

breakthrough

YM

**Upgrading London's
Bond Street Station**

The Next
Generation
of the ITA

Roundtable:
Searching
for Superstars

**Underground Induction
in Indianapolis**

Client:

› Southern Nevada Water Authority (SNWA)

Contractors:

Vegas Tunnel Constructors
› Salini Impregilo S.p.A.
› S.A. Healy Co.

15 Bar

Tunnelling under **highest water pressure** to secure the water supply for the dry-running city of Las Vegas. Herrenknecht and Vegas Tunnel Constructors jointly mastered even unpredictable conditions with a powerful TBM.

Worldwide

Unique project at Lake Mead: 140 m depth, 4,4 km tunnel length, 3 years' determined work.

Record

Outstanding success for a Herrenknecht Multi-mode TBM: for the first time a tunnel boring machine **tackled and withstood** 15 bar water pressure.

Pioneering Underground Technologies

› www.herrenknecht.com/lakemead





Welcome to 'Breakthrough'

What you have in your hands is the result of a new era for the International Tunnelling and Underground Space Association (ITA). The development of this new magazine has been driven by enthusiastic young members of the ITA, who have put a lot of work and effort into creating an innovative and interesting publication, which both young and more experienced engineers will benefit from reading.

With the increased growth of our industry, it is important that we also increase our human resources and know how, in order to respond to society's increased demand for the use of underground space in the future. The ITA Young Members group will be a platform for young professionals to meet, to exchange knowledge, and to have open and free discussion between individuals with similar experience and needs. I would also like to see ITA Young Members actively participating in the ITA's activities and joining our Working Groups and Committees.

The ITA is the world's best platform for knowledge sharing and networking within the field of tunnelling and underground space use. Within the ITA we have some of the industry's leading international players, and young professionals will greatly benefit and learn from these individuals by becoming involved in our organisation. In turn, young members will contribute new thoughts and ideas to our activities, helping to develop and secure the future of the ITA.

I congratulate the Young Members group for creating this magazine, and I hope you as a reader will find it interesting and enjoyable.

Søren Degn Eskesen, ITA President



Strengthening the International Network

Welcome to the first edition of "Breakthrough". It is with great pleasure that we are able to launch this magazine less than a year after the formation of the ITA Young Members (ITAYM) at the 2014 World Tunnel Congress, in Iguassu Falls, Brazil. It is hoped that through this magazine ITA Member Nations will see the importance of, and the opportunities that lie within, the ITAYM.

As with all new groups, the ITAYM has had a busy first year: forming its Steering Board, establishing the main objectives and key activities of the Group, and writing by-laws to create a committee that is both integrated with the ITA and meets the needs of young professionals.

Our 2015 objectives set out to create an international networking platform for young tunnelling professionals so that they can have a voice within the ITA. These objectives centre on the importance of encouraging young professionals to join the ITAYM, supporting Member Nations in establishing their own national Young Member groups, and strengthening international ties between existing young members. We have also invested time preparing for the first official ITAYM General Meeting, which will be held at the 2015 World Tunnel Congress, in Dubrovnik, this May.

The ITAYM Committee for 2014-2016 consists of representatives from the following Member Nations: Australia, Canada, Denmark, Norway, and the United Kingdom. As Chair of the ITAYM, I would like to acknowledge the time and effort that the committee members have invested in helping the ITAYM to gain momentum and achieve its founding objectives. I would also like to thank and encourage all Member Nation chairs and young member representatives for their commitment to their national young member committees. Hopefully this trend will continue to develop and more Member Nations will jump on board.

I hope that our readers will be inspired by this magazine and encouraged to strengthen networking amongst young professionals across the globe.

Jurij Karlovšek, Chair ITAYM

Front Cover

When finished, more than half a million passengers per day will walk through the tunnels that Daniel Bimson and Sebastian Kumpfmüller are helping to build for London Underground's Bond Street Station Upgrade (see page 12).



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, listed below, or the ITAYM Young Members Committee (opposite).

Note to YM Member Nations

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



Editor

Amanda Foley

amanda@tunnellingjournal.com

Tel: +44 (0) 7973 158 065



Contributing Editor

Kristina Smith

kristinasmith.editorial@gmail.com

Tel: + 44 (0)7833 230 853



Sales Manager

Daniel Lee-Billinghurst

daniel@tunnellingjournal.com

Tel: +44 (0) 7818 422 712

Art Editor

Mike Hooker

Technical Illustrator

Pete Beach

Brought to you by the publishers of

Tunnelling
journal

TGS Media Ltd. The Old Library, Webster House
Dudley Road, Tunbridge Wells, Kent, TN1 1LE United Kingdom
Tel: +44 (0) 1622 720 631 www.tunnellingjournal.com

The publishers, authors, associations, and groups mentioned cannot accept liability for errors or omissions. All rights reserved. No part of this publication may be reproduced in any form without prior permission of the copyright holder and the publisher, application for which should be made to the publisher, TGS Media Ltd. ISSN Breakthrough (Print) ISSN 2059-1241, Breakthrough (Online) ISSN 2059-125X.

Meet the ITAYM Board

The governing structure of the International Tunnelling and 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. The Chair and the Vice-Chair are subject to the approval of the ITA General Assembly. Steering Board members are elected for alternating periods to ensure continuity of the group. The mandate is for two years.



Jurij Karlovšek
Chair

Jurij is an Engineers Australia registered Civil Engineer, specialising in geotechnical engineering and tunnelling. He works as a Postdoctoral Research Fellow at The University of Queensland, Australia, where he recently obtained his PhD in the field of TBM segmental lining integrity detection.

Jurij's career to date spans three continents, with experience in both industry and academia; including design, consulting work and research, teaching, and creation of course content. He is the founding Young Professional Engineer Representative of the Australasian Tunnelling Society's (ATS) Executive Committee. Jurij's philosophy is grounded in the belief that industry and academia should work together in the pursuit of innovation.



Petr Salak
Vice Chair

Petr obtained his Masters in Civil Engineering at the Czech Technical University in Prague and is currently a Senior Tunnel Engineer with Dr. Sauer & Partners, in the UK. He has extensive experience in tunnel and shaft design, site supervision, design management, and his speciality is Sprayed Concrete Linings (SCL). He is a past Chair of the British Tunnelling Society's Young Members Committee, and was awarded 'Young Tunneller of the Year' by the ITA in 2014.

Petr champions student events to promote tunnelling as a career, and the creation of domestic YM Groups, based on the uniqueness of each nation. He enjoys spending time with his young family, travelling, scuba diving, and skiing.



Lasse Vester
Treasurer

Lasse graduated with a Masters in Building Technology from the Technical University of Denmark, in 2012. Since then he has worked as a Design Engineer on the Fehmarnbelt Fixed Link project (see page 39). Before his Masters degree, Lasse worked for Danish contractor E Pihl & Søn AS on construction projects in the Copenhagen area.

Lasse is currently Chair of the Danish Tunnelling Society's Young Members Committee and is heavily involved in his national tunnelling organisation.

Outside of work he is a bit of a foodie, and enjoys cooking for family and friends. He also plays football for a local Copenhagen team, and spends as much time outdoors hiking or trekking as he can.



Nichole Boulton
Secretary

Nichole Boulton completed her Bachelors and Masters degrees in the Earth Sciences department at Simon Fraser University, in BC, Canada, in 2005, and has been working for Golder Associates ever since. She has experience in engineering investigation, design and construction for projects in Canada, Australia, and Chile.

She is registered as a professional geoscientist (P.Geo) with the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC), and is on the Board of Directors of the Tunnelling Association of Canada (TAC) as a representative for Young Members. She loves her dog, Kevin – who grew up in her office and now spends most of his time waiting for her to come home and chill out with him.



Sindre Log
Marketing & Press

Sindre gained his Masters in Civil and Environmental Engineering at the Norwegian University of Natural Science and Technology (NTNU), in 2010. After completing his thesis on hard rock TBMs, Sindre joined The Robbins Company, one of a few specialist tunnel boring machine manufacturers in the industry. He started in the cutter department, working on projects globally, before gradually taking on more responsibilities. He is now General Manager of Robbins' Norwegian subsidiary. He has been involved in the Norwegian tunnelling society (INFF) for some time, and was one of the founders of the Norwegian Young Members group.

Sindre is a dedicated fly-fisher, football fan, and the father of the youngest TBM enthusiast in the world.



ITA-AITES Secretariat

c/o EPFL GC D 1 402 (Bât. GC)
Station 18 CH - 1015 Lausanne, Switzerland

Tel: + 33 69 587 13 85 Fax: + 41 21 693 41 53

E-mail: itaym@ita-aites.org Website: www.ita-aites.org



Breakthrough is endorsed by the ITA



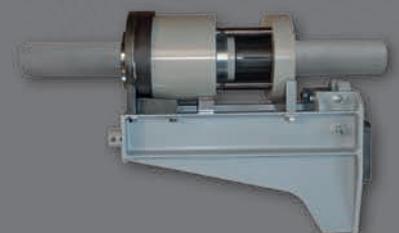


DELIVERING THE SUPPORT YOU NEED

A Milestone in the Development of the AT-Pipe Umbrella System

Squeezed Connection

- Fast and easy connection of umbrella pipes
- Constant cross section in the coupling area
- 1.5 times higher ultimate load in the connection area than the elastic design load of a normal pipe
- Recommended for all advances where a pipe umbrella is installed because of its static load-bearing capacity



Local Presence – Global Competence

www.dsi-tunneling.com

Contents...

- 08** **Uniting Nations**
Since the formation of the ITAYM the number of national YM tunnelling groups has tripled. Breakthrough finds out why
- 12** **Behind the Blue Hoardings at Bond Street Station**
Three tunnel engineers on London Underground's Bond Street Station Upgrade explain their work on the project
- 18** **How to set-up a Young Members group**
The ITAYM's quick-fire guide on how to build a professional network with other young tunnellers in your country
- 19** **Promoting the Use of Tunnels and Underground Space**
Find out more about the ITA's aims and how its Committee on Education and Training can assist in career progression
- 20** **Searching for Superstars**
An international panel of leading industry employers discuss the qualities it takes to be a successful tunneller
- 28** **Norway's Tunnelling Legacy**
A booming tunnelling market, with no end of work in sight, is inspiring a new generation to seek careers underground
- 30** **Breakthrough's Book Club**
We asked the industry to nominate its top reads for young tunnellers, which inadvertently prompted a bit of a debate
- 32** **A Week in my Life**
ITAYM Secretary, Nichole Boulton, chronicles a hectic week at work as an Engineering Geologist
- 34** **Going Underground**
Tunnels and underground space have a vital role to play in the urban development of the world's cities
- 39** **Building the world's longest immersed tube tunnel**
ITAYM Treasurer, Lasse Vester, describes his work as a Design Engineer on the record breaking Fehmarnbelt tunnel
- 42** **The 2nd Arabian Tunnelling Conference**
A Young Engineers Forum was one of the highlights of the ATC2014 Conference in Abu Dhabi, last December
- 43** **The Masters Graduate**
Geoconsult Singapore's Senthil Nath recently completed his ITA endorsed Masters in Tunnelling at Politecnico di Torino
- 44** **Underground Induction in Indianapolis**
A TBM Shift Engineer, and his boss, provide some insight for young engineers looking at a career underground
- 47** **The Masters Candidate**
Donaldson Associates' Gerard Quigg is enrolled in the ITA endorsed Masters in Tunnelling at Warwick University
- 48** **A Career in Tunnelling?**
Breakthrough asked a 15-year old high school student to go online and research a career in underground construction
- 50** **Wanderlust**
Mechanical Engineer, Matias Iovine, gets to travel the world in his job as a Robbins' TBM Field Service Engineer
- 52** **BTS Young Members Conference 2015**
The British Tunnelling Society's Young Members (BTSYM) hosted their second conference on the 27th March
- 56** **Holding back the Water**
Korean young engineers explain how groundwater is being controlled on the country's first mined subsea tunnel

YM MEMBER NATION REPORTS

UK	24	Denmark	38	USA	46
Norway	26	Australasia	40	Greece	49
Canada	31	UAE	42	Korea	55





Uniting Nations

In the space of two years, the number of young members' groups within tunnelling associations around the world has more than tripled. Kristina Smith looks into the reasons for this sudden explosion of interest in the industry's organisations.

Graduate engineer Kate Cooksey had only been working for Morgan Sindall Underground Professional Services (now known as UNPS) for seven months when she was called into the office by her boss. He wanted her opinion on a promotional video for young people that the British Tunnelling Society (BTS) was planning.

Being young and keen, Cooksey suggested that the money could be spent on other ventures, and promptly went away to put together a list of ideas. One of those ideas was to set up a young members' group of the BTS, which was to be the first of its kind around the world.

That was back in 2008. Fast-forward seven years to 2015, and there are now 17 countries with young tunnellers' groups, and that number is steadily increasing month on month.

The catalyst for this growth came in 2014, with the formation of an International Young Members Group within industry umbrella organisation, the International Tunnelling and Underground Space Association (ITA). Tunnelling is a boom industry and, with a current global skills shortage, everybody can appreciate the vital role young professionals will play in its continued expansion.

The core purpose of the ITA Young Members (ITAYM) is to provide a platform for young people to meet and exchange information and ideas – with each other

and with more experienced industry professionals. "There are members with such a high level of expertise within the ITA and that is something young members should take advantage of," says Jurij Karlovšek, the ITAYM's inaugural chair. "We need young people to get involved in the organisation, learn from these experts and continue the work they've done so far."

The leaders of the ITA are keen to get young engineers onto its influential Working Groups and Committees, which develop policy and guidelines for the industry, a significant step for an organisation where years of experience are usually the ticket for getting onto one of these groups.

"We want young members to be integrated into all the activities within the ITA," says ITA President, COWI's Søren Degn Eskesen. "We want them to be part of the Working Groups and Committees so that they can bring in new ideas and contribute to the future development of the ITA."

Those young professionals who do get involved will also be getting a massive career boost: the chance to learn from, and network with, the industry's leading international players.

The idea

Like several of his colleagues on the ITAYM committee, Karlovšek has personal experience of establishing a group for young tunnelling professionals. As a

postgraduate student, he moved from Slovenia to Australia to complete his PhD at the University of Queensland, and headed to an Australasian Tunnelling Society (ATS) meeting in a bid to meet like-minded people from the industry.

"As a migrant in a new country, I realised that the easiest way to find people with similar knowledge and interests as my own was to go to technical society meetings," says Karlovšek. "When I did, I found that I was by far the youngest person in the society." Looking to remedy that situation, he approached the ATS with an idea to create a young members' group in 2012.

We want young members to be integrated into all the activities within the ITA. We want them to be part of the Working Groups and Committees so that they can bring in new ideas and contribute to the future development of the ITA.

**Søren Degn Eskesen,
ITA President**



In 2013, Karlovšek attended a meeting headed up by Petr Salak at the ITA's annual World Tunnel Congress, in Geneva, Switzerland. Salak, who had moved to London from his native Czech Republic, had joined the British Tunnelling Society Young Members (BTSYM) group for the same reasons Karlovšek had sought out the Australasian Tunnelling Society.

When Salak was elected to chair the BTSYM in 2013, he decided to link up with other similar organisations overseas. Unable to find any through the power of Google, he put together a proposal to create an international young members' group with support from Cooksey, then BTS President Damian McGirr, and others – which is how he came to be presenting at the Congress in Geneva with McGirr.

Also there, and keen to be involved in the new group, was Sindre Log, founder of the Norwegian young members group. The Norwegian Tunnelling Society (NFF) had started its group in 2010, this time an initiative from the main organisation, which was collectively feeling its age.

"In Norway – and in the whole tunnelling industry – the average age is going up, so one of the important things that people of our generation have to do is to help bring in the tunnellers and engineering professionals of the future," says Log, who as one of the society's few members under the age of 30, was the obvious choice to head up the Norwegian group.

