user-friendly (responsive to smartphones and tablets). In addition, an English version of the website has been created, to make content available to an international audience. Diego Sebastiani and Luigi D'Angelo were appointed to be actively involved in this process. Among the other things, they proposed a new section called "The Italian Art of Tunnelling", which displays photos and information on some of the biggest tunnelling projects in Italy (from the past, present and planned/future). The goal is to make the website not only a tool for SIG members, but also a "showcase" for the wider public of Italian know-how in this sector.

We would like to take this opportunity to encourage new relationships and connections worldwide so, please, take a look at our SIG YM webpage: (www.societaitalianagallerie.it/menu/young-members-en/ym-group/), write to us at ym@societaitalianagallerie.it and let us know if you are interested or involved in projects in Italy, or even if you are just planning to spend some time in Italy: it would be great to meet up!

An online welcome meeting held for new SIG Young Members

#WTD2020

By Chrysothemis Paraskevopoulou

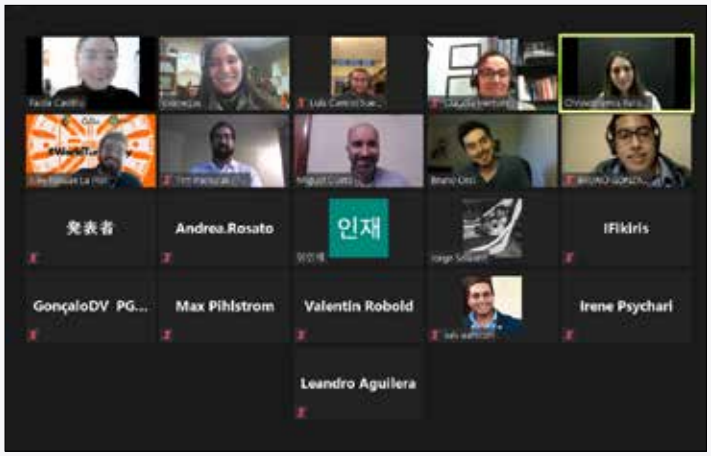
On December 4th, 2020, the ITAym joined national Young Member groups to celebrate #World Tunnel Day and St Barbara's Day (the patron saint of tunnellers and miners) during a 24-hour online Zoom-marathon meet-up.

The idea was brought about by a small group of young professionals from the UK, Canada, Brazil, Italy and Greece who initially got together to discuss a collaborative online webinar prompted by COVID-19 travel restrictions. The idea was communicated to the wider ITAym community and before long a 24-hour online marathon was on the table. It was an ambitious idea, especially with organisation beginning just three weeks before the celebration, but representatives from each continent were assigned to the task and the programme quickly started coming together.

The main goal of the event was to demonstrate that there are no real borders between the various countries of the international tunnelling industry; a fact that's evident on the large number of tunnel projects being constructed around the globe by international joint ventures and consortiums. The ITAym wished to emphasise this further and highlight the importance of celebrating this international day together.

Organising the event was actually rather challenging. However, the response of the various young member groups was very positive. In the end, 28 national YM groups participated in the Zoom meet-up, which began in Oceania and gradually moved to Asia, Africa, Europe and the Americas.

More specifically, the countries who hosted were: Australia, Japan, S. Korea, Malaysia, Singapore, India, Kenya, Greece, Italy, Spain, Portugal, France, Switzerland, Austria, Czech Republic, Poland, Germany, UK, Denmark, Sweden, Finland, Norway, Canada, USA, Mexico, Colombia, Brazil and Chile. Each Young Member group was given a slot where it presented various YM activities and initiatives as well as interesting underground projects.



Screenshots from the #WTD 2020 24hr Zoom marathon meet-up

The event was extremely successful with more than 450 participants joining the marathon worldwide and over 3,000 clicks on the Zoom link through the day. The whole thing was recorded and is available to watch on the ITAym YouTube channel (bit.ly/ITAym2020).

The ITAym would like to acknowledge that this event was a collaborative effort and thank everyone who contributed. Our wish is to make this world meet-up an annual event and a tradition for years to come. Stay tuned for more information about #WTD2021!

Thanks to the efforts of national YM groups #WorldTunnelDay trends on Twitter every December highlighting the importance of the industry

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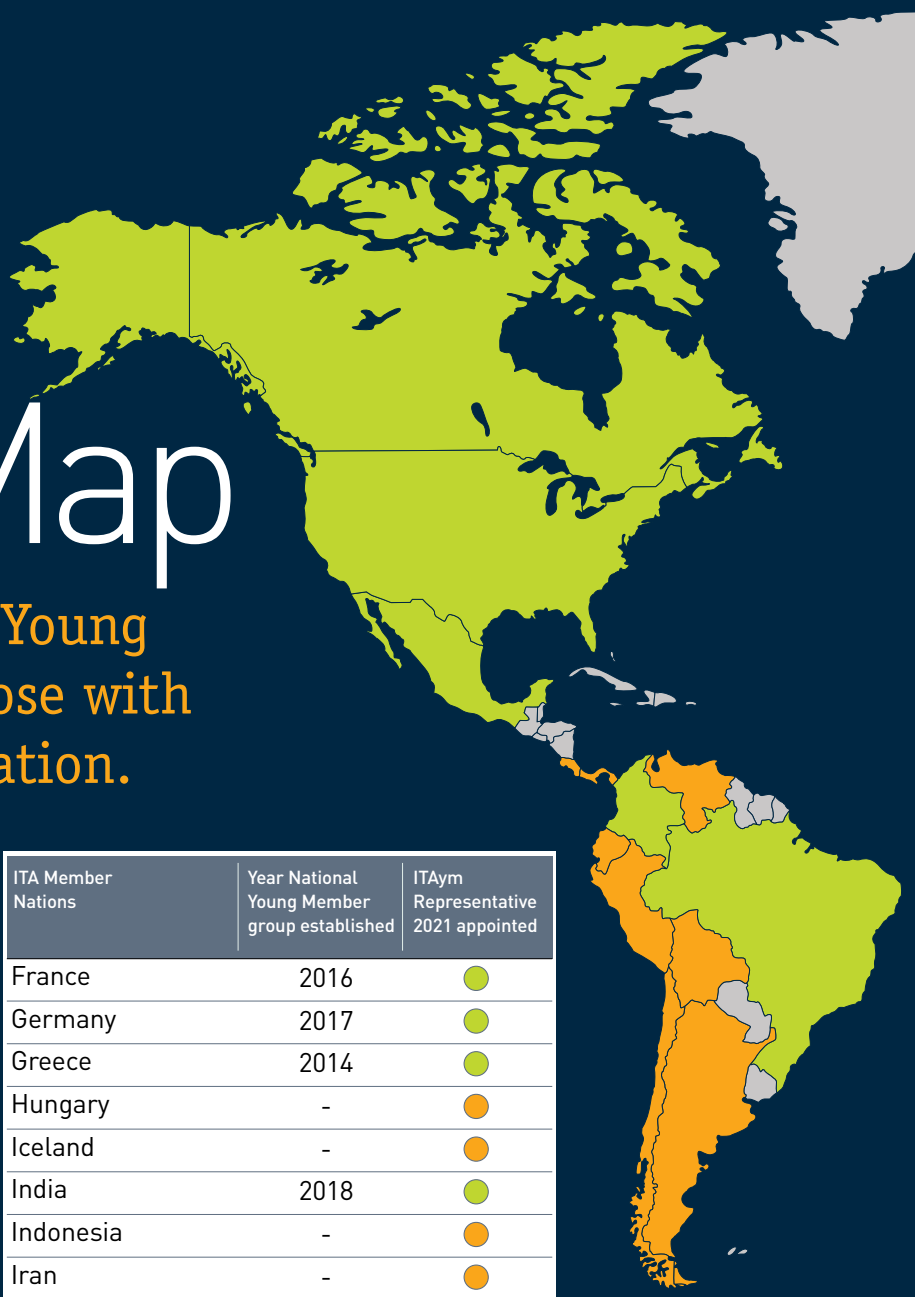
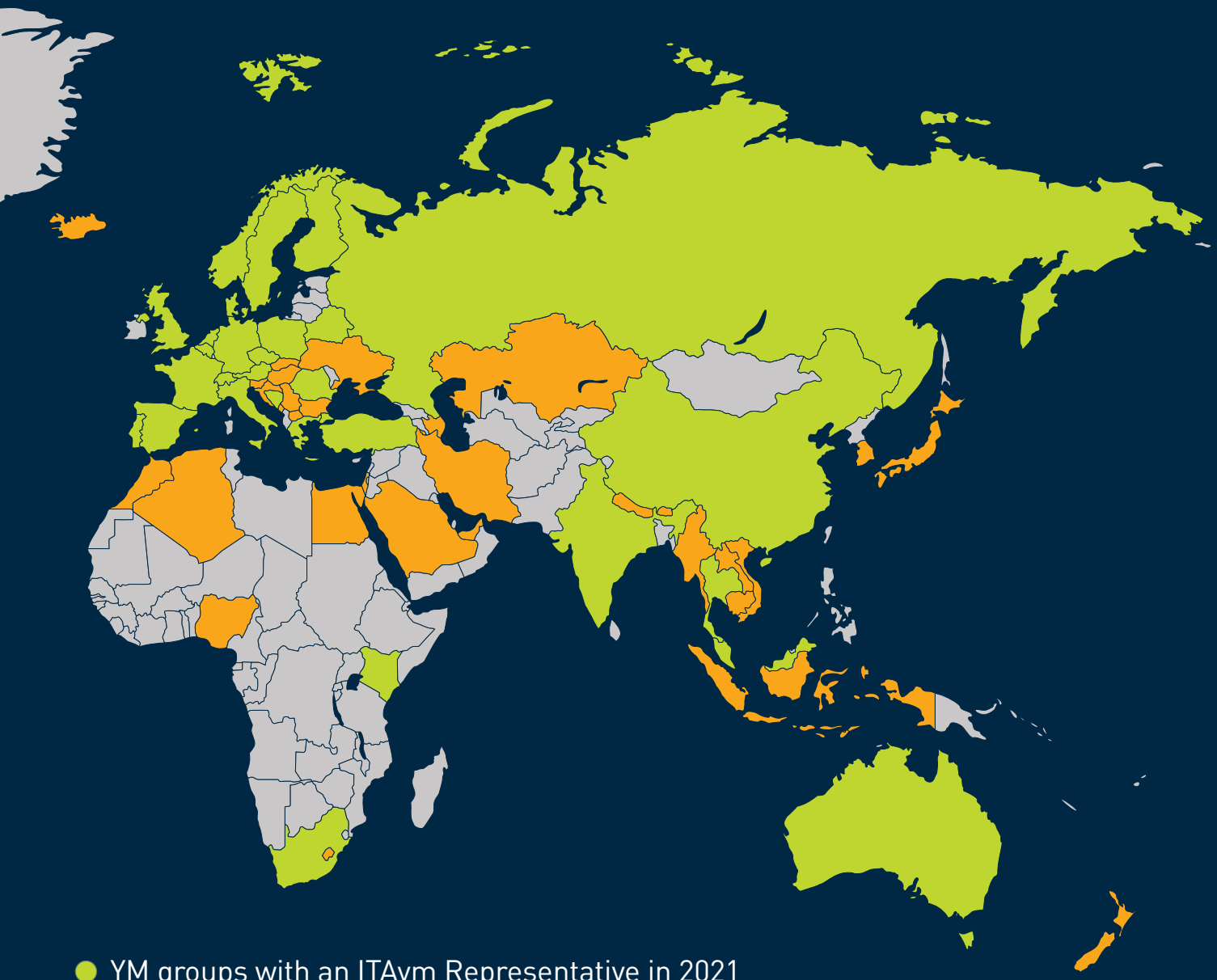
World Map



This map represents all Young Member Nations and those with active ITAym Representation.

