

# breakthrough

Issue 5 2019



**A Week in The Life  
on Thessaloniki's Metro**

**ITACUS Embraces  
Young Members**

**Young Tunnellers  
Visit the Brenner  
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**Exploring Naples'  
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# Welcome to 'Breakthrough'

Dear readers,

Welcome to the 5th edition of Breakthrough, the International Tunnelling and Underground Space Association's Young Members group's (ITAYM) initiative to promote opportunities for the next generation of tunnellers. Hopefully in the following pages you will learn something new about the people and tunnels of the ITA family of member nations that informs, inspires or excites you.

A lot of things have developed since the ITAYM group was founded in Brazil, in 2013, but the enthusiasm and energy this group is still as vibrant as ever. If this is your first introduction to the world of tunnelling then I hope it is just the start of a long and rewarding journey.

I was fortunate enough to attend the 4th ITA Tunnel Awards in Chuzhuou, China, last November where a truly outstanding collection of seven young engineers were vying for the Young Tunneller of the Year award. With representation from China, Italy, India, Iran, Malaysia, New Zealand and Norway, the diverse group highlighted how excellence comes in many different forms with examples of site, design and academic distinction all on show.

As the future of this amazing industry, I believe, now more than ever before, young tunnellers have the chance to work in a truly global community. I often recount a moment at the ITAYM networking event at the ITA's 2016 World Tunnel Congress (WTC), in San Francisco, where a group of young tunnellers were having a passionate discussion about the acceptable crack width for shotcrete. It is fantastic to have shared experiences and it is moments like this that remind me we all deal with the same issues in our profession... and that shotcrete always cracks no matter what you do.

If you're joining the ITA in Naples, Italy, for the week of WTC2019, then we hope you can connect with other like-minded tunnellers from around the world and continue to grow this outstanding global network of young professionals. If you can't make it to Naples, please stay in touch via our social media, regular newsletters and through your local young member association. If you're not sure who your young member association is, then get in touch and we will help connect you.

Happy tunnelling!



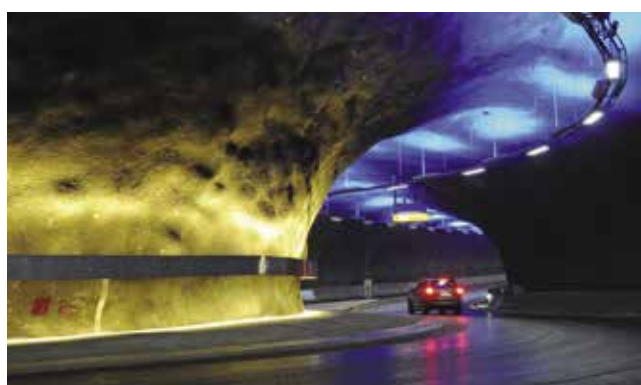
Keith Bannerman, ITAYm Chair

## Front Cover

Stefano Casale, a Geologist working for BBT SE, on the Brenner Base Tunnel's 'Mules 2-3' construction lot (see p31). The €8.38 billion project will significantly increase railway capacity and greatly reduce travel times between Fortezza, Italy and Innsbruck, Austria, via a 55-kilometre (34-mile) long rail tunnel connection through the base of the Alps.







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Breakthrough is endorsed by the ITA



## 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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# 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.



## Keith Bannerman

Keith is an enthusiastic tunneller who never misses an opportunity to get his boots dirty. Since graduating in 2008 with a Bachelor of Civil Engineering from the Queensland University of Technology (QUT) he has gained experience as a designer, cost engineer, site engineer and most recently as part of a client delivery team. Keith has been an active member of the Australian Tunnelling Society for over 10 years and is currently the ATSym Chair, as well as sitting on the ATS Executive Committee. When not wearing his high viz, you can usually find him outdoors with his wife, kids and dog enjoying the sunshine.



## Jasmin Amberg

Jasmin gained her Bachelors and Masters in Civil Engineering at the ETH Zurich, in Switzerland. From 2013 – 2018 she worked as a Tunnelling Engineer at Gähler & Partner AG. Since 2018, she has been employed as a Junior Project Manager at Amberg Engineering AG. Jasmin is the founder and Chair of the Swiss Tunnelling Society (STS) Young Members group. Outside of work, she likes cooking and spending time with her family and friends, when she's not busy acting as a basketball coach or referee.



## Giuseppe Gaspari

Giuseppe graduated in 2005 and subsequently got his Masters in Geotechnical Engineering at Sapienza University of Rome, Italy. While working with Geodata Engineering in Turin, he also gained the ITA-AITES Masters in Tunnelling at the Politecnico di Torino. He is founder and President of the Young Member groups of the Italian Geotechnical Association (AGI) and of the Italian Tunnelling Association (SIG) and plays an active role representing and boosting young members on the board of the Ontario chapter of the Tunnelling Association of Canada (TAC). Giuseppe is a passionate traveller and is addicted to a number of different sports.



## Jekaterina Jonsson

Jekaterina graduated in 2012 from Luleå university of technology with a degree in Civil and Rock Engineering. She got into tunnelling through a Masters study on blasting efficiency at a Swedish nuclear fuel and waste management company and worked on the Stockholm Bypass project in both the design and construction phases 2012-2018. Jekaterina is a technical consultant at Geosigma, currently assigned as project leader for construction projects in utility tunnels and a rock specialist on the Stockholm subway expansion project. She is a committee member of the Swedish YM group. Jekaterina spends most of her time off outdoors ice skating, camping, climbing and skiing.



## Chrysothemis Paraskevopoulou

Chrysothemis is a Tunnel/Mining Engineer (MEng) with post-graduate studies (MSc) in Tunnelling from NTUA (GR). In 2016, she completed her PhD, which involved working on a joint Research Project between Queen's University and ETH Zurich. She is currently an EMBA candidate. 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 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.



## Nicolas Ziv

Nicolas ZIV is a civil engineer and urban planner, presently working on the development of Data Science algorithms to improve Tunnel Boring Machine (TBM) productivity at Tunnel Lab, the R&D department of Bouygues Travaux Publics, a French-based contractor. Nicolas undertook an industrial PhD in partnership with ESTP-Paris, developing new methods to manage the complexity of construction projects based on systems engineering, functional analysis and constructability. At Egis, Nicolas worked on the design and planning phases of several transport infrastructure projects, including the extension of Lyon Metro's line B, the Greater Paris metro and the Madinah Metro Network. Nicolas also participated in the creation of the AFTES Young Members association in France.



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## ATSym team active in Australia

The ATSym team all made their way to Melbourne for the ATS Tunnel Design and Construction Short Course, in November 2018. The schedule included two and half days of technical presentations and interactive workshops, relating to past projects, design issues, site safety and innovations being introduced today. Attendees covered an array of experience, from university students to internationally-recognized professionals who travelled from across Australia and internationally to attend the course. The team also shared ideas and initiatives with the target of improving the visibility of the young members team with events and networking opportunities.

The event also saw the 2018 David Sugden Writing Award presented to Matthew Bennett. The group has also been successful in its proposal to tour the top three papers from the 2018 awards around the country. Matthew Bennett, Aaron Lippett and Brodie Aitchison will each present in Melbourne, Sydney, Brisbane and Perth over the coming months, keep an eye on the ATS

website for event specifics.

The David Sugden Award was originally instigated in 2004 to encourage young engineers to develop the art of technical writing. The 2018 competition has seen a new high-water mark in the received submissions, with several outstanding papers that would have challenged for the prize in any other year. Matthew Bennet's paper on 'Vulnerable Road User Inclusion in Spoil Removal Route Planning' was selected by the independent review panel as the recipient of the 2018 award. Matthew's prize includes a trip to the WTC2019 conference in Naples, Italy, this May.

ATSym celebrated the ITAym's #WorldTunnelDay on the 5th of December. This day is traditionally celebrated as St Barbara's Day, the patron saint of tunnellers. The Sydney team organised a joint ATS/ Rail Technical Society of Australasia (RTSA) entitled 'TBMs and Trains' to bring together young rail engineers and young tunnellers. The post event networking led to new connections between professions.



ATSym Team: (L-R) Simon Brinkmann (NSW), Aaron Lippett (NSW), Monique Quirk (QLD), Keith Bannerman (ITAym), Will Houghton (WA) and David Suter (VIC)

Keep in touch via the ATS facebook page (@AustralasianTunnellingSociety) or ats.ymc@gmail.com if you would like to know more about ATSym! Also visit the ITAym facebook page (@ITAYoungMembers) to keep up with what the next generation of tunnellers area up to in all corners of the globe.



ATSym TBMs and Trains Networking

## Danish YMs prepare for WTC2021 in Copenhagen



Earlier this year, the Danish Tunnelling Society's Young Members appointed a new Steering Committee Chair, Matas Bazevicius from Ramboll, as the previous Chair, Stine Kristensen, has moved to work in the UK. Matas has successfully joined the Steering Committee and continues to work on the group's main goals; to promote collaboration with universities and the use of social media. The new goal and ambition of 2019 is to organise a small technical seminar with

paper submissions and presentations by young professionals and students interested in underground engineering.

In addition, the Steering Committee has a strong focus on involvement in the upcoming World Tunnel Congress (WTC 2021) in Copenhagen. Two of the YM Steering Committee members are part of the organizing committee and we are looking forward to offering more help from young professionals and be part of this fantastic event.



# Brazil expands its network to reach new members

Over the last year, the Brazilian Young Members group (CBTYM) have organised a number of events with guest speakers broadcasting live on the group's Facebook page, these have included "TRE Altamira - Monitoring Ground Displacement with Satellite Radar Systems" by Carolina Athayde and Javier García Robles and a talk on the "Behaviour of Shotcrete with Additives" by Professor Antonio Figueiredo and Renan Pico. A number of presentations have also been given by CBTYM members at universities, such as the Instituto Mauá de Tecnologia, Universidade Presbiteriana Mackenzie and Fundação Santo André.

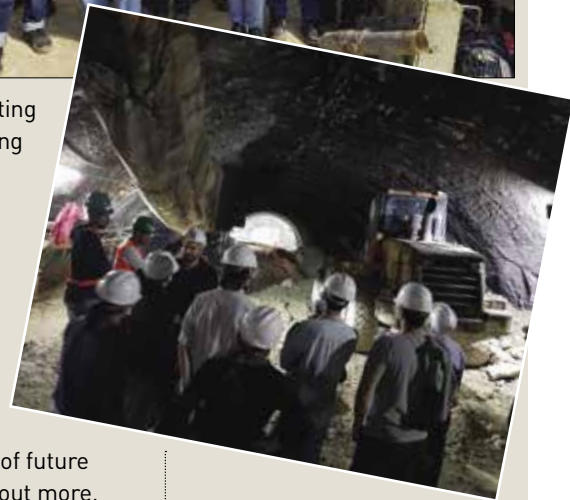
Last summer, the CBT Young Members group arranged a visit to the job site of São Paulo Metro's Line 4 extension. Participants had the opportunity to see, in practice, the constructive aspects of tunnels executed by

the conventional methodology (NATM). Following a brief explanation of the concepts and techniques used in the construction of the tunnels, the group went into the field to observe the application of these concepts. The visit included a brief passage through a section of the future Vila Sônia Station, built by the cut-and-cover method, using diaphragm walls. Visitors then descended through the access shaft to the tunnels still under construction.

Work has also been focused on the creation of a social network for the CBT Young Members, as well as a new monthly newsletter, which will provide news on upcoming CBT and CBTYM events and agendas. By the end of 2018, the Brazilian Young Members group had grown its membership to 514 people, representing an increase of 10% on 2017. Goals for 2019 include a further increase in activity on social



networks, generating engagement among CBTYM members and a greater visibility for the group; further events that are available to all members, either by live streaming or webinars; as well as a number of future site visits. To find out more, visit the group's Instagram, Facebook, Twitter or LinkedIn accounts @CBTYM.



*The Young Members group on their site visit to São Paulo Metro's Line 4 extension.*

# STUVA-YEP gains momentum in Germany

Since the German Forum for Young Engineering Professionals (STUVA-YEP) was founded in 2017, it has continued to establish itself. Following the first meeting in spring in 2018, another two events with around 50 participants each took place. In October 2018, the German young members met in Stuttgart for a series of lectures followed by an excursion on the topic "Geological challenges at the Stuttgart-Ulm rail project" sponsored by PORR Deutschland GmbH and ARGE ATA and ATCOST21. The Stuttgart-Ulm rail project is currently one of Europe's largest infrastructure projects with Deutsche Bahn as the client.

In spring 2019, the third meeting took place at Frankfurt Airport on the topic "Building new infrastructure under the challenges of existing infrastructure" and was sponsored by Schüßler-Plan

Ingenieurgesellschaft and Wayss & Freytag Ingenieurbau AG. Four interesting lectures were followed by an excursion to the Gateway Gardens, a new quarter, which is being developed at the Frankfurt Airport and will be connected to Frankfurt city by a new tunnel.

The next major event planned will take

place within the framework of the STUVA-Conference. In contrast to the previous events, the focus lies here on a General Assembly and the election of the Steering Committee. The STUVA-Conference is the largest tunnelling conference in Germany and will take place in Frankfurt on the 26-27 November, 2019.



*Meeting at Frankfurt Airport*

## Mexico's young member group initiates activities

The Young Members Group of Mexico was formed in October 2017, as an initiative of the Mexican Association for Tunnel Engineering and Underground Works (AMITOS), and led by Carlos Ramirez de Arellano and Wendy Romero. The group consists of 150 members, of whom 108 are engineering students related to tunnels and 42 are engineers who are already in professional practice. Among the projects that members of the YMG are working on include: The tunnels of the Mexico-Toluca Interurban Train, Line 3 of the Guadalajara Subway, the

Emisor Oriente Tunnel, and the Line 12 extension of Mexico's City subway, among others.