Salak's idea for an international organisation was welcomed with open arms – by his peers and by Degn Eskesen, who was also at the meeting and about to be elected ITA President. "We got backing from the top," says Salak, "which has meant that we have been able to achieve a lot in a very short amount of time."

A task force was set up to lay down the by-laws and objectives for the group, with support from an unofficial ITAYM steering committee consisting of Salak, Karlovšek, Log, Nichole Boulton of Canada, and Lasse Vester of Denmark. And after the formal launch of the group and a call to action at the World Tunnel Congress in Iguassu, Brazil, last spring, the message spread quickly.

One of the ITAYM's initial goals is to encourage more countries to get involved. It's going well. At the time of going to print there were young members' groups in Australia, Brazil, Bolivia, Canada, Colombia, Czech Republic, Denmark, Greece, Hungary, India, Italy, Norway, South Africa, South Korea, Turkey, the UK and the USA.

Bridging generations

The ITAYM's primary aim is to provide a technical networking platform for young professionals and students in the industry. "We want to create an arena where young people can meet and exchange experiences across national borders and across projects," says Log. "I am one of the lucky guys who got to work internationally at an early stage of my career; you learn a lot of things that you can bring back to your home country. It's good for everyone to be involved internationally if they can."

Knowledge transfer from the older to the younger generations is also on the agenda, an aim that is mirrored in many

of the individual country's groups. In the USA, for example, where the Underground Construction Association Young Members' (UCAYM) is in its infancy, their meetings – held as free online seminars due to geographical constraints – are very much focussed on this.

"All the speakers we have lined up for our webinars so far are senior members of our national tunnelling organisation who are sharing their knowledge," says Chair Tony Bauer. "It's really valuable to have an exchange of ideas between people from different companies, rather than to only learn from the people you work with."

As well as looking up to more experienced colleagues, a vital task for any young members' group is to look down to the next potential generation of young engineers. In countries where there are established groups, this has already become an important part of the work they do. "As a more recent graduate, you are still at an age where you can relate to students. You know what's going on in schools and what you can do to encourage that generation," explains Cooksey.

The ITAYM will provide a forum for different nations to exchange ideas for reaching out to schools, colleges, and universities. The BTSYM, for example, has shared its initiative to create a Teachers' Pack of lesson plans on tunnelling science and theory for secondary school children, which is currently being trialled in London.



Kate Cooksey, UNPS Ltd

- Chair of the first ever young members' group in the UK.
- Studied a Masters in Civil Engineering at Cardiff University
- Chartered Civil Engineer and Business Development Manager, seeking out new work for UNPS.
- Most memorable project: "I was on the Crossrail bid team and went all the way through Contract 510 as part of the BBMV (Balfour Beatty/Bemo/Morgan Sindall/Vinci) Joint Venture. I had to learn at the sharp end how bidding to do work for a certain price transfers to delivering the work for that price."



Jurij Karlovšek, University of Queensland

- Current ITA Young Members' Chair and Founder of ATS Young Members group.
- Obtained a PhD at the University of Queensland, Australia; Studied Civil Engineering at the University of Ljubljana and the University of Western Sydney.
- Researching how to integrate other engineering and social science disciplines into tunnelling and underground space.
- Most memorable project: "Working on site for Japanese construction company Nishimatsu Construction on an international internship as part of my Civil Engineering Degree. Being underground, seeing tunnel excavation while a jumbo was drilling rockbolts and placing mesh to prevent collapse, was an amazing experience."

New mindsets

If older generations are to encourage younger generations, they must be prepared to accept new ideas too. Young members' groups can be a great way to trial and introduce new ways of working. Expect ITAYM to make good use of social media, for example – a move the parent organisation could then follow.

Despite its use of social networks, however, this generation values face-to-face interaction as highly as any other age group. Senior managers will need to take a different attitude to personal and professional development, for instance signing off on younger members of staff attending conferences both at home and overseas.

Young member nations will be lobbying conference organisers to offer better rates for young professionals and students. The ITA has led the way, with reduced prices for the under 35's at its 2015 World Tunnel Congress, in Dubrovnik, this May.

"Normally conferences are only attended by older engineers because it's hard to encourage the bigger companies to sponsor young people to go," says Bauer, who would like to use the big industry conferences in the USA as an opportunity for virtually-linked members to finally meet face-to-face. "Maybe holding a young members event there will provide a reason for companies to approve the trip."

It's difficult to see a downside in this proliferation of young members' groups. Tunnelling is a fast-growing and fast-developing industry; it needs to attract intelligent young people; and it needs to develop the bright young people it already has. Anything that helps with that can only be a good thing.

Young members' groups can also become a feeder mechanism for the committees and working groups of national tunnelling organisations. "People who are active in the young members groups will naturally step into the main committees when the time comes," says Salak. "We need to encourage more people who are enthusiastic and hard-working to take on these roles."

Encouraging individuals to get involved can be positive for an employer too. Beyond the aspects of technical and professional development, there are lessons in networking, collaboration, and group initiatives to be had.

Cooksey, a fresh-faced graduate at the beginning of this story, illustrates the point. "Back then, I never expected that I would be leading the group," she says, "but it was



Petr Salak, Dr. Sauer & Partners

- As former BTSYM Chair, developed and proposed the idea of the ITA's Young Members Group.
- Studied a Civil Engineering Masters Degree at the Czech Technical University, in Prague.
- Currently Design Manager for SCL Temporary Works at Crossrail's Farringdon Station, London.
- Most memorable project: "I was Resident Engineer on a project to create a new service tunnel under the Dorchester Hotel, in London. That was a fantastic project to work on because there was a good team working on it, we had great co-operation. And we saw quite a few famous people too..."



Anthony Bauer, Gall Zeidler Consultants

- Attended BTSYM while visiting the UK, Chair of the recently formed young members' group in the USA.
- Studied Civil Engineering at Virginia Polytechnic Institute and State University.
- Project Manager, co-ordinating design teams on a number of different projects.
- Most memorable project: "I was Deputy Tunnel Design Manager for the Vauxhall Station Upgrade, in London. It was a really complex project and I had been involved from the earliest stages of the design. What made it more exciting was that for nine months I was flying from Washington DC to London, spending two weeks there and two weeks here."



Sindre Log, The Robbins Company

- Founder of the Norwegian Young Members' group and member of the ITA Young Member's Board.
- Studied an MSc in Civil Engineering at NTNU, the Norwegian University of Science and Technology.
- General Manager for tunnel boring machine (TBM) manufacturer Robbins, in Norway, with responsibilities ranging from technical to commercial, and business development.
- Most memorable project: "During my first two years with Robbins as an engineer, I focussed on technical aspects of TBMs and visited more than 20 machines all around the world. That was a great time."



Main Objective:

- Provide a technical networking platform for young professionals and students.

Secondary Objectives:

- Enable exchanges of experience and ideas.
- Bridge the gap between generations.
- Improve awareness to new generations.
- Provide young professionals and students with a voice in the ITA.
- Look after the next generation of tunnelling professionals and pass on the aims and ideals of the ITA.

a great experience for me. It was a chance to really put my leadership skills to the test and learn how to form professional working relationships with people who worked for competing companies."

At the age of 30, she's still pretty fresh-

faced. And, having won a fistful of accolades in the industry and beyond, she has recently been promoted to the role of Business Development Manager within her company. All that enthusiasm and networking seems to be paying off. 



SUPPORTING YOUNG TUNNELERS FOR OVER 60 YEARS



Since 1952, The Robbins Company has been committed to hiring novice engineers and honing them into industry experts.

Robbins continually adds young people to its worldwide team, and is a strong supporter of educating future generations about tunneling, as well as an ongoing sponsor of the ITA Young Members Group (ITAYm).

Learn more at www.TheRobbinsCompany.com.

BOND STREET
IMPROVEMENTS UNDER WAY

Behind the Blue Hoardings at Bond Street Station

Three young engineers involved in the current upgrade of London Underground's Bond Street Station take a journey around one of the most complex Sprayed Concrete Lining (SCL) tunnel projects undertaken in the UK's capital.



Nina Obereder is 26 and works as Sprayed Concrete Lining (SCL) Engineer for Dr. Sauer & Partners, which provides design services to the contractor on the Bond Street Station Upgrade (BSSU) project. She holds a Master's degree in Environmental Engineering from the University of Natural Resources and Life Sciences in Vienna, Austria. Through a guest lecturer who focused on tunnelling, and a summer job on the Brenner Base Tunnel project, in Austria, Nina discovered her passion for tunnelling.



Daniel Bimson is 28 and a Tunnel Engineer on London Underground's Deep Tube Tunnels team. He studied Civil Engineering at the University of Bath, United Kingdom. Daniel joined the Bond Street Station Upgrade project at the end of his London Underground civil engineering graduate scheme and had a crucial involvement in the delivery of the tunnels design. He is currently seconded to the Bond Street Station joint venture contractor Costain/Laing O'Rourke (CoLOR), working as a Shift Engineer to gain hands on experience of delivering Sprayed Concrete Lining (SCL) tunnelling works.



Sebastian Kumpfmüller is 31 and the Substitute Senior Sprayed Concrete Lining (SCL) Engineer for Dr. Sauer & Partners' design team on site at Bond Street Station. He holds a Master's degree in Construction Management and Engineering from the University of Applied Sciences in Graz, Austria. Sebastian has gained international experience on highway tunnels, rail tunnels and underground station projects in Austria, the USA, and most recently in the UK.



Christmas shoppers pass by the OSD building on Oxford Street



Sebastian points out the new station layout



Daniel and Sebastian inspect one of the tunnel headings

Bond Street station is an important spot on London's Tube map, serving tourists, residents, and businesses in the heart of London's busy West End. "At peak times the station reaches full capacity and deals with a total of 175,000 passengers a day. This figure is predicted to increase to 225,000 passengers a day when London's new Crossrail train service commences in 2018," says Sebastian Kumpfmüller, who works on the engineering design team for the Bond Street Station Upgrade (BSSU) project.

The purpose of the upgrade scheme is to provide essential congestion relief by means of a new station entrance and ticket hall, and the construction of around 500 metres of new tunnels beneath Oxford Street

that will become escalators, lifts, and passageways. Additionally, the project will deliver step-free disabled access to the station, from street level to all platform levels, and will provide improved fire safety and provision for interchange with the new Crossrail station that is directly adjacent.

"We face two major challenges on this project," says London Underground's Daniel Bimson. "One is to keep the station operational every day and not disrupt tube services with the construction works, and the other challenge arises due to the age of the original Bond Street Station."

Bond Street Station was originally constructed in 1905, with upgrades following in

the 1920s and 1970s. Since technologies advanced over time, each phase was built using different construction methods. This meant that a huge amount of intrusive surveying work had to be completed during the design and prior to the start of tunnelling for this latest upgrade project. New Sprayed Concrete Lined (SCL) tunnels are being built as close as 200mm (8 inches) to existing structures, with some even connecting. Therefore, it was extremely important to understand how the existing structures would behave under the new conditions and establish exactly how the existing station is made up to corroborate archive drawings.

SCL Method

Sprayed Concrete Lining (SCL) is a tunnel construction method that can be used in soft ground conditions such as the London Clay found at the Bond Street Station site. This method is very suitable for a project involving challenging ground conditions, changing tunnel geometries, varying tunnel lining thicknesses and difficult transitions and junctions between new tunnels.

At the Bond Street Station Upgrade additional factors like the close proximity of existing operational Underground infrastructure, and the need to minimise ground movements in order to protect Grade-Listed buildings on the surface above the station, contributed to the



Concrete is applied using a remote controlled shotcrete robot

decision to employ the SCL method.

“Located in the heart of London’s shopping district, the site setup presented itself as the first challenge that had to be tackled,” explains Nina Obereder, who also works for the Dr. Sauer & Partners design team. “The only available area was within the footprint of Oxford Street Nos. 354 to 358, a total area of just 300 square metres. During construction an oversite development (OSD) building is designed to house welfare facilities, a site office for Costain/Laing O’Rourke (CoLOR) the project’s joint venture contractor, mechanical and electrical workshops and cranes to service the works.”

The sprayed concrete equipment is set up within the basement and sub-basement areas of the OSD building. This required extensive temporary works to make the installation fit, especially given the need to house the SCL supplies, which include multiple dry aggregate silos and multiple shotcrete (sprayed concrete) pumps.

Thirty SCL structures are built from the OSD, starting with two shafts from the sub-basement slab. Shaft 1 is 20.5 metres deep and has a diameter of approximately 11 metres, and Shaft 3 has a

total depth and diameter of approximately 10 metres. The Southern Tunnels that were broken out from the bottom of Shaft 1 include about 180 metres of SCL tunnels and will be part of a new interchange between the Jubilee line, the Central line, and the new Crossrail Tunnels. Shaft 3’s Northern Tunnels comprise some 220 metres of tunnels – most of them very challenging from an engineering point of view – that will facilitate faster access and exit to/from the Jubilee line level of the station.

Using the SCL method, the profile of each of the new Bond Street Station tunnels is divided into different sections (Top Heading, Bench and Invert) depending on the size of the tunnel, encountered ground conditions, and the equipment used (see diagram).

Each section is mined separately, using an excavator, to a designed length and profile. Immediately after each section is excavated, sprayed concrete (with steel fibres incorporated into the mix to provide reinforcement) is applied until the designed lining thickness and profile is achieved. This is called an “advance”. Once the invert section is supported the lining of a new portion of tunnel is

completed, and this is called “ring closure”. In soft ground conditions at shallow depths, such as at Bond Street Station, this is a vital point – and one of the key elements of the SCL method – in guaranteeing stability and stress re-distribution around the tunnel.

The finished structure is then monitored for any signs of deformation/convergence due to the continuing construction works and to avoid any settlement on the surface. Designed for a 120-year

lifespan, the final lining of the tunnel is completed with a layer of spray applied waterproofing membrane, followed by a secondary layer of sprayed concrete.