ITA Member Nations	Year National Young Member group established	ITAym Representative 2021 appointed
Algeria	-	●
Argentina	-	●
Australia	2013	●
Austria	2016	●
Azerbaijan	-	●
Belarus	2014	●
Belgium	-	●
Bhutan	-	●
Bolivia	-	●
Bosnia Herzegovina	-	●
Brazil	2015	●
Bulgaria	-	●
Cambodia	-	●
Canada	2014	●
Chile	-	●
China	2021	●
Colombia	2018	●
Costa Rica	-	●
Croatia	-	●
Czech Rep.	2020	●
Denmark	2014	●
Ecuador	-	●
Egypt	-	●
Finland	2018	●

ITA Member Nations	Year National Young Member group established	ITAym Representative 2021 appointed
France	2016	●
Germany	2017	●
Greece	2014	●
Hungary	-	●
Iceland	-	●
India	2018	●
Indonesia	-	●
Iran	-	●
Israel	-	●
Italy	2016	●
Japan	2016	●
Kazakhstan	-	●
Kenya	2021	●
Korea (S)	2010	●
Lao DPR	-	●
Lesotho	-	●
Macedonia (FYROM)	-	●
Malaysia	2019	●
Mexico	2016	●
Montenegro	-	●
Morocco	-	●
Myanmar	-	●
Nepal	-	●
Netherlands	2017	●



- YM groups with an ITAym Representative in 2021
- YM groups without an ITAym Representative

ITA Member Nations	Year National Young Member group established	ITAym Representative 2021 appointed
New Zealand	-	●
Nigeria	-	●
Norway	2010	●
Panama	-	●
Peru	-	●
Poland	2019	●
Portugal	2019	●
Romania	-	●
Russia	2021	●
Saudi Arabia	-	●
Serbia	-	●
Singapore	-	●
Slovakia	-	●

ITA Member Nations	Year National Young Member group established	ITAym Representative 2021 appointed
Slovenia	-	●
South Africa	2016	●
Spain	2016	●
Sweden	2017	●
Switzerland	2017	●
Thailand	-	●
Turkey	-	●
UAE	-	●
Ukraine	-	●
United Kingdom	2008	●
USA	2014	●
Venezuela	-	●
Vietnam	-	●

A Legacy of Lessons

Many of the tunnelling industry's most iconic projects have also been the most challenging. Kristina Smith spoke to several leading industry experts about the projects that shaped them as young engineers and the lessons they learned as a result.

Andy Schmidt – Manapouri Second Tailrace

If you see an opportunity, don't be shy, take it!

"Everything I've done has led to a new experience, new abilities, and on to the next job," says Andy Schmidt, who is currently the Ventilation Mine Officer on the NZ$1.2bn Central Interceptor Wastewater Project, in Auckland, New Zealand – a role that only three people in the country are qualified to take on.

Schmidt is an Otago School of Mines graduate and has had a varied career that started in coal mining in New Zealand and has seen him moving between mining and tunnelling in New Zealand, South Africa, Mozambique, Australia and the UK. He worked on his first tunnel project while travelling, as a Site Engineer on the Channel Tunnel, which links the UK and France. But if he had to pick the project that moulded him most profoundly, it would be the Manapouri Second Tailrace Tunnel, in the late 1990s. "That was my steepest learning curve," he says.

The Manapouri Second Tailrace Tunnel project tested everyone who worked on it. National Geographic made a film about it, 'The Toughest Tunnel', a title which indicates the difficulties Schmidt and his colleagues faced. Located under the western arm of Lake Manapouri in the Fiordland National Park, at the far south of South Island, New Zealand, a Robbins hard rock tunnel boring machine (TBM) was faced with super-hard rock, instability around fault lines and large inflows of water. "It was a 10m diameter machine, the largest hard rock TBM at that time, and it was pushed to its maximum," says Schmidt. "We literally almost destroyed it getting there. We had to stop a few times and repair it; the cutterhead was basically rebuilt and the belt magnetic picked up the bits of the cutters."

The Robbins rock TBM breaks through in 2001

The project, as its name suggests, added a second tunnel to the Manapouri Hydroelectric Power Station, which was built in the 1970s. A design error meant that the plant did not work properly; friction between the water and the concrete walls of the tailrace tunnel reduced the hydrodynamic head, which meant the plant could not be operated at its intended capacity.

In addition to the rough ground, there was the challenge of linking the two tunnels once the second one was complete. Divers had to install a steel bulkhead to shut off the original tunnel. Contractor Fletcher Dillingham Ilbau (FDI) built a full-size mock-up of the tunnel and submerged it in the lake so that the divers could practice the installation process.

Schmidt who had come to the project wanting an engineer's role, accepted the only safety position as the Safety Manager. As someone who had started as a miner, and who's natural inclination was to muck in with the workers on tunnelling projects rather than stand around waiting to carry out engineering duties or survey checks, this was a natural role for him. But it was a lot of responsibility.

"I was basically on my own as the Safety Manager, looking after 200 people on the project," he says.

There were so many issues that did not have textbook answers. Schmidt found himself doing lots of research and planning. And then came the task of convincing the project leaders to take

The tunnel is under the stunning Doubtful Sound on Lake Manapouri

on his methods. "Sometimes you are the bearer of bad news," he says. "It's your job to sell to them what you need to do and get it accepted, while being mindful that the project has to make money."

Schmidt followed his time at Manapouri with 10 years at Waihi Gold Mine, in New Zealand, as the Safety Manager. Then as Tunnel Safety Manager in Auckland's Waterview Road Tunnel on a 14.5m diameter EPB TBM. Schmidt's knowledge of mining and tunnelling is invaluable now on the Central Interceptor project. In his role as Ventilation Mine Officer, working for the Ghella Abergeldie Joint Venture between an international and local contractor, Schmidt is deploying his technical and management experience gathered over his career to date. "It's like all the pieces of the jigsaw are coming together," he says.

His advice to young people entering the industry is to take the chances you are given: "You can plan things to a certain extent, some things just happen, call it fate," he says. "If you see an opportunity, don't be shy, take it. If you've had a hard day or week, stop, take a breath and look back over the last three months and see the progress made."

Andy Schmidt leads a safety briefing on the Central Interceptor Wastewater Project, in Auckland, New Zealand

Find out more about the Manapouri project here:
https://www.nzgeo.com/video/manapuri-the-toughest-tunnel/

Andy Thompson – Storebaelt (Great Belt) Tunnel

It's good to talk

When Andy Thompson joined consulting engineer Mott Hay Anderson in 1988, there were around 750 people in the company. Today, that company is called Mott MacDonald and it employs 17,000.

Over his 30-plus years with Motts, Thompson has worked on a number of highly-challenging landmark projects, including the Strategic Sewer Disposal Scheme (SSDS) Stage 1, in Hong Kong, and the East Side Access Project, in New York, where he oversaw the construction and programme management of the $10.6bn project. There are challenges on every tunnelling project – that's part of the game, says Thompson – but one of his earliest projects, Denmark's Storebaelt (Great Belt) railway tunnels, definitely had more than its fair share. "That was an extremely challenging project, which was on the limits of technology for the time," recalls Thompson, who is now US East Tunnel Design Manager for Mott MacDonald.

The four Howden Wirth earth pressure balance TBMs (EPBMs) at 7.85m (30ft) diameter were considered to be pushing the envelope for sub-aqueous tunnels at the time and were pushed to the limit of their abilities. "The technology was very much in its infancy, in the late 1980s and early 1990s, with very few relevant project examples from which to draw lessons learned," explains Thompson. "Compared to the modern breed of EPBM's they did not have the same mixing capability or a good ability to inject conditioning foams."

Storebaelt was one of the first TBM projects in the world to use polymers for muck conditioning to improve pressure control.

Thompson arrived on site as part of a beefed-up construction management team, formed after a devastating tunnel inundation in 1991, which occurred during tool maintenance on one of the TBM's cutterheads. There were many more challenges to deal with. The ground, which contained boulders and abrasive sand lenses, wreaked havoc, wearing down the the cutterhead structure; repairing them was difficult and onerous because the groundwater pressure was so high.

The inundation of the Storebaelt tunnels also flooded the TBM launch pit on Sprogo Island

As hydrostatic conditions ranged from approximately 2 bar to a maximum of 8 bar the use of compressed air for interventions was always expected to be limited. While several different decompression tables were adopted throughout the early reaches of tunnel (from British, to US and French diving tables), clearly a new approach was required for the deeper middle segment of the drive.

The project deployed several different methods to lower the pressure so that miners could work safely on the repairs. Finally, 'Project Moses', the largest undersea dewatering scheme ever conducted in an international waterway was implemented. This had the target of lowering the hydrostatic pressure to 2 bar at the invert, with a higher prevailing pressure at the crown, thereby inverting the pressure distribution across the face. The highly-successful programme dewatered the ground from barges moored above dewatering wells.

There was also a fire. "I was doing my grocery shopping on a Saturday morning when I saw our job on the TV," remembers Thompson. "There was smoke coming out of the tunnel." An oil leak through a pinprick in one of the lines had ignited. The machine was completely gutted and some of the reinforced concrete segments that lined the tunnel had spalled, exposing the reinforcing bars inside them. That section had to be lined with cast iron segments brought in from the Channel Tunnel.

The tunnel lining had the potential for

collapse. Quick collaborative thinking by everyone, effectively turned this from a potential disaster into very robust solution. What Thompson saw on Storebaelt was how major problems were solved by people putting their heads together. "Project Moses was developed by our geotechnical manager and the contractor's geotechnical manager," he says. "We found solutions together."

The construction manager's role should never be to constrain the contractor unnecessarily, he says. "There's a quote that always sticks with me: 'We don't succeed unless the contractor succeeds'. That doesn't mean you roll over, you work with the contractor, develop a working relationship and mutual respect." When such a relationship doesn't exist, big problems can invariably become greater.

An important skill for any tunnelling engineer is the ability to talk with anybody, says Thompson. He started honing his communication skills during his very first job in a gold mine in South Africa where he spent two years after graduating from Newcastle University with a BEng in Mining and became responsible for production at the young age of 23. After returning to the UK on the A20 Round Hill Project, he spent time talking to the miners and foremen.

"Just because somebody does not have a formal qualification does not mean they don't know what they are talking about," he says. "I learnt a lot from seeing how the foremen and the lead miners organised themselves. You need to learn how to communicate, and that is something I am not sure – with the separation between engineering and construction – is happening as much as it should. It's an important part of the growing up process."

The Storebaelt Tunnel entrance on Sprogo Island

Read more about the Storebaelt Tunnel here: https://www.mottmac.com/download/file?id=39538

Daniel Spörri – Gotthard Base Tunnel

Once in a lifetime

When Daniel Spörri arrived at the Gotthard Base Tunnel, he was a young Shift Engineer with four years' experience. Over the next 15 years, Spörri would work on three of the five construction lots for the 57km tunnel, facing a whole range of challenges that many engineers could only hope for in a lifetime.

Passing beneath the Alps, the Gotthard Base Tunnel is the world's longest railway tunnel. It runs at depths of up to 2,300m creating huge stresses in the ground, squeezing rock and instability around the two parallel tunnels as they were constructed. For the first four years, Spörri worked on the construction of the first of the two 800m-deep shafts at Sedrun, part way along the route between Erstfeld and Bodio, sunk from a cavern in the mountain. Spörri's company Implenia was working in joint venture with South African company Shaft Sinkers.

Spörri, newly married, had moved with his wife to live in Sedrun near to the site. Because of his language skills, he found himself translator as well as engineer. "I was the link between the English-speaking construction site and the German-speaking local contacts, especially during off-peak hours, such as nights and weekends," he explains.

"As fascinating and exciting as the shaft sinking work was, it was also dangerous. Numerous minor accidents and, unfortunately, several serious accidents occurred on the construction site, in many cases during off-peak hours. And so, my mobile phone often rang in the middle of the night or during weekends. That was mentally very stressful at the time."

After Sedrun, Spörri moved to the Faido construction site as Site Manager, one of the five sections of the tunnel. The challenges were different here: a huge construction site with its associated technical and logistical issues and the ground itself. "The unforeseen, very demanding geological conditions with downfalls, squeezing rock conditions and rockfall posed enormous challenges for everyone involved in the project," says

Breakthrough on the Gotthard Base Tunnel

The Gotthard Base Tunnel lies deep (2,300m) under the Gotthard Pass

Spörri. "Every day could bring another surprise and since work was carried out seven days a week, 24 hours a day, quick decisions had to be made constantly."

During his time on the Gotthard Base Tunnel, Spörri discovered the difficulties of working on international joint ventures. He learned that forming a high-functioning team from a group of people with diverse backgrounds and mentalities is no mean feat, especially on such a huge project where the next phase always brings something different.

"Every tunnelling project is a team effort where everyone has to fulfil his or her assigned task with the common goal in mind, as well as they possibly can. This applies not only to the contractor, but also to the client, planner and supervisor, and especially to the cooperation between all these project participants," says Spörri.

Unforeseen geological tensions on the Faido section, and the adjacent Bodio section which Spörri worked on subsequently, made excavation far more difficult than expected. Initially, this led to great tensions between the JV and the client - including the client's planner and supervisor - from a technical and a financial point of view, says Spörri.

"It was only when the mutual recriminations gave way to the will to find a common solution that the right technical measures could be efficiently determined and decided upon in a constructive dialogue," he says. "Admittedly, the financial aspects took a little longer, but here, too, fair solutions were found in the end."