The first meeting of the YMG-Mexico was in March 2018, in which some of the members shared their work activities showing analysis, geotechnical design, construction monitoring and instrumentation, mentioning the most important challenges in their work areas. Following the presentations, the group shared opinions with the Board of Directors of AMITOS who, with their extensive experience, gave feedback to each of the presentations. This first meeting of the YMG served

to personally introduce each member to the group and create interaction that will allow the future to have a consolidated group that is capable of carrying out activities in support of the young community of tunnel engineers in Mexico.

During the meeting, activities planned for the group were discussed, through which it is intended to generate relationships among students, professionals and experts, have an exchange of knowledge,

*Keendy Hernandez gives a presentation on Slope Stability*

academic support, approach to the labour community, and other activities that enrich the professional and academic growth of the members.

This commencement of activities will be the foundation of a solid group of students and professionals committed to the widest possible outreach to promote underground works. May this be the first of many more meetings!



## UCAYM webinar series and 2019 ITA Awards in Miami

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, its primary goals are to support the professional development of those in the industry, provide networking opportunities to its members and create close links with universities to recruit new talent. The current UCA Young Members Executive Committee consists of Everett Litton, Demetrio Criscuolo, Ritika Kundu, and Luis Avila.

UCAYM host online presentations from industry experts and researchers to share project experience, lessons learned, or cutting-edge research every month. This year started off strong with the UCA Young Members hosting a series of educational webinars that included presentations such as: Current Trends in Procurement delivery of Major Tunnel Projects, by Steven R. Kramer of COWI, on January 30, 2019; Underground Challenges and Innovative Construction solutions by Jeffrey M. Hammer, of Taylor Brothers, on February 21, 2019 and Lunar Tunnel Boring, by Dr. Jamal Rostami of the Colorado School of Mines,



*CSM Scholarship Recipients at NAT 2018*

on April 24, 2019.

Steve's presentation described different procurement and delivery methods such as design-build, progressive/modified design build, construction management at risk and public-private partnerships as well as the challenges faced as they were applied to a wide range of tunnel projects across the US.

Jeffrey discussed his personal experience on two large and challenging tunnel projects and concluded with message that receiving the approval to design, plan and/or construct an underground structure requires tunnel engineers to work through numerous challenges and consider many options in order to reach successful completion of a

project. Dr. Jamal Rostami presented the design of a custom Lunar Tunnel Boring Machine (LTBM) specifically for use in the lunar environment and boring in lunar material. There are more webinars lined up for coming months and all are welcome to register. For more updates check the UCAYM's LinkedIn page.

UCAYM have posted scholarship applications for student attendance to the Rapid Excavation & Tunneling Conference (RETC). As part of the RETC event ([www.retc.org](http://www.retc.org)), UCAYM are also planning to host the UCA Young Member Scholarship Orientation in Chicago, Illinois, on Sunday, June 16, 2019. Additionally, a UCA Young Member Networking Event is planned for Monday, June 17, 2019, to provide networking and job seeking opportunities for young professionals in the industry.

This November 18-20, the Cutting Edge Conference ([www.ucaofsmecuttingedge.com](http://www.ucaofsmecuttingedge.com)) will host the ITA Awards, in Miami, Florida. The UCAYM will once again head up a dedicated session for Young Engineers and look forward to welcoming finalists in the Young Engineer of the Year category of the Awards to participate in the event.





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## Colombia's ACTOS-NGT put ethics front and centre

Now in its second year, Colombia's ACTOS-NGT (New Generation of Tunnellers) has defined its 2019 work plan, which is based on the ethics and good practice of engineering, as defined by the new board of directors headed by engineers Paola Castillo (Chair) and Camilo Ramirez Chair (Vice-Chair). ACTOS-NGT is aware of the difficult scenarios caused by corruption that are being witnessed on underground engineering projects in Colombia. That is why the young members will work together to raise awareness among young professionals about the importance of ethics and morality in underground engineering.



The new work plan includes seminars, a review of the Colombian Tunnel Design Manual by the members of the group, and work agreements among several strategic partners such as: Colombian Society of Engineers - SCI Young Members Group, Colombian Geotechnical Society - SCG and the American Society of Civil Engineers - ASCE.

Meanwhile, ACTOS-NGT is fulfilling its objectives of generating knowledge and strengthening relations with other young members groups in the world and will participate this year at the 2019 World Tunnel Congress (WTC) in Naples, Italy, with an oral presentation that will be given

by the ACTOS-NGT Chair.

ACTOS-NGT relayed their experiences as a group at their first General Assembly, which took place during the XIII Andean Seminar on Tunnels and Underground Works held in November 2018, in Bogota, at which they were able to interact personally with the Ibero-American Presidents of tunnel associations from other countries and young tunnellers from Latin America. This was the first time as a young member group they acquired the right to hold an annual meeting and give an oral presentation at the Seminar.

Finally, ACTOS-NGT invites all young members groups around the world to attend the

upcoming XIV Andean Seminar on Tunnels and Underground Works, which will be held in the city of Medellin, on October 10 and 11, 2019, and is organised by the Colombian Tunnelling & Underground Works Association (ACTOS) and Antioquian Society of Engineers and Architects (SAI). It will be a unique opportunity to get involved with Colombia's development in tunnelling infrastructure, in terms of technology, construction and design, as applied to tunnels excavated in rock from the Andean Mountain Range and also where professional, academic and business relations will be strengthened.

## TAI Young Members group launched in India



India is a rapidly developing nation with construction activities going on across the country. The huge demand for the construction of metros, railways, highways and hydro power projects has resulted in a vast scope for tunnelling. This provides numerous opportunities for young tunnelling professionals to develop their skills and connect with a global industry. To provide a platform for collaboration and development, the President of the Tunnelling Association of India (TAI), Dr. Mangu Singh, launched the Young Members group on 21 December 2018 at the General Assembly of TAI.

The idea to set up a group in India originated when Sandeep Singh Nirmal, a tunnel engineer working with AECOM, proposed that the TAI set up a platform for the development of young tunnelling engineers in India. The TAI provided administrative guidance to Sandeep, who started connecting with young engineers across India and pitched the idea of establishing TAIYM (TAI Young Members). The idea was met with great enthusiasm and to willingly contribute to set up the group.

In June 2018, the group grew to 10 unofficial members who worked together to define a mission and vision statement for TAIYM. The group was guided by Sandeep, who had experience of working with the

BTSYM (British Tunnelling Society Young Members) for 1.5-years as an active member.

By July 2018, the logo for TAIYM was ready and the news that TAIYM was going to be a reality was published in the TAI journal. In September 2018, the number of official young members grew and motivated engineers such as Senthil Nath and Akshay Mitra Panwar joined the group. By the end of November 2018, 50 young professionals had expressed interest in joining the group.

The preparatory work for setting up the group and the enthusiasm of young professionals to join the group was presented to TAI General Assembly, which launched the group officially on 21 December 2018. At present, the group has 40 officially registered members and the numbers are growing.

TAIYM is planning to organise their first event in March 2019 which will be completely organised by the young professionals. TAIYM is currently working on planning their annual events, committee structure and collaborations with the global industry. TAIYM looks forward to contribute the best to network motivated and quality professionals who would develop their skills and contribute at national as well as global platforms.



# World Tunnel Day 2018

Following two incredibly successful campaigns and increasing international involvement from many of the new ITA Young Member national organisations, the World Tunnel Day event returned in 2018, marking the third #WorldTunnelDay.

World Tunnel Day is a social media event held in the first week of December, to coincide with the Feast Day of St Barbara, the patron saint of tunnellers and miners. The goal is to raise public awareness of the tunnelling industry by holding celebratory events and posting photos, video clips and messages on twitter, Instagram and facebook in order to get the subject trending worldwide.

We would like to encourage as many people, project teams, companies and organisations as possible to join in again this December using the hashtag “#WorldTunnelDay” and promote our industry!



## Sweden's BYM launch mentor programme

Over the course of 2018, Sweden's BYM (Young Members) group has continued planning and in August launched its mentor programme, called DevelopYM. BYM, now an official branch of the Swedish Rock Engineering Association, launched DevelopYM with 10 mentor-mentee pairs.

DevelopYM was envisioned to allow senior members of the industry in Sweden to sign up and offer their knowledge and support to young engineers. Mentors were encouraged to detail what specific skills they could best offer. Mentees were encouraged to apply and detail what they would be keen to learn more about. Examples listed by both mentors and mentees are practicalities of underground work, rock mechanics and career paths.

The first kick-off event allowed all pairs to meet for the first time. Following a workshop and a lecture from a motivational speaker, each pair was given time to plan when and how often to meet up in the year ahead.

BYMs plan is to allow the mentee to drive the progress of the pair and set the stage for where to go. The mentor aims/tries to do their best to accommodate and steer the discussion towards the goal of the mentee, based on years of experience and knowledge of our profession. So far meetings have involved a variety of activities such as site visits, technical discussions and advice on future career paths.

As part of the DevelopYM programme, all participants were required to sign a Code of Conduct, now the official Code of Conduct for the Swedish Rock Engineering Association. The Code of Conduct requires



*Above: The BYM DevelopYM group kick-off meeting where thoughts were shared on various aspects of the mentor-mentee relationships.*

*Left: BYM members met up with colleagues from Norway to tour the Follo Line project.*

good behaviour and specifies the programme to be a non-recruitment forum.

So far 9 out of 10 pairs still meet up and reactions have been positive. This year's DevelopYM will be concluded in September 2019, where the next group of mentors and mentees will be brought into the programme. A midterm meeting was held at the end of January where all mentees and mentors gathered to present their progress so far. There were also discussions with all participants as well as discussions within groups

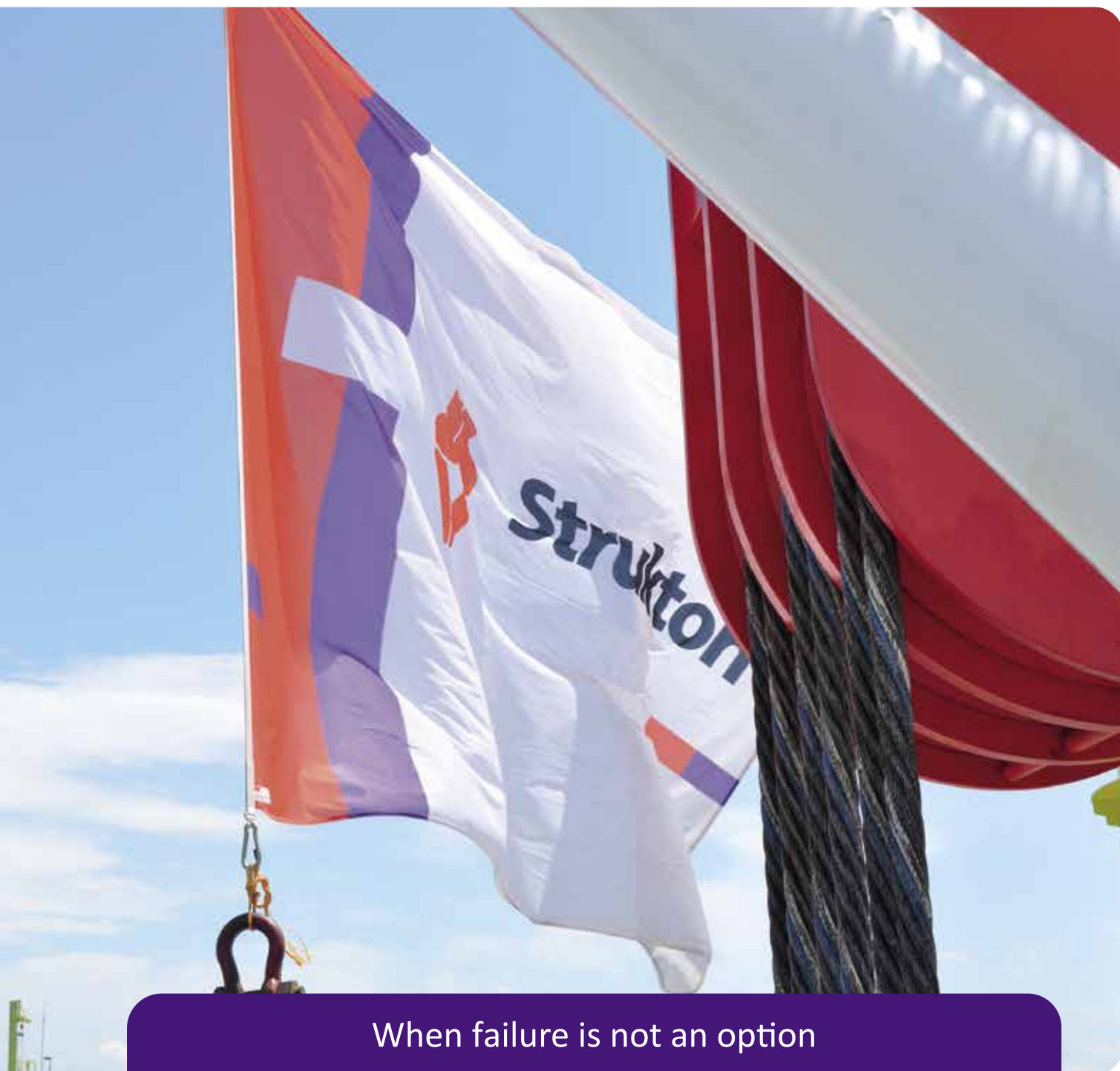
where mentors and mentees were separated. The mentor/mentee only groups discussed topics ranging from how to steer the mentor-mentee relationship to sharing good places to meet up.

In 2018, BYM also partnered with Norway's Young Member association for a one-day visit to Oslo and the Follo Line project, organised in conjunction with the annual Norwegian meeting/congress "Fjellsprengingskonferanse". Seven members from BYM attended for a site visit and seminar on the specifics of

TBM boring in the Oslo area.

The group networking page on Facebook now consists of 251 members, suggesting a tapering off from the extensive growth seen over the last two years. BYM is planning to have lectures on work life after graduation for university students around the country, attempting to reach a broader audience and attract more young members to the profession. Considering the numerous projects underway and in planning the industry is in need for the next generation of skilled tunnellers.