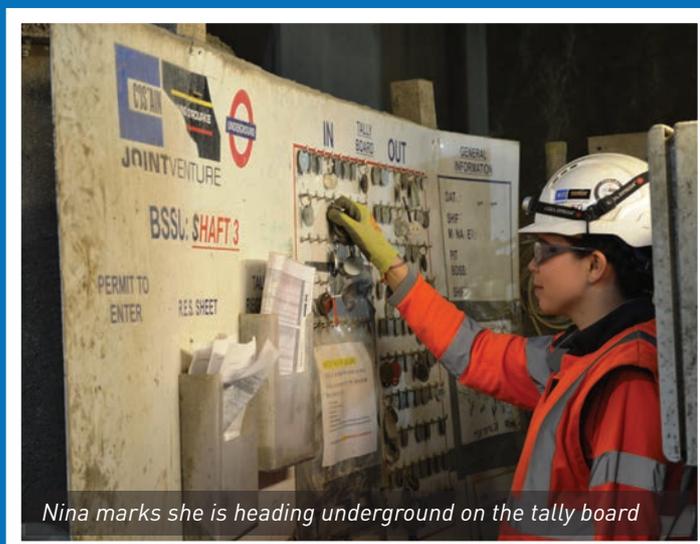
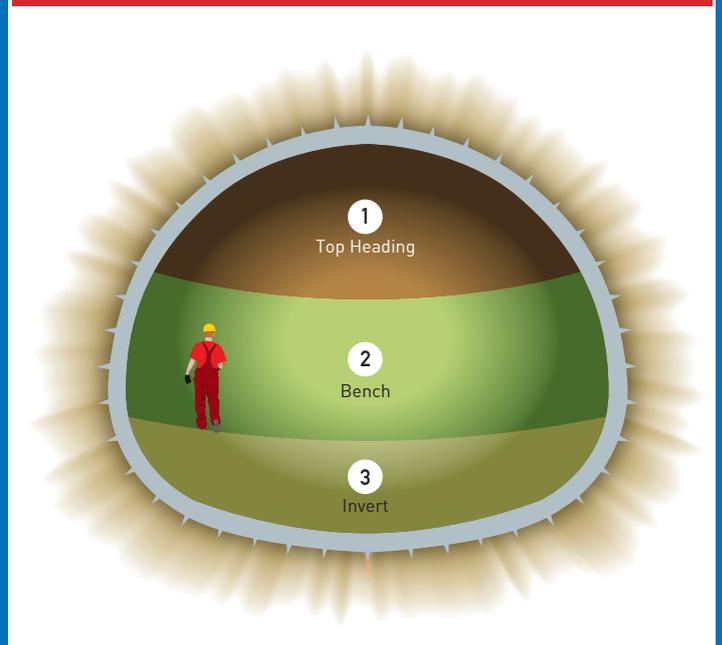
Geology

On the Bond Street Station Upgrade project about 90% of the tunnelling is carried out in London Clay, whilst the deepest tunnels of the project are excavated in the top of the Lambeth Group. Both are marine geological formations,

The OSD and the shafts and tunnel headings beneath it



The top heading, bench, and invert of the SCL method



Nina marks she is heading underground on the tally board

30 YEARS OF INNOVATIVE TUNNEL SOLUTIONS



TUNNEL DESIGN
GEOTECHNICAL ENGINEERING
CONSTRUCTION MANAGEMENT
INSTRUMENTATION & MONITORING
WATERPROOFING & WATER CONTROL
TUNNEL REHABILITATION
MINING SUPPORT SERVICES

www.dr-sauer.com

Salzburg – London – Washington – Toronto



VISIT US @ WTC 2015 in Dubrovnik, Croatia and RETC 2015 in New Orleans, USA

deposited through falling sea levels about 50 to 55 million years ago. Historical and new exploration boreholes were drilled prior to the design and construction of the tunnels to determine the extent of each formation. In tunnelling terms the encountered conditions are considered soft ground.

For SCL tunnelling this provides ideal conditions, as the exposed clay is mostly dry and has a good stand up time that allows smooth excavation and spraying of the SCL lining. Due to the deposition process however, there is the potential for occasional lenses of sand and the contractor has to be prepared all times during the works in case one of these lenses is encountered. The design includes contingency measures for temporary support and in-tunnel water control that can be utilised if the ground conditions require it.

A challenge for the contractor is the handling and removal of the excavated material or muck due to the location of the project in central London, just off Oxford Street. Up to 14 lorries leave the site each day to carry away the muck. In addition there are lorries delivering aggregates for the sprayed concrete mix and other materials. "In total about 2,100 lorries, each holding 18.5

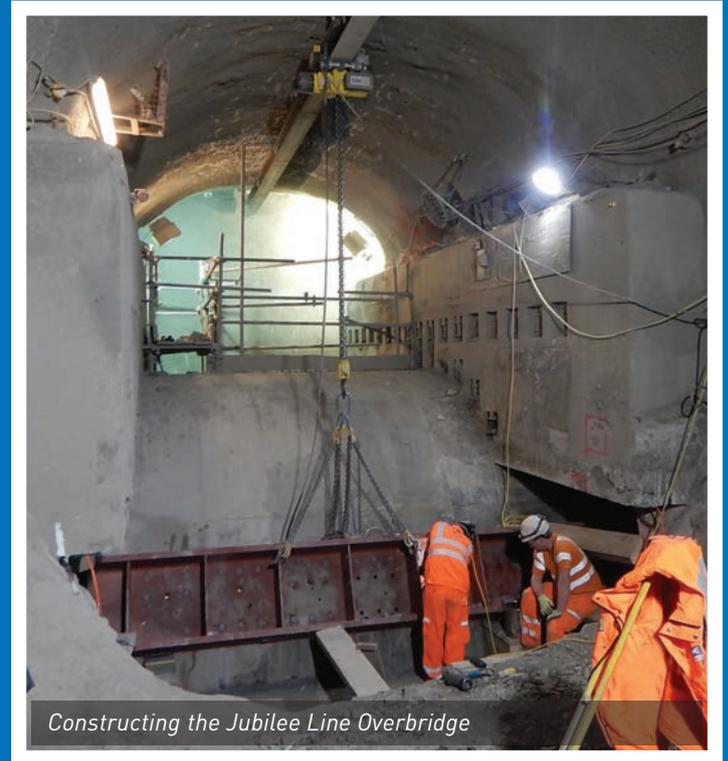
tonnes of material, have been transported away from the site to date. With this amount of muck Big Ben could have been filled twice," says Nina.

All the excavated material is taken away to the Wallasea Island site, in the Thames Estuary, where it is being reused to landscape a bird sanctuary. This is where the Crossrail tunnel project has been taking its muck too. On the occasions where the excavated material contains cast iron segments (that have been removed from existing structures), they are segregated and disposed of separately.

Jubilee Line Overbridge

A highlight of the Bond Street Station project was the construction of the Jubilee Line Overbridge. A hybrid of traditional hand mining and SCL tunnelling methods was used to successfully construct this new passage over the existing southbound Jubilee line platform tunnel, with the platform fully operational during the construction.

In the first stage, two small hand mined headings were advanced from a temporary SCL headwall on either side of the tunnel. Each was approximately 9 metres long and 2 metres wide



Constructing the Jubilee Line Overbridge

and up to 3.5 metres high. Once completed, cast in situ reinforced concrete walls were poured inside each heading to form the permanent tunnel walls for the overbridge.

In the second stage, the central portion was excavated with an excavator, and a SCL crown was applied over the cast walls. The SCL tunnel advanced one meter at a time and included burning out steel frames and breaking out temporary support timbers from the hand mined headings. At the end a temporary SCL headwall was sprayed in order to stop the tunnelling works for the duration of the final stage of the Jubilee Line Overbridge works.

This included removing the top pre-cast tunnel lining segments of the Jubilee line platform tunnel, after the installation and concreting of load transfer beams on either side of the existing tunnel. The segments were removed while a pre-erected crash deck inside the Jubilee line platform tunnel prevented them from falling onto the tracks or the

platforms. A temporary steel deck was then placed on top of the remaining rings to facilitate further construction of the SCL tunnels. Later in the project a permanent deck will be constructed.

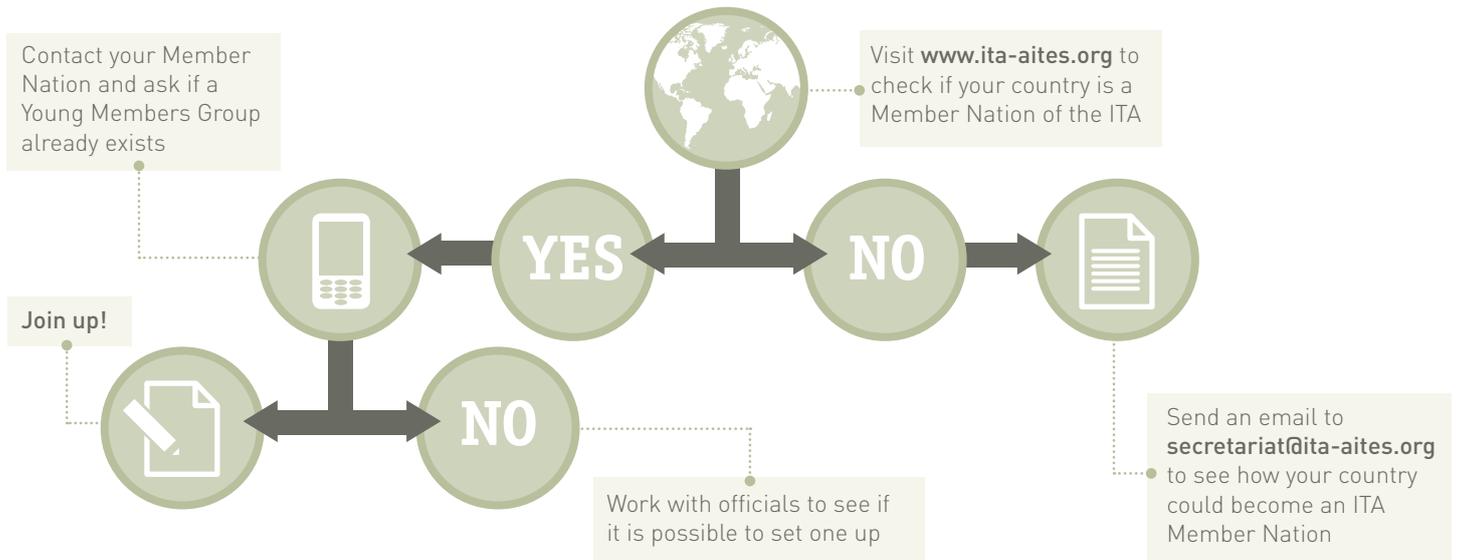
Nina, Daniel, and Sebastian all agree that these parts of the project where new meets old, the close proximity of existing structures, and operational London Underground tunnels and breakthroughs to the existing station, are the most interesting and most satisfying to deliver successfully.

Safety is a key priority on such a large scale infrastructure project in order to prevent injuries to the 60 or more people (engineers, miners, carpenters, fitters, electricians, and banksmen) working each shift, in two twelve hour shifts, seven days a week. Safety is also important in terms of protecting existing structures and the members of public using them within the existing operational Bond Street Station and on the surface of Oxford Street. 



Ducting provides ventilation for the tunnel headings

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 organize the board and the aims and objectives of your group, prepare a simple set of by-laws and start working to organize 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!

Promoting the Use of Tunnels and Underground Space

The International Tunnelling and Underground Space Association (ITA) is a technical organisation that is committed to developing economical, sustainable, and safe solutions that promote the increased and optimised use of Underground Space.

One of the ITA's key strengths is its ability to reach out to a network of more than 20,000 experts – from both the tunnelling industry and world-class universities around the globe – via the conferences and meetings that are organized by the ITA and its Member Nations.

The ITA currently federates 71 Member Nations and 300 Affiliate Members, including 15 Prime Sponsors and 60 supporters. It is governed by an Executive Council composed of 15 elected members, hailing from various Member Nations and representing many different sectors of the global tunnelling community.



The ITA has had a Special Consultative Status with the United Nations (UN) since 1987, and has been involved in various UN initiatives:

- Habitat II, the Second United Nations Conference on Human Settlements
- Feasibility studies for a fixed-link between Europe and Africa in the form of a subsea tunnel underneath the Gibraltar Strait
- Poverty Reduction within the UN Development Programme
- The World Urban Campaign – A UN-Habitat event that provides a platform for public, private and civil entities to promote advocacy initiatives and share practical tools for sustainable urbanisation
- UN-ISDR “Making Cities Resilient programme” – During the fourth session of the Global Platform for Disaster Risk Reduction, organised by UN-ISDR, the ITA presented a vision for cities of the future, where underground space would be used as a solution to the challenges presented by urban growth
- The World Urban Forum – In April 2014, the ITA organised a side event with training sessions on underground of space use

ITA Committee on Education and Training

Training and Education were identified as key strategic priorities for the ITA in 2000, and were again confirmed as being both one of the greatest challenges and one of the direst needs facing the industry in 2007 and 2014. This is why the ITA Committee on Education and Training (ITA-CET) was established: ITA-CET's role is to promote education and training throughout the tunnelling and underground space industry and assist in its coordination. ITA-CET's primary goals are:

- Coordinate interaction and exchanges among member universities
- Plan, coordinate and prepare training sessions and short-courses
- Establish the content, framework and requirements of professional Masters courses endorsed by ITA, and analyse proposals for endorsement
- To disseminate training and educational materials



In 2009, the ITA decided to support the creation of a Foundation for Education and Professional Training in the field of tunnelling. The ITA-CET Foundation facilitates short courses and programmes with technical input from the Committee. Since 2009, the Foundation has organised more than 40 events, providing training for over 4,000 students and young engineers.



Mechanized Tunnelling
29-30 June 2015
Guadalajara, Mexico

AMITOS (the Asociación Mexicana de Ingeniería de Túneles y Obras

Subterráneas) and the ITA-CET Foundation will co-organise a two-day training session on 'Mechanized Tunnelling'.

The training session aims to provide general information to young engineers and update tunnelling professionals on topics related to Mechanized Tunnelling.

More information and registration details can be found on the AMITOS website (www.amitos.org), or visit the ITA-CET website (http://www.itacet.org/Training_session)

Searching for Superstars

Tunnelling offers young professionals the opportunity to work on the world's most challenging projects in its biggest cities. Kristina Smith asked some of the industry's leading employers what they are looking for in return.

If you want to work in the world's most dynamic and developing cities; if you want a job that is different every day; if you can think on your feet and stand up for yourself, then tunnelling is the industry for you.

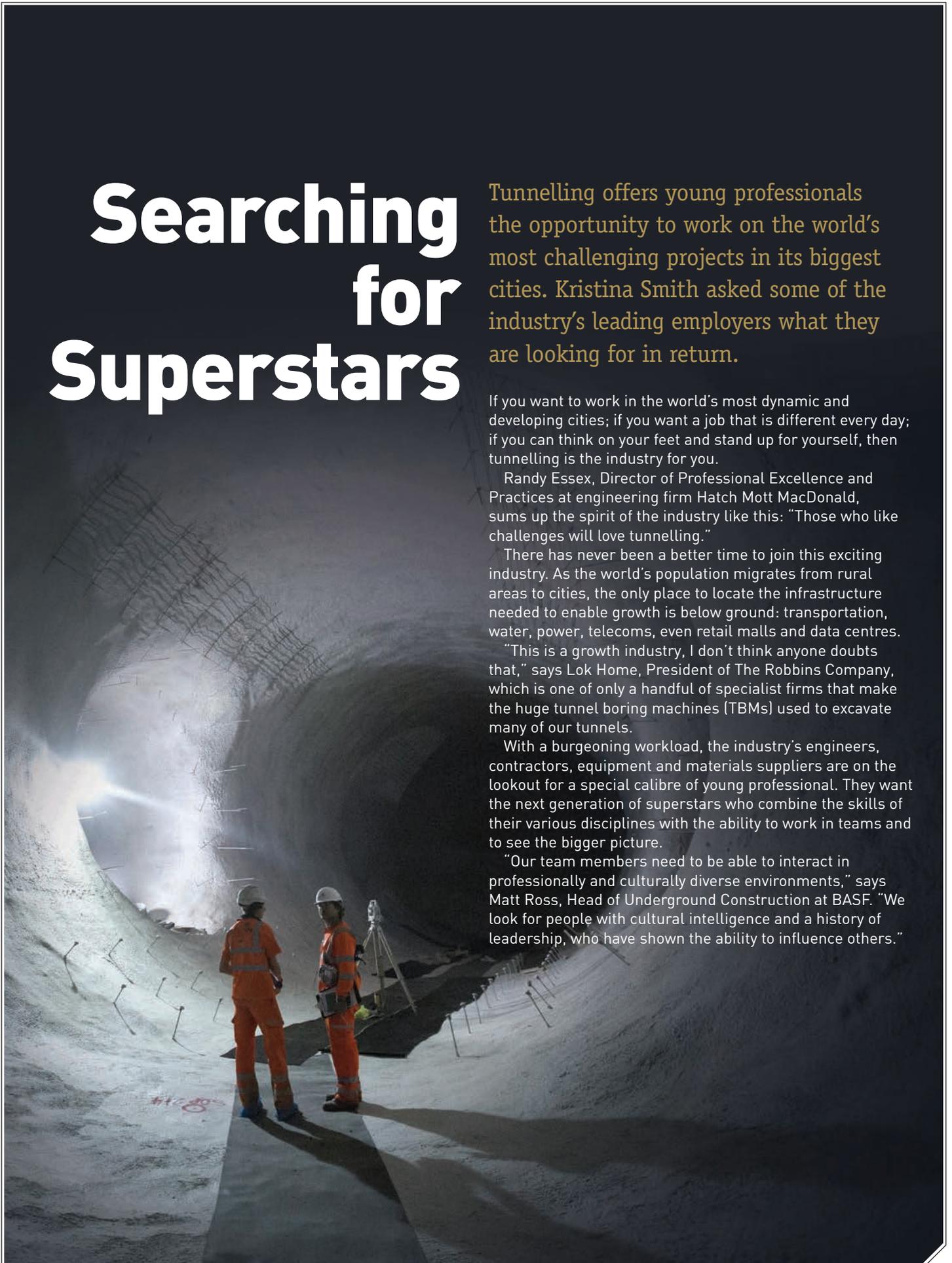
Randy Essex, Director of Professional Excellence and Practices at engineering firm Hatch Mott MacDonald, sums up the spirit of the industry like this: "Those who like challenges will love tunnelling."