Although the projects Spörri has worked on after the Gotthard Base Tunnel have been much smaller, many of the lessons he learned there have proved useful. Cooperation between team members and a constructive approach gives the best results, he says, with conflict only leading to additional cost and frustration. As projects become larger and more complex, so the need for early collaborative planning between all parties becomes more important.

Spörri's experiences at Gotthard also imprinted the importance of safety on him: "As a supervisor, you are responsible for safety by law, but of course there is also the human component, as there are personal fates behind every accident."

At 57km-long the Gotthard Base Tunnel is the world's longest and deepest rail tunnel

Find out more about the Gotthard Base Tunnel here (or search YouTube): https://www.ice.org.uk/eventarchive/challenges-of-the-gotthard-base-tunnel-london

Helmut Wannenmacher – Niagara Tunnel

Pushing the limits

Helmut Wannenmacher looks back on the Niagara Tunnel Project with fondness and nostalgia. But the truth is that his time there was some of the most stressful and demanding of his life.

The 10.2km-long Niagara Tunnel in Canada was constructed to carry water from above Niagara Falls to the existing Sir Adam Beck hydroelectric generating station. The project encountered numerous problems, including huge overbreak in the Queenston shale formation, which slowed down progress and, ultimately, prompted a realignment of the tunnel. It also deployed an unusual method of pre-stressing the unreinforced concrete lining, which had to take internal pressures of up to 13 bar.

Wannenmacher first went over there from Austria with his wife and first child, who was a baby then, in 2006. "It seemed like a cool idea, to bring my family. But on site, you are working from six in the morning to eight in the evening. I didn't have time for my family."

After a year and a half, Wannenmacher moved back to Austria. But the problem that he had started trying to solve while he was there remained: how to pre-stress and monitor the deformations of the concrete lining of the tunnel using grout. This involved injecting the grout at a defined pressure between a waterproofing layer below the final cast concrete lining and the initial shotcrete layer, compressing both the final liner and the surrounding rock.

"This technique was very old," says Wannenmacher. "But it was so old that there was no one really around we could ask to transfer the theory to hands-on practice."

A year after Wannenmacher had left Niagara, the project wanted him back, to pick up where he had left off to solve the pre-stressing problem. Wannenmacher agreed, travelling to and from Canada spending three weeks on the project and then two back at home. "It was difficult," he says, "But I explained to my wife that it was something I had to finish and she understood."

The first trials were not successful. "At that point, we felt really lost because we could not see pressure increase and a corresponding deformation of the lining," he says. Wannenmacher remembers evenings spent with his colleagues, with whom he shared accommodation, drawing out the problem, racking their brains to identify the problem and to work out what the solution could be.

"Our imagination back then could not think that a grout could travel up to 100m behind the final lining and the membrane."

"What you do not learn at university, what you need to know all the time, is how to deconstruct a problem," says Wannenmacher. "If the problem is too big for you, you need to start breaking it down, and you need a lot of people with different skills and background to widen your perspective. You have to understand the problem from every aspect. Listen to the guy in the tunnel, listen to the mathematician, everybody has to tell their story."

They did come up with the successful solution. "We modified the whole process. From one moment to the next, it started working perfectly."

After a challenge like Niagara, more straight-forward projects can be less exciting, admits Wannenmacher, who

finished there in 2013. "That was a problem for a couple of years," he says. "But I feel I was lucky to be there and to be a part of it."

The Niagara project also helped raise Wannenmacher's profile in the international tunnelling community. He wrote and presented numerous papers and still has people asking him for information today, which he says he is always happy to share.

Wannenmacher feels that there won't be another project like Niagara, not just because it was in such a unique location and had such unique characteristics and challenges, but because there is not much of an appetite to innovate in that way on tunnelling projects today: "Projects are getting bigger, but there is not too much interest in pushing the limits. At Niagara, that is what we were keen to do."

Find out more about the project here: https://www.researchgate.net/publication/260539810_A_Case_Study_of_the_Niagara_Tunnel

Breakthrough of the 14.4m diameter Robbins hard rock TBM (the largest in the world at that time) in March 2011

Lalit Kumar – Pir Panjal Tunnel

Forging the way for NATM in India

In 2004, Lalit Kumar was a young tunneller working on the 11km, single tube Pir Panjal tunnel, part of the Udhampur-Srinagar-Baramulla Railway line (USBRL) project. The 272km line joins the Kashmir valley with the Indian Railways network and is India's biggest rail project since independence.

The Pir Panjal tunnel, which passes through the Himalayas, is the longest operational transportation tunnel in India (there are currently some longer tunnels under construction in northern India through the Himalayan range). It was the first railway project to use the NATM tunnel construction philosophy extensively in India, Kumar's first experience in NATM tunnelling and a project that pioneered the use of the technique in soft ground.

"NATM tunnelling was limited to some metro projects like Delhi Metro (DMRC) at Chawri Bazaar Station and some big caverns for hydro projects," says Kumar, now General Manager at RITES. Put simply, NATM (New Austrian Tunnelling Method) – or the Sequential Excavation Method (SEM) – involves the sequential excavation of the ground, advancing a few metres at a time, and supporting the ground as you go using sprayed concrete and other primary support elements like rockbolts, wire mesh, forepoles and steel arches, depending on the type of ground encountered.

Tunnelling in soft ground was considered difficult at that time in India, says Kumar. Because the first 585m of the tunnel from the North Portal was in soft ground, those planning the project expected progress to be slow. So, they added a 52m-deep shaft from the point where the hard rock started so that tunnelling could start there, using drill and blast, while the soft rock section was completed.

However, the use of NATM meant that the tunnelling rate in the soft ground was far faster than expected: around 100m per month rather than the predicted 30-40m per month. By the time the shaft was completed, the tunnel had already reached that point. "That was a big achievement, which deeply strengthened our hopes and raised our energy level many folds towards the tunnel construction," remembers Kumar. "Also, it busted the perception that it is difficult to maintain good tunnelling rates in soft ground conditions comprising fluvioglacial deposits."

The project was a learning ground for Indian contractors who were used to drill and blast techniques, involving heavy steel ribs, lagging and concrete. However,

The collapse near the junction of the access tunnel and the main tunnel on Pir Panjal

the learning curve was not a smooth one, says Kumar, as various problems were encountered along the way, some predicted and some unexpected.

Near the junction of the access tunnel and the main tunnel, 765m in, a semi-circular cavity developed due to a sudden ingress of a large quantities of water that had collected in a weak zone. "The depth of the cavity varied from 2.5m to 6.5m and the length of the collapse was about 7m," says Kumar. "The material released from the cavity was highly fractured black shale with fault gouge and some volcanic tuff."

To deal with this issue, the contractor had to backfill the section of the tunnel near the face, drill holes to release the water pressure, fill the cavity with grout and install rock bolts and grouting to support the top of the tunnel so that excavation could begin again. They then began excavating in smaller advances of 0.5m until the original face was reached, extending that to 1m until the rock conditions were back to normal again.

Water ingress was also a problem at the points where two rock types met. At 316m in, water was flowing from the face at a manageable rate of 20 litres per second. However, during the face drilling, the rate of water ingress increased to 150 litres per second, filling the tunnel up to its junction with the access tunnel. Work stopped for nearly 70 days during this period, while long drain holes were drilled and pipes to support the roof of the tunnel were installed. "The lesson learnt was the need to probe ahead of the face to anticipate adverse geology," says Kumar.

Another shock was the sudden sound of rock cracking at around 2,700m. "It caught us off guard," says Kumar. "It was a rock burst and it was sudden."

A rock burst is often violent, occurring due to a sudden fracture of a highly stressed, brittle rock mass with a rapid release of energy, explains Kumar. With strata consisting of moderately fractured rock, with the high overburden pressure, the ground was highly susceptible. To deal with the situation the advance length was reduced to 1.2m with forepoles and additional rockbolts installed to control deformation.

Validation of the design, using extensive instrumentation and monitoring, was another new technique learnt by Lalit and others on Pir Panjal. "The experience made us more confident in anticipating the qualitative and quantitative assessment of geotechnical risks and tackling difficult types of strata," says Kumar.

There were many other challenges for this project, says Kumar, not least its remote location and a lack of workers who were skilled in the NATM technique. The Pir Panjal tunnel was completed in April 2012 and operational from June 2013 on the railway line from Banihal to Srinagar. The remainder of the USBRL project is still under construction.

Find out more here: https://onlinelibrary.wiley.com/doi/abs/10.1002/geot.201400008

Installation of rockbolts, wire mesh and steel sets during NATM excavation

2020's Young Tunneller of the Year

Each year the ITA Tunnelling Awards recognises a young professional that has made an outstanding contribution to the tunnelling and underground space industry. In 2020, the Young Tunneller of the Year finalists were presented virtually, due to COVID-19 travel restrictions. Here, Breakthrough celebrates their successes.

THE WINNER

Joshua Barry, Australia

Josh has 13 years of experience in the analysis and design of tunnels, caverns and shafts in various ground conditions. Since 2019, Josh has been based in Melbourne as Aurecon's Australian Tunnels Manager providing technical expertise, mentoring, resourcing and coordination between Aurecon's regions. Having worked on projects in Hong Kong, Thailand, Australia and New Zealand, Joshua has gained considerable international experience in the concept and detailed design, construction monitoring and project management of large-scale civil engineering and infrastructure tunnel projects. Projects of note include South Island Line (Hong Kong), Express Rail Link (Hong Kong), Melbourne Metro, NorthConnex (Sydney), City Rail Link (Auckland), WestConnex (Sydney) and West Gate Tunnel (Melbourne). Josh is currently leading the construction phase service underground works for the Aurecon-Jacobs Joint Venture (AJJV) on West Gate Tunnel, the largest TBM ever (15.6m EPB) to be excavated in the southern hemisphere.

THE FINALISTS

Laurence Delplace, Belgium

Laurence has been working in the tunnelling industry since she graduated from the Swiss Institute of Technology, in Lausanne. Her first role was at Herrenknecht, in Germany, the world's leading manufacturer of Tunnel Boring Machines (TBMs). Driven by her desire to broaden her expertise, Laurence then joined Amberg Engineering, a Swiss-based engineering office specialised in tunnelling and underground space, where she was able to accelerate her career from Project Engineer to her current position as Regional Manager and Team Manager for Amberg's offices in France and Belgium. Laurence is very passionate about the tunnelling industry and very proud of her significant contributions to the industry since the early days of her career.

Dimitrios Litsas, Greece

Dimitris is a civil engineer with more than eight years' experience in international tunnelling projects including Doha Metro (UAE), HS2 (UK) and the Hampton Roads Bridge Tunnel (USA) and holds a PhD (NTUA) in the field of tunnelling. For the last three years, he has worked for Mott MacDonald in the UK as a Senior Tunnel Engineer delivering innovative designs for tunnels and underground structures for international major projects. He specialises in the design and structural analysis of sprayed concrete and segmentally lined tunnels to Eurocode and US standards. He has served as General Secretary of the Greek Tunnelling Society (GTS) and as national representative of the GTS-YMG.

Quingfang Liu, China

Quingfang has 10 years of experience working in the tunnelling industry, having gained his Master's degree at China's University of Mining and Technology in 2011. Since then, he has worked in the tunnel design branch of China Railway sixth survey and Design Institute Group where he has worked on projects such as Changsha Metro (Hunan), Changsha Nanhu Road Xiangjiang Tunnel (Hunan), the Honggu Tunnel (Nanchang, Jiangxi), Suai Tunnel (Shantou) and a long deep buried submarine tunnel (13.5m diameter) across the Pearl River estuary. He loves tunnel and underground engineering work and always has his own unique ideas when encountering technical problems. Throughout his career Qingfang has achieved frequent engineering awards, filed numerous patents, and led a young team through hard work and strong business ability.

Sandeep Singh Nirmal, India

Sandeep holds a Masters in Tunnelling & Underground Space from the University of Warwick, UK, and was a recipient of the ITA's ITA-CET scholarship in 2015. He is a current member of the ITAym Steering Board and was voted Young Tunneller of the Year in 2019 by the Tunnelling Association of India (TAI). He has 9.5 years' experience working in the UK and India with active engagements with professional development organisations such as the British Tunnelling Society, Institution of Civil Engineers and TAI. He co-founded the TAI Young Members (TAIym) group in 2018 and is currently Chair. He co-founded the annual Symposium of Young Tunnellers of Asia (SYTA) and led the team to host SYTA 2021. He is also an active member of the BIS committee (Rock Mechanics Sub Committee, CED 48, working on drafting Indian codes and handbook on tunnelling).