## When failure is not an option

### Introduction

Strukton Immersion Projects is the specialist company within Strukton for the floatation, transport and immersion of tunnel elements and caissons.

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# Naples Underground

With the ITA World Tunnel Congress (WTC2019) being held in Naples, Italy, this year, Dr Chrysothemis Paraskevopoulou, Lecturer and Assistant Professor at the University of Leeds, in the UK, takes a look at the historic underground structures of this ancient city.

Naples or Napoli, coming from the Greek word Neapolis – which means New (-nea) City (-Polis) – is the regional capital of Campania and the third-largest municipality in Italy, after Rome and Milan. It is one of the oldest continuously inhabited urban areas in the world and has more than 400 kilometres of tunnels and underground structures lying beneath its densely populated streets.

The region was first settled by Ancient Greeks in the 2nd millennium BC. By the sixth century, the city limits of the nearby Greek city of Parthenope had shifted and had been re-founded as the 'new city' of Naples, which eventually became one of the foremost port cities of Magna Graecia.

Following the Mount Vesuvius eruption in 79 AD – one of the most famous and deadly volcanic eruptions in European history – Naples survived, unlike the nearby cities of Pompeii and Herculaneum to the south, which were swallowed by volcanic magma and ash. Naples played a major role in the merging of Greek and Roman society and was a significant cultural centre under the Romans. It served as the capital of the Duchy of Naples (661–1139), then of the Kingdom of Naples (1282–1816) and finally of the Two Sicilies, until the unification of Italy in 1861.

Naples is known, not only for inventing the pizza, but also for its underground city "Napoli Sotteranea" (Naples Underground), the Renaissance aqueduct system, the catacombs of San Gennaro and San Gaudioso, the Bourbon Tunnel and the Fontannelle Cemetery.



*The modern-day city of Naples*

The Ancient Greeks first began excavating Naples' volcanic tuff in the third and fourth centuries BC and used it as construction material to build the walls and temples of the ancient city. They also excavated caverns to store water that were used as part of Naples water supply for approximately 23 centuries. Later, the Romans expanded these excavations with tunnels to form an underground aqueduct, known as the Aqua Augusta, developing an underground network of tunnels to supply water to the city.

This water system is considered to be one of the most advanced engineering achievements of that time. The water source for the aqueduct originates in the Serino region, some 50km away where the elevation was relatively low, prohibiting

a steady flow of water above ground. Consequently, in order to achieve sufficient flow, engineers decided to use gravity, taking the water underground in a steady downward grade from the source into the city centre, in some cases 30 metres below the surface. The tunnels gradually became smaller as they reached the heart of the city to increase the flow pressure of the water, which was stored in numerous cisterns and wells around the city.

The extent of Naples' underground aqueduct network was eventually revealed due to the bombing that took place during World War II, when many of the structures were uncovered as a result of engineering works that were being carried out to repair, strengthen and reinforce the foundations of buildings that had suffered





*The Bourbon Tunnel*



*Fontannelle Cemetery*



*An excursion through the Bourbon Tunnel*

bomb damage. In 1941, almost 250 miles of tunnels and waterways under Naples were cleared of water and refuse. Most of the wells were sealed, stairways were built, and electricity was installed. The Neapolitans who waited in the shelters as the bombs pounded overhead left markers of their tense days and weeks there, drawing on the walls and leaving behind forgotten relics such as beds, sewing machines, radios and toy cars.

It is believed that a mud slide from Mount Vesuvius, triggered by rainfall mixing with volcanic ash, covered the ancient city of Naples long-ago. As the years went by, new buildings were built on top of the long-forgotten structures, burying them up to 40 metres below today's streets. Beneath the 18th century cloister at San Lorenzo Maggiore are the remains of a first century AD Roman market, a barrel-vaulted shopping arcade and a road with remnants of ruins, including the domed oven of an ancient bakery and a communal laundry



*Underground passage leading to 'Nero's Theatre' a 6,000 seat Graeco-Roman theatre*



*One of the underground cisterns of the ancient Graeco-Roman aqueduct*

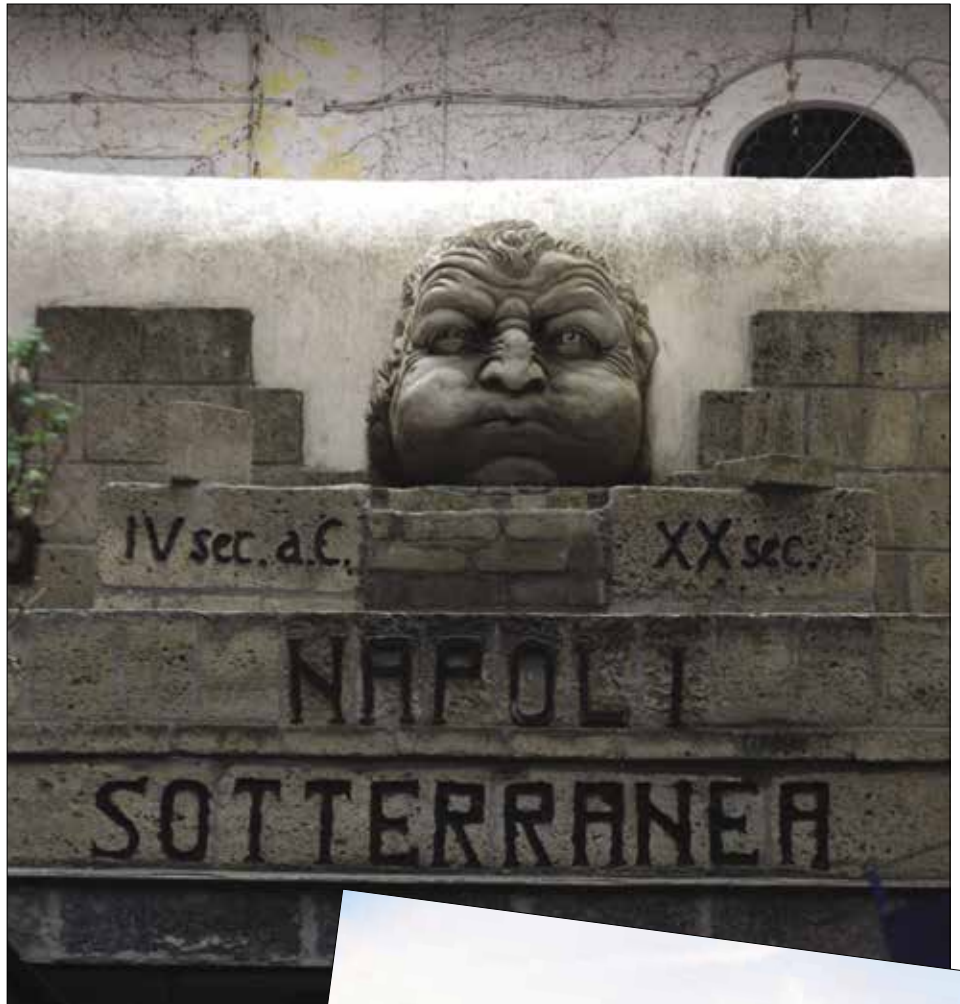


with tubs and drains, which were all once at street level. Another historic structure revealed in this part of the city was 'Nero's Theatre' a Graeco-Roman theatre with a capacity of 6,000 where the Roman emperor Nero is said to have had his own dressing room and once sung through an earthquake. The theatre's diagonally-shaped tuff bricks were specifically designed to provide structural stability in the walls.

The catacombs of Naples demonstrate the paleo-Christian history of city. The Catacombs of San Gennaro, named after the patron saint of Naples, date back to the second century AD and have become the most famous of the Roman catacombs. The vast site is thought to have originated as a small tomb, which held the bodies of a noble family, who then provided further space for the Christian community. Its expansion began in the fourth century AD following the deposition of the remains of Saint Agrippinus, the first patron of Naples, to the underground basilica dedicated to him. This was later compounded when San Gennaro's remains were relocated to the site in the fifth century. The presence of the martyr turned the upper catacomb into a pilgrimage site and the lower catacomb became a coveted place for burial. The San Gaudioso Catacomb, located under the Basilica of Santa Maria dell Sanita, is considered to be the second most important cemetery in the city and was also previously used as a necropolis and Hellenistic hypogeum.

The Bourbon Tunnel (Il Tunnel Borbonico), is named after King Ferdinand II of Bourbon, who fearful of the revolution-prone populace of Naples, had the tunnel designed in 1853 as an underground passage that connected the Royal Palace to the military barracks and other underground tunnels and aqueducts. However, two years after construction of the tunnel began, the king passed away and it was abandoned until World War II when it was used as a bomb shelter for up to 10,000 Neapolitans. The tunnel was then used as a storage facility until the 1970s and now contains decades of debris, including vintage cars and a discarded fascist monument. In the 2000s the tunnel was restored and it is now open to the public for tours.

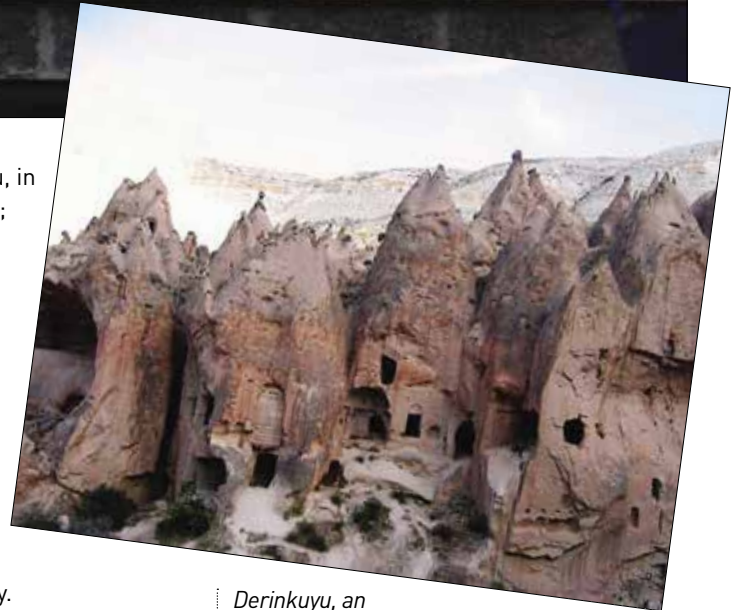
The Goreme and Derinkuyu cities, in the Cappadocia region of Turkey; the Wieliczka Salt Mine, in Krakow,




Poland; the Giza Plateau, in Egypt; Shaanxi, in China; and the City of Petra, in Jordan; are a just a few of the many examples of ancient underground cities and structures. What is noteworthy is that the ancient Greeks, Romans, Egyptians, etc. developed many of these underground spaces for similar reasons that we do today.

The ancient Neapolitans used the subsurface for mining activities, shelters, religious purposes, water storage and supply and even for transportation. It should also be noted that the regional geology contributed to this development. If Naples had not been built on volcanic tuff (similarly Cappadocia), a material with generally good mechanical behaviour, the ancient Neapolitans would probably not have managed to build such elaborate underground structures and develop their underground city in the way they did.

Furthermore, if Vesuvius had not



*Derinkuyu, an underground city in Cappadocia, Turkey*

triggered mud slides, the ancient city of Naples would not have been preserved in such good condition. If Naples had not been heavily bombed during World War II, the underground city might have not been revealed at that time. In conclusion, the Naples' Underground is a great example of underground space development and how it has evolved through time. It is highly recommended you pay a visit to one of the many tours if you ever find yourself wondering the streets of Naples. 





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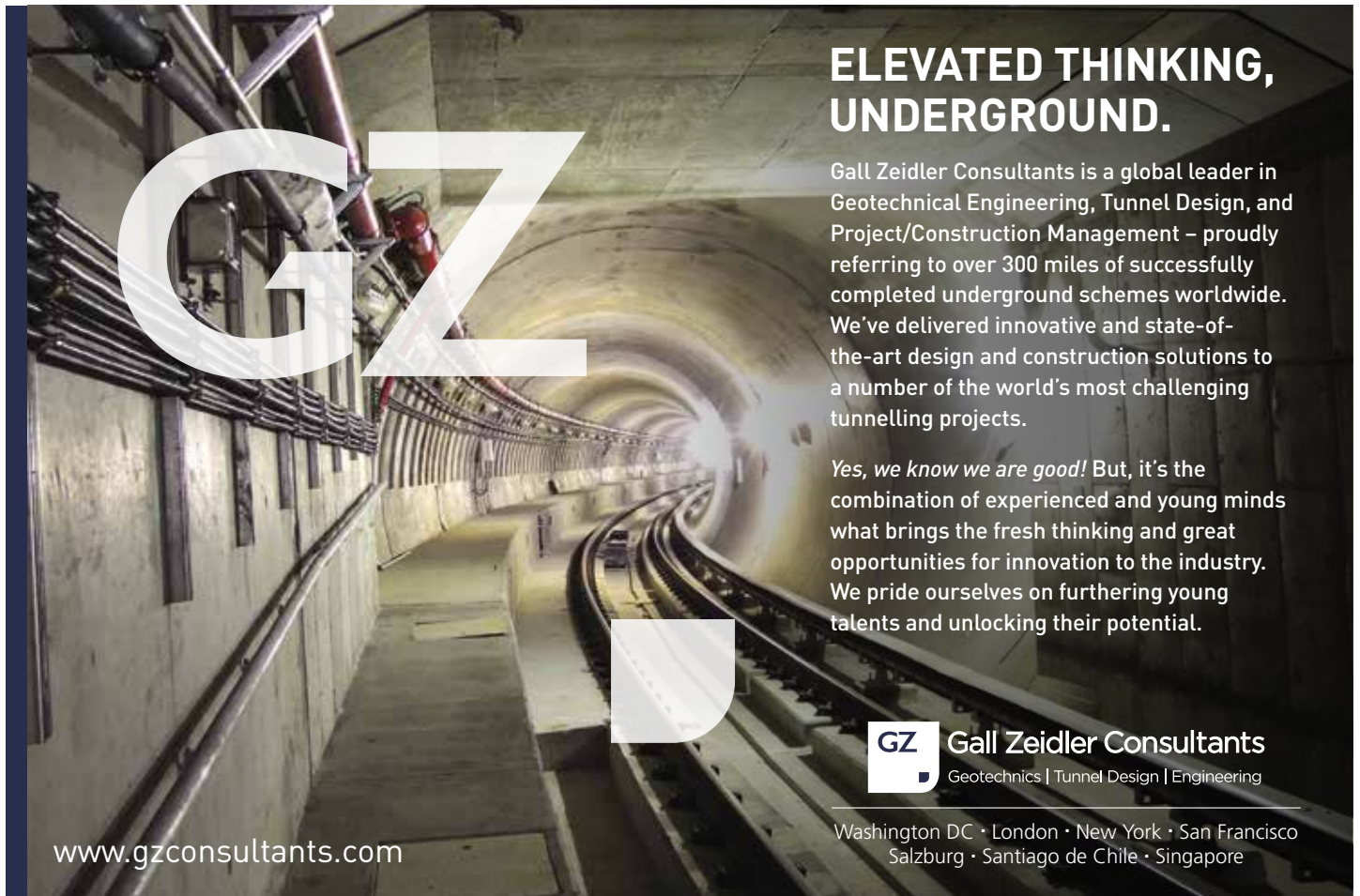
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# Underground Vision

A new generation of young professionals are talking across disciplines to make better use of underground space for the cities of the future. Breakthrough's Kristina Smith reports

Rosanne Verloop was just 24 and starting her master's degree at the Delft University of Technology when Itacus – the ITA's Committee on Underground Space – asked her to join their steering board in 2017.