There has never been a better time to join this exciting industry. As the world's population migrates from rural areas to cities, the only place to locate the infrastructure needed to enable growth is below ground: transportation, water, power, telecoms, even retail malls and data centres.

"This is a growth industry, I don't think anyone doubts that," says Lok Home, President of The Robbins Company, which is one of only a handful of specialist firms that make the huge tunnel boring machines (TBMs) used to excavate many of our tunnels.

With a burgeoning workload, the industry's engineers, contractors, equipment and materials suppliers are on the lookout for a special calibre of young professional. They want the next generation of superstars who combine the skills of their various disciplines with the ability to work in teams and to see the bigger picture.

"Our team members need to be able to interact in professionally and culturally diverse environments," says Matt Ross, Head of Underground Construction at BASF. "We look for people with cultural intelligence and a history of leadership, who have shown the ability to influence others."



Searching for Superstars

BORN TO DIG

There is something important that all would-be tunnelling professionals need to know: you will either love being underground or you will hate it. And you need to find out where you stand early on.

Gavin Bradford, who is Construction Manager for the consortium delivering Australia's longest ever road tunnel, NorthConnex, says: "They need to have that glint in their eye and a true desire to go and dig a hole. They need to be a bit adventurous and be truly willing to try a few different methods of tunnelling in their first ten years."

"Some people feel a little bit intimidated at first, but I would urge any young person joining the industry to go underground as soon as they can, then they will really understand what it's all about," says Home, "I'm definitely looking for young people who are willing to get their hands dirty."

Robert Galler, Head of Subsurface Engineering at Austria's Leoben University and Chair of the steering committee for the International Tunnelling and Underground Space Association's (ITA's) education body ITA-CET, makes sure his students find out early on whether they've got the tunnelling gene or not. "They come with me in their first semester and visit construction sites. I want them to find out whether this is an environment that they would like to work in for the next 30 to 40 years."

Some find it isn't for them, says Galler. Others go underground and fall in love. "Some people follow me into a tunnel and say 'Wow! I want to do that!'"

The other quality that everyone on our panel is looking for is social skills and the ability to work in diverse and varying teams. More complex projects - both technically and in terms of how they are funded and managed - lead to more complex problems that require input and co-operation across multiple disciplines.

"I want someone who is able to work within a group, including being a good listener," says Essex. "I would take a B+



team player over an A++ solo act any day of the week."

The ability to form networks and relationships is vital in a business like BASF, says Ross: "Working for such a large organisation means that growing social and professional networks is extremely important. We believe as trust develops, decisions are quicker. The absence of this trust hampers our ability to get things done."

Construction firms who visit Leoben University to recruit undergraduate students are definitely looking at their ability to interact with others, says Galler. "Austrian contractor Strabag, for example, takes our young people to Chile for three to six months to see if they have potential," he says. "They want to see their communication skills - as well as

what they have learned already in their first two or three years at university.

"If you have a good grounding, you can still learn new things whether you are a consultant or a contractor, but what we are really looking for is very strong social skills. The level of social skills governs whether a contract goes well or not."

For global contractor Odebrecht, finding young people who can work within the company's ethos and moral code is vital, says Danilo Abdanur, who heads up the group's Rail Transport Community, an internal organisation for its tunnelling professionals. "When we work with universities to take students onto our trainee programmes, we always look for very good students and we see if they match with our culture. That's the most important thing."

■■ If you have a good grounding, you can still learn new things whether you are a consultant or a contractor but what we are really looking for is very strong social skills. The level of social skills governs whether a contract goes well or not. ■■

Searching for Superstars

AMBITION TO SUCCEED

The industry's leading companies are working hard to stimulate and develop their most promising young people, partly due to the growth of the tunnelling industry and partly because young professionals are demanding it. Many of our panel talked of a new drive among the under-35s to rise quickly up the ranks.

"There is a sense of entitlement with young engineers," says Bradford. "In my view part of this is due to the reality that 'employability is the new loyalty'. In other words, engineers are always looking for their current employer to be giving them the leg up to their next role. If they don't get it, they will go somewhere else."

"Hatch Mott MacDonald has an active young professionals' organisation that provides outlets for our young people to prove themselves," says Essex, "Those who demonstrate their strengths will more than likely move up the ranks. We're trying to convert that sense of entitlement to one of empowerment."

"They want to grow rapidly and be a big boss very fast, which has both positives and negatives," says Abdanur. "The good side is the company benefits as people are more active and want to get on."

Odebrecht has several well-established training programmes, starting with 'Young Constructor' and progressing to others, depending on whether young people are found to be suited to entrepreneurial and management or technical roles. In 2011, its Rail Transport Community, one of 16 Odebrecht communities, developed a six-month tunnelling programme to provide its young engineers, and some older ones too, with theoretical knowledge.

Abdanur's idea to create the programme, which involves around six months of distance learning and residential courses, came in response to Odebrecht's growing workload in the tunnelling sector. "We were very busy with tunnelling projects and came to the conclusion that we needed to expedite the training," he says. "Our people receive lots of practical learning as they are on job sites every day, but we want them to really



understand why things are happening."

At Hatch Mott MacDonald, the trend is toward more practical learning. "Studies show that 70% of all true learning occurs through on-the-job experience," says Essex. "One of the more effective approaches is to bring individuals from similar projects together for a group peer review. This is a powerful way of sharing knowledge and revealing common trends."

Both Abdanur and Essex emphasise the importance of involving the younger generation in decision-making. "We need a culture that says everybody around the table can voice their opinion. Invariably, young engineers will bring something new to the discussion that will help us to cut to the quick more effectively," says Essex. "The ability to apply judgement to a process is the goal."

This is a strong part of the Odebrecht culture, says Abdanur, and one of the reasons why retention is not a problem: "In our organisation there's a good mix between the younger and older generation, even at a governance level. Our Chief Executive took on that role when he was 37 years old," he says.

▣▣ Studies show that 70% of all true learning occurs through on-the-job experience. ▣▣

BASF keeps its future leaders interested by moving them between divisions and countries and promoting from within. "To avoid stagnation in the management team, executives are offered positions in different divisions within the company to challenge existing management in one of those divisions," says Ross, who himself worked in a number of roles in Singapore before moving recently to Germany to take on responsibility for BASF's global underground business.

Ultimately, like generations before them, young people in the tunnelling industry will move from company to company and from project to project. Bradford believes that the successful employers will be those whose senior managers show leadership and dedication to developing the next generation.

"Far too often, people reach general manager and project director level and become absorbed with the self-promotion and self-preservation associated with survival at those levels," he warns.

"The superstars are always looking. If someone comes to me and says they have been offered a better role on another project, I tell them to take it, and I wish them luck. But I also tell them to give me a call when that project's finished, because I may have something even better for them..."

Searching for Superstars

MECHANICAL WONDERS

The size of tunnels we can construct is getting bigger and bigger. And that is primarily due to the sophistication of the tunnel boring machines (TBMs) that are often used to construct them.

"Having a universal tunnelling machine is on the horizon," predicts Essex. "They are becoming mechanical wonders. However, the need for increased training in mechanical engineering will become a precept for tunnel engineering."

"Engineers will have to ensure they have the mechanical, electrical and survey skills to adapt to the high-tech gear as it becomes even more sophisticated," says Bradford. "The intrinsic beauty and paradox, if you like, of tunnelling is that it involves harsh steel on rock smashing stuff with the finesse of guiding this gear at extreme precision."

Several of our experts also underlined the importance of computer skills. These are required for a wide range of activities from designing in 3D and 4D models - time being the fourth dimension - to



harnessing, analysing and feeding back the vast amounts of data that are generated by equipment and measuring devices during the construction of underground space.

This is a rapidly-developing area, says Galler. "The need for computer skills is really increasing tremendously." Galler comments that it is challenging to interest Austrian students in this topic. "We have more PhD students in this field coming from

outside Europe," he says.

"Engineers who have the ability to conceive, create and communicate these 3D and 4D models will run to the head of the class very quickly," says Essex. "Modelling of expected and actual processes and deformations will redefine the literacy of our engineering business."

For Ross geotechnical know-how will become more important, as tunnels are built deeper in the earth and with larger diameters spanning several different layers of rock. "Geotechnical considerations are a key cost driver," says Ross, "therefore expertise and understanding in this area will become more important." **b**

Modelling of expected and actual processes and deformations will redefine the literacy of our engineering business.

Our Panel



Danilo Abdanur
Construction Manager and Leader of Rail Transport Community, Odebrecht

Odebrecht is a huge international construction firm that employs over 180,000 people, 10,000 of those in tunnelling. The company is particularly active in North, Central and South America and Africa.



Randy Essex
Director of Professional Excellence and Practices, Hatch Mott MacDonald

Hatch Mott MacDonald is a multi-disciplinary engineering firm with a focus on transport, pipeline and water/wastewater infrastructure, and particular expertise in tunnelling. It employs experts across a wide range of fields.



Lok Home
President of The Robbins Company

Robbins has been manufacturing tunnel boring machines, huge mechanical moles that dig their way through the ground, for over 60 years. Its machines and people work on projects around the world.



Gavin Bradford
NorthConnex Construction Manager, Transurban

Transurban manages and develops urban toll road networks in Australia and the USA. The Aus \$3 billion NorthConnex project is a twin 9-kilometer motorway tunnel that will connect the M1 Pacific Motorway to the M2 Hills Motorway, in the suburbs of Sydney.



Robert Galler
Head of Subsurface Engineering at Leoben University & ITA-CET Chair

The ITA is the industry's global body, which helps to set standards and promote the industry and good practice within it. The ITA's Committee on Education and Training (ITA-CET) organises and approves lectures and training sessions around the world.



Matthew Ross
Global Head of Underground Construction, BASF

BASF is a global construction chemicals company whose tunnel division offers specialist products and knowledge to carry out a range of duties, from consolidating and supporting ground to waterproofing tunnels to improving the operation of a tunnel boring machine.

BTS Young Members: Going from strength to strength



01
The current BTSYM Management Committee (left to right): Matthew Breeze (Schools and Universities), Mateusz Wojtasik (Professional Development), Eoin Ó Murchú (BTSYM Chair), Gavin Roche (Media), and Matthew Lane (BTSYM Secretary)

02
Mateusz Wojtasik and the BTSYM contingent on a tour of the Victoria Station Upgrade works

As the British Tunnelling Society Young Members (BTSYM) moves forward into its seventh year, it is clear that the drive and enthusiasm of those involved has yet to wane. The society is growing from strength to strength, with the number of members and active participants steadily growing each year. Regular tunnelling lectures, workshops and socials are organised throughout the UK and the desire to network with tunnelling colleagues across the client-consultant-contractor spectrum is great to see; something that will only improve the UK tunnelling industry in the long term.

The past twelve months have been particularly busy for the BTSYM. The ever popular BTS Design and Construction Course is traditionally seen as the best manner of attracting new tunnelling talent to the BTSYM. The 2014 course was no different with many of the current BTSYM membership attending and assisting with the running of the course at Warwick University.

The BTSYM's regular evening lecture series has continued throughout 2014/2015 to date. The 2015 season kicked off in earnest this February with two successful and greatly received lectures in both London and Birmingham. The London lecture "SCL Liverpool Street & Whitechapel Stations - A Case Study" discussed the design and project management steps utilised in the application of Sprayed Concrete Linings (SCL) on London's Crossrail project, with particular reference to the Laser-Shell technology to improve health and safety and efficiency on site.



Meanwhile in Birmingham, Matt Sykes (Arup) came to the Midlands Arup office in Solihull to discuss their continuing work with the CERN nuclear physics laboratory, which is located on the Franco-Swiss border, near Geneva. This inaugural Midlands talk was greatly received by all and will hopefully offer a greater opportunity for the BTS Young Members working outside of the capital to network.

In April, the BTSYM gave a joint lecture with the London Excellence society on "Developing and maintaining collaborative relationships in business" – a key skill the society aims to facilitate its members in achieving. Further lectures were also held in Derby and Birmingham in early May, with the aim of growing the membership base and becoming



a truly national society. The expansion of the lecture series outside of London has also spurred ad-hoc social and networking events for tunnellers outside the capital – which really is fantastic to see.

In tandem with regular lectures, the BTSYM offers workshops on a variety of tunnelling issues from waterproofing design, to settlement assessment and finite element modelling. In recent months successful workshops were held on “Construction Contracts and Dispute Resolution” with our colleagues from Pinsent Masons law firm and “Non-linear concrete design”. Further workshops will be organised throughout the UK in 2015. Numbers are limited to full BTSYM members initially, which offers an additional incentive for people to join the society.

A number of successful site visits were also organised this year, with members visiting the Victoria Station Upgrade, Tottenham Court Road Upgrade and the Marblaegis Mine, in East Leake.

This year BTSYM engineers have already delivered lectures at Stephenson College, Coalville, and have been active in supporting university events through the Institution of Civil Engineers. Over the spring and summer months the BTSYM Schools and Universities sub-committee shall be building on last year’s success in engaging the next generation of engineers. The BTSYM will be running events in schools throughout the UK and at the regional Big Bang Fairs to showcase tunnelling in May, June and July. The BTSYM has also developed a Teachers Educational Pack for lesson planning around tunnelling science and theory for students who may be interested in civil engineering. This has been trialled in a number of schools in the London area and we hope to roll it out on a bigger scale this year.

An important part of what the BTSYM does is seek recognition for our members for the stellar work they do in the industry. The BTSYM Media team has been hard at work improving our branding and increasing our ever growing social media presence. This year also saw the continuation of our quarterly newsletter, as well as the introduction of our ‘Digging Deep’ interview series. Both have continued to draw great exposure for the BTSYM and the



03 Attendees of the BTSYM 5th Anniversary Dinner gather in the foyer of the Institution of Civil Engineers, London

04 Peter Coppenhall passing on his tunnelling knowledge to engineers of the future at last summer’s London Big Bang Fair

05 The BTS Annual Dinner is an event not to be missed and the young members have made their presence felt in reason years, filling up a number of coveted tables

tunnelling industry, with Digging Deep gaining over 4,500 views on Facebook alone.

The social aspect of the society is also very strong with the annual Christmas Jumper night setting the scene for the festive period each year. With regular formal and informal social events throughout the year, socialising is very much encouraged.

Finally, the BTSYM’s biggest success this year (and possibly to date) was the Conference the society convened on March 27 (see p52). From the superb venue, the numbers in attendance, to the high quality of the presentations given, it went as well as we could have imagined.

The BTSYM has had great year to date and this is down to its hard working and diligent membership – from the management committee to the associate members. Should you require any further information on the BSTYM please don’t hesitate to contact the 2015 Chair Eoin Ó Murchú or visit the BTSYM website, facebook or twitter pages. 