My Summer in The Himalayas

Ahmed Shaz received his Master's in Rock Mechanics & Underground Structures from IIT Delhi, in 2015. Before joining RITES Limited, in 2019, he worked with L&T Construction on the design of metro tunnels. At RITES, he works as a specialist in tunnel design and slope stability and is involved in a number of prestigious projects such as the USBRL Rail Link in Jammu & Kashmir and the tunnel Detailed Project Report works for the Shinkun La, Lachung La and Tanglang La passes in Ladakh.

Head of the Shinkun La Pass (Alt. 16,615ft)

It was early July, 2020, and most of India was in the middle of a heat wave. However, we were standing at an elevation of 5,054m (16,615ft), at the top of the ice-laden Shinkun La mountain pass – a largely untouched Himalayan axis that connects Himachal Pradesh and Zanskar (in the territory of Ladakh) – surrounded by snow. We were on a reconnaissance visit for the new Shinkun La Tunnel.

There was a rudimentary road leading to the pass, rough and unmade, with loose adjoining slopes prone to landslides and rockfalls, but it was still closed at that time due to uncleared snow and avalanche debris. Our vehicle could only get within about a kilometre of the pass, so the rest would have to be trekked on foot. Our colleague, Dr Amit (who is around 50) managed the distance to the top of the pass, crossing the snow and ice-cold streams with his walking staff, but at that point he left Naseem and myself (the younger members of the three man team) to go on without him. Our target was to reach the proposed North Portal site for the new tunnel on the other side of the pass.

It was around 11.30am in morning and we agreed that we would return to the head of the pass by 1pm where Dr Amit would wait for us. As our GPS system didn't recognize the road, we didn't know exactly how far to proceed, so we were relying on the mountains and valleys as a guide to our destination. What we didn't think about was our elevation. Being inexperienced in working at such high altitudes [Shinkun La is of a similar height to Everest Base Camp] we had not taken onboard that the numerous small switchbacks, one after the other, had caused us to descend 400m (1,300ft).


The pass when we arrived in early July

It took much longer than we'd estimated, and we did think about turning back, but our energy and enthusiasm and a desire to save time for the whole team prompted us to push on. After all, the only other way to reach the proposed North Portal would be to return to our base in Keylong (about 70km and 3.5 hours away), then drive to Leh (about 375km and a further 12 hours), then from Leh to Kargil (about 220km and another 5.5 hours) and from Kargil to Padum, in Zanskar (235km and 12 hours), and, finally, from Padum to the proposed North Portal (another 90km and 10 hours); pretty much a 10-day round trip. So, we kept moving on until we reached the portal site at around 3.30pm.

Having taken the required observations, we began our return journey and very quickly realized what we had done. A 400m difference in elevation at 5,000m, breathing 50% of the oxygen our bodies were used to. No phone signal, no other living beings, snow everywhere, air as cold as ice and the temperature about to dip to -20°C for the night. We had only just arrived in the area and the need to acclimatise was echoing in my mind with every step. At

that altitude, every foot upwards feels like a mile and every ounce of weight feels like a ton. At one point, I gave up and told Naseem to save himself and go on without me. I was concerned about Dr Amit waiting for us at the pass and worried he wouldn't have gone back to the vehicle without us. I was anxious about whether or not our vehicle would get stuck at night as we had crossed many streams on the way here. Family, friends, colleagues, work, all started coming at me in flashes. I couldn't feel any sensation in my face or lips and my heartbeat sounded as if I was listening to it with a stethoscope.

With Naseem (who is much fitter) motivating me, all I did was keep moving, slowly climbing over the snow and avalanche debris. Somehow, at around 7:30pm we managed to reach the top of the pass, where our driver was standing on a cliff waving his hands at us and a highly-perturbed Dr Amit was waiting inside our vehicle. I almost passed out when we reached the truck, but somehow I got inside, and our skilled driver managed to cross all the streams on our way back to our guest house in Keylong. Life safe.

This was Shinkun La (and it was only our first day)!

Working for RITES, we were acting as the Detailed Project Report (DPR) consultant for the Shinkun La Tunnel, in Joint Venture with Geoconsult. When constructed the new tunnel under the Shinkun La pass will be the highest altitude tunnel in the world (at 4,862m or 15,950ft) and will provide all-weather connectivity to Ladakh, which currently gets cut off from the rest of India for seven months of the year due to the heavy snows and avalanches in the Himalayan mountain passes.

All together, we had a maximum five month summer work season, with just three months of reasonable weather to effectively work in the field. We were there to complete the DPR for the new tunnel, but also to plan a 100km long road connecting Padum, the main town of Zanskar, with the National Highway (NH-3) in Himachal Pradesh (via the new tunnel). The most challenging part of the assignment would be mobilizing the drill rigs to the site investigation locations, which would require about 10km of approach roads to be constructed, all within the window of this short three-month work season.

The project area is as remote as it is beautiful. Yaks, ibex and wild horses roam around and sometimes stop and stare at you as if you are an alien. The route for the 100km long road through the Zanskar Valley to Padum is another world - no phones,

no electricity, no roads, no shops, just some six or seven villages, some of which have as little as two houses. It is a beautiful, virtually untouched, place with vast mesmerizing views of rolling valley meadows, with gushing streams of the brightest turquoise blue water, all surrounded and framed by the giant snow-capped Himalayan peaks. There are white Gompas (Buddhist fortifications) and beautiful monasteries, hundreds (and sometimes thousands) of years old, carved into the sides of the mountains. Herds of Pashmina goats can be found nearer the villages. Truly a place of peace, a place of meditation.

By early August, once the roads were clear of snow and debris, our camps were set up at the drilling locations near the planned portals. The sites are about a three hour drive from Keylong, where our guest house (base camp) was situated. Every team member was required to acclimatize for a week in Keylong, before moving to Shinkun La, the lesson learnt from our experience! Our excavators started making the trace cuts for the approach roads as soon as they arrived on site and by mid-August five drill rigs had been mobilized at each portal site.

Life went smoothly for the first month, then the snow melt heavily recharged the all the streams, making access to the site (across the streams) very challenging. COVID and the related restrictions were another major issue that we had to tackle on a daily basis.

Work was proceeding fairly steadily however, considering the estimated level of difficulty expected, despite certain events that intermittently sent chills down our spines. Frequent landslides


South Portal drilling camp in August


North Portal drilling site


Weather closing in.

blocked the narrow road; at one point trapping a team at the same place where I thought I was about to lose my life that first day. Some health issues persisted among the team, such as breathlessness, due to the low pressure and oxygen deficiency. We had oxygen cylinders and a medical kit readily available to mitigate that. We also had a backup plan - on any given day, if a team that was scheduled to return to Keylong from site didn't arrive by 9pm, then a search team was immediately dispatched from Keylong. The system helped team members who had got stuck in landslides on a number of occasions.

Because of the high altitude and lack of oxygen, the efficiency of machines was also reduced, and wear and tear was quite high. Every now and then something would break or a machine would fail and for each repair we would have to send a team hundreds of kilometres to Kullu, Mandi, or sometimes even to Delhi. We therefore deployed three teams whose only role was to be stationed at spare parts shops to courier required parts as soon as they were needed at site (thanks to the precious satellite phone provided on site by Mr Chand, the Executive Director of the National Highways & Infrastructure Development Corp. (NHIDCL), which saved hundreds of man-hours).

The honeymoon period only lasted a month however, by mid-September the first snowfalls arrived, announcing that winter was on the way. Fortunately, our geological mapping of the project area, topographic survey works, road inventory survey, Environmental Impact Assessment (EIA) / Social Impact Assessment (SIA), traffic survey and other field works had been completed in this time. The major challenge now was to complete the AEM survey and GT investigation within the remaining time frame.

Even early winter is very harsh, with bitingly cold winds that chill your bones, and bonfires became a basic requirement for survival. Staying at the site camps also started to become difficult.

It was October when our Chinook helicopters, hired by NHIDCL from the Indian air force, arrived to conduct the Airborne Electro-Magnetic Survey (popularly known as an AEM survey). This is basically a geophysical survey. In the biting cold, all survey works had to begin by 6am, as air turbulence is low at that time of day. It never happened in one go. Many flights were made, some were successful, some were not. But the pilots kept putting forth their best efforts to carry the huge antenna over the tunnel alignment to capture geological features up to 700m beneath the surface. What an amazing experience that was. Fortunately, the survey got completed in the best possible manner around mid-October.

Then came the technical issues with drilling, when temperatures started to dip below freezing in October, especially at night. The availability of water started to become an issue. All the nearby streams and water cisterns were frozen solid by morning. Water pipes, if not emptied at night, would burst. By mid-October our diesel also started freezing at night. There was sheet ice on the road leading to the drilling locations and a heavy risk of vehicles skidding. Tire chains were used on the vehicles in these conditions and diesel capsules were purchased to stop the diesel from freezing. Ice was removed from


Chinook hellicopter in the air undertaking the AES survey

machine parts daily before work in order to mitigate breakdowns. Fires were also built near the machines and pits on a regular basis to melt the ice down. Normal cement stopped setting in these temperatures and the grouting works for the boreholes, which were collapsing, were affected. We got assistance from specialist construction chemical companies to get accelerators effective enough to set cement in these temperature in the shortest possible time.

Then our team got infected with COVID. This initially shattered hopes of completing the work in the very limited window left available and ruined the energy levels of the rest of the workers. However, before it could affect progress, new members were brought in and supplied new energy and enthusiasm on site. The team members affected were provided with the best medical facilities available in the area and everyone gradually recovered.

It was acknowledged that asking people to work in these conditions required full winter gear. Thus, all team members, including supervisors, operators, labourers and helpers, were provided with high quality down jackets and pants, waterproof gloves, woollen socks and hats. In addition, tons of wood was delivered to site on a daily basis to keep the fires going and the workers warm at the drilling locations. The conditions soared to such a level that when you drank water from your flask you had to pick the ice from your beard afterwards. By this time we had stopped staying at site and the whole team was moving to and from Keylong every day. A contributing reason for this was that wild animals, including snow leopards, had begun coming down at night in search of water at the site (as it was all frozen higher up) and it had become too risky to sleep in tents.

Work continued with renewed intensity through the snow and extreme conditions. In-situ testing was being carried out simultaneously on the boreholes and we fought the adverse weather on a daily-basis. Every extra day that we were able to work felt like a gift from nature to finish what needed to be done.

A day came when the site had become inaccessible, even using our 4 x 4 vehicles, due to accumulated snow on the approach road. This when we hired sled bikes and full team was sent to site that way. Thankfully, by then the Snow & Avalanche Study Establishment (SASE) had provided us with some comfortable shelters near to site, which reduced travel for the team significantly by eliminating the 140km/6 hour round trip to Keylong every day.

When you work in these conditions, there is no separation between client, contractor or sub-contractor. Everyone working in the vicinity acts as a team, even if they are not directly part of the project. There is a huge sense of camaraderie and you end up forming priceless bonds with one another. The people who live and work in such conditions have never ending stories of survival on a daily basis. And, especially when there is no cellular network, the relationships you form and the conversations you have are the only form entertainment, far better than anything else.

With dedication, we were finally able to successfully complete our field work on the 12th November. The Indian meteorological department had predicted a huge snowfall on the 15th November, which would close the pass again for the next seven months. We had two days to vacate the area. The challenge was the logistics of demobilizing all our resources, machines and accessories before they got trapped on site for half a year. Since the road was closed, we had to use the excavators to drag the machines several kilometres, to the trucks that we had stationed at the national highway. It was terribly cold. You could not directly touch steel with your hands and getting water on you could be catastrophic. But it was now, or in seven months, so all our team with the help of our site friends put in their best effort, without regard for the length of the day or the effects of the cold.

It took two full days and nights, but we succeeded in the end. It was evening on the 14th November when we left the site area with our final belongings. And, as predicted, the blizzard started the next morning and closed the passes. Fortunately, following a tremendous team effort, our task was complete. We had formed a special bond with the place, and the people, with lots of lessons learnt and definitely with a new sense of confidence.

We submitted the DPR by the end of December, completing the highly prestigious project in less than 5 months. That's truly a commendable accomplishment and we are ready, even more equipped and experienced to take such challenges in future.

Snow leopard tracks appear as streams freeze

The North Portal drill rig in October

Camaraderie in the camp as the cold closes in

THE WORLD'S MOST CHALLENGING TUNNELS

Trying to come up with a 'Top 10' most challenging tunnels ever constructed is not easy and there are many worthy candidates that haven't made Breakthrough's list. But the lessons learned on these projects are invaluable and we recommend you check out past conference papers, technical articles in back issues of trade journals (such as *Tunnelling Journal*) and videos online, to learn more about these projects and the amazing journeys of the tunnelling engineers who built them!