"I think combining years of experience with fresh perspectives can be a great formula," says Verloop who, as Itacus' Young Talent Ambassador, gives advice on how to get young people involved, speaks at events and helps organise outreach.

The involvement of young people – there are several on the board – has helped catalyse Itacus' national action programme, says Antonia Cornaro, Itacus' co-chair. "It really took off when we involved the ITA's young members. They have a huge enthusiasm for this topic," she says.

The national action programme sees tunnelling engineers and geologists sitting down with architects, planners, transport engineers, local authorities and others to generate ideas and strategies for optimising the use of underground space. Itacus' purpose is to get those involved in strategic decisions about a city's infrastructure to think about underground space in the same way that they think about above-ground space. It should be properly valued, considered for a wider range of uses and – above all – carefully planned so that the most can be derived from it.

"In every country, planning underground space is a grey zone," says Cornaro. "Often it is not regulated at all. It's first come, first served. And that really needs to change." Because every country is different in terms of its legislation, geology and existing underground development, it's vital to start communication and conversations at a local level, explains Cornaro.

## The art of communication

Han Admiraal, whose consultancy, Enprodes, focusses on the strategic management of urban underground space, set up Itacus back in 2007. Cornaro, a trained urban planner, who is the Business Development Manager for Amberg Engineering, joined in 2011 after they met at the World Tunnelling Congress (WTC) in Helsinki and exchanged their views on underground space development. They share a huge passion for their subject and are both able to communicate in an engaging way, whether talking to small groups or conference audiences.

“The involvement of young people – there are several on the board – has helped catalyse Itacus' national action programme. [Young members] have a huge enthusiasm for this topic.”

*Rosanne Verloop, Itacus' Young Talent Ambassador*



Itacus' co-chair Antonia Cornaro (left) with Young Talent Ambassador Rosanne Verloop

“In every country, planning underground space is a grey zone,” says Cornaro. “Often it is not regulated at all. It's first come, first served. And that really needs to change.”

*Antonia Cornaro, Itacus' co-chair*

Verloop with Itacus' co-chairs Han Admiraal and Antonia Cornaro



“The ultimate aim, is to have academia pick up on the subject. We want universities to teach this underground space topic early on in urban planning, transportation planning and in civil engineering.”

*Antonia Cornaro, Itacus' co-chair*

“Han and Antonia are so enthusiastic, I wanted to stay in touch with what they were doing,” says Verloop of her early interactions with Itacus, which came through an internship at Amberg.

Cornaro and Admiraal's message to the tunnelling industry is this: there's no point in just talking to each other about how wonderful our tunnels and underground space are. We need to get the message out to a wider audience, listen to what they say about their day-to-day problems and come up with joint solutions.

Itacus has formed strong links with Isocarp, the International Society of City and Regional Planners, and has spoken at many events outside the tunnelling industry over the years and has produced several headline-attracting publications. Co-chairs Admiraal and Cornaro have recently published a book, 'Underground Spaces Unveiled – Planning and Creating Cities of the Future', which came out in March 2018.

In writing the book, Cornaro and Admiraal wanted to appeal across multiple disciplines. “By telling stories and bringing in hands on, state-of-the-art examples we managed to get the attention of architects and designers,” says Cornaro.

The ultimate aim, says Cornaro, is to have academia pick up on the subject: “We want universities to teach this underground space topic early on in urban planning, transportation planning and in civil engineering.”

There has already been interest from academic institutions.

“Our goal is to reach a lot of people, particularly young people who are early in their professional careers,” she says. “We feel they can make a big difference in the way they approach projects.”

*Antonia Cornaro, Itacus' co-chair*

Members of YPTD gather in Glasgow, Scotland



ETH Zurich has expressed an interest in developing a course, as has the University of Colorado Boulder, for its one-year masters course on tunnelling. There has been great interest too from China, Japan and Korea, says Cornaro, where underground planning around cities is already well advanced.

“The goal is to reach a lot of people, particularly young people who are early in their professional careers,” she says. “We feel they can make a big difference in the way they approach their projects.”

### Think Deep – The ITACUS National Action Programme

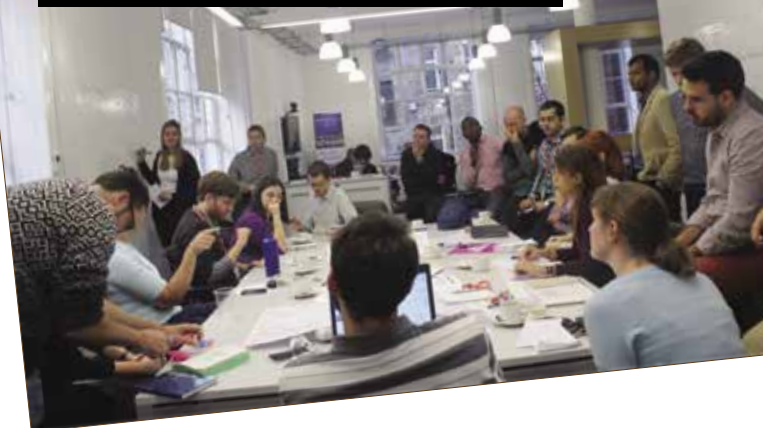
The first of Itacus' national action groups, Think Deep UK (TDUK), celebrated its one-year anniversary in the summer of 2018.

Over the course of its first year, TDUK pulled in diverse groups of professionals to tackle three subjects and produce technical reports: how underground space adds to social value, the future of transport and how to plan cities in 3D.

“We are made up of a variety of disciplines including urban planners, architects, geologists and lawyers. We all have the same vote and the same say in what we are doing,” explains Petr Salak, who set up TDUK. Salak, who is now Managing Director of Dr Sauer & Partners in Israel, is on the Itacus steering board and was one of those responsible for setting up the ITA Young Members' movement in 2014.



Young professionals meet in Glasgow to discuss the Clyde Waterfront regeneration plan

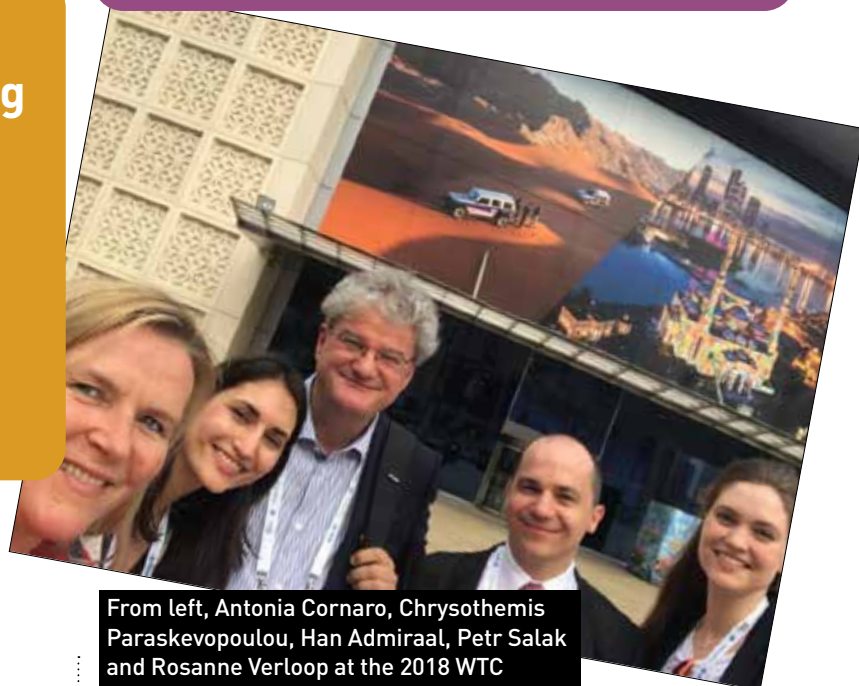


“It really turns on our young members in the ITA to make them think about projects in a more multi-disciplinary way.”

*Antonia Cornaro, Itacus' co-chair*

“We are made up of a variety of disciplines including urban planners, architects, geologists and lawyers. We all have the same vote and the same say in what we are doing.”

*Petr Salak, MD, Dr Sauer & Partners, Israel*



From left, Antonia Cornaro, Chrysothemis Paraskevopoulou, Han Admiraal, Petr Salak and Rosanne Verloop at the 2018 WTC

“It’s important that we invite not just people who are pro, but those who are against too,” Salak continues of the TDUK workshops. “That way, the results can sometimes be surprising and they are also more valuable and robust.”

Now there are other Think Deep groups formed or forming too, in Nigeria, Sweden, Australia and the Netherlands. Abidemi Agwor, who is president of the Tunnelling Association of Nigeria, heads up Itacus’ national action programme.

Itacus, in partnership with Isocarp, is also spreading its message around the world through its Young Professionals Think Deep Programme (YPTDP). This involves a diverse group of young professionals meeting in a city to brainstorm the re-development of an area within that city over a week.

To date, sessions have been held in Glasgow, UK and in Wroclaw, Poland. “It really turns on our young members in the ITA to make them think about projects in a more multi-disciplinary way,” says Cornaro.

The goal is to use the output from the YPTDP sessions to create a book of case studies. This would follow the format of one of Itacus’s early publications, entitled ‘Think Deep: planning, development and use of underground space in cities’, which showcased some thought-provoking case studies.


Itacus had hoped to conduct five such sessions in the past two years, but this has proved challenging, explains Cornaro.

Although all the young professionals and experienced tutors give their time free of charge, a total of over 1,000 hours, a sponsoring organisation – such as a city council – must pay for travel, accommodation and travel expenses, a bill that comes to between €25,000 and €30,000.

Several well-advanced events have fallen through at the last minute due to changes in circumstance at the sponsoring bodies. Currently locations in Nigeria, Bolivia, Hong Kong and the Netherlands are on the table.

### The right approach

Itacus’ efforts to create multi-disciplinary teams echoes the efforts of clients on some of the world’s megaprojects. These huge programmes to create new transport or utility infrastructure involve so many different aspects of a city and its population, that a project team needs to think with many minds.

Teaching and encouraging young professionals to think and interact like this must be the right approach and other committees and groups within the ITA could learn some lessons from Itacus about how to engage and enthuse young people in their endeavours. 

# The Young Members World Map

## Norway

Est. 2010  
NFF Yngres Nettverk

## United Kingdom

Est. 2008  
BTSYM

## Denmark

Est. 2014  
DFTU

## Netherlands

Est. 2017  
TTOW Young members

## Belgium

## Germany

Est. 2017  
STUVA-YEP

## France

Est. 2016  
AFTES Young Members

## Portugal

## Spain

Est. 2016

## Switzerland

Est. 2017  
STSym

## Canada

Est. 2014  
TACym

## United States

Est. 2014  
UCA of SME YM

## Mexico

Est. 2017  
GIJ-AMITOS

## Colombia

Est. 2018  
ACTOS-NGT

## Brasil

Est. 2015  
CBTYM

## Argentina





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# A WEEK IN MY LIFE

Fotis Gaitanis is a Civil Engineer working for AKTOR S.A., part of the ELLAKTOR Group, on Line 1 (the base project) of the Thessaloniki Metro, located in the second largest city in Greece.

Fotis has four years' experience in construction and infrastructure projects. Since 2018, he has been working on a challenging project of reburial and in-situ conservation of a large-scale archaeological site, which was found during the construction of Venizelou Station on the Thessaloniki Metro.



## MONDAY

It's 6:10am and the phone is ringing. Answering the call, I hear the voice of the site foreman: "I'm sorry, it seems there's been a mix up in schedule of the excavation disposal trucks. We won't be able to get rid of the excavated material before 9:00am," he says in a worried tone.

"I'll talk with the drivers directly and we will figure something out," I reply. A solution is needed as soon as possible, due to the fact that I have a meeting with the site's chief archaeologist at 7:00am.

I leave home by 6:30am and

head to Venizelou Station, dressed in my site gear, while I set up a new schedule for the excavation waste disposal.

At 7:05am the meeting with the lead archaeologist starts and we review plans of the archaeological site taking into consideration the decisions of the Central Archaeological Committee. After a three-hour meeting, we finally agree on what is to be conserved in situ, what will be removed, and what will be relocated from the archaeological site. I then quickly provide an update to my department chief and head straight to the reburial project.