For more information on the BTSYM and its role in the industry, or on any of its upcoming events please visit their website: www.britishtunnelling.org.uk/btsym

 Like them on facebook: www.facebook.com/btstrongmembers

 or follow them on twitter: www.twitter.com/btsym

All other enquiries can be made to: btsym@britishtunnelling.org.uk

A bright future for Norway's Young Members Network

Norway is a country with a long tradition of proud tunnellers and miners. Bringing this legacy to new young tunnellers is part of the Norwegian Tunnelling Society Young Members' mandate. In Norwegian we call ourselves the "Young Network" of NFF, which reflects one of our main goals: to create a platform for students and young tunnellers to build their own personal network in the industry.

The Norwegian young members network (YN) was established in the spring of 2010, as there was a clear need to encourage more young people into the tunnelling industry and, just as importantly, to keep them there.

Our biggest event is a field trip that is arranged every other year. We travel to a specific region of Norway for 2-3 days and try to visit as many interesting projects as possible. These trips have had an attendance of between 15 and 40 young engineers and students, and have been a great success.

The first trip we took was to the west coast of Norway, where the focus was on landslides, subsea tunnels, and the CT rockbolt. The next trip was to the southwest region, with a focus on mining and strait crossings. And last year we visited the north of Norway to see the Røssåga Hydroelectric Project – where the first tunnel boring



machine (TBM) in Norway for 20 years was excavating (see page 28) – and the Rana Gruber iron mine. These site visits were accompanied by presentations from industry experts on hydropower projects, TBMs, and mining.

The day before the annual Norwegian tunnelling conference, the young members network have a tradition of arranging a one-day gathering near Oslo. While in previous years we have visited major on-going projects, such as the E6 Fellesprosjektet, The Løren Tunnel and Holmestrand Station - In 2014 the gathering was held at Atlas Copco's facilities, where the latest Atlas Copco machinery and equipment was demonstrated.

Several presentations on new technology in tunnelling were also given, including some very good talks by recent Masters students.

In addition to keeping young engineers happy, one of the young member network's greatest responsibilities is to encourage young people to choose tunnelling as a career. One of our most important events is therefore the annual "tunnelling evening" at the Norwegian University of Science and Technology (NTNU, formerly NTH). Between 80-100 students typically attend this event and high profile speakers are invited to inspire and motivate students to come and work in our industry.

In addition to these re-occurring events, there are several smaller informal gatherings at different locations throughout the year. Among these was a very interesting debate on the topic "Drill and blast vs TBM tunnelling," which was held with a high-profile panel representing all sides of the industry.

With a booming tunnelling industry and bright prospects for the future, Norway needs good tunnellers. In this setting the Norwegian young member's network has a more important role than ever. 

01 Participants at our site visit to the Rana Gruber iron mine in 2014

02 Site visit at Røssåga hydropower plant in 2014 where we got to witness the revival of hard rock TBMs in Norway!

03 Young students enjoying refreshments after our annual "tunnelling evening" at the Norwegian University of Science and Technology (NTNU).





MSc Tunnelling and Underground Space

Study at the UK's centre of excellence for tunnelling and, in a rapidly expanding global industry where suitably trained engineers are in high demand, your career opportunities will be boundless.

Taught by internationally-recognised academics and industry experts, and developed in partnership with the British Tunnelling Society, our postgraduate course will give you cutting-edge knowledge, understanding and skills to design and build the underground infrastructure of the future.

WARWICK

SCHOOL OF ENGINEERING

We also offer short courses for Continuing Professional Development (CPD).

Accredited by **ice**
Institution of Civil Engineers

Endorsed by **British Tunnelling Society** and **ITA AITES**

warwick.ac.uk/tunnelling

+44 (0) 24 7652 2046

eng-pgadmissions@warwick.ac.uk

Image courtesy of Morgan Sindall

UNDERGROUND AND UNDERWATER (RAMBOLL TUNNELS EVERYWHERE)

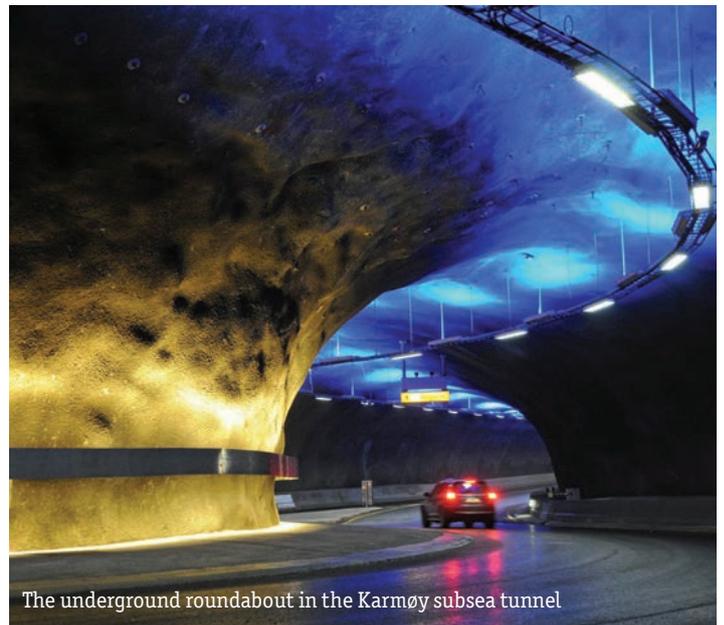
See more at ramboll.com/tunnels

RAMBOLL

WE ARE 12,300 ENGINEERS, DESIGNERS AND CONSULTANTS ACROSS 35 COUNTRIES
WHO ARE CONSTANTLY STRIVING TO ACHIEVE SUSTAINABLE AND INSPIRING SOLUTIONS

Norway's Tunnelling Legacy

The Norwegian tunnelling market is once again booming, and has a number of high profile projects currently underway. These include the world's longest and deepest subsea road tunnel, Rogfast, and the 19-kilometer long twin tube Follo Line rail tunnel. There is also talk of large shipping tunnels, oil and gas excavation from subsea tunnels, and new high-speed rail tunnels. In a country with a population of only five million people, and a strong petroleum industry, who will build these tunnels?



The underground roundabout in the Karmøy subsea tunnel

When you think of Norway, the first things that cross your mind are the Northern Lights, the midnight sun, mountains, steep valleys, beautiful fjords and cold weather – and to be honest this is not just a stereotypical view of the country. This landscape, combined with a population that is widely distributed across the country, explains why Norway has such a long and proud history of tunnelling and underground solutions.

The tradition in many parts of Norway was that the oldest son in the household took over the farm, while the second and third sons were sent out to work as a 'Rallar'. Rallar is a general term for the workers that built the railways and roads in Norway early in the last century. A big part of this job was blasting tunnels. The tradition secured a good work stock that made it possible to excavate the large number of existing tunnels in Norway. If there were bigger projects, the Norwegians could always call in some 'Rallare'* from Sweden.

Young Norwegians currently seem more eager to work in tunnels than they have for



Rolf Martin Myrlund

years. In 2015, the Norwegian University of Science and Technology (NTNU), in Trondheim, received more than three applications per study position for its program in Civil and Environmental Engineering.

Professor Amund Bruland confirms this, and says students are more interested in civil engineering, tunnelling, and geological subjects than they have been for any number of years. The professor's tunnelling classes are now attended by twice as many students as in recent years.

One of these students is Rolf Martin Myrlund. Rolf is about to complete the fourth year of his five-year

masters program in civil and environmental engineering. He has just returned to Trondheim after a five-month exchange programme with the University of Svalbard (UNIS), where he, amongst other subjects, has taken classes in engineering geology in cold climates.

Rolf was spellbound by his first summer internship in tunnelling. "In tunnelling you see progress every day. That combined with all the great and interesting people you meet makes the industry very exciting. I also really enjoy the feeling of being underground with thousands of tons of rock over my head."

This hands-on approach to tunnelling, combined

with the possibilities of working internationally, has convinced Rolf to seek a career underground.

The university in Trondheim (formerly NTH) is widely known for its research on Tunnel Boring Machine (TBM) performance in hard rock, based on the vast TBM project experience Norway gained from the late sixties to the mid-nineties.

Although the Norwegian tunnelling industry was a world leader in mechanised tunnelling at that time, it had been 20 years since the last TBM operated in Norwegian rock when the TBM 'Iron-Erna' (named after the Norwegian prime minister Erna Solberg) began excavation at the Røssåga hydroelectric project, in early 2014. Røssåga was the first of several high profile TBM projects scheduled for next few years, which will reintroduce TBM tunnelling technology in Norway.

As in previous times, when the Norwegians called on the Swedes when a big project came along, the Norwegian tunnelling industry has recently



The Svalbard Global Seed Vault was built into the mountains of Spitsbergen, south of the North Pole, as a fail safe in case of a global crisis

grown more international. Large and challenging projects have tempted international contractors to enter Norway's market and a significantly higher percentage of projects have been awarded to international contractors in recent years. This has manifested itself on the major main contracts for the 19km long Follo railway tunnel, which have all been awarded to international joint ventures.

Safra Abdeen traded exciting projects in Hong Kong to come and work on Norway's Eiganes tunnel about a year ago, and is now working as a Tunnel Engineer on the project. The Eiganes tunnel is part of a greater refurbishment of the road system on the Norwegian west coast, which also includes the 14km Ryfast subsea tunnel and the 26.7km Rogfast Subsea tunnel. When completed, the Ryfast tunnel will be the longest and deepest subsea tunnel in the world - but only for a few years, until the Rogfast tunnel is finished and takes over the world record.

Safra has been well received in the Norwegian



The Laerdal Tunnel is the longest road tunnel in the world



Safra Abdeen

tunnelling community, and is already fluent in Norwegian. "Organisations are generally flatter on Norwegian tunnelling projects. Tunnellers are given more responsibilities and work more independently. There is also a larger focus on getting real results and a greater feel of cooperation between the

different parties involved."

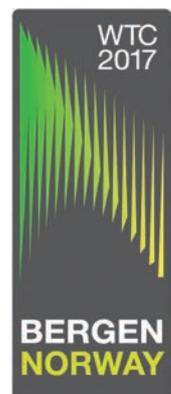
Safra first became interested in the tunnelling industry due to its big machines and explosives. She elaborates: "Tunnelling is an important job that builds societies. It is also practical hands-on work, which gives physical results and a real sense of accomplishment."

Both Rolf and Safra see a good future in the industry. "Both domestically and globally the tunnelling industry has very good prospects. A lot of the challenges we see in regards to globalisation and centralisation can have effective solutions underground," says Safra.

With all-time high applications and graduations from universities,

technological developments, and internationalisation, the Norwegian tunnelling industry is better prepared than ever to take on these new megaprojects and the future challenges offered by society. The future for young people that have chosen a career underground seem brighter than ever. 

**The life as a 'Rallare' in Norway is beautifully described in Jan Guillou's book "The Bridge Builders" published in 2011.*



Norway will be the host of the 2017 World Tunnel Congress in Bergen

Book Club

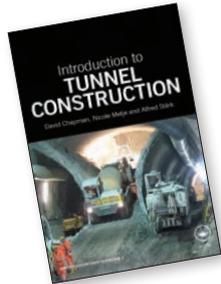
Breakthrough visited some popular LinkedIn tunnelling groups and asked members of the industry to nominate their top books for young tunnel engineers. This prompted a bit of a debate, with many pointing out that soil and rock mechanics should come first, but here are our top five!



1 Underground Excavations in Rock

Evert Hoek & E. T. Brown

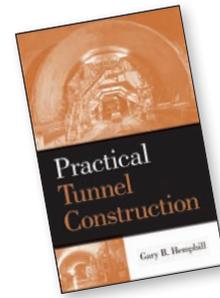
By far the most nominations were for books written by Dr Evert Hoek et al., with *Underground Excavations in Rock* topping the list: "I literally pulled apart two paperback versions of 'Underground Excavations in Rock' to use as training manuals for young tunnel engineers on Hydro projects in Sri Lanka, Papua New Guinea and Manila," Rab Brown, Klang Valley MRT, Malaysia.



2 Introduction to Tunnel Construction

David Chapman, Nicole Metje & Alfred Stärk

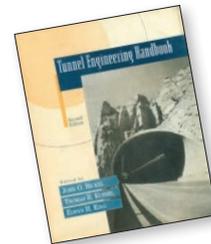
This book covers a whole range of areas that you need to know to embark on a career in tunnelling. It also includes a number of case studies, to demonstrate how the theory applies in practice. Clear, concise, and heavily illustrated, this is a book aimed at final-year undergraduates and MSc students and is an invaluable starting point for young professionals.



3 Practical Tunnel Construction

Gary Hemphill

Practical Tunnel Construction is an important resource for students. By taking the reader through a brief introduction and history, to a comprehensive discussion of how geological factors affect tunneling, Hemphill covers the various stages and technology that are common without using complex equations.



4 Tunnel Engineering Handbook

Edited by John O. Bickel, Thomas R. Kuesel, Elwin H. King

This Handbook provides comprehensive coverage of the design, construction, and rehabilitation of tunnels, bringing together information on all the principal types of tunnels. An essential resource for all practicing engineers engaged in the design of tunnels and underground construction.



5 Handbook of Tunnel Engineering I & II

Bernhard Maidl, Markus Thewes, Ulrich Maidl

This two-volume handbook has been the standard reference for German-speaking tunnellers for nearly 30 years. The English edition is based on a revised version of the third German edition and reflects the latest knowledge in geomechanics, structural design, machine and construction process technology and construction management.



The Basics

"Study the basics in mechanics and mathematics, structural engineering, strength of materials, concrete and steel design – Terzaghi for soil mechanics and Goodman for rock mechanics. That's all you need! Go on site, listen and learn, and get dirty!" Hannes Lager, Global Contractor Business, Arup.



The Web Site

"Evert Hoek, a leading industry expert on rock mechanics, has a comprehensive reference library and video series available online called 'Hoek's corner', a great resource for today's generation," Jens Classen, Director of Mechanized Tunnelling, Toto Costruzioni. www.rocsience.com/education/hoeks_corner



The Trade Press

Several of the industry's trade press share free content on the internet. Both 'Tunnelling Journal' and 'Tunneltalk' have full archives that are free to access online, and this content collectively offers a vast resource of technical articles by industry experts and international project reports.

ITA TUNNELLING AWARDS 2015

19 November 2015 | Hagerbach | Switzerland

The ITA has announced its first independent awards initiative: The 2015 ITA Awards Conference and Banquet, which will be held at the Hagerbach Underground Conference and Exhibition Gallery, in Switzerland.

The awards are designed to identify and celebrate outstanding achievement in tunnelling and underground space development, and promote recognition of the industry's remarkable contributions to engineering and society.



It is time to raise awareness of the vital work in which our industry is engaged and the challenges that are faced, and overcome, in the development of underground space.

ITA President
Søren Degn Eskesen

Judged by a panel of eminent industry experts, the ITA Tunnelling Awards will shine a spotlight on the individuals, companies, and project owners behind the very best projects and innovations.

Entries from every corner of the world are welcome in the following categories:

Outstanding Project of the Year - up to €50 million

Tunnelling Project of the Year - between €50 million and €500 million

Major Project of the Year - more than €500 million

Renovation/Upgrading project of the Year

Technical Innovation of the Year

Environmental Initiative of the Year

Safety Initiative of the Year

Innovative Use of Underground Space

Young Tunneller of the Year.

Nominations should be submitted by Friday August 14, 2015, through the ITA's dedicated Awards website: awards.ita-aites.org

Follow the ITA Tunnelling Awards on twitter: @itaAward

Canadian Young Members Gets Established



The Canadian Young Members Group was initiated by creating a Director position on the Tunnelling Association of Canada's (TAC) Board for a person to be responsible for initiating and leading the Group.

With support and encouragement from the Board, the first official meeting was held in conjunction with the TAC 2014 conference, on Oct 29, 2014, where 25 young professionals met for dinner and a productive discussion about what everyone would like to see from the TAC-YM. There were many great ideas and volunteers for outreach activities.