World's Longest & Deepest
GOTTHARD BASE TUNNEL, SWITZERLAND

The 57km (35-mile) long Gotthard Base Tunnel, in the Swiss Alps, is the world's longest and deepest railway tunnel. Passing 2,400m below the peaks of the mountains, the project overcame major fault zones, squeezing ground and rock bursts. The total project (which measures around

152km (95-miles) of tunnel including cross-passages, access adits and shafts) took 17-years to complete, with 80% of the excavation by TBM and the remainder by drill & blast. The TBMs were blocked by a collapse, almost trapped by squeezing rock, and had to cross water-bearing faults with rock and water temperatures reaching 48°C. The final breakthrough took place on the 15 October 2010 with the line going into operation in 2016.

First Subaqueous Tunnel
THAMES TUNNEL, UK

Subaqueous tunneling was considered all but impossible until the cast-iron tunneling 'shield' was developed by Marc Brunel in 1818. His three-story high horseshoe-shaped shield was used to construct the 400m-long 'Thames Tunnel' 23m below London's waterway. Divided into twelve frames (resulting in 36 cells for

workers to excavate from) the shield was closed at the front with moveable timber boards and advanced by screws that pushed against the brickwork lining. Despite the novel use of the shield, the project experienced five tunnel floods, six deaths, and a seven-year abandonment during its 18-year construction process. But, when Isambard Kingdom Brunel completed the tunnel in 1841, it changed the face of soft ground tunnelling forever.

Connecting a Continent
EUROTUNNEL, FRANCE/UK

When it opened in 1994, the 50.5km-long Channel Tunnel realised a 200-year ambition to connect the UK with France, transforming transport and logistics in Europe. Travelling

38km (23-miles) under the English Channel, the tunnel has one of the longest subsea sections in the world, dipping to depths of 75m below the seabed. The engineers who designed and built the project worked at the very limit of mid-1980s and early-1990s technology, employing 11 TBMs to construct the 8.8m diameter rail tunnels. The UK crossover cavern remains the world's largest undersea rail cavern to this day. Tunnel construction took six years, involved about 13,000 workers, and remains the largest design-build project in UK engineering history.

Blast from the Past
MONT CENIS TUNNEL, FRANCE/ITALY

The 13.7km (8.5-mile) Mont Cenis Tunnel was the first of the great Alpine rail tunnels. Running between France and Italy, under the Fréjus pass, many pioneering techniques were developed during its construction, which began

in 1857 and took 14 years to complete. These include the use of dynamite for blasting, the invention of the air drill, rail-mounted drill carriages, hydraulic air compressors; and a complete construction camp for workers (including housing, medical facilities and a mechanical repair shop). As the first long-distance rock tunnel driven from two headings, surveying techniques were also refined, and ventilation was developed using forced air from water-powered fans and an improvised air duct in the tunnel.

Plagued by Disaster
STOREBAELT (GREAT BELT) TUNNEL, DENMARK

In the late-1980s, construction began on the Storebælt Fixed Link, an 18km bridge and tunnel system connecting Denmark's largest islands. The 8km (5-mile) Storebælt Tunnel was excavated by four 8.8m diameter earth pressure balance TBMs (EPBMs), technology that was in its infancy at the time.

Tunnelling was incredibly challenging, dealing with huge boulders in extremely variable, potentially unstable and highly abrasive glacial tills, with groundwater pressures of up to 8 bar. Two of the tunnels flooded causing mining to be stalled for 10-months (see p20). Then a fire broke out damaging the lining so badly that engineers were worried it might give way. The project also achieved notable firsts, including a deep-well vacuum dewatering programme, called 'Project Moses', which remains the largest deep-sea dewatering scheme ever conducted in an international waterway.

TBM Tunnelling at High Pressure
LAKE MEAD INTAKE NO.3, USA

Ninety percent of Las Vegas' water supply is obtained from the Colorado River at Lake

THE WORLD'S MOST CHALLENGING TUNNELS

Mead (behind the Hoover Dam). So, when drought conditions led water levels in the lake to recede, a new low-level intake (Intake No.3) was required to guarantee future supply.

Tunnelling was complicated by the sedimentary and volcanic geology, as well as the depth and corresponding hydrostatic pressures, requiring a state-of-the-art rock TBM capable of mining at up to 17 bar. Ultimately, the trials faced by tunnellers included three inundations of water and debris during attempts to excavate the TBM starter tunnel (eventually leading to a new tunnel alignment), and several tricky TBM interventions on a machine that was defining new technical limits. The 27.22m diameter Herrenknecht dual-mode TBM broke through at the end of its 4.8km (3-mile) drive in December 2014, two years later than planned, but providing a big step forward for TBM technology.

Squeezing Ground & Flowing Mud

GILGEL GIBE II, ETHIOPIA

Some 250km south-west of Addis Ababa, on the Omo River, the Gilgel Gibe II Hydroelectric Plant was built to increase Ethiopia's power generating capacity by 80%. Excavation of the project's 26km (16-mile) power tunnel was extremely difficult, with crews experiencing large mud/water inflows, unstable faces of ravelling, running and blocky ground and high loads on the two 6m diameter TBMs and the precast lining. In October 2006, just over a year into construction, disaster struck when the intake portal TBM hit a fault that discharged mud at 40 bar pressure, pushing the TBM backwards and crushing a portion of the tunnel's lining. After a two-year delay, the TBM started up again to excavate a 230m bypass. The second TBM, driving from the outlet portal, fared better despite passing through several fault zones and experiencing hot water inflows of up to 54°C.

Highly Fractured Rock & High-Pressure Inflows

PINGLIN (XUESHAN) TUNNEL, TAIWAN

Excavation of the 12.9km (8-mile) long Pinglin Tunnel, a key component of the Taipei-Ilan Expressway, under the highest peak of the Xueshan Mountain Range (3,886m), in northern Taiwan, began in July 1991 and was a constant challenge during its 15-year construction. Engineers encountered extremely difficult conditions in the seismically active geology, including highly fractured rock and massive inflows of water at high pressure that caused severe delays. The project's TBMs, including the pilot tunnel TBM, became stuck on multiple occasions, with one of the machines on the westbound tunnel being completely buried by a collapse. Along the alignment, six major faults were met, with 98 fracture zones and 36 high-pressure groundwater sources. Altogether, 25 lives were tragically lost during this extremely difficult project.

Rock Bursts & Cathedralling

OLMOS TUNNEL, PERU

Massive overburden, over 16,000 rock bursting events, cathedralling and surface flooding that washed away the project camp and tunnel access road; tunnellers on Peru's Olmos Tunnel had to deal with it all. The 20.1km (12.5-mile) Trans-Andean tunnel (12.5km of which was driven by TBM) was designed to accomplish the Herculean task of transferring water from the Huancabamba River

on the Eastern side of the Andes to drought-ridden areas on the Pacific Ocean Watershed (as well as to two proposed hydroelectric plants). The gauntlet of unforeseen challenges encountered on the project made the eventual breakthrough (in December 2011) of the 5.3m diameter Robbins Main Beam TBM, which was brought in to complete the tunnel, all the sweeter.

Ancient Ground & Archaeological Finds

THESSALONIKI METRO, GREECE

For more than a century, the city of Thessaloniki, in Greece, balanced the choice of preserving buried antiquities or building a subway system. Construction of the metro system was first proposed in 1910, and seriously planned during the 1980s, but has been subject to severe delays due to major archaeological discoveries (as well as resulting funding issues),

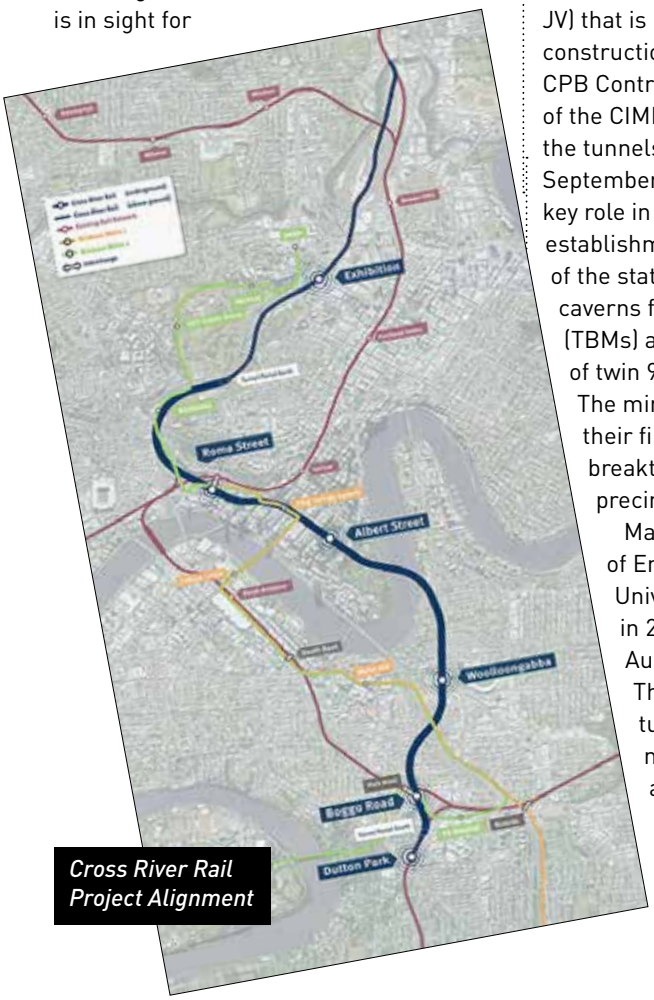
with more than 300,000 items collected by archaeologists since construction began in 2006 (Line 1 was originally scheduled to open in 2012 and is currently scheduled for 2023). The project triggered the largest archaeological dig in Greek history, covering an area of 20km^2. Many artifacts will be put on display at in-situ station exhibitions, while major discoveries at Venizelou Station will make up the world's first publicly accessible archaeological site contained within a metro station (see Breakthrough, 2019, p27).

Cross River Challenge in BRISBANE

Australia is currently a hub of tunnelling activity and Brisbane, capital of the state of Queensland, is also no stranger to it. Currently underway is the largest transport infrastructure project in Brisbane's history, the construction of Cross River Rail (CRR) project, which includes new twin 5.9km long rail tunnels and four new underground stations.

The city of Brisbane is split by the Brisbane River and home to approximately 2.5 million people, its current rail network, which has limited river crossings, is increasingly coming under pressure. The $5.4b Cross River Rail project will provide an additional crossing over the river for north and south bound rail traffic, removing the current bottleneck.

The light at the end of the tunnel is in sight for



Cross River Rail Project Alignment

Mathieson Stosic

Mathieson Stosic, a Tunnel Engineer for CPB Contractors (CPB) as part of the CPB, BAM, Ghella and UGL Joint Venture (CBGU JV) that is responsible for the design and construction of the tunnels and stations. CPB Contractors and UGL are both part of the CIMIC Group. Mathieson joined the tunnels team at Woolloongabba in September 2019 and has since played a key role in the construction team for the establishment of the site, construction of the station box, two underground caverns for two tunnel boring machines (TBMs) and more recently excavation of twin 900m-long mined tunnels. The mined tunnels are currently in their final stages of excavation, with breakthrough at the Boggo Road precinct in sight.

Mathieson received his Bachelor of Engineering at the Queensland University of Technology (QUT) in 2015 and is a member of the Australian Tunnelling Society (ATS). The CRR project, Mathieson's first tunnelling project, has provided many opportunities for growth and development.

Breakthrough recently caught up with Mathieson for a Q&A on his experiences on CRR and as a young tunnel engineer:

What was your experience prior to Cross River Rail?

Prior to Cross River Rail I worked on a diverse range of infrastructure projects that broadly encompassed an airport, bridges, bulk earthworks, highways, micro-tunnelling, gas and public utilities. Although none of these scopes are specific to tunnelling, I have found each of them have provided extremely valuable learnings to draw knowledge from.

Why Cross River Rail and tunnelling?

Cross River Rail has been in my sights since I started university. While I was studying, an earlier proposal of the project was undergoing consideration, which sparked an interest for me. Due to the size and complexity of the project I was naturally drawn to the challenge, but I was also interested in helping deliver something back to Brisbane and being able to say I was part of such an iconic project.

As for why tunnelling, my view is that it is the way forward for developed cities around the world. Space in cities is becoming increasingly scarce, particularly with the rates of urbanisation occurring and from a logical point of view, maximising the use of a cities underground space is an excellent way to solve multiple issues at once. In my spare time I travel as much as possible and my favourite way to really get to know a city is by using their metro networks.

What has been your favourite part?

There have been many enjoyable parts of the project so far. At the moment I am looking forward to the breakthrough of the roadheaders. Aside from this, other memorable moments include St Barbara's Day [the patron saint of tunnellers] and the completion of the mined caverns.

Besides site-based milestones, it is really something quite special to experience the passion that every tunneller and tunnel engineer has for their job.