It's 3:30pm and I have been at the reburial site for five hours, providing workers with guidelines and correcting actions according to the approved methodology and design plans.

At 5:00pm I head to a nearby café with two colleagues, where

we share stories about our day, previous work experiences and personal lives.

## TUESDAY

At 6:30am, I'm following my daily routine, making my way to the Venizelou Station site

Welcome to  
Thessaloniki...



by bus, when I'm notified that we need to secure access for the archaeological staff at the future western ventilation shaft of the station.

Arriving at the Venizelou site, I meet the archaeology department's senior engineer and head to the ventilation shaft, where the archaeological excavation will take place. It's a small area of 108m<sup>2</sup> with half of it being underground. In careful consultation with the archaeological plans of the previous dig sites, we make a calculative guess about the appropriate space necessary for both the scaffolding and storage area of excavated material. These two factors are crucial for the smooth and fast completion of the archaeological excavation.

We check our assumptions again and collaborate with the lead archaeologist, to start constructing the necessary safe access point to the dig site. Safety is of utmost importance and I have to double-check every joint, every support, every nail, and every material to assure that the archaeology staff can use it safely.

By noon we are almost ready for the new archaeological dig site, so I have enough time to check on the progress of the reburial just a few meters away.

The project has moved faster than I expected so I contact the laboratory to schedule a field test for the next day.

The day ends with a working dinner about the succession of tasks for the timely construction of the station slab according to the given timetable.

## WEDNESDAY

6:20am: It's going to be a busy day today! By 7:00am I am on site at the archaeological dig. It's the first crash test for the reburial system. We use granular sand for the reburial material and the aim is to achieve modified proctor compaction greater than 95%.

At 11:00am everything is ready for the nuclear density gauge with the test readings being great. After a few hours of reviewing designs and technical drawings, it's time for a small celebration. We go out with the reburial team for a late afternoon drink.

## THURSDAY

It's 6:00am and the first day of work at the new archaeological dig site. The work site is already full of people, voices and

vehicles!

Our team is reinforced with 32 more workers, two site archaeologists, and two technical designers. There follows a lengthy briefing about health and safety on site.

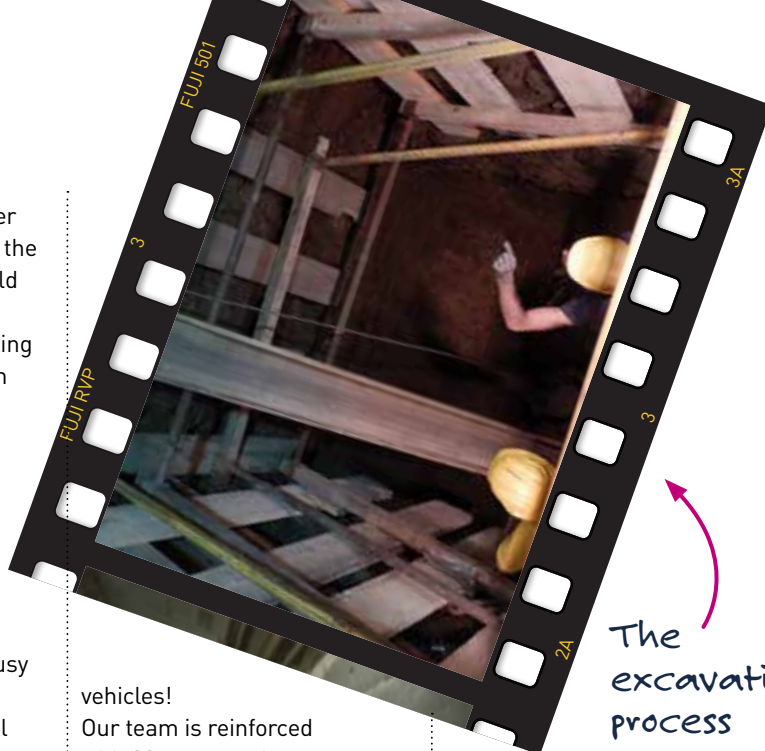
Accompanied by the health and safety team, I make sure that every new employee is supplied with the necessary means of personal protection. After that, the new personnel follow me on a short tour of the site and I answer questions about the construction of the station and the future of the archaeological site. This "team-building exercise" is very valuable for integrating new personnel into the project.

At 11:30am, the chief archaeologist of the Ephorate of Antiquities from Thessaloniki

City arrives at the site, in order to be briefed about the construction of the conventional concrete walls in the in-situ area and how we will be able to ensure that no damage will be caused to the archaeological finds. Luckily, it's not the first time we have faced a problem like this. After a lengthy explanation our proposal is accepted.

## FRIDAY

At 7:30am, I am on an inspection of the new archaeological dig site. Two ancient walls constructed of mixed natural stone and burned clay brick masonry



The excavation process



The new dig site

Protection of archeological finds during construction





are emerging centimetre by centimetre from the ground. One of them is right next to the access scaffolding. Despite my best efforts in planning, the chosen position proved to be far from ideal. Swift action must be taken, in order to change the position of the access scaffold as soon as possible and ensure that the archaeological dig can continue without further complications. I call for a brief meeting with the site foreman, the site archaeologists, and our two most skilled and experienced workers to think of a new plan. By 7:30pm we have finally successfully relocated the access scaffold.

## SATURDAY

It is 7:30am and the city is covered in thick fog. My day starts with the paperwork of possible contractors, replying to e-mails, and checking whether we received the parts and materials we have been invoiced for. I also calculate the weekly production results and record the progress in the project calendar.

This Saturday, work ends early, at 3:30pm, so I join a group of friends in a walking tour around the city, followed by board games at my house. Today, is a relaxing day after all.



*The process of reburial*

## SUNDAY

*My Day OFF!!*

# Thessaloniki's Metro of Antiquities

For many years, Thessaloniki faced the choice between preserving its antiquities or building a subway system. First

proposed during the 1910s, and first seriously planned in the 1980s, construction of the two-line, twin-tunnel, Thessaloniki metro system – comprising Line 1 (the base project) and Line 2 (the Kalamaria

Extension) – has been subject to severe delays due to major archaeological finds in the city centre, with more than 300,000 items collected by archaeologists since construction first began on the line in 2006 (the original schedule had Line 1 opening in 2012).

The project triggered the largest archaeological dig in northern Greek history, covering an area of 20km<sup>2</sup> (7.7-mile<sup>2</sup>). Artefacts have been discovered across the entire network, ranging in date from the Hellenistic Period all the way up until the city's great fire of 1917.

Between the New Railway Station and Sintrivani/Ekthesi, the metro runs below

Egnatia Street (one of Thessaloniki's main arteries). Egnatia follows the Roman Via Egnatia, which connected Rome and

Constantinople as one of the two most important roads in the Roman and Byzantine empires. The portion of the Via Egnatia that passed through Thessaloniki was the city's Decumanus Maximus (main road) and runs below present-day Egnatia Street at a

depth of about 5.4 metres (18ft).

Although the location of the Via Egnatia in Thessaloniki was known when the metro line was planned, it was uncertain what else was buried nearby. The metro was planned to run at 8 metres (26ft) below ground, leaving only 2.6 metres (8.5ft) between it and the ancient road. The discovery of a Byzantine road at

Venizelou station was a major archaeological find: 75 metres (246ft) of the marble-paved and column-lined road was unearthed, with shops, other buildings, and plumbing, which one scholar called "the Byzantine Pompeii". A tetrapylon – a Byzantine monument that once stood at

a major crossroads of the Decumanus Maximus – was also found at Venizelou site.

There has also been much controversy as to what should be done with these artefacts and, as a result, Attiko Metro – the entity that is overseeing construction of the project – re-designed several stations in a solution that became known as 'antiquities and metro'. Some finds discovered on the line will be put on display at permanent in-station exhibitions, while major discoveries at Venizelou Station will make up the world's first publicly-accessible open-air archaeological site contained in-situ within a metro station.

*A gravesite uncovered near the future subway station of Syntrivani.*



*A paleochristian mosaic floor depicting a phoenix found in a grave in the station of Syntrivani.*

*The tetrapylon at Venizelou station*



In five years' time, every passenger descending to the platforms will see a well-preserved 84-metre long segment of the ancient avenue; they will walk over the same stones on which, from the 6th to the 14th centuries, residents and merchants went about their business in the bustling commercial heart of the city. **b**

# Amongst the Alps

In November 2018, Young Members from Austria, Switzerland and Germany met up for a fascinating regional event at the Brenner Base Tunnel, in the European Alps.

On November 16, 2018, the ITA Austria Young Members and Swiss Tunnelling Society's Young Members organised a regional event for young Austrian, Swiss and German tunnelling professionals. The day began at Innsbruck's Main Station, in Austria, where 22 young professionals gathered to be picked by bus for their visit the Brenner Base Tunnel (BBT).

On the way to the BBT Infopoint in Festung Franzensfeste, Italy – which is at the southernmost construction section of the project – the participants crossed the Brenner pass by bus. In the future, it will be possible to make this journey through the new railway tunnels, which will pass through the base of the mountains.

Following an introduction to the project by BBT SE's Project Manager, the young engineers visited the construction site H61 Mules, the biggest contract section of the whole Brenner-Base Tunnel, where they were able to marvel at the huge caverns in which the concrete mixing plant is situated and took a look at the construction of a

shuttering carriage that is being used to form the concrete lining of the tunnel. After gaining some insight and taking some photos the group, the young tunnelling experts travelled on to the construction site H33 Tulfes – Pfons.

During a short lunch on the road to H33 the participants got to know each other and were able to exchange experiences. In Zenzenhof, Mathias Ruetz from Amberg Engineering, and Roland Weger, from Lombardi, presented the technical characteristics of the H51 Pfons-Brenner, which will soon be launched. They also explained how the results of the project's exploratory tunnel helped inform the geological and geotechnical parameters for the main tunnel contracts.

Subsequently, the group was equipped with safety gear and transported by minibuses through the tunnel-system of H33. There the young experts were able to take a look at the construction of the inner lining and got some explanations about the installation of the tunnel sealing system.

Some handmade wooden formwork (used to shape concrete) was also shown. In the evening the participants met up at the Stiftskeller restaurant, in Innsbruck, to discuss their impressions of the day, got to know each other and also celebrated one of the participants 30th birthday until the early hours of the morning.

Due to the preceding night, some preferred to sleep a little longer in their hotel beds. However, 14 participants got up early to take part in an optional discovery tour of the Sill-Schlucht (Sill River Canyon) and Innsbruck city, including the Bergisel ski jump. The event ended after a packed 1.5 days, full of interesting content and people. The members are all now looking forward to meet each other again.

The organisation committee (Jasmin Amberg of Switzerland's STSym and David Gunacker of ITA Austria – YM) would like to thank their sponsors (ITA- Austria, Austrian Society for geomechanics – ÖGG, Gruner AG, Lombardi SA and the Swiss Tunnelling society – STS) who made the event possible and affordable.

A special thank you also goes to the Project Manager of BBT, Romed Insam, for taking the time to explain the project to the interested group of young tunnellers and to facilitate the guided tours.

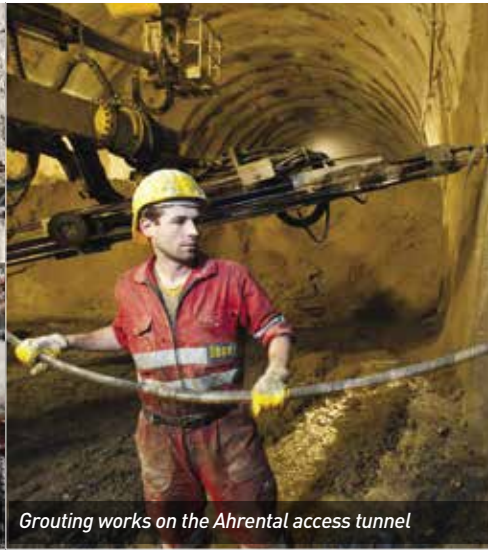




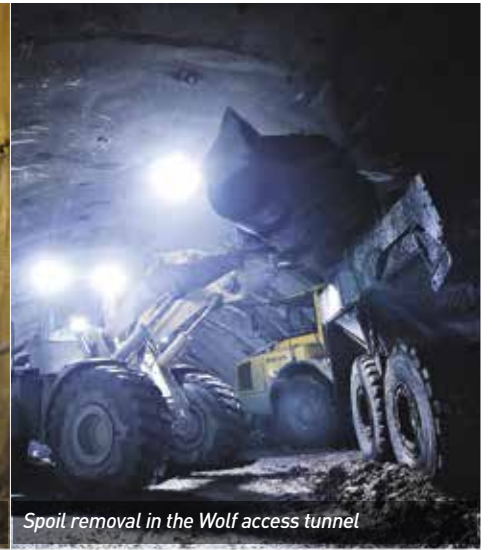
# THE BRENNER BASE TUNNEL



Charging and blasting in the Wolf access tunnel



Grouting works on the Ahrental access tunnel



Spoil removal in the Wolf access tunnel

The Brenner Base Tunnel (BBT) is a 55-kilometre (34-mile) long railway tunnel connecting Innsbruck, in Austria, and Fortezza, in Italy. The €8.38 billion project is being delivered by BBT SE, which is a European public limited company, and will ultimately reduce the travel time from Fortezza to Innsbruck from 1 hour and 15 minutes to 25 minutes.


In May 1994, a railway bypass was opened south of Innsbruck, known as the Inn Valley Tunnel. This 12.7km tunnel links to the Brenner Base Tunnel. Passenger and freight trains along this stretch will therefore not only travel through the Brenner Base Tunnel, but for a few kilometres, through the Inn valley tunnel as well. This line, totalling 64 kilometres, will become the longest underground railway connection in the world.

The BBT consists of two tubes, each 8.1 metres wide, running 40-70 metres apart from one another. The tubes are each equipped with a single track, meaning that train traffic through the tubes is one-way. The two tubes are linked every 333 metres with crosspassages. These can be used in

emergencies as escape routes.