Since our first meeting, we have had young professionals visit the University of British Columbia and McMaster University and give presentations on what it is like to work in the tunnelling industry to undergraduate and graduate level courses.

The TAC-YM Chair, Nichole Boulton, is currently working on two small hydropower projects, and has been able to take small groups to site to observe the day to day tunnelling activities and the work that a tunnel geologist performs (see p32).

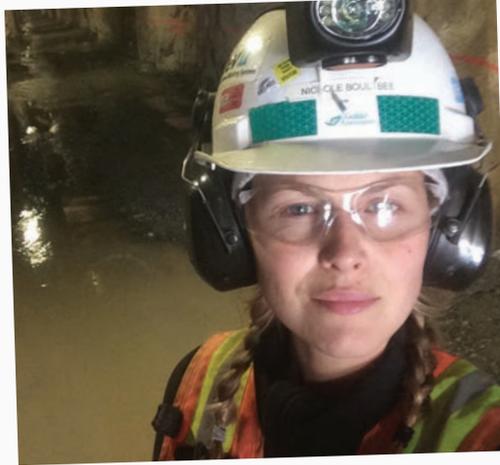
The TAC hosts a monthly lecture



series with invited speakers, which is well attended by its members, young members and students – the speaker for the month of April was a Young Member presenting a watermain upgrade for the City of Vancouver.

In the coming year there will be more opportunities for visits to local Vancouver tunnel projects, and additional outreach at universities. The TAC 2015 Workshop will also be held at Queens University, in Kingston, Ontario, and we hope to see increased involvement from that area of the country as a result.





Nichole Boulton
Engineering Geologist

A Week in my Life

Nichole Boulton is an Engineering Geologist with Golder Associates, based in Vancouver, Canada. She has ten years of experience in engineering investigation, design, and construction for tunnelling and infrastructure projects in Canada, Australia, and Chile. Nichole specializes in rock support design and construction supervision to monitor design compliance in tunnels. She is currently working on two hydroelectric tunnels.

Saturday

5.30am. Leave home for Tunnel #1 east of Vancouver. This particular day I have arranged to bring two members of the Tunnelling Association of Canada's Young Members Group to site with me, there were grumbles about the early Saturday morning, but they were excited for the opportunity to see a drill and blast tunnel in operation! After travel to site and safety orientations, its 9am when we hurry in to inspect the Upstream tunnel excavation, as the crew is currently loading the round for the next blast and we want to have a look before they push the button.

With the smell of explosives in the air I explain the procedure to the YM's and observe the tunnellers in action. I inspect the rock mass and complete my mapping of the tunnel face, crown, and sidewalls, and show the YM's some of the more interesting rock properties before we briskly walk out so they can finish up and blast. By 10.30 we are walking in to the Downstream end of the tunnel and



Inspecting and mapping
the tunnel rock mass

we find the tunnellers have mucked out the recently blasted round, and they are preparing to install the pattern support. We spend some time mapping the rock mass and discussing the support to be installed, then proceed to make our way out of the tunnel. The geology has been

doing some interesting things in the recent rounds, and there are some very interesting quartz veins and intrusions to look at, so there is some definite rock-nerding and sample collecting happening on the walk out. By 3pm the YM's are back in Vancouver and able to enjoy the rest of their sunny Saturday afternoon.

~~Sunday~~
A day off
Finally!!

Monday

5.15am. I leave Home for Tunnel #1 with a senior geotechnical engineer and a junior geotechnical engineer (again – grumbles about the early morning!). The senior engineer is coming along to review my work and advise on the recently changed and interesting geology on site, and the junior geotechnical engineer is training with me in preparation for starting work on our other tunnel project north of Vancouver.

Prior to heading into the tunnel we start with examining rock outcrops at the portal and discussing the alteration and deformation that we see. We then head underground, and while I'm completing my tunnel mapping and support observations I talk through it all with my trainee and making sure he understands the structures that I'm observing, and the feature measurements and data that I'm collecting.

My reviewer is standing back and observing both of us, taking in all of the interesting geology to come up with a large scale idea of what types of deformation our rock mass has experienced in its life. After a slow walk out of the tunnel that includes many stops at points of interest in the rock we are ready to leave site early afternoon. 5.00pm we arrive back at the office and meet with our project director where we discuss our day and briefly switch gears in the discussion to the design that needs to be produced ASAP for Tunnel #2 that is getting ready to start construction. 5.30pm home.



Tuesday

Office day - 9am. The day starts with taking the site truck in to the shop for some maintenance, and then promptly gets busy with organisation and design and drawing review for Tunnel #2, completing daily reports, and mapping records for Tunnel #1.

I fit in a sushi lunch with the bosses – which is mostly filled with planning discussions regarding how to finish off Tunnel #1 and start up Tunnel #2 at the same time. We decide that we are all very busy, and should probably seek assistance from other staff in the office in order to get our deliverables to the client on time (and that we all would rather be on the beach in Mexico).

The day finishes with a conference call discussing management options for potentially acid generating tunnel rock at 6pm.

Always time for sushi!



Thursday

6.45am. I leave the office for Tunnel #2 with the senior and junior engineer (we were supposed to leave at 5.30am – but the grumbles about the early mornings were louder when I tried to make it happen twice in one week...).

Our site visit is to do an initial tunnel inspection after the tunnel has been closed for the winter. We look for any changes that may have occurred, and observe some small blocks that have fallen from the sidewalls, and some minor shear zones that have degraded slightly. Overall the tunnel is in very good shape. We complete our tunnel works, and get the junior engineer settled at site and ready for drilling supervision the next day. When we return to the office at 3pm, there is just enough time for another round of design drawings review, home by 6.30pm.

Friday

5.30am. Mapping and support inspection at Tunnel #1 again. I anticipate a normal length day, however there are additional inspections required just as I am finishing my normal mapping and support inspection duties. As the tunnel will be completed soon, recommendations regarding the final state of the tunnel are required. My very long, but productive, week finishes at 7.30pm when I arrive back home. 📍



Back in the office reviewing designs and drawings

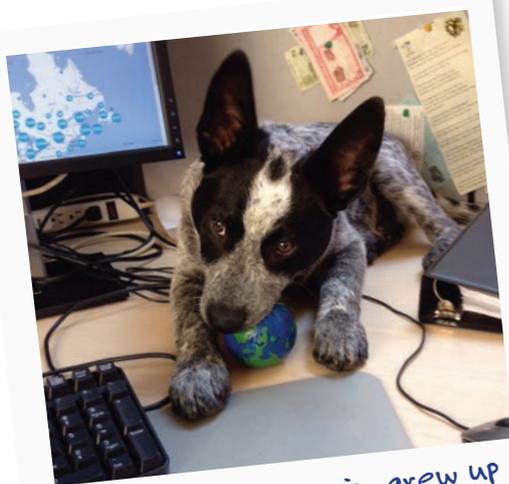
Wednesday

5.30am. I am back out to Tunnel #1. I have no visitors with me today, so it's a quicker visit. I'm able to inspect the Upstream and Downstream tunnel faces, and the support installed within a couple of hours.

I arrive back at the office at 3.05pm – just in time to be five minutes late for another conference call on the tunnel rock management options. At 5.30pm I'm free.



Mapping and support inspection at Tunnel #1



Nichole's dog, Kevin, grew up hanging out in the office

Going Underground

Tunnels and underground space have a vital role to play in the urban development of the world's cities. Antonia Cornaro, Business Development Manager for Amberg Engineering and Vice Chair of the ITACUS Committee highlights some current examples.

Tunnels have been part of the urban fabric of our cities for a very long time. In the early 7th and late 8th centuries BC, engineers created the Siloam Tunnel underneath the City of David, in Jerusalem. It was intended to transport water and as such is an early example of a utility tunnel.

In modern times, tunnels started to play an important role in cities, first for sections of railway and later to carry the first metro systems in cities like Moscow, Paris and London. New York City could probably not function as a city without its extensive subway system, and the same holds true for London, which continues the expansion of its underground transport system today with the £18 billion Crossrail project.

Efficient and sustainable infrastructure is vital for economic development, which is why virtually every major urban metropolis is building or extending rapid underground transport and utility tunnel systems to cope with growing populations and the corresponding demand for mobility. But a city's underground space can be used to much greater effect if it is considered for a whole range of other functions too, freeing up ground-level space for other uses including green spaces, and helping to reduce the impact of climate change.

Today, over half the world's population is urban but population forecasts show this figure will rise to 80% by 2050. The future mega cities will be concentrated in South East Asia, the Americas and Africa. But Europe will see urban growth too. Of the medium-sized cities, for instance, Stockholm is one of the fastest growing, meanwhile Paris, London and Moscow will soon have to serve 10 million inhabitants and upwards.

Already we see a growing trend towards making better use of the underground. Data centres, shopping centres, archives, libraries, art galleries, swimming pools, sports centres and warehouses have already been built beneath major cities.

Bars, night clubs, and even restaurants, are appearing in disused former bunkers,

ideal, because there are no noise issues.

In the crowded city of Tokyo, Japan, engineers have created automated underground bike storage facilities, which transport bikes from the surface to racks below ground. Locating data centres underground brings multiple benefits. Not only is the land above-ground preserved for other uses, but waste heat from the computer servers can be used to efficiently heat homes, as seen in Helsinki, Finland.

Today it is possible to build underground in most soil conditions. Although it is most cost effective to build in hard rock such as granite, there are sophisticated techniques to build in soft sedimentary rock and even under water.

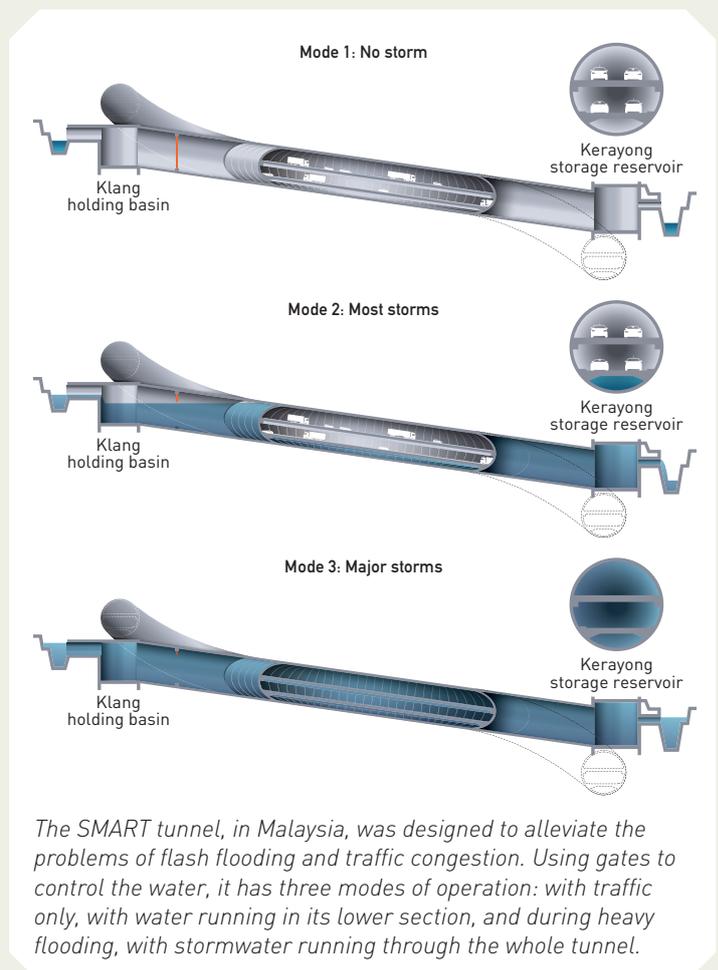
Land use issues aside, there are many other advantages to building underground. Buildings and infrastructure housed beneath the earth's surface are better protected against climate threats caused by the greenhouse effect such as floods, heavy rain or erosion.

Bangkok and Kuala Lumpur have underground infrastructure tunnels for storm water runoff to store water during heavy rainfalls and protect the city against floods. The Stormwater Management and Road Tunnel (SMART) in Kuala Lumpur, Malaysia – which opened in 2007 – had paid

for itself within three years of operation by alleviating seven potentially disastrous floods in the city centre.

A further advantage of building underground is that it requires less energy to maintain a constant temperature – something that may be of importance when we start to experience more extreme temperature swings. Additionally, it helps us create more sustainable developments by reducing our energy demands.

Below, we take a look at some recent and ongoing projects. Some demonstrate the positive impact of tunnelling on urban and economic development, while others showcase some of the more unusual uses to which the world's cities are putting underground space.



01 London: old railway shaft becomes cultural venue

The Rotherhithe shaft was completed in 1843 and used as an entrance to the Thames Tunnel and to provide ventilation for the steam trains that ran in the tunnel. Its construction was revolutionary in its day: a brick tower was built above-ground and then allowed to sink into the soft ground by the river.

Closed to the public 150 years ago, visitors to the Brunel Museum, which is housed in the Thames Tunnel Engine House next door, can currently view the shaft, which is protected due to its historical significance, via a temporary staircase. The museum is fundraising to provide more permanent access and to transform the shaft into a gallery and performance space.



02 Singapore: underground science park saves limited land on the surface



Currently in the feasibility stages, the developer behind Singapore's Underground Science Park is government agency JTC, which is responsible for Singapore's industrial infrastructure. Situated on land between Science Park 1 and Science Park 2, near Kent Ridge, in Singapore the underground building would house

laboratories, offices and a data centre.

One of the challenges of creating underground space is that the initial capital investment is higher. But in Singapore, land is extremely limited, which could mean that this ambitious project becomes a reality. JTC has already built an underground oil storage facility at Jurong Island.

04 Stockholm: growing the metro and the population

Stockholm is planning to extend its metro line from Odenplan to Arenastaden, the city's new commercial and entertainment district, by 2025. It is an overall investment of 20 billion SEK that will extend four lines, all of which are in central urban areas requiring complex tunnelling works.

The new lines will allow the urban population to grow and allow people to move between new housing areas and employment centres as well as recreational areas. Amberg Engineering is involved in the planning and design of the extension of one of these metro lines.

03 Sochi: building a new economy



Construction of a 4.4km railway and a 3.2km road tunnel near Sochi, in the Russian Krasnodar region, made the Winter Olympics possible and the mountains and ski resorts more accessible to a greater number of people.

The railway tunnel, for which Amberg Engineering was consultant and adviser, presents an important element of the only rail line to connect the Sochi resort with central parts of Russia. As well as carrying cargo traffic to supply the construction sites in Sochi, the tunnelling projects provided important new transport links aimed to boost Sochi as a major all-year-round tourist resort with skiing during the day and sea-bathing in the late afternoon.

Critical voices have questioned the government's mega-investment into the region. But the new tunnels will provide an instrument for boosting urban and economic development for years after the Olympic Games.

05 Gotthard Base Tunnel: linking Europe

At 57km long, the Gotthard Base Tunnel is the longest high-speed rail tunnel in the world. The economic benefits of the high-speed rail link through the Alps will come from its ability to provide a faster and more reliable link between northern and southern Europe. It will also enable a shift of freight traffic from road to rail.

Due to open in June 2016, the Gotthard Base Tunnel was built using TBMs and Drill & Blast tunnelling and is now being fitted out with electrical and mechanical equipment. It is one of three tunnels – the others being the Zimmerberg and Ceneri Base Tunnels – that make up the Gotthard rail link, which will reduce travel times between Zurich and Milan from the current 4 hours, to 2.5 hours.