Many of the veterans don't show it, but when difficulties arise onsite or tight deadlines come up you really see them kicking into new gears. Everyone is always striving to find any edge to continually improve safety, productivity and the quality of the works.

What were your biggest challenges and learning experiences on the project?

One of the biggest obstacles I faced in my role on CRR is, when put simply, that I have never worked on a tunnel before. The project evolved quickly throughout each stage and before I knew it, we were tunnelling. Besides project-based design and planning documentation, the tunnellers and senior engineers provided valuable insights along the way.

Other challenges that I have experienced in this role include testing hundreds of rock bolts and managing production in variable environments, such as hard rock tunnelling to soft ground tunnelling with low cover under sensitive infrastructure.

What does a typical day look like?

A typical day starts with my alarm going off at 4:30am and rolling out of bed for some breakfast. While preparing for the day and getting to the 6am pre-start, my focus is to understand the position from overnight works and how this may impact the plan for the day ahead. After pre-start I always inspect the tunnel and tunnel face. This provides a valuable visual of the tunnel and aids with identifying issues that may not have been communicated in shift handovers.

When returning to my desk, my attention is directed towards tasks such as reporting, procurement, planning, quality assurance, costings and problem solving onsite. After lunch the 'Permit To Tunnel' (PTT) is completed, my next priority then becomes ensuring that a works instruction is prepared and delivered along with the PTT to the tunnel foremen for the next 24hrs of work. As this captures current and future geological conditions and upcoming ground support requirements, there are always interface requirements with other teams. Once this is handed over, the remainder of the shift is typically spent catching up on paperwork or researching to find ways to resolve issues onsite.

Road header at work in the mined tunnels

Woolloongabba to Boggo Road Mined Tunnels during construction

Aerial photo of Brisbane City showing the location of the Woolloongabba Site

Mathieson onsite – First cuts at the Woolloongabba cavern site

Working in the Age of COVID-19

The COVID-19 pandemic forced change almost overnight. Will some of those changes be permanent? Kristina Smith reports

In July 2020, contractor Dragados US carried out its factory acceptance of a 6.5m-diameter Herrenknecht Mixshield tunnel boring machine (TBM), which will be constructing an outfall tunnel in Los Angeles, USA. Normally, this would involve parties from offices in LA, New York, Washington and Madrid travelling to Herrenknecht's facility in Schwanau, Germany, to go over every inch of the machine and its corresponding documentation. This time the acceptance process was just as detailed but conducted virtually, over seven days, 30 hours of which were live-streamed.

The COVID-19 pandemic has forced every part of the tunnelling industry to re-think how it does things. There have been forced changes to cope with travel bans and increased health risks, new ways of working and an increased use of digital technologies.

In general, civil construction projects have continued to operate, albeit under 'COVID safe' arrangements. This is a recognition of how essential infrastructure is to everyone's lives and of the significant contribution that a healthy construction programme makes to a country's gross domestic product (GDP).

ADAPTING FAST

When countries around the world began locking down in March last year, the construction industry had to adapt fast. Responses varied from country to country and from state to state. Some closed down for a period of time, others continued without a break.

"In the beginning, there was so much uncertainty, we didn't know if sites were going to be open or closed," remembers Mike Smithson, who heads up Skanska USA's underground heavy civil projects in the West, overseeing the Regional Connector Transit and the Westside Subway Extension projects in LA. "Early on we were taking an extra half-hour at the end of the shift to button up in case we weren't coming back again."

Skanska started with a 'hybrid remote working' model for support staff, where they would work at home three days a week, coming into the office for two days. "That became burdensome for the field guys, who were being bombarded with questions from the people who were at home," says Mike Smithson. "The field guys were getting worn out, so we put a stop to it."

There have been multiple changes to the way work is being carried out underground, says Smithson. From the addition of face coverings, longer breaks to ensure

Herrenknecht's virtual TBM acceptance test

> [a 'hybrid remote working' model for support staff], became burdensome for the field guys, who were being bombarded with questions from the people who were at home. They were getting worn out, so we put a stop to it.
>
> **Mike Smithson — Senior Vice President at Skanska**

personal hygiene, banning shared food, and reducing the number of people travelling in elevators.

Despite the added difficulties of voices muffled by masks and safety goggles getting steamed up, Skanska found that during the summer of 2020, its accident count actually went down, perhaps due to longer safety briefings and heightened awareness. In the Fall, that trend reversed, however. "We would attribute that to fatigue due to the lockdown and the more difficult working conditions," says Smithson.

In the UK, the Thames Tideway super-sewer project opted to close most of its sites for around a month to take stock of the situation and set up new processes. Only one site remained open, because to stop the TBM at that point would have risked ground movement.

Aside from new working practices on individual sites, Tideway also re-thought interfaces – where neighbouring contracts were working in the same area at the same time – so that some parts of the works were re-sequenced. Contractors organised workers into 'bubbles' to limit the spread of the virus and staggered start times on site.

London has struggled with overcrowding on some of its metro lines. In Autumn 2020, and again in January 2021, there were warnings that overcrowding on the Jubilee Line could lead to restrictions on the construction sector.

In Singapore, where workers from India and Bangladesh live in dormitories as part of their employment contract, there were many outbreaks of COVID amongst construction workforces. Singapore stopped construction altogether initially, but tunnelling projects for the Mass Rapid Transit (MRT) project and the Deep Tunnel Sewerage System (DTSS) restarted after a month due to their critical nature.

VIRTUAL TEAMS

For consulting engineers, the disruption to working patterns were perhaps less severe than for those based out on site. Many consultancies have tunnelling teams whose members are located in offices around the globe, which means they already communicate virtually on a regular basis.

Like many consultancies, HNTB's planning and design staff have been mostly working at home since March 2020, although all offices have remained open, operating under COVID-safe rules. "Both our clients and organisation have adapted well to a virtual work environment," says Sanja Zlatanic, Senior Vice President and Chair of HNTB's US National Tunnel Practice. "The technology existed that allowed us to do so without skipping a beat or missing a deadline. Communication with our clients and colleagues across the industry remained seamless; going forward it's highly probable that the virtual environment will continue to require even more intentional and planned interactions."

Similarly, systems to convey and organise project information digitally, from ground movement, to production, to TBM parameters, are well established. But with consultants' and clients' employees confined to their home offices, they became much more frequently used, as a way to monitor progress and issues remotely. Video walk-throughs, sometimes generated by drones, took the place of site inspections and visits.

Suppliers also had to adapt to working remotely too. Early on in the pandemic, many companies reported problems as team members were trapped at home, self-isolating or quarantining, or sometimes trapped overseas, unable to fly home.

Normally experts are always on hand when problems occur on site; each company has a team of specialist and experienced trouble shooters who fly around the world to give their specialist advice. Now, the use of remote technologies such as internet-of-things based technology becomes more useful than ever.

With three manufacturing locations and an additional three sales and service locations in China, Herrenknecht has been dealing with the impact of the pandemic since January 2020. "Our engineers are available for our customers and their projects ready to provide with the best possible support," says Cornelia Lietzau,

Selina, the last of the Thames Tideway TBMs, is delivered by using a giant vessel called the Skylift 3000, in Bermondsey, London

> Despite the fact that underground transit has not been a major COVID-spreader, some of the biggest challenges likely comprise creating underground transit facilities that look safe, feel safe, are safe and that bring back ridership with confidence.
>
> **Sanja Zlatanic - Senior Vice President and Chair of HNTB's US National Tunnel Practice**

Communications Manager at Herrenknecht. "We are doing our best and whatever is possible to handle the requirements, prerequisites and measures within the context of the project partners and the specific national requirements. To keep in touch, we make use of all of the available communication channels."

Will the air miles of those specialists ever reach the level they did before the pandemic? It seems unlikely. Once the lifting of restrictions makes travel between and within countries more possible, perhaps only the most extreme and unusual problems will necessitate actual – rather than virtual – visits to site.

Meanwhile, the challenge will be how to most effectively mix remote and office working. One of the ingredients missing from a daily timetable of Teams, Zoom and Webex meetings is the opportunity for spontaneous interactions and communications. "As we move on into post-pandemic times, the challenge will be maintaining the advantages of these technologies while sustaining the rewards of in-person communications," says Zlatanic.

The Westside Subway Extension's final breakthrough under Wilshire Boulevard, in Beverly Hills, California

PROJECTS ON HOLD

With the pandemic causing ridership figures to plummet to almost zero, some planned metro projects have been put onto the back-burner.

"The majority of our projects have been able to continue forward, but some did go on hold due to budget constraints," says Zlatanic. "Many of our projects are owned by public transportation agencies that have suffered from the severe drop in ridership. They have done a heroic effort maintaining operations and prioritising elements of their capital programmes."

One of the tasks that the tunnelling industry must help address now, says Zlatanic, is how to convince people to get back onto public transport. "Despite the fact that underground transit has not been a major COVID-spreader, some of the biggest challenges likely comprise creating underground transit facilities that look safe, feel safe, are safe and that bring back ridership with confidence," she says.

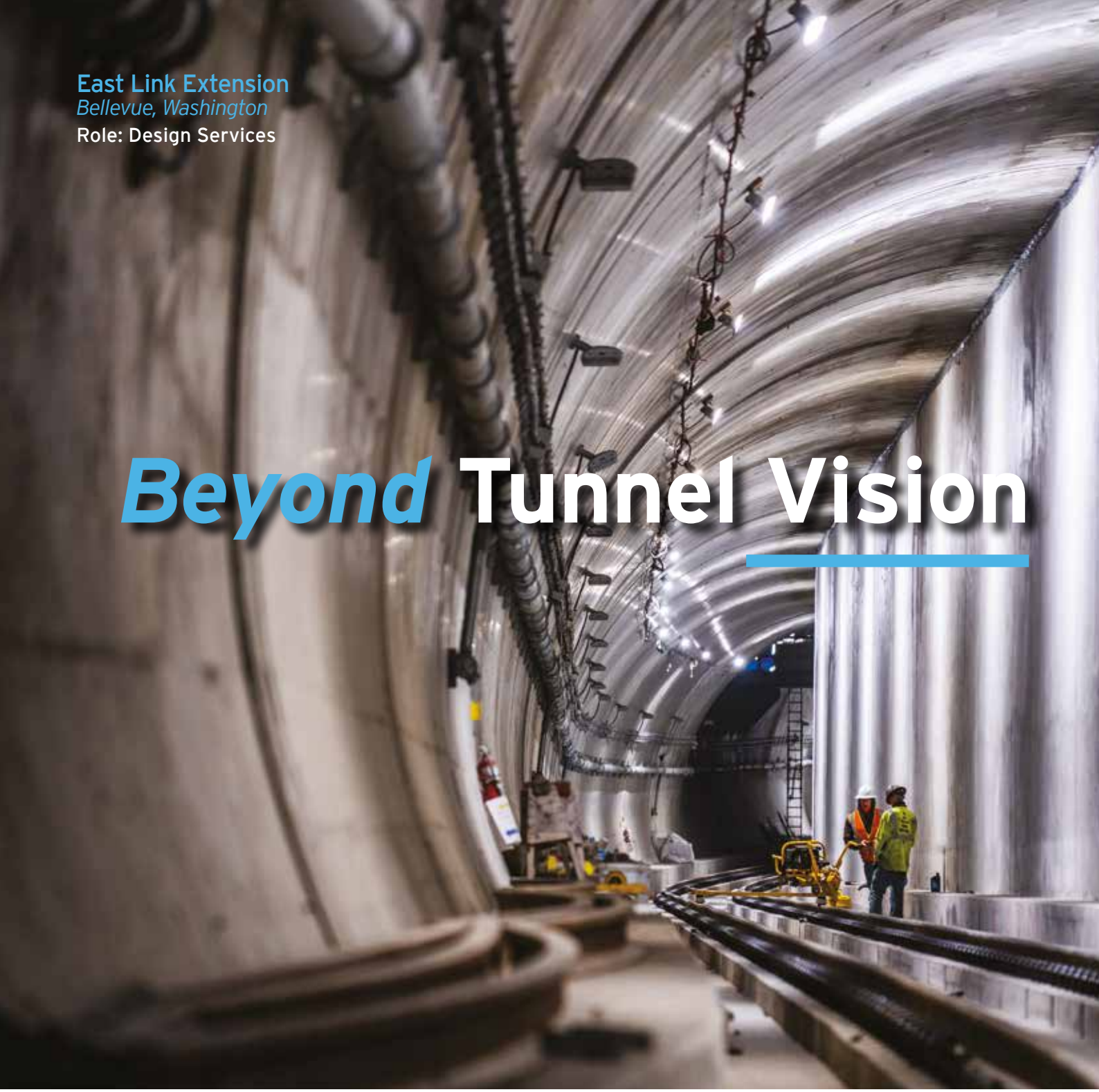
Zlatanic urges the industry to pull together to work out how new technologies can be applied to the different aspects of public transport, from air filtering, to crowd control, to sanitising surfaces. "It would be of utmost benefit to the industry if multiple overlapping studies could be assembled and common conclusions drawn that are accessible to the entire industry; this way learning curves could be eliminated and positive experiences effectively shared," she says. To this end, HNTB has carried out a study that looks at how to use architectural and ventilation design to make the spread of airborne pathogens less likely in stations, train carriages and buses.