A unique feature of the BBT is the exploratory tunnel running from one end to the other. This tunnel lies between the two main tunnels and about 12 metres below them and has a diameter of 6 metres, noticeably smaller than the main tubes. The excavations on the exploratory tunnel have provided important information about the rock mass reducing construction costs and times to a minimum. The exploratory tunnel will be essential for drainage when the BBT becomes operational.

The BBT is being excavated through rock using a combination of drill and blast excavation and the use of tunnel boring machines (TBMs), depending upon geological conditions. About 50% of the overall tunnelling is being done by blasting and about 50% by TBM.

The slope in the base tunnel is 6.7‰ on the northern side and 4‰ on the southern flank of the Brenner. The apex height is 790 above sea level, lying 580 metres below the Brenner Pass itself (1,371m). 

## KEY DATA

Length of the new Brenner railway line from Munich to Verona

**425km**

Total tunnel length from the Innsbruck bypass to Fortezza

**64km**

Length of the base tunnel from the Innsbruck portal to the Fortezza portal

**55km**

Internal diameter of main tunnels

**8.1m**

Internal diameter of exploratory tunnel

**min. 5m**

Design speed for goods trains

**160km/h**

Design speed for passenger trains

**max. 250km/h**

Elevation at the upper surface of the rails at the Innsbruck portal

**608.8m**

Elevation at the upper surface of the rails at the Fortezza portal

**747.2m**

# from Five

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

Kristina Smith reports...

## Loving that sinking feeling

**Robbert Martens**

■ Senior Project Engineer, Strukton Immersion Projects

■ BSc in civil engineering and MSc in water research management at Delft University of Technology

How do you work out that what you want to sink immersed tube tunnel segments for a living? In Robbert Martens' case, he got to try it as part of a three-year training programme and realised that it was a job he could love.

After six years with Strukton Immersion Projects, Martens' love of the job has been confirmed. "The most important thing about your job is that you like what you are doing," he says. "Then you will be motivated to get the best out of yourself."

Asked to pinpoint what he likes most about working at Strukton, Martens highlights the people he works with – "It's a great team to work in" – and the fact he has the chance to grow professionally and as a person. Last year he was promoted so that his role is to oversee and organise projects.

As a teenager, Martens was attracted to both civil engineering and architecture. After attending university open days, he decided that civil engineering was the subject for him. "When I saw the structures that civil engineers were building, I thought 'that's what I want to do'." His advice to people at the same point in their lives now is to find something they love. "Go with your heart," he says. "Find out what gives you the best smile."

Having studied for a Bachelor's Degree and a Master's Degree at Delft



University of Technology, Martens was employed at Jelmer, which provides multi-company training to civil engineering graduates. Here he benefited from three years spent working for government, an engineering firm and a contractor. And at the contractor's – Strukton – he stayed.

"For me, it worked very well," he says of the training programme. "When I finished my studies, I did not know what sort of firm I wanted to work for."

Martens' six years at Strukton have taken him to various countries. Though Strukton designs and installs immersed tube tunnels, recent years have seen it carrying out mostly installation – or immersion projects. Martens has worked on the immersion of the Söderströmtunnel in Stockholm, Chioggia Flood Barrier in Venice and Marieholmstunnel in Gothenborg.

Positioning an immersed tube tunnel segment involves placing a huge precast concrete structure on the base of a river or the sea in a very precise way. What was once done 'manually' with divers and surveyors is now far more automated with aspects such as adjusting water levels in the buoyancy tanks monitored

■ The most important thing about your job is that you like what you are doing, then you will be motivated to get the best out of yourself.■



Preparing for immersion operations

remotely from dry land. Divers are still involved, but in a checking capacity only.

Martens' role involves a combination of engineering work in the office, preparing for the immersion operations combined with practical input on site. During the preparation phases he will be looking at the techniques and equipment that will be used, planning what will happen when. During the immersion, he would be monitoring the screens that convey information about loading, levels in the ballast tanks and positioning.

In the future, Martens believes that contractors will become more and more involved in the design, rather than simply taking a design produced by others and delivering it. "In Holland we are already seeing a shift that has been going on for a couple of years, with more responsibility for the design works going to the contractor. Now, as a contractor, we talk to the client about their requirements and how they want it to be fulfilled."



## From rock psychologist to digital champion

**Magdalena Stelzer**

■ Junior Project Manager in the BIM Department, Amberg Engineering

■ BSc in civil engineering, environment and economics and MSc in civil engineering, geotechnics and hydraulic engineering from the Technical University of Graz

When Magdalena Stelzer was studying civil engineering and geotechnics at university, she could never even have dreamed of her job today.

"Civil engineering and even tunnelling, as a branch of engineering, is so much more diverse than I thought," she says. "I never thought that I would be doing what I am doing now, just because I did not know what the possibilities would be."

Stelzer, who is a junior project manager in the BIM department at Amberg Engineering, is at the forefront of the industry's transition to digital construction. At the age of 27 she is the Swiss representative on the ITA's Working Group 22, 'Information Modelling in Tunnelling', and part of buildingSMART Switzerland, an organisation working to create open international standards for collaboration and information exchange in the construction industry.

It was really only chance that brought Stelzer to geotechnical engineering. She had been looking towards a career in architecture but, while attending an open day at the Technical University of Graz in her home city, she went to a presentation about civil engineering. "I realised that I fitted much better there," she says. "I am perhaps more of an analytical and rational thinker than artistic."

During her studies, she was attracted to the challenge of geotechnical engineering. She remembers her soil mechanics professor, Roman Marte, describing geotechnical engineers as "the psychologists among civil engineers". This appealed to her, she says.

"It's interesting because things are

■ It's interesting because things are not so obvious. You need to analyse, understand and interpret the conditions well, to find an adequate solution. With geology that can be tricky. We are, in a way, psychologists. ■■

not so obvious," says Stelzer. "You need to analyse, understand and interpret the conditions well, to find an adequate solution. With geology that can be tricky. We are, in a way, psychologists."

As well as her geotechnics lectures, Stelzer remembers the many site visits organised by her university as a highlight of her studies. And she appreciates how the solution-focussed way she was taught to think helps her today in her work.

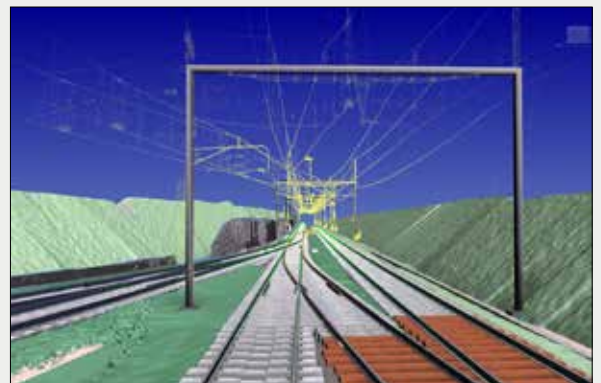
After a short stint working as a site manager for Schleith, a medium-sized civil engineering contractor in Germany, Stelzer moved to Switzerland and her job with Amberg. She started as a project engineer, working on analysis, design and co-ordination, mostly on international projects and this led her to look at the way BIM was being used on projects and internally within Amberg.

Amberg's BIM department deals with all aspects of digital engineering. "What I like best in my current roles is that I work much more with people than I ever thought I would do. Soft skills are really important," she says. "During my studies I sometimes thought that maybe I would not be happy if I was just working at my desk with my computer. It's not like that at

all. Projects are still done by people, with people, not machines.

It is an exciting time to be involved in digital construction and the move to Construction 4.0, says Stelzer, but a hugely challenging time too. "Tunnelling is a very traditional and slow-moving discipline and it will be difficult for many organisations and individuals to adapt to the speed the ongoing transformation brings along," she says. "Also, young people who are starting work today have a different mindset. The combination of those two things will be a big challenge."

But young people, too, should take time to learn the technical disciplines they need at the beginning of their careers. "It's important to get to know how things work and to find your place," says Stelzer. "Being one of 'those young ones' I remember that every day."



## Home-grown metro mastermind

**Prathap Muniyappa**

- Lead Designer (Tunnel & Geotechnical) at Geoconsult India
- Bachelor's degree in civil engineering at SJC Institute of Technology Chikkaballapur, affiliated to Visvesvaraya Technological University, in Karnataka; Master's in Geotechnical Engineering from the Department of Civil Engineering at Indian Institute of Technology Madras

As a child, Prathap Muniyappa dreamed of being a civil engineer. He imagined travelling around the world to help construct amazing structures like the ones he saw on TV programmes.

Things haven't quite happened as the young Muniyappa imagined. Instead the world has come to him. At the age of 31, he has worked for three large European design consultants in India: Systra, which is headquartered in Paris, Geodata of Italy and now Geoconsult, of Austria.

Since graduating with a master's degree in geotechnical engineering from the Indian Institute of Technology in Madras, Muniyappa has been building up expertise in metro tunnel engineering. Over that time, he has worked on major metro programmes in India and beyond - Delhi, Bengaluru, Chennai, Kolkata, Ahmedabad, Mumbai, Hanoi and Makkah - mostly as a designer but with a stint working for a contractor too.

Now Muniyappa is working as detailed design consultant for Mumbai Metro Line 3 Package 06 with contractor J. Kumar-CRTG JV. The project includes three underground stations - CSIA Domestic Airport, Sahar Road and CSIA International Airport - together with 4.2km of TBM tunnelling and scissor crossovers, constructed using NATM.

"The best thing about my current role is being involved in all the stages of a project including detailed designs, assisting the construction team, on-site coordination with clients and overall



being in charge of the design and supervision," says Muniyappa.

Having gained a bachelor's degree in civil engineering at SJC Institute of Technology Chikkaballapur affiliated to Visvesvaraya Technological University in Karnataka, Muniyappa also studied his two-year master's at the Indian Institute of Technology Madras one of India's most respected engineering universities. The most useful aspects of the master's course was finite element modelling and constitutive modelling in geomechanics, says Muniyappa. His studies concluded with a project on the numerical analysis of supported excavations using PLAXIS and FLAC software packages.

"This gave me a good understanding of the basic concepts of numerical modelling, which was enhanced by my experience working for the different design consultants," says Muniyappa. "It has been interesting to work for three different companies and understand their different approaches to design."

The global recession, post-2008, meant that Muniyappa's plans to work on civil projects overseas did not materialise. However, having studied

■ The best thing about my current role is being involved in all the stages of a project including detailed designs, assisting the construction team, on-site coordination with clients and overall being in charge of the design and supervision. ■

India's infrastructure plans, he realised that there would be a demand for engineers to work on tunnelling projects for both metros and highways. That insight on Muniyappa's part has led to him gaining huge experience in the sector and developing expertise on a succession of projects.

"You don't have to study a specific tunnelling course to become a tunnel designer," says Muniyappa. "When you have a passion to learn and you are keen to be a part of the project, you should focus on your work first, learn from consultants, and your approach will make you a good engineer."



## From gold mines to globe trotting

Aaron McClellan

- Tunnel Superintendent, Kiewit
- Bachelor's in geological / geophysical engineering, University of Nevada-Reno

How has Aaron McClellan managed to cram so much into less than a decade of work? The Tunnel Superintendent has been on projects in Portland in the US, Toronto in Canada, London's Crossrail in the UK, Rio de Janeiro in Brazil and has even had a spell putting tunnel boring machines (TBMs) together at a specialist factory in Germany. Currently, he's 700 feet (215 metres) below the Hudson River digging a bypass to a leaking water tunnel that supplies New York City.

The really interesting thing is that he's done all this while working for one company, contractor Kiewit, which is headquartered in Omaha, Nebraska, in the US.

You could say that curiosity has carried McClellan around the world; his brain just longs to learn how things work. "There's nothing like being able to understand those things from the bolts up," he says of TBMs.

McClellan studied geological and geophysical engineering at the University of Nevada-Reno, planning to follow two generations of McClellans into the gold mines of Nevada. However, a couple of internships with mining companies changed his mind. "Mining felt like it was about going in, grabbing what you needed, almost leaving nothing behind. I thought it would be more fulfilling to leave something useful behind. I'd like to show my kids what I've done in the future."

McClellan's first two projects were in soft ground and gave him a good insight into the mechanical challenges that TBM tunnelling can present – quite literally, as the machines had to be taken apart. Colleague and mentor Christof Metzger suggested that McClellan could gain more in-depth knowledge from a period at Herrenknecht's factory in Germany. McClellan spent three months there assembling machines and has subsequently sent another nine Kiewit people there to do similar programmes.



But that wasn't enough for McClellan. He wanted to work for Herrenknecht out on site and eventually spent four months as an apprentice mechanic on London's C305 Crossrail contract. "I was with a great group of mechanics who taught me what these machines can do in the real world," he says.

Metzger's tunnelling connections around the world led to the next, rather unexpected, trip to Rio de Janeiro where McClellan worked on a soft ground project for a year-and-a-half helping overcome issues with the TBM there.

■ Mining felt like it was about going in, grabbing what you needed, almost leaving nothing behind. I thought it would be more fulfilling to leave something useful behind. I'd like to show my kids what I've done in the future. ■■

Back from Brazil, Kiewit brought all that field experience to bear, putting McClellan to work on all its soft ground bids in North America. "That time immensely expanded my knowledge, not only of TBM operations, but of the tunnelling industry as a whole," he says.

And now he is Tunnel Superintendent on a hard rock TBM job, the bypass for the Delaware Aqueduct. Though McClellan imagined that working in hard rock – where the face is open so that you can see the geology – would be much easier than soft ground where the face is closed, it hasn't proved to be the case. There have been huge challenges here, not least faults producing water at 20 to 25 bar pressure.

"The challenges here are very similar to what I was used to in the soft ground world: trying to figure out something you cannot see, relying on pumps and pressure sensors and analysis of what's working and what's not. It's probably the reason why I still do this. Geology is ever-changing and complicated, and we get to do crazy stuff with it and that's neat."