06 Madrid: underground motorway revives city



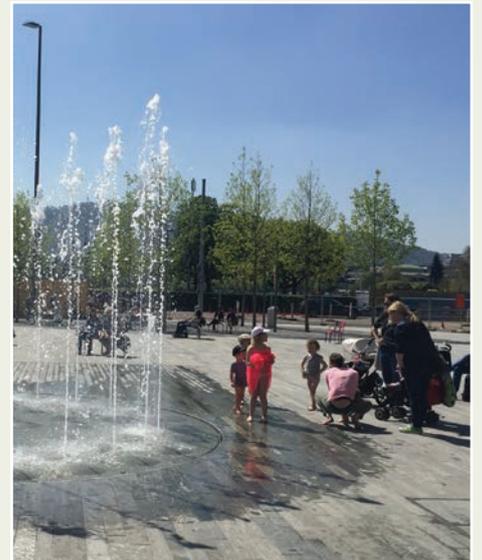
Spain's M30, a multi-lane highway, once brutally divided the city of Madrid into two parts. Now half of the 100km-motorway runs through the city in a tunnel. The tunnel freed up 80 hectares of land for new parks, promenades and open spaces along the river Manzanares, which was previously cut off from Madrid's inhabitants by the highway with the land around it largely abandoned.

City residents and tourists alike

now benefit from the mammoth tunnelling project. The transformation has had a direct impact in the form of soaring property prices and is a great environment for walkers and joggers.

Many other cities have embarked on projects to move their inner city highways underground. Those with similar recently completed or ongoing projects are Oslo, Boston, Seattle, Sydney, Seoul and Rio de Janeiro.

07 Zurich: from car park to public space



The Sechseläutenplatz, in front of Zurich Opera House, is now Switzerland's biggest urban open space. But the 16,000 square metre town square has only recently been reclaimed. Much of the square had been used as a car park since the 1960's, but now nearly 300 cars can be housed in an underground parking garage.

The project has been 13-years in the planning, design and construction, a process that was slowed down by the discovery of thousands of archaeological remains during the nine-month dig. The area is now a well-used public space and tourist attraction with cafés, outdoor events, trees, seating and a fountain.

08 Rotterdam: rail makes way for new community



The visually stunning horseshoe-shaped Markthal Rotterdam opened late last year, and is home to a huge food market, as well as 228 apartments. Its construction was made possible by relocating an elevated 19th Century rail line below ground into a cut-and-cover tunnel, which runs for 3km below the city surface.

As well as freeing up space for new living accommodation and shopping, the move is expected to boost Rotterdam's economy, with between 4.5 and 7 million visitors to the market predicted each year.

09 Suez: boosting a whole country



The expansion of the Suez Canal, which runs between the Mediterranean and Red Seas, is at the top of Egypt's economic agenda. The £8 billion development plan includes a new channel alongside the existing one – which will double the number of ships able to pass each day – and six tunnels to connect the Sinai peninsula to the main part of Egypt.

The development will have a tremendous effect on Egypt's economic output. The tunnels will open up the Sinai peninsula for development, which has had poor links to the rest of Egypt, with plans to transform a 76,000 square kilometre area into a logistical, industrial, technological and educational centre.



What is the ITACUS mission?

ITACUS is the International Tunnelling and Underground Space Association's (ITA) Committee on Underground Space.

ITACUS believes the use of underground space can significantly contribute to meeting numerous global urban challenges by:

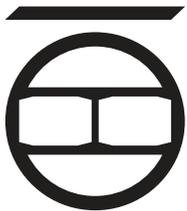
- Helping cities cope with rapid urbanisation and the related shortage of space
- Making cities more resilient against natural hazards and the effects of climate change

By telling the world and engaging fellow professionals in conversation, ITACUS is working for 'an urban underground future'. Twice a year ITACUS organises a roundtable to discuss opportunities, challenges, policy issues and legislation relating to underground construction. Around the table are designers, urban planners, architects, politicians, officials and researchers as well as representatives from contractors and transportation and energy companies.

Acknowledgments

The author wishes to acknowledge the work of the ITA Committee on Underground Space (ITACUS), which is committed to an urban underground future, and especially its Chair and thought leader on underground space, Han Admiraal. Working together with international professional partners such as ISOCARP, ICLEI, and IFME and policy leaders such as UN Habitat and UNISDR, ITACUS contributes by demonstrating how an urban underground future will help cities to become resilient and sustainable.

Status report from the Young Members in Denmark



01 & 02
Danish Young Members visit the 620m long Nordhavnsvej cut and cover tunnel, which is part of Copenhagen's new Northern Harbour Link highway bypass

03
Members of the DFTU-YM visit the underground works for the Brewhouse Project

On a fresh but cold February evening in 2014, the Danish Society for Tunnelling and Underground Activities established a Young Members Group as part of its organisation. The purpose of this group is to create a technical and social networking platform among young professionals in the industry and to promote awareness of the tunnelling industry and the use of underground space.

The first meeting of the Young Members Group, called DFTU-YM, took place on February 26, 2014. The event included a keynote speech from Jon Banyai (co-founder of the BTSYM), a presentation on the Fehmarnbelt Fixed Link project (see opposite page) and the founding of a general assembly. The meeting attracted around 40 young professionals who immediately signed up for membership, and the general assembly voted for the establishment of a Steering Committee to ensure that regular events and meetings were planned.

Following the establishment DFTU-YM, the Steering Committee got itself organised, and membership of the group has grown to around 60 participants. The first official event following the founding meeting, was arranged in June, when around 25 young professionals visited a construction site (the Brewhouse Project) at Copenhagen's harbour front.

"The Danish Young Members Group aims to try and arrange events where participants can get the

inside story on some of the complex underground works that are currently being constructed. It is very interesting to hear discussions from different sides of the industry – designers, contractors and clients – sharing their views on the technical aspects of these projects and getting to know each other in another forum," says Lasse Vester, Chair of the DFTU-YM.

Danish YM site visits

In the fall of 2014 the Danish Young Members group arranged an event on Sprayed Concrete Linings (SCL), with an introductory lecture by Alun Thomas, head of the tunnelling department at multi-disciplinary engineering firm Ramboll. Following this, a site visit was arranged to the refurbishment works at the New Nørreport Station, an underground station on Copenhagen's rail/metro system where sprayed concrete has been used.

"Further to the events the DFTU-YM arranges, the young members also participate in events arranged by the Danish Tunnelling Society, in order to bridge the gap between generations," says Lasse.

In the coming year, the DFTU-YM plans to arrange site visits to a several tunnel projects in the Copenhagen area and hopefully another "technical topic special" on TBMs. The Danish Young Members will also participate at the 2015 World Tunnel Congress, in Dubrovnik, where they will be present at the ITAYM stand in the exhibit area. 

Follow the Danish Young Members on



Building the world's longest immersed tube tunnel

Denmark has a tradition of building fixed links, as both large bridges and tunnels. In the past 25 years, the Great Belt Bridge, connecting the islands of Funen and Zealand, and the Øresund Fixed Link, connecting Denmark and Sweden, have been built. Together these links make it possible to travel from mainland Europe to Sweden, and the rest of Scandinavia, through Denmark.

The country is now planning to build a third fixed link, between Denmark and Germany, under the Fehmarn Strait. The Danish state, through client organisation Femern A/S, is taking on a huge challenge with this new link. The project will



I have contributed with technical input to the Environmental Impact Assessment, been part of the development of the tender documents for the immersed tunnel, and I am heavily involved in the development and execution of our Building Information Management (BIM) approach.

Lasse Vester, Design Engineer, Femern A/S

be built as an 18km long immersed tube tunnel that will carry both rail and road traffic. As well as being the world's longest immersed tube tunnel, the Fehmarnbelt tunnel will also serve as the world's longest combined road and rail tunnel.

The tunnel is an EU priority project on the TEN-T infrastructure network. It will link with existing road and rail infrastructure in Copenhagen and Hamburg, and slash 160km off of the current 350km journey between the two cities. This will cut 45 minutes off journey times by car and reduce train journeys by an hour and a half.

Young engineer Lasse Vester, 27, works as a Design Engineer with the client Femern A/S, who has



the task of designing, planning and overseeing the construction of the fixed link. "Working on a project of this scale is of course immensely interesting! I have a lot of different responsibilities in our organisation. I have contributed technical input into the Environmental Impact Assessment, been part of the development of the tender

documents for the immersed tunnel, and I am heavily involved in the development and execution of our Building Information Management (BIM) approach. Working across such different roles makes you realise just how many areas of expertise are required for such a project to come to life," says Lasse.

The tunnel will be the largest infrastructure project ever taken on in Denmark, as well as one of the largest in Europe at the moment. The project is currently in the late stages of global tender. Contracts are expected to be signed this year, and construction of the tunnel is scheduled to commence in 2016. The cost of the project is estimated at around 7 billion Euro.

Status report from the Young Members in Australasia



The University of Queensland Geotechnical Engineering Centre, in collaboration with the Australian Geomechanics Society (AGS), has hosted a number of "Roadshows" to introduce geotechnical, geomechanical and tunnelling engineering disciplines to students enrolled in any aspect of engineering

The Australasian Tunnelling Society's Young Members (ATSYM) hold events throughout the year in Australia and New Zealand. As our membership is so geographically spread out, ATSYM's are as a general rule, encouraged to attend the free ATS technical sessions that are run once a month in individual states. These sessions provide a great opportunity for professional development and networking, as well as information on current projects.

There are currently six state ATS Committees. These are overseen by the ATS National Executive Committee, which includes the ATS Young Professional Engineer, who represents Australia as one of the ITA Young Member Nation representatives. ITAYM Chair Jurij Karlovšek is the current ATS Young Professional Engineer.

In addition to the ATS' technical events, the ATSYM also participate in the following events:

The University of Queensland (UQ), in collaboration with Australian Geomechanics Society (AGS), has hosted a number of "Roadshows" to introduce geotechnical, geomechanical, and tunnel engineering disciplines to engineering students. To date, four half-day roadshows have been organised at UQ, Brisbane, and similar events have also been hosted at other universities in New South Wales and Victoria.

The ATS Biannual Tunnel Design and Construction Short Course 2015, will be in Brisbane, on the 7-9 October. Young professionals attending the course are encouraged to submit project posters, which will be presented and discussed at one of the event's social functions. On Friday 9th October, technical experts from the industry will provide practical demonstrations in a live project environment at the

Mt Coot-tha Quarry. During this workshop, delegates will be able to participate on a number of tunnelling applications.

A number of tunnelling conferences (including those run by Criterion and Informa) and the 15th ATS Conference (supported by AusIMM), have all taken on board the need to reduce fees for YMs, and have provided free passes for students with an interest in tunnelling and underground space construction. At the last event held in Sydney, 14 students were given free passes, where they were introduced to Australasia's thriving tunnelling industry.

ATSYMs, students, and members of the public were also invited to several site visits in 2014. This year the following site visits have been arranged: QLD – Legacy Way Project and Woolloongabba sewerage upgrade Projects, in Brisbane; NSW – T2E St Helena Tunnel in Ewingsdale, in Byron Bay, the VAPS Project (Vehicle Access and Pedestrian Safety Project) under the Sydney Opera House, and the North-West Rail Project, in Sydney.

Other ATSYM news

Typically, between February and April each year, companies advertise graduate positions to students. ATS YM Victoria Representative Berni Hines has suggested that the ATSYM should put together a framework presentation pack that promotes the Australasian tunnelling market to students before this advertising goes out. Berni has proposed two packs, catering to First and Penultimate year university students. The presentations would cover topics such as an induction to tunnelling, current tunnelling projects, looking for the right employer, networking and technical societies.

Two undergraduates (Tim Gibson and Tim Shaw) have been engaged in their final Honours thesis on Fire and Safety aspects of the BaT (Bus and Train) Tunnel project. ATS YM QLD representative Keith Bannerman organised a site visit to the Legacy Way project for the students, to further their understanding of the tunnels' construction.

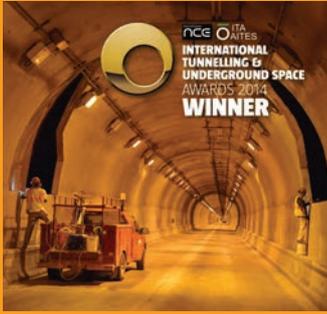
Over the year, ATSYMs have been invited to attend several social events with ATS members. These are generally casual in nature, but generate a lot of technical discussion. It is common that ATS sponsors cover the costs of these events, and the ATSYM gives its thanks for their continued support. 

ATS TUNNEL DESIGN & CONSTRUCTION SHORT COURSE 2015

Short Course:
7-8 October 2015,
Marriott Hotel,
Brisbane, Australia

Tunnelling Applications Workshop:
9 October 2015,
Mount Coot-tha Quarry,
Brisbane

A World Leader in Tunnel Engineering, Geotechnics, and Construction Management



- Crossrail, London
- Riyadh Metro
- Silver Line, Washington, DC
- Vauxhall Station, London
- Chinatown Station, San Francisco
- Istanbul Straight Crossing
- Bond Street Station, London
- East Side Access, New York
- Sentosa Gateway, Singapore
- University Link, Seattle
- Santiago Metro
- Port of Miami Tunnel
- Ruta del Sol, Bogotá



Gall Zeidler Consultants
 GEOTECHNICS | TUNNEL DESIGN | ENGINEERING

www.gzconsultants.com

Washington, DC • London, UK • New York, NY • Walnut Creek, CA • Salzburg, Austria • Singapore • Santiago, Chile

THE UNDERGROUND ENGINEERING EXPERTS



Regensdorf, Sargans, Chur (Switzerland), Bratislava (Slovakia), Brno (Czech Republic), Drammen (Norway), Gurgaon-Haryana (India), Madrid (Spain), São Paulo (Brazil), Singapore
www.amberg.ch



2nd Arabian Tunnelling Conference

Young Engineers Forum | 9-10 December 2014 | ADNEC, Abu Dhabi

01



01
The stunning Abu Dhabi skyline at night

02
Petr and Jurij prepare for the panel discussion

03
Olivier Vion presents at the Young Engineers Forum

The Arabian Tunnelling Conference & Exhibition (ATC) was held on the 9-10 December 2014, in Abu Dhabi, UAE and was inaugurated by His Excellency Essa Al Maidoor (Chairman of the United Arab Emirates Society of Engineers). As part of the conference, Maged Farouk Hanna (General Manager of the UAE Society of Engineers), introduced the Young Engineers Forum, an initiative to present the challenges involved in tunnelling and underground space projects to young engineers and students.

The programme also dealt with the importance of continuing professional development, as well as how best to forge a career in the tunnelling industry.

The forum was one of the highlights of the ATC2014 and generated a high level of interest from more than 100 students from various universities in the region. They listened enthusiastically to presentations by leading international speakers and participated in a lively Q&A panel discussion.

The forum began with a presentation by ITA President, Søren Degn Eskesen, followed by Professor Edgar Small (American



03



University in Dubai), Jonathan Cottam (Managing Director of Gulf Rock), Karin Bappler (Head of Geotechnics at Herrenknecht), Nick Chittenden (Regional Manager of BASF) and Olivier Vion (ITA Executive Director).

The panel discussion was chaired by Professor Small, and consisted of Zenah Mattar (Junior Project Manager at Furgo), Jurij Karlovsek (Postdoctoral Research Fellow at The University of Queensland) and Petr Salak

(Senior Tunnel Engineer with Dr. Sauer & Partners). The questions asked of the panelists covered a broad range of topics; from the specific nature of how each of the young engineers got into tunnelling, to outlining their understanding of management and leadership in the industry, and their vision of what it really means when we speak of sustainable impacts in tunnelling.

The panelists were required to reflect on whether or not their undergraduate education prepared them for the demands of industry and the expectations of their bosses. The liveliness of the discussion also came from the fact that the panelists asked questions of the students in the audience, in order to glean what their future intentions were.

All in all, the panel discussion was an informative, frank and successful undertaking and brought together a diverse group of young engineers who were able to impart some of their experience, vision and insight into the tunnelling industry.