In the shorter term, those projects that were already on site as the pandemic took effect, face financial challenges. New ways of working, pauses, delays in deliveries of materials have all caused project costs to rise.

Tideway announced that the cost of its programme would be rising by £223m to £4.1bn. Over in LA, project costs have been rising too, says Smithson:

"Our productivity has been impacted. We are seeing an increase in overtime to try and maintain the schedule," he says. "Especially in California where we have had significant changes in worker protection and worker compensation, there have been significant unforeseen expenses."

Just how these additional costs will be covered remains to be seen. "The owners are in the same boat too: their costs are increasing," says Smithson, who also worries about the pressure on his management teams. "It's exhausting to try and maintain schedule and still be safe and cost effective," he says. "The last thing we want to do is deliver projects late, but there comes a point where the contractor can only carry so much



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> Mutual trust and unshakeable stamina have always driven us forward together. I am confident that our international family of passionate tunnelling and mining pioneers will emerge even stronger after the global coronavirus crisis.
>
> **Herrenknecht CEO and founder Martin Herrenknecht**

burden and push the job so much."

NEW RESPECT

It is still too early to say what the long-term effects of the pandemic on the industry will be. The hope is that the industry will be better placed for the future, having demonstrated its adaptability and resilience. That is certainly the sentiment from Herrenknecht CEO and founder Martin Herrenknecht:

"Mutual trust and unshakeable stamina have always driven us forward together," he says. "I am confident that our international family of passionate tunnelling and mining pioneers will emerge even stronger after the global coronavirus crisis."

The pandemic has given many a greater insight into their colleagues' lives outside work, with video meeting views of people's homes and the need to understanding how family commitments somehow mesh with work. Smithson observes a new, more empathetic culture. "We are showing each other more respect than we used to, we are considering how our actions effect other people whether that's thinking about where to stand or having respect for people's opinions."

Zlatanic is glad that the pandemic has boosted interest in the safety and experiences of those who use underground transport and she urges her fellow engineers to be more forward-looking and better prepared for similar challenges in the future: "We need to recollect what we have learned from the COVID-19 pandemic, consider solutions carefully and pursue mitigation measures now that can be put in place before the next event.

"As engineers, we love to plan and be in control; 2020 tested our patience and resolve and we have discovered how resilient we are as a society and as individuals. We learned to remain proactive and think long-term. Implementing sustainable and robust transportation systems, deploying cost effective and energy-efficient solutions, and raising awareness of the need to pre-plan would keep our industry going in the long run."

Tools for remote working have come into their own during the pandemic

Study and research mirrors industry

There are only a handful of specialist tunnelling Masters' courses around the world, so finding a way to deliver them during the pandemic – and afterwards – is important for the industry as well as for the individual universities and students. And, as for the industry, some elements are very difficult to deliver remotely.

Usually, students travel from all over the world to attend the specialist Masters' course run jointly by TU Graz and Montanuniversität Leoben, in Austria. Obviously, the pandemic made travel difficult, if not impossible. The university took the decision to pause the start of its next course for a year, beginning with a new approach in April 2021.

"We did not know how the participants would react, but we have had a positive reaction," says Thomas Geisler, Programme Manager for the Masters' course. "For some of them, it may be better to stay at home and follow the course remotely."

Usually, the six modules that make up the Masters' are delivered in three-week periods, with all students travelling to Austria for them. Now the modules are stretched out to eight weeks, with lectures delivered between 11am and 3pm (UTC+1) to accommodate as many of the different time zones as possible. The next module will be delivered in 'partial presence' mode, says Geisler, with those who can attending some modules live.

Thomas Geisler is the Programme Manager for TU Graz's Masters' course

Professor Daniele Peila heads the Politecnico di Torino Masters in Tunnelling

TU Graz's lecturers and professors have had plenty of experience delivering lectures and lessons remotely since last March, says Geisler, and have picked up some tips and tricks. One interesting observation is that lectures are better attended virtually than in person, says Geisler.

There are challenges, of course, from teaching tunnelling virtually. Field trips to visit projects are not possible. Instead, students will present to each other about projects they have been involved in. Sessions in the rock testing laboratory are also off the agenda; TU Graz has been busy filming testing procedures with commentary from professors to visually explain the tests.

Daniele and a research group in the lab at the Politecnico di Torino, in Italy

At the Politecnico di Torino, its post-graduate Masters in Tunnelling and Tunnel Boring Machines continued with remote lessons in 2020. This year it is launching an MSc track in geo-engineering in English, aimed at students who don't already have a Masters', with plans to offer a mix of remote and direct learning.

Although remote teaching has worked well, tunnelling is an industry where people need to be able to interact with one another, says Professor Daniele Peila, who is responsible for the course. "It's important that students get to work in groups, including with people they don't like very much, because this is what happens in life," he says.

Peila also worried about the less-able students. As an experienced professor, he can observe just by looking who is and isn't grasping a concept during a live lesson. During virtual lessons, lecturers must engage with their students more frequently to check on their comprehension and involvement.

On a positive note, students' virtual experiences at university are preparing them for changes once at work: "I believe that the world of engineering and the way that engineers work will change," says Peila, who acts as a consultant and adviser to the industry, alongside his academic roles. "We will be doing more work through virtual meetings. Sometimes it makes sense to do that, rather than travelling for five hours to attend a one-hour meeting. So, our students have to learn these new tools too."

From Florence to DC: Working in the US Capital

Federico Bonaiuti is an Associate Engineer currently working for Lane Construction Corporation on the Northeast Boundary Tunnel (NEBT) Project in Washington, DC. He completed his bachelor's degree in civil engineering at the University of Akron, in Ohio, in 2019, where he had the chance to spend an internship on the Ohio Canal Interceptor Tunnel Project, in the city of Akron. During that internship, Federico fell in love with the work and decided to pursue a career in tunnelling.

Federico Bonaiuti grew up in Campi Bisenzio, just north of Florence, Italy, and completed high school in 2013. He then moved to the US to continue his education, at the University of Akron, in Ohio, to expand his horizons, face new challenges and discover new parts of the world. During his bachelor's degree, Federico had the chance to undertake three internships, one of which was on the Ohio Canal Interceptor Tunnel project, in the city of Akron, and that guided him towards a career in tunnelling. It was his first experience on a tunnel and he found the numerous construction activities – such as ground improvement, support of excavation, concrete structures, instrumentation, traditional tunnelling and mechanical tunnelling – both challenging and fascinating.

In 2019, Federico joined the Lane Construction Technical Team on the $580 million Northeast Boundary Tunnel (NEBT) Design-Build project, in Washington, DC. Lane is one of America's leading heavy civil construction companies specialising in highways, bridges, tunnels, mass transit and airport systems. In 2016, the company merged with the global construction leader Webuild (previously Salini Impregilo) and became a national leader in the tunnelling sector by also merging with US tunnelling contractor SA Healy.

The NEBT is part of the major DC Clean Rivers programme to prevent sewer overflows into the Anacostia and Potomac Rivers during heavy storm events. The design-build project includes the construction of an 8,230m (27,000ft) long tunnel, 219m (720ft) pipe jacked tunnel, seven deep shafts and diversion facilities. During his time on the project, Federico has worked in the technical office following the construction of various ground improvement works, support of excavations, permanent concrete linings, instrumentation, construction permits with public agencies, and key technical and production aspects of the 3.5m (11.4ft) diameter pipe jacking machine.

The main tunnel boring machine (TBM), named 'Chris', mined the tunnel while advancing through the Patapsco/Arundel Formation, which is predominantly silt and clay, and the Patuxent Formation, which is predominantly sands and coarse material. During excavation, the TBM faced several challenges, undercrossing active sensitive underground utilities, the WMATA Orange Line subway, Amtrak High Speed Rail, CSX Commercial Rail and a WMATA Red Line station. During these tunnelling activities, the NEBT Team worked 24 hours a day, seven days a week, to ensure that no unexpected ground movement occurred. The intensely urbanised area above the NEBT Project required an extensive instrumentation programme with approximately 1,000 instruments including ground and structure monitoring points, multiple anchor extensometers, inclinometers, piezometers, vibration meters, and tiltmeters. The continuous monitoring of the instruments ensured that the construction activities proceeded safely and without any disturbance to the public.

On April 21, 2021, 'Chris' completed her final breakthrough into a shaft filled with water to minimise water inflow from the external aquifer. Currently, the TBM

has been dismantled at a postage stamp sized shaft site located at the intersection between R Street and Rhode Island Avenue and the team is now working at all sites completing the excavations of the near surface structures, making adit connections between the shafts and main tunnel, and constructing the concrete permanent liners for all the structures, as well as excavating a smaller pipe jacked tunnel at the Mount Oliver Road Site (MOR).

The 3.47m (11.4ft) diameter TBM, named 'Tala' is an Earth Pressure Balance (EPB) machine. Excavation activities commenced on August 16, 2021, and breakthrough is anticipated to occur on October 6, 2021. The tunnel is 219m (720ft) long and is being advanced through the Patapsco/Arundel Formation, which is predominantly silt and clay. The TBM will arrive at a diversion chamber structure and drop shaft that connects to the main NEBT storage tunnel.

Among his duties, Federico worked on arranging the delivery sequence of the TBM with the machine manufacturer to ensure that the work site weight and size constraints were not exceeded. To verify that all phases of construction could be implemented as designed, he prepared a 3D model where several clashes were solved ahead of construction. The 3D model was also used to present the construction activities to the client, train new employees, and ensure that any needed changes to the tunnel design do not alter any other construction phases. Currently, Federico is working as a Shift Engineer during the excavation phase while also carrying out his other duties in the technical office.

During his tenure on the project, Federico actively participated in preparing and submitting construction permits to public agencies and worked with them to ensure that all vertical drilling activities were performed in compliance with environmental requirements. This was a key task to ensure that the project could proceed on a timely basis. As of now, all construction permits have been obtained and Federico appreciates the dedication and collaboration between contractors and public agencies to ensure that the project is completed on time with the right construction approach.

Lane completed the Anacostia River Tunnel Project, in 2016, which made a significant improvement to the water quality of the Anacostia River. The NEBT Tunnel is expected to be completed in 2023 and afterwards the company hopes to participate in the upcoming Potomac River Tunnel Project, which is the final tunnelling component for the DC Clean Rivers programme.

Federico feels privileged to be working on the NEBT Project in DC and believes that there are many opportunities in tunnelling for young engineers. In his opinion, tunnelling is exciting due to unexpected surprises and technical challenges that are always different from previous experiences. "The tunnelling industry is an outstanding place to shape and round out an engineering background since it involves every aspect of the construction business," he says. Federico is keen to discover what the future has to offer and hopes to continue working in tunnelling for many years to come.

Key Facts About the NEBT Project

- The NEBT is the longest and largest component of DC Water's Clean Rivers Program (7m or 23ft inside diameter tunnel).
- 4,442 concrete lining rings installed.
- The tunnel is located 27m to 50m (86ft to 164ft) below ground and is 8,230m (27,000ft) long.
- The project is being constructed downtown and complies with urban noise and vibration limits, dust controls, traffic controls and various public agency requirements.
- Once the project is completed, combined sewer overflows (CSOs) into the Anacostia River will be reduced by 98% from the 1996 baseline and reduce the risk of flooding in the areas it serves from 50% to about 7%.

Federico Bonaiuti inside the Mount Oliver Road Pipe Jacking Tunnel on the NEBT Project (safety glasses removed for photography purposes only)

The launch site with thrust frame and cylinders for TBM Tala at the Mount Oliver Road Site on the NEBT Project

BREAKTHROUGH'S RESOURCE CENTRE

ATS TUNNEL DESIGN GUIDELINE LAUNCH

In November 2018, the Australian Tunnelling Society (ATS) held a short course on tunnel design, bringing ATS Young Members together from across Australia. During discussions at the event the need for a general reference to elementary tunnel design was expressed and the decision made that the ATSYMs would work to put together such a guide.

By early 2019, a group of volunteers had been identified, who began meeting regularly. A table of contents was designed and the writing of sections divided up. By December 2019, the document had been passed to the wider ATS for review. That review process was completed in 2020 and the first edition of the Tunnel Design Guide is now out!