Hard rock TBM assembly on the Delaware Aqueduct bypass in the US

## Seizing opportunities in China – and beyond

Jiamei (Cathy) Peng

■ Designer on the Nanjing Heyan Yangtze River-Cross Channel with China Railway Siyuan Survey and Design Co, a wholly owned subsidiary of CRCC

■ BEng in Civil Engineering from Southwest Jiaotong University; Masters in Underground Engineering at Tongji University

Though Jiamei Peng has always lived and worked in China, she already has international experience. Even before she left university, Peng had worked with overseas companies, helping them to gain insight into the Chinese market.

While studying for her master's degree in Underground Engineering at Tongji University, where she also worked as a teaching assistant, Peng carried out research and analysis for companies including tunnel boring machine company Herrenknecht and fibre manufacturer Electro Plastic Concrete (EPC). She also travelled to Brazil in 2014 to the World Tunnelling Congress with a paper she had written on ground penetrating radar.

Professor Bai Yun, who leads the master's course, allocated projects according to his student's personalities and strengths, says Peng: "I am outgoing



and better at English than some of the other students, so he decided that I should co-operate with foreign companies."

Peng's current role is as a designer on the €897million Nanjing Heyan Yangtze River-Cross Channel, working for China Railway Siyuan Survey and Design Co, a wholly owned subsidiary of CRCC, which is a state-owned construction company. She has worked on this project since its inception and is proud of the fact that she knows it inside out.

"I was involved in all the early stages of the project: feasibility studies, preliminary design, tender design and construction design. I think I know it very well," says

■ I would like to learn the different approaches to design management in different countries. Opportunity only favours the prepared mind. ■■


Peng, who is 29 years old. "I could answer detailed questions asked by the client, contractor or consulting engineer."

The Nanjing Heyan Yangtze River-Cross Channel project will create two 14.5m diameter tunnels beneath the river bed. Though there are several tunnels under the Yangtze, this crossing will have to cope with the largest water pressures in Yangtze River – up to 7.9 bar (0.79MPa) – due to sand layers amongst the strata.

Peng started work for China Railway Siyuan Survey and Design Co in 2015, and spent a year working on Lines 5 and 7 of the Nanjing Metro, before moving to the Yangtze River-Cross Channel in 2016. She was attracted to civil engineering because her father and cousin are bridge engineers and studied for her first degree at the prestigious Southwest Jiaotong University, which was the first university in China to offer civil engineering degrees.

Peng says that she chose underground engineering because she likes the fact that so much is unknown, with technology developing all the time. Female tunnelling engineers are still rare in China, explains Peng, and there are still some areas in China where it is considered bad luck for women to be in tunnels under construction.

Peng says she learnt a lot from the many case studies that Professor Bai Yun provided during the course. Learning about Finite Element Analysis at university has been invaluable for her work. If she had to add another topic to her studies, she would suggest that the courses provide more information on international project practices.

"I would like to learn the different approaches to design management in different countries," she says. "Opportunity only favours the prepared mind." 



The launch shaft of the Nanjing Heyan Yangtze River-Cross Channel






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# Stockholm's New Metro

Jekaterina Jonsson is a specialist in rock engineering and Lead Tunnel Design Engineer at the New Metro project in Stockholm. In her current role, Jekaterina represents the client during the design phase of the Södermalm sub-project, with the responsibility of leading the works so that rock design is carried out according to the technical guidelines and requirements of the project.

Stockholm is the capital city of Sweden and the most populated urban area in all of the Nordic countries. The city stretches across an archipelago of 14 islands where Lake Mälaren flows into the Baltic Sea. The cobblestone streets and ochre-coloured buildings of Gamla Stan (the old town) are home to the 13th-Century Storkyrkan Cathedral, the Kungliga Slottet Royal Palace and the Nobel Museum, which focuses on the Nobel Prize.

Stockholm expanded from a small medieval town with just 6,000 inhabitants in the late 15th Century to a metropolitan region with population of around one million by the 1950's and 2.3 million by 2018 – with more than a million now living in the city centre. The population is expanding at a rate of around 40,000 people each year, and the metropolitan population is expected to be 2.7 million by 2030, making Stockholm one of the fastest growing conurbations in Europe.

Stockholm's Metro system currently comprises three existing lines: The Green Line, the Red Line and the Blue Line. The Green line, which is partly submerged under the city centre, crosses Stockholm south-east to west and was constructed in the 1940's. The Red Line, which was constructed in the 1950's and 1960's, runs from the north-east, below the city centre, and over ground to the southern suburbs of Stockholm. The Blue Line is fully situated underground and connects the north to the city centre and was constructed in 1970's.

## The New Metro Project

The rapid growth of Stockholm calls for a significant amount of residential construction and also the expansion of existing infrastructure. Stockholm's Metro currently carries nearly double its designed capacity and runs at almost maximum capacity during rush hour.

<b>Client:</b> Region Stockholm, Extended Metro Administration	<b>Estimated production time:</b> 6-8 years
<b>Project scope:</b> Expansion of the Stockholm metro	<b>Estimated production cost:</b> 16.7 billion SEK (€1.58bn)
<b>Tunnelling method:</b> Drill and blast with continuous pre-grouting	



Jekaterina out on site

Therefore, in the autumn of 2013, a government group was set up to negotiate an agreement on the expansion of the Metro and construction of more housing. In January 2014, the Swedish government, Stockholm County Council (now Region Stockholm), the City of Stockholm, the municipalities of Nacka and Järfälla and the City of Solna all signed the agreement.

Extended Metro Administration is the entity that has been tasked with the planning, project and implementation stages of the metro expansion. The aim is to create an accessible and cohesive region, by reducing travel times in Stockholm as the city grows, while creating efficient journeys with low impact on the environment and health. This will facilitate the construction of 82,000 new homes with good infrastructure in Järfälla, Nacka, Solna and Stockholm.

The New Metro project includes nearly 20 kilometres of new track and 11 new stations on four sections, which have been divided into six sub-projects: the northbound extension of the Blue Line

(project Barkarby); the southbound extension of the Blue Line (Project Södermalm, Söderort, Nacka); a new Yellow Line (project Arenastaden); and an expansion of a depot (project Högdalen). In addition to this, a new Grey Line, which runs from Fridhemsplan to Älvsjö, has recently been given the go-ahead and will be incorporated into the New Metro project development this autumn.

New metro tunnels will mostly be constructed as single track (with a cross section 26m<sup>2</sup>) and when applied as double-track tunnels (with a cross section 58m<sup>2</sup>), with additional caverns for rail switches, ventilation shafts and niches for technical installations. Commonly, along the track tunnels runs a smaller service tunnel.

## Södermalm Sub-project

Sub-project Södermalm is a southbound extension of the existing Blue Line. Södermalm includes the construction of three access tunnels, 4.5 kilometres of track tunnels and a service tunnel, two stations and an elevator shaft.



Jekaterina works closely with the Project Manager and Coordinating Design Manager to develop cost-effective technical solutions in compliance with the project's technical requirements. This calls for continuous dialog with the assigned design team of the Sweco/Typsa construction consortium.

Currently, the tender documents for the access tunnels have been finalised and the management team – including Jekaterina and the team from Sweco/Typsa – are focused on the development of detailed rock designs for the track tunnels and stations within the main contracts.

The southbound extension begins at the majestic station of Kungsträdgården, at the end of the existing Blue Line, and passes under the central core of Stockholm with its many historical buildings. Partition walls need to be installed and rock excavations are restricted to eliminate as much impact as possible on the fully operational station and the surrounding buildings. Communication and consideration of affected parties are an important requirement for the team.

The team is faced with many challenges as the tunnels pass under open water with limited rock cover and zones of weakness. Prior to the design development, investigation of rock cover and rock quality are made by probing and core drilling,



*Stockholm Metro with its planned extensions*

as well as water loss measurements to determine the hydraulic properties of any fractures. The main risks of underwater tunnelling are tunnel instability and uncontrolled flooding. Therefore, careful grouting of the rock is performed prior to any tunnelling.

Tunnelling is designed to be carried out in sequence with temporary ground reinforcement applied to control the stability of the structures during the

construction phase. Permanent heavy reinforcement – for instance shotcrete (sprayed concrete), steel ribs or cast in-place concrete – are installed to eliminate the long-term risk of erosion of grouting materials in fractures and the wear of installations by corrosion. For the tunnels under open water custom tunnel sections are developed, which requires regular coordination with other technical specialities through inter-disciplinary



*Existing station Kungsträdgården*

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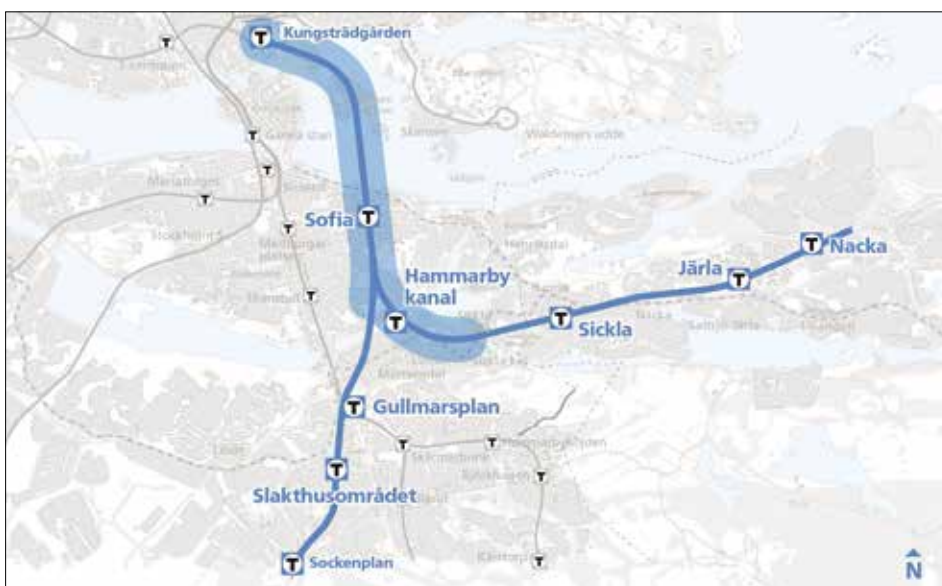
audits, to detect possible conflicts at an early stage.

Further south on the metro extension, yet another tricky task arises as the tunnel passes underneath the rocky island of Södermalm and reaches Sofia station. Sofia is to be Stockholm's – as well as one of the world's – deepest metro stations, at about 100 meters below ground, and will be reached by eight express elevators though a vertical shaft of 400 square meters in cross section.

The client and designers frequently assemble at workshops to share results from investigations, rock mechanics analysis and production planning, to verify the buildability of proposed technical solutions. Jekaterina's main task here is to guard the clients' interests in terms of cost-effective solutions that place a great amount of consideration on the safety of the work environment during the construction phase.

The final part of the Södermalm sub-project is the Hammarby kanal station, which has its station platforms situated under the waterway with entrances on both sides of the canal. Underwater excavation for the station is considered to be a critical passage mainly due to potentially poor rock quality in combination with large tunnel spans.

The initial rock mechanics analysis was carried out in the early stages of the project and the design team are setting up the scope to develop a detailed design in regard to mitigating the remaining uncertainties and risks.




*The alignment of the Södermalm sub-project*



*Södermalm in profile*

Jekaterina is excited and proud to be a member of the Södermalm team and the New Metro project. To enable Stockholm to keep on growing at its present rate, or even

faster, Jekaterina, along with the team and Sweco/Typsa's designers, are working daily to ensure that procurement and construction work can begin on schedule. 



*Stockholm - above ground*

# Teotihuacán's secret tunnels


Romero Tonix Wendy and Ramirez de Arellano de la Peña Carlos of the Mexican Association for Tunnel Engineering and Underground Works' (AMITOS) Young Members group describe the recent archaeological find of a tunnel under Mexico's ancient pyramid city of Teotihuacán.

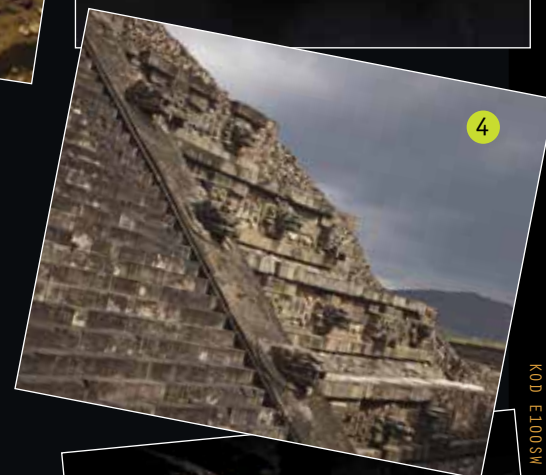


Located 30 miles northeast of Mexico City, the archaeological site of Teotihuacán was once one of the great Mesoamerican cities, dating back to 400 BC. This civilization was an influential society, its inhabitants were known for a high degree of sophistication in their cultural development, giving the Teotihuacán site a sacred significance. One morning in 2003, Sergio Gómez Chávez, an archaeologist with Mexico's National Institute of Anthropology and History (INAH), discovered a tunnel in front of the Temple of the Plumed Serpent when heavy rains caused a sinkhole to appear. The finding represented the start of an investigation that is now known as the Tlalocan Project (road under the earth). During excavations, a 103m long tunnel was found, varying in depth from 14m to 17m. During the exploration of the tunnel around 1000 tons of material was removed, recovering about 75,000 ancient objects, such as ceramic vases, jade carvings, pyrite, mirror-shaped hematite, and thousands of shells and snails imported from distant places, which formed offerings.

The tunnel is impregnated with pyrite, highlighting the brightness of this metallic mineral; at the end of the tunnel, three caverns were also found oriented towards the directions of the cosmos of the universe, celestial region, earth plane and underworld. In the caverns, the rock was carved to represent a mountainous landscape; in small valleys, traces of mercury were found and is thought to have been used to represent the sacred water of the underworld.

In June 2017, experts from the INAH, with the support of researchers from the National University of Mexico (UNAM), found another cavern of 15m in diameter at 8m depth under the Moon Pyramid and a tunnel that leads south of the Moon Square. This finding was possible through the Integral Conservation Project of the Moon Pyramid, led by the archaeologist Veronica Ortega; it was the result of an electrical resistance survey, which quantifies the force with which a given material opposes to an electric current flow.

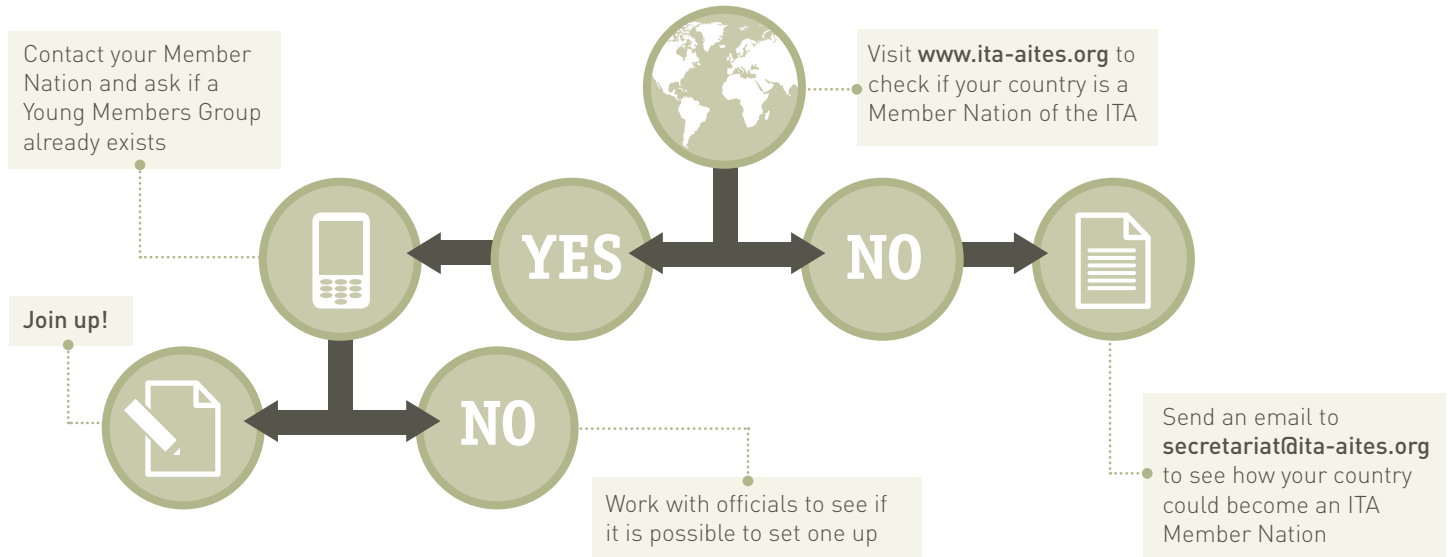
The experts continue with exploration under the Moon Pyramid and announced that this tunnel could confirm Teotihuacans reproduced the same pattern as in the tunnel of the Plumed Serpent, a kind of emulation of the underworld, as for them the underworld was the place where the origin of life is recreated, as well as plants and food, so it can be thought that its use was strictly ritual. 



1. An ancient vase is pieced together from fragments found in the tunnel. 2. The carved jade statues. 3. A flying dog saucer that was found intact in the tunnel. 4. The temple of the Plumed Serpent is adorned with carved snake heads and serpentine bodies. 5. A scan of the tunnel under the Plumed Serpent pyramid.



# How to set-up a Young Members group



## SETTING UP A YM GROUP

1.



Contact your national tunnelling association about the idea of establishing a Young Members group.

2.



Use your own network! Invite your friends and colleagues to help establish the group, spread the word, and get publicity.

3.



Arrange a gathering for those that are interested in contributing. Discuss what people would like to get out of the Young Members group, how to organise yourselves, etc. There are no requirements for form or content – it is up to yourselves and your Member Nation officials to decide what you want.

6.



The ITAYM Group can assist with by-laws or give examples from other countries. Cooperate with the ITAYM Group to get contacts internationally.

Contact Breakthrough magazine to spread the word about your new group and to promote your activities!

5.



Work with your Member Nation on how to organise the board and the aims and objectives of your group, prepare a simple set of by-laws and start working to organise events and bring young members together.

4.



Set up a kick-off event where you invite as many people as possible. Invite an interesting speaker or give a presentation on a high profile project to attract people. Encourage participants to get involved. Organise a social function afterwards to encourage networking within the group.

**YOU NOW HAVE YOURSELF A YOUNG MEMBERS GROUP – ENJOY!**

# ITA TUNNELLING AWARDS 2019

November 18-20, 2019 | Miami, Florida, USA



Since 2015, the ITA Tunnelling Awards has sought to reward ground-breaking innovations and outstanding projects in the tunnelling and underground space industry. The 2019 Awards will take place on 18 November, in Miami, Florida, USA, alongside the 2019 Cutting Edge tunnel conference, which runs from the 19 to 20 November.

The ITA is now calling on candidates for the eight categories from all over the world. Last year in China, projects from Asia, Middle east, Europe have been rewarded. This year, the ITA would like to encourage everyone to put forward an entry for small

or large projects, in new construction or renovation, as well as initiatives in terms of new technologies or innovative underground space use.

Nominations for the following categories must contain projects for which the major civil engineering work was completed between 1st January 2017 and 1st April 2019. The Young Tunneller of the Year rewards an individual born after 1st January 1984 and who has brought an outstanding contribution to tunnelling.

**Looking forward to seeing you all in Miami!**

*Nominations for the nine award categories, including Young Tunneller of the Year, will be announced by mid-July 2019, through the ITA's dedicated Awards website:*

<https://awards.ita-aites.org>

*Or follow the ITA Tunnelling Awards on twitter @itaAward*



To find out more about the 2019 Cutting Edge conference, visit:  
[www.ucaofsmecuttingedge.com](http://www.ucaofsmecuttingedge.com)

Major Project of the Year - more than €500 million
Project of the Year - between €50 million and €500 million
Project of the Year (Inc. Renovation) - up to €50 million
Technical Project Innovation of the Year
Technical Product/Equipment Innovation of the Year
Innovative Underground Space Concept of the Year
Safety Initiative of the Year
Sustainability Initiative of the Year
Young Tunneller of the Year



# 2018's Young Tunneller of the Year

## THE WINNER



### Giuseppe Gaspari, Italy

Giuseppe is a Chartered Civil Engineer with a MSc in Geotechnical Engineering, Masters in Tunnelling and TBMs and a Kellogg-Schulich 2019 executive MBA candidate. He is currently a Senior Advisor for Arup, based in Toronto, Canada. He began his career in the Geodata Engineering centre of excellence in Turin, Italy, and has since managed the design of numerous underground projects in Europe, Singapore, India, Canada and the US. Giuseppe has been a member of the ITAym Steering Committee since 2016, was the Founding President of the Young Member groups of both the SIG (Italian Tunnelling Society) and AGI (Italian Geotechnical Association) and currently sits on the WTC2019 Committee.

## THE FINALISTS

### He Yingdao, China

He Yingdao is a Senior Engineer with nine years' experience and a Masters in Engineering. He has a focus on the design of large-scale underwater tunnels, in particular, the road-metro shield tunnel arrangement. He has participated in the compilation of a book, published five papers, been granted eight patents for inventions and 11 patents for utility models and awarded three prizes for provincial/ministerial level outstanding design.

### Jack Muir, New Zealand

Jack has global industry experience working in Australia and New Zealand, Asia, Africa and the Middle East. He is currently Aurecon's Tunnel Leader for Victoria and South Australia and has a track record of developing solutions to complex problems. He is a digital leader driving the Aurecon Underground Engineering business to innovate and has a unique vision of the role of tunnels in a rapidly changing world.

### Senthil Nath, India

Senthil is a civil engineer with more than 10-years of experience working on geotechnical projects such as tunnelling, deep foundations and site supervision. He has worked on a wide range of tunnelling projects (soft ground, hard rock, deep caverns) with project experience in multiple countries (Singapore, India, Indonesia, Malaysia, UAE, Germany and Bangladesh). He is the recipient of the Hulme Prize and ITACET Foundation Scholarship. In 2016, he won the title 'Young Tunneller of the Year' at the NCE tunnelling Awards, in London, UK. He has served as an ITAym steering board member and is the current Chair of Young Geotechnical Society in Singapore (SYGeoSS).

### Fredrikke Syversen, Norway

Fredrikke is currently Project Manager on the New Water Supply Tunnel in Oslo, Norway. She obtained her Bachelors degree in Geology and Earth Science at Lund University and her Masters degree in Geotechnical and Geoenvironmental Engineering at Oslo University (UiO). Thanks to her mentors and team members, she




The 2018 finalists at the ITA Awards

has been able to maintain a continuous and steep learning curve since the start of her career. This has been a huge motivation to her.

### Mandy Ang Yian Yong, Malaysia

Mandy has been fortunate in her career to be a part of various cutting-edge tunnelling innovations. The earliest being the world's first Variable Density TBM, designed to overcome the complex, karstic, subsidence-prone geology of Kuala Lumpur. Following this, Mandy joined Dragages-Bouygues in Hong Kong, where she supervised the largest TBM ever built. She was assigned with multiple roles, as a hyperbaric and disc cutter engineer and operated the TBM. Now Mandy is back in Malaysia working on the KVMTR2 project.

### Morteza Javadi, Iran

Morteza has more than 10 years of professional experience in tunnelling and underground excavation across four major projects including the Amirkabir Tunnel, SUM, Shooshtari Highway and Tehran-Shomal Freeway. He has been involved in the design of more than 40 tunnels. During this time his designs have successfully overcome numerous geotechnical challenges based on the attitude of "linking theory to practice". Morteza has also contributed to more than 60 book chapters, journals and conference papers and over 150 technical reports. 

# Colombian Mountain Challenge



Colombia is a special country in Latin America, it has a complex geomorphology that includes the three subdivisions of the Andean Mountain Range (central, eastern and western), composed by a young geology, with high rainfall and seismicity.


In 1997, the Colombian government made the decision to construct the Bogotá-Villavicencio highway, which includes numerous road tunnels that cross the eastern mountain range. It is the only connection between central Colombia – where the capital city, Bogotá, is located – and the eastern region, which represents 40% of the country's territory, and consequently has the highest traffic growth in the country.

Currently, it takes 3.5 hours to make the 90km (56-mile) journey between Bogotá and Villavicencio using the highway, which passes through some very challenging terrain. The area is extremely prone to landslides, therefore almost 28km (17.4-miles) of the road corridor has been constructed as tunnel, representing an estimated investment of over 450 million dollars.

In recent years, a major upgrade of the highway has underway and the construction of a number of new tunnels have been carried out as part of this project, which is due for completion in 2023. Colombian civil engineer Henry Gómez, who works for Metroandina – the firm responsible for the design and construction of the modernization project – has served in a key role on a number of these tunnels. Henry is a member of the Colombian Young Members group ACTOS-NGT (New Generation of Tunnellers) and graduated from the University of La Salle, in Bogotá, with a specialisation in geotechnics from Pontificia Universidad Javeriana.

He became interested in tunnels during his final semesters, when he studied an elective subject called “tunnels and underground works” and participated in a research project on the subsidence generated by tunnels in Bogotá's soils. Since then, he has dedicated his work to tunnels, structures that have given him the greatest personal satisfaction, but also where he has spent some critical moments of his life.

In 2013, he suffered an accident in the Gualanday Tunnel (a 914m long tunnel in Tolima). Henry was doing a routine inspection at the face of the tunnel when a rockfall occurred and he was seriously injured. The incident initially made him rethink his work as a tunnel engineer and it was some time before he was able to return and enter the tunnel. It was a time when Henry reflected on the challenges he faced in life and at work and eventually this allowed him to re-enter the tunnel with more confidence and a new respect for the work that he does.

Henry explains that his two years as a tunnel engineer on the Bogotá-Villavicencio Highway project have been full of challenges, such as crossing the El Mirador fault in the Buenavista Tunnel, which consists of saturated friable sandstone, terrain difficult to advance through that has to be compacted with grout injections. Plus, the continuous geotechnical monitoring that must be performed on sedimentary rocks with high deformation rates and ensuring the adequacy of tunnel support in real time. In his free time, Henry is studying for an online Masters degree in Tunnels and Underground Works with the Spanish Association of Tunnels and Underground Works (AETOS) and the National University of Distance Education (UNED). 



*The Bogotá-Villavicencio Highway project*



# DRIVEN TO THE CORE



## SUPPORTING YOUNG TUNNELERS

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## Supply tunnelling for the delivery of water.

**Washington / USA.** The construction of the sewer tunnel *Northeast Boundary* aims to improve the water quality of the Anacostia River as well as a general increasement of the capacity of District's sewer system. Completion of the new 8,23 km long tunnel will reduce the overflow to Anacostia River by 98 %.

**H+E takes on a key role.** The continuous transport of the muck takes place via a tunnel belt conveyor with a total length of 8,11 km and a cross conveyor to reach the muck pit on shaft side. Northeast Boundary tunnel section of the overall project is the curviest TBM driven part in the tunnel. To master this challenge, we installed booster stations as required. On top, a vertical belt storage is placed next to the shaft. Clever Conveying – for an efficient infrastructure for industrial nations as well as emerging and developing countries.

### Technical data:

- Tunnel Diameter: 7.01 m
- Min. Radius: R274 m
- Mineral: EPB
- Conveyor Length: 8,109 m
- Belt Width: 800 mm
- Capacity: 700 t/h
- Installed Power: 1 x 160 kW (Main drive)  
4 x 160 kW (Booster top)  
3 x 90 kW (Booster bottom)
- Belt Storage Capacity: 400 m / vertical
- Installation: 2019



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