The guide is intended to grow with time. The contents were deliberately limited and the Authors chose the more common topics for Australian tunnel engineers. It is hoped that readers will provide suggestions for improvement, both in terms of the current content, and content that would be useful to include in the future editions.

The guide is intended to provide guidance on each of the topics covered. There are useful references, as well as recommendations for choices that designers usually make. However, the guide is not intended to be comprehensive.

The guideline is available for download via the Members Section of the ATS website under "Technical Papers".

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A special thanks to Ed Taylor who championed this initiative as President of the ATS. His enthusiasm and desire to encourage the next generation of tunnellers has helped make this publication possible.

ITACET LUNCHTIME LECTURE SERIES A SUCCESS

Earlier this year, the ITACET Foundation – the International Tunnelling and Underground Space Association's (ITA) foundation for Education and Training – launched an online Lunchtime Lecture Series to maintain links with ITA Member Nations during the pandemic. The monthly sessions began in February – taking place every second Tuesday of the month (@ 13:00pm CET) – and have covered diverse topics such as drill & blast tunnelling, contractual practices, compressed air working, waterproofing and automation in tunnelling.

Each of the lectures are presented by leading industry figures – brought together by the Foundation and the ITA's Working Groups and Committees – and have averaged about 180 participants from roughly 35 countries. Initially, the plan was to charge a nominal attendance fee to register for the lectures. However, due to the success of the series, it has now been decided that the 'live' lectures will remain free to all.

The Foundation's aim is now to build on the success of the series – there are some great topics coming up – and plans are underway for further development in 2022. Traditional ITACET training sessions are still being organised, both online and in-person, but it is hoped that the new lecture series will now permanently complement these existing offerings.

Tim Babenderede delivering a Lunchtime Lecture on compressed air

The link to register each month will be on the ITACET Foundation website, on the 'Forthcoming sessions' page: www.itacet.org/sessions/forthcoming [You can also find links on the ITACET Foundation LinkedIn page and posts].

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5 from five

How do young engineers find their way into the tunnelling industry and how do their studies help with their working lives and careers? Five people from around the world share their stories with Breakthrough.

Kristina Smith reports...

The Earth Spoke

Akshay Panwar

- **Senior NATM Engineer, Geoconsult**
- **MEng in NATM Engineering from TU Graz, Austria; MTech Rock Engineering and Underground Structures from IIT Delhi; BTech Civil Engineering Dr MGRE & RI, Chennai, India**

Akshay Panwar's first job after leaving university with a Masters in rock engineering was working on the Rohtang Tunnel, an 8.8km-long tunnel beneath the Himalayas in Himachal Pradesh, India. This was a huge and impressive project, constructing a tunnel around 12m in diameter up to 1.8km deep.

"When I went inside the tunnel, I felt like it was alive," says Panwar. "You could hear the ground reacting to what we were doing, feel how it was behaving. At that depth, everything becomes amplified; I could see many things that I had just been learning about happening right in front of me."

Panwar had a thirst to learn more, reading books and learning from experienced engineers on the project. "I realised that tunnelling as a science is very raw. It's all very project-specific," he says. "I felt that I needed a more holistic education."

And so, Panwar's next step was to enrol on the NATM Engineering course run jointly by the Technical University of Graz and the Montana University of Leoben. Using his savings to fund the course and travelling to Austria for three weeks out of each of the six semesters, Panwar continued working during his studies.

The course at Graz was everything he had hoped for, taking students all the way through the tunnelling process from site investigation, to design, to execution.

> When I went inside the tunnel, I felt like it was alive. You could hear the ground reacting to what we were doing, feel how it was behaving.

"The professors who taught the course have a lot of practical experience and are experts in their field throughout Europe," says Panwar.

Industry experts also deliver guest lectures at Graz and it was one of these lecturers, from Geoconsult who offered Panwar his current role. Panwar is working right now on the Mumbai metro, Pune Metro and rail projects in Northern India. Though he spends around 80 percent of his time in the office and 20 percent on site, it is the site work that he loves the most:

"I have always wanted to work with nature in some way and one of the things I really like about this role is that I get to visit a lot of remote locations and work on civil engineering challenges that are very large in scale," he says. "You learn a lot more about tunnelling from being inside a tunnel rather that outside it."

5 from five

Managing Director at 33-years old

David Juárez

- **BSc Civil Engineering National Autonomous University of Mexico**
- **Managing Director, Herrenknecht Tunnelling Services Mexico**

"The first time I visited a tunnel, I fell in love," says David Juárez, Managing Director of Herrenknecht Tunneling Services Mexico.

One of the great things about his civil engineering degree at the National Autonomous University of Mexico was that the course included lots of visits to sites around Mexico City. "They didn't keep us in the classroom, they showed us what the industry was like in practice," says Juárez, whose parents are both engineers.

Another positive of the course was its connections and reputation with industry. Juárez was offered a job with Ingenieros Civiles Asociados (ICA) within two weeks of leaving university, at that time the biggest contractor in Mexico.

ICA was quick to hand responsibility to the young engineer. Soon he was overseeing two tunnel boring machines (TBMs) on the Tunel Emisor Oriente project. "I was thrilled," he says. "I was doing what I wanted to do so soon after leaving university." However, he admits it could be stressful too, sometimes working 20 hours a day.

After three years with ICA, he moved to TBM manufacturing giant Herrenknecht. Posted first in Herrenknecht's mining department in Schwanau, Germany, Juárez found himself working with young engineers from all the world's main mining countries, giving him a more international perspective. "It was a great work environment, the company trusted and invested in young talent," he says.

His first posting was to Chile, introducing prototype machines to El Teniente copper mine. "It was really challenging," he says. "You are

> The first time I visited a tunnel, I fell in love.

coming from outside the country, working with local contractors, using prototype machines. There were all sorts of problems, but in the end, it was incredibly satisfying."

His next move with Herrenknecht was back to his hometown of Mexico City, where a tunnelling boom in 2015 meant there were over seven major projects underway. Initially, Juárez oversaw three projects and was then trained up to take on the role of Managing Director for his region, aged 33.

Now 35, he loves the variety of his job, a mixture of market research, business development, engaging with owners and contractors to understand projects and problems and propose technical solutions.

Hands-on course prepares for life on site

Dominic Preest

- **Bachelor of Engineering Technology, Unitec Institute of Technology, Auckland**
- **Project Engineer, McConnell Dowell Constructors**

Dominic Preest chose to study a diploma in civil engineering at Unitec Institute of Technology in Auckland, New Zealand, because he wanted to do something practical. Part way through the course he decided to switch to a Bachelor of Engineering Technology because he felt it would give him more options.

It certainly led to a job straight from his studies. Preest was employed by McConnell Dowell as a Site Engineer. "I felt quite comfortable that I knew what I was doing due to the practical components of the course," he says.

After working on the construction of a mine shaft, Preest moved to the Waterview Connection in Auckland, creating New Zealand's longest and deepest road tunnels. "I did surface work at first and then moved underground once the tunnelling began," says Dominic.

After working on a large-diameter tunnelling job, Preest's next posting

was Army Bay in Whangaparoa, a 1.2m-diameter microtunnelling project. Here the team set a new world record for the longest tunnel of its kind, only to beat that record on the next microtunnelling job, at Snell's Algies, which Preest also worked on.

One of the best things about his current role is the problem solving, says Preest. For example, between Army Bay and Snell's Algies, the team made several refinements to the machine to make it safer and more efficient.

As Project Engineer on a microtunelling job, Preest's responsibilities are far-ranging. "On a small job, you basically set up the project from a farm field," he explains. "On a large project, you are only responsible for a small part of the works."

Although with the benefit of hindsight, Preest wishes he had elected to take more structural units during his course at Unitec to help him design temporary works, he really appreciates his geology field trip notes – which apply to the ground around Auckland that he is tunnelling through now.

> Tunnelling is not a nine-to-five job," says Preest, "but there are constant technical challenges and opportunities to innovate, which makes for a really interesting career.

> The true spirit and character of a team shows when things are not going to plan and in tunnelling that is important because every project will provide unexpected challenges.

Reaping the rewards of early site experience

Thomas Rengshausen

- **Technical Services Engineer, PORR Group**
- **MSc in Geotechnical Engineering and Tunnelling, Ruhr-Universität Bochum; BSc in Civil Engineering, Universität Duisburg-Essen**

While Thomas Rengshausen was still studying for his Bachelors' degree in civil engineering at the Universität Duisburg-Essen, in Essen, Germany, he got his first job on site: a six-month placement on the Crossrail project, in London, with contractor Hochtief Murphy JV.

Although placements are not required by the course, Rengshausen applied for several internships because he wanted to find out what working on a tunnelling project was like – and whether he would enjoy it.

His six months on Crossrail's contract C310, a tunnel under the River Thames, convinced him that tunnelling was for him. "It was a great team," he says. "There were many young engineers from Germany, great people from Murphy, many interns and it was a young team. Also, London is a great city to live and work in."

The internship also guided him towards an MSc that specialised in geotechnical engineering and tunnelling at Ruhr-Universität Bochum. "What I enjoyed most about my Masters' degree was the project work with other students," says Rengshausen, "for example, we were provided with a fictional tunnelling project and had to plan technical measures and find solutions for the different stages of construction."

Rengshausen started work for Porr while he was still studying for his Bachelors' degree, working part-time on the Emscher sewer tunnel project, which was located near to his University. On graduating, he moved to Porr's offices in Dusseldorf for six months working on tenders and a R&D project developing a geopolymer shotcrete for tunnel fire protection, a project he continued to contribute to whilst at Ruhr-Universität Bochum. Today, he is working as a Shift Engineer on site at Frankfurt Metro Line 5.

Working whilst studying taught Rengshausen something that is difficult to teach on a degree course: "You don't learn at university how important the human factor is," he says. "The true spirit and character of a team shows when things are not going to plan and in tunnelling that is important because every project will provide unexpected challenges."

5 from five

Networking, nosiness and making your own luck

Divik Bandopadhyaya

- **Tunnelling engineer, London Bridge Associates, seconded to Costain-VINCI-Bachy Soletanche JV, as the project-wide asset protection engineer, on Tideway East**
- **BEng Civil Engineering, University of East London; MSc Tunnelling and Underground Space, University of Warwick**

> One of the things I like about asset protection is that it combines multiple elements: commercial, behavioural, strategic and technical...

Looking at Divik Bandopadhyaya's CV, one of the most striking things is the number of internships he completed whilst studying, with companies such as AECOM, Atkins, Arup, Herrenknecht. His secret? Networking.

"The background I come from gives me the confidence to approach anyone," he says. His peers still mention the time he approached the High Commissioner of Vietnam, who was visiting the Institution of Civil Engineers (ICE) in London, for a chat.

Born and educated in India, Bandopadhyaya moved to the University of East London in 2012 to study civil engineering. He joined the ICE as a student member and was often to be found at the HQ in Westminster, talking to whomever he could.

Today Bandopadhyaya, 27, chairs the British Tunnelling Society's (BTS) young member group. He gained an interest in tunnelling while studying. "The University of East London is at the Royal Docks, next door to two huge tunnelling projects at the time: Crossrail Canning Town on one side and the Lee Tunnel on the other," he explains.

After a summer internship with global TBM manufacturer Herrenknecht in Germany, the University of Warwick's MSc in Tunnelling and Underground Space was the obvious choice. "It is only MSc in the UK with such heavy involvement from industry," he says. "At Warwick you have certainty that the industry is deciding and delivering the course content."

The Warwick course also delivered a close band of allies to add to Bandopadhyaya's network: "We all became really good friends, working together all day and then spending the evenings in a bar carrying on discussions. The camaraderie was great."

Bandopadhyaya's job as a tunnelling engineer at London Bridge Associates (LBA) came through a conversation with ex-chairman Bob Ibell who was lecturing at the MSc course. His experience at LBA has been varied, with a big chunk of time spent on secondment with Costain-VINCI-Bachy Soletanche JV as the route-wide asset protection engineer on the East contract of Thames Tideway Tunnel, London's £4.1bn super-sewer project.

"One of the things I like about asset protection is that it combines multiple elements: commercial, behavioural, strategic, technical," says Bandopadhyaya. His advice to any would-be tunnelling engineers is to remember that there are many more roles than purely technical ones. "Why not start looking at commercial issues, or policy or planning? It's about thinking above your own tiny bit of scope, talking to people and creating your own opportunities."

breakthrough

Contributing to Breakthrough

If you would like to get involved in Breakthrough magazine by contributing an article, or suggesting potential content for future editions, we would be delighted to hear from you! Please feel free to contact Breakthrough's editorial team or the ITAYM Young Members Committee (see details on page 4).

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