It is hoped that the Young Engineers Forum will once again take place at the next Arabian Tunnelling Conference, which will be held in Dubai on the 23-25 November 2015. More information about this conference can be found at www.atcita.com.

As an incentive for students to come and attend the Young Engineers Forum in Dubai this year, it should be pointed out that the price of registration is four times lower for students than the regular registration fee. This is an example that should be taken up by other conferences and the ITAYM Group is looking forward to future cooperation with the UAE Society of Engineers. 

What does yoga have to do with tunnelling?

FameLab is an international communications competition designed to engage and entertain by breaking down science, technology, and engineering concepts into short three-minute presentations. Contestants from around the world take part armed only with their wits and a few props that they can carry onto the stage.



At the FameLab UK final, Aimi Elias, a Project Engineer for London Underground, explained

how Sprayed Concrete Linings (SCL) are being used on the Crossrail project (see p12), with the help of some yoga moves.

“Engineering is under-represented when it comes to public engagement. I’d like to invite all young engineers around the world to be more vocal about what it is they do, and share their passion,” says Aimi. “Some people think speaking well in public comes naturally, but communication is a skill that can be learned – I wasn’t able to speak in public like this a year ago. It’s been a great learning experience, and I have built up skills I will use throughout my career.”

The 2015 international FameLab final will be held at the Cheltenham Science Festival, in the UK, this June and will be streamed live for all to watch.



To find out more about FameLab and the countries participating visit: www.famelab.org

To see Aimi’s talk, watch this video at the 59th minute: <https://youtu.be/9ze4aRoLKzq>

THE MSC GRADUATE



Senthil Nath Geoconsult Asia Masters in Tunnelling and TBMs Politecnico di Torino, Italy

Senthil Nath is an Executive Civil Engineer with Geoconsult, in Singapore. He recently completed the ITA endorsed Masters course in Tunnelling at the Politecnico di Torino, in Italy.

Q: How did you become interested in engineering?

A: My father was a civil engineer with Indian Railways and I became interested. After school I studied civil engineering at Anna University, in Chennai, covering every aspect. I became attracted to geotechnics and soil mechanics and was able to do a Masters in Geotechnical Engineering, via a German student exchange scholarship. It was a sandwich course with one year at the India Institute of Technology and the rest at the Technical University in Dresden.

Q: What got you into tunnelling?

A: I was able to find work as a Geotechnical Engineer with Keller India, in New Dehli, for two years – gaining contracting experience – and then to expand the design side, I managed to join Golder Associates, covering fields from mining to rail. But I became increasingly interested in tunnelling, which seems to me to cover all aspects of engineering.

Q: Why did you decide to do the ITA endorsed Masters in Tunnelling and TBMs at Turin?

A: I discovered the Turin course browsing the internet, and the possibility of a scholarship through the ITA Committee for Education and Training (ITA-CET) Foundation. I managed to get the scholarship and quit my job.

Q: What did you like most about the course?

A: The course is very industry orientated, with up to date information appropriate to starting work immediately. It covers the full spectrum of tunnelling, from geology and structure, to safety [that was really good] and contract finance. They draw on a lot of senior industry figures including consultants, contractors, developers and TBM manufacturers like Herrenknecht and Robbins, for about half the lectures. Some lecturers are from other universities like ETH Zurich or Ruhr University Bochum. I spent six months at the university and then did a six month work placement, during which I did my thesis. The course is in English, but I did learn some Italian too.

Q: What advice would you give to other young engineers considering the course?

A: This is an excellent choice for a direct route into tunnelling. I would definitely recommend it.

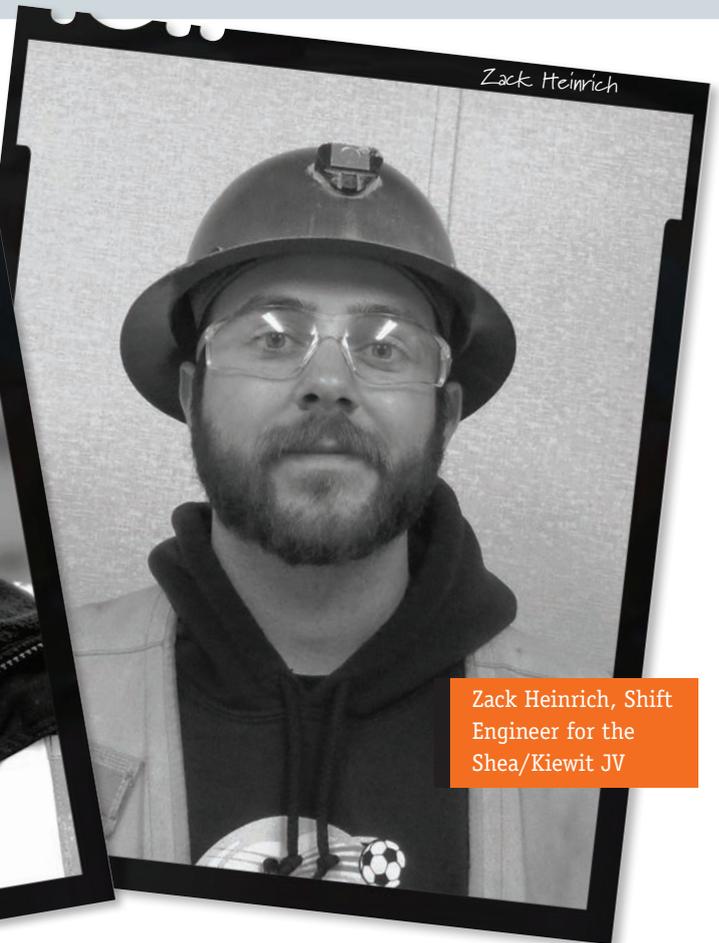
Check out Senthil’s tunnelling blog ‘Experiences & Excerpts; Ideas & Impressions; Reviews & Ramblings of a Civil Engineer’ at <http://geo-technical.blogspot.it>

Stuart Lipofsky



Stuart Lipofsky, Project Manager for Tunnelling Contractor J.F. Shea

Zack Heinrich



Zack Heinrich, Shift Engineer for the Shea/Kiewit JV

Underground Induction in

[Indianapolis]

Stuart Lipofsky, Project Manager for tunnel contractor J.F. Shea, has decades of experience in the tunnelling industry, including the highly challenging Arrowhead Tunnel project, in Southern California, USA. He is currently working at the Indianapolis Deep Rock Tunnel Connector, in Indiana.

Zack Heinrich, Shift Engineer for the Shea/Kiewit contracting joint venture (S-K JV), graduated from Marquette University in Milwaukee, Wisconsin, with a Civil Engineering degree, and has been at the Indianapolis Deep Rock Tunnel Connector for the last year and a half, learning more about the industry.

Zack Heinrich and his boss Stuart Lipofsky are key players on the Indianapolis Deep Rock Tunnel Connector. The tunnel will help to improve the quality of life in Indianapolis by reducing the amount and frequency of raw sewage overflows into the city's rivers and streams. Here they discuss their unique perspectives on working in the tunnelling industry, with insights for young engineers looking towards a career in underground construction.

What type of training does S-K JV implement for young engineers?

Stuart: Well, everything and anything. We start off by teaching young engineers about tunnel safety. There are 10-hour OSHA and 30-hour OSHA certifications [OSHA is the USA's federal agency for Health & Safety], as well as CPR and STS [Safety Training Supervisor] certifications. First and foremost, we emphasise safety training and getting involved in work through safety. After that, training can involve work with engineering, surveying, scheduling, reports, subcontracts, and drawings.

What types of duties do you have as a shift engineer?

Zack: We do discharge water readings/testing, fabrication drawings, and quality control. We also keep record of various data on-site, daily reports, and activities associated with the on-site water treatment plants [the tunnel travels below the White River and all water from the tunnel construction must be filtered through these treatment plants].

What types of things have you learned thus far?

Zack: This is my first tunnel job. I've had some experience at a precast plant as an engineer there, but with regards to tunnelling, there was not much specialized education from college. The main thing I have learned thus far is the processes of the work.



It is great that I constantly get to design ways towards better efficiency.
Zach Heinrich

What kinds of skillsets would you recommend that young engineers have if they are looking to start a career in underground construction?

Stuart: We look for someone who doesn't mind working in the field, who has a technical background, but doesn't mind getting dirty. We are looking for future project engineers and hopefully, project managers, and that takes a certain type of individual. They might have to work graveyard shifts, pull bolts in the tunnel, or do quality control – they have to be okay with performing a variety of tasks.

Zack: They need to be very willing to get their hands dirty. I'd recommend knowing how to be organized and detail oriented. Liking being outside is definitely important, and overseeing the work being done.

What kinds of skillsets can be learned in the tunnel?

Stuart: When I was a young engineer I learned about tunnel construction through books, but here you can see it being built right in front of you. You find out right away if something you've designed works OK. You might hear complaints from the crew if it needs to be refined – when you don't hear complaints then you know you've designed it correctly. It is a rewarding experience to design something as an engineer, and to see it work well.

Zack: When I design something I like to be able to see right away how it works, and how it might be improved. We do get together with teams of mechanics and they can guide us in the development of these items; often we need a high safety factor.

What is an example of something you have designed and implemented on this project?

Zack: We had to back up the tunnel boring machine (TBM) out of a blind heading, so it could be launched again to bore a tunnel wye. During that process we had to engineer everything to transfer weight to the backup decks. We designed beams for that process with the help of the project engineer.

What is the most interesting thing you have learned so far on the project?

Zack: Being in this whole new world is amazing; I didn't know much about tunnelling before this project. Just seeing how massive the tunnel is, and knowing we are doing something not a whole lot of people know about is a great feeling.

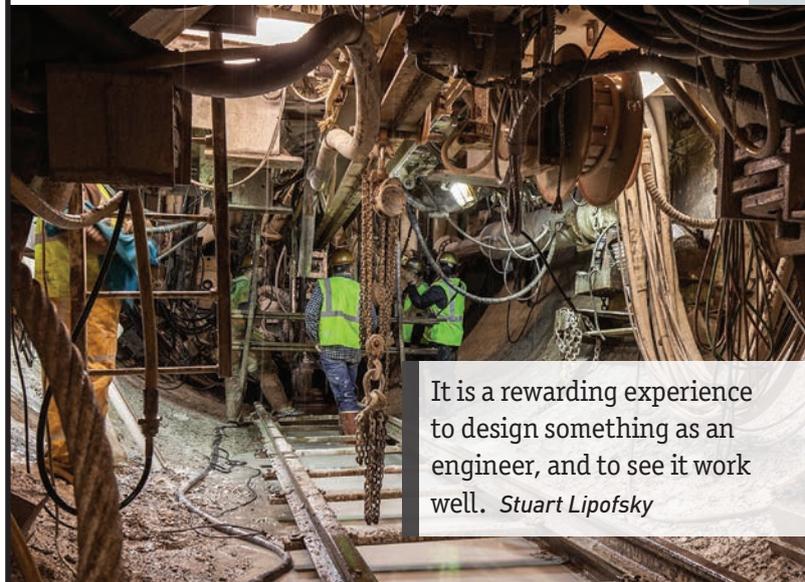
What do you hope Zack and other young engineers get out of the shift engineer position?

Stuart: Very hands on experience. We work with things in real time, from crew, to equipment and materials. I want them to be able to see and plan and execute. Essentially, I want them to learn everything I know. The more they know, the less time I spend teaching them. Of course none of us will ever know everything; some things just have to be figured out and we find the best way to get it done.

Would you recommend a shift engineer position as a good place to start out in the tunnelling industry?

Zack: Yes - I've seen a lot, it's the best way to learn, just for future career opportunities and to gain more experience. It is great in that I constantly get to design ways towards better efficiency.

Stuart: Engineers that get out of school should go out in the field and see how things are built. If nothing else, they become much better design engineers. When I graduated, I had some older more experienced men tell me I should get construction experience to be a better engineer. I went on-site and I never went back. It's made me a much better engineer. 



It is a rewarding experience to design something as an engineer, and to see it work well. *Stuart Lipofsky*

USA Young Members Débuts



From mass transit projects on the East Coast, to vast Combined Sewer Overflow projects across the Midwest, to ambitious water transfer projects out West, nowhere can you find a diversity of tunnelling schemes quite like in the United States. All of these projects have something in common – talented young professionals working on the design and construction of these Megaprojects that will be around for generations to come.

The tunnelling industry in the USA has historically been more “underground” than traditional civil engineering fields (pardon the pun) and struggles to attract college graduates. Many young people you talk to have typically ended up in the underground construction industry purely by chance. This challenge, paired with the need to develop the technical skills of those already in the industry,

has led to the formation of the Underground Construction Association’s Young Members (UCAYM).

The UCAYM was founded in June 2014 and is headed up by Anthony Bauer of Gall Zeidler Consultants (Chair), Erin Clarke of Jacobs Engineering (Professional Development Chair), and Shannon Goff of McMillen Jacobs Associates (University Outreach Chair). Our primary goals are to support the professional development of those in the industry, provide networking opportunities to our members, and create close links with universities to recruit new talent.

One such link is with the Colorado School of Mines via its UCA Student Chapter. While the UCAYM is just getting started, we hope to work closely with new and existing student chapters to provide a direct connection to the industry through collaboration and

01
Anthony Bauer is the Chair of the UCAYM Committee.



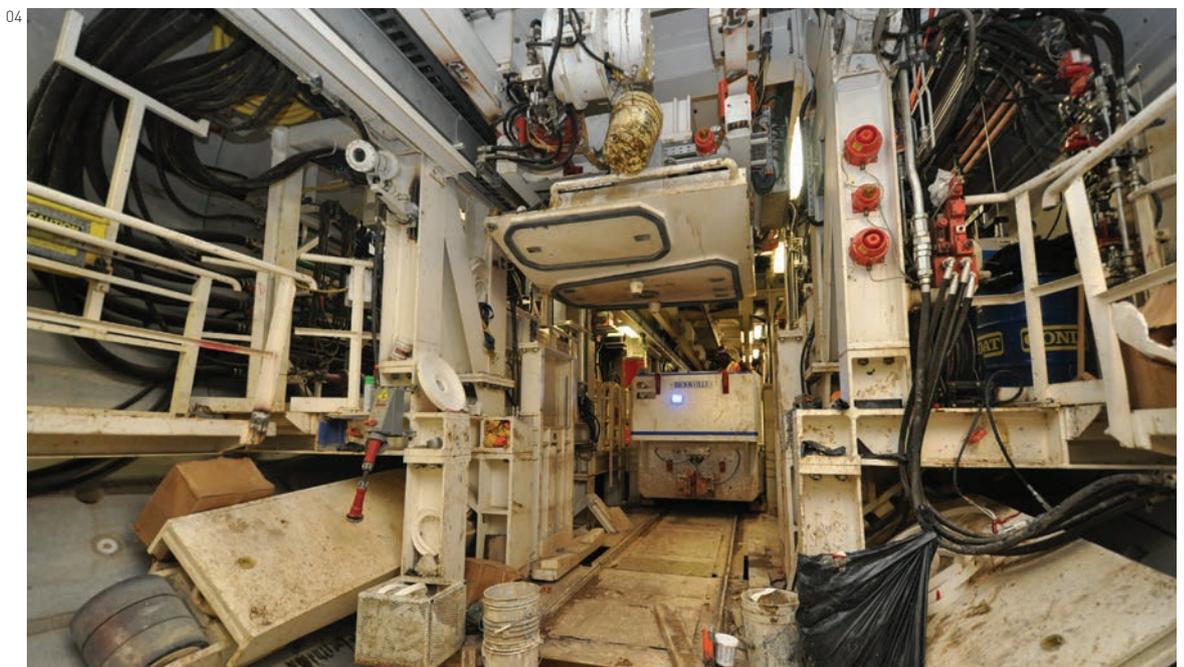
02
Shannon Goff is the University Outreach Chair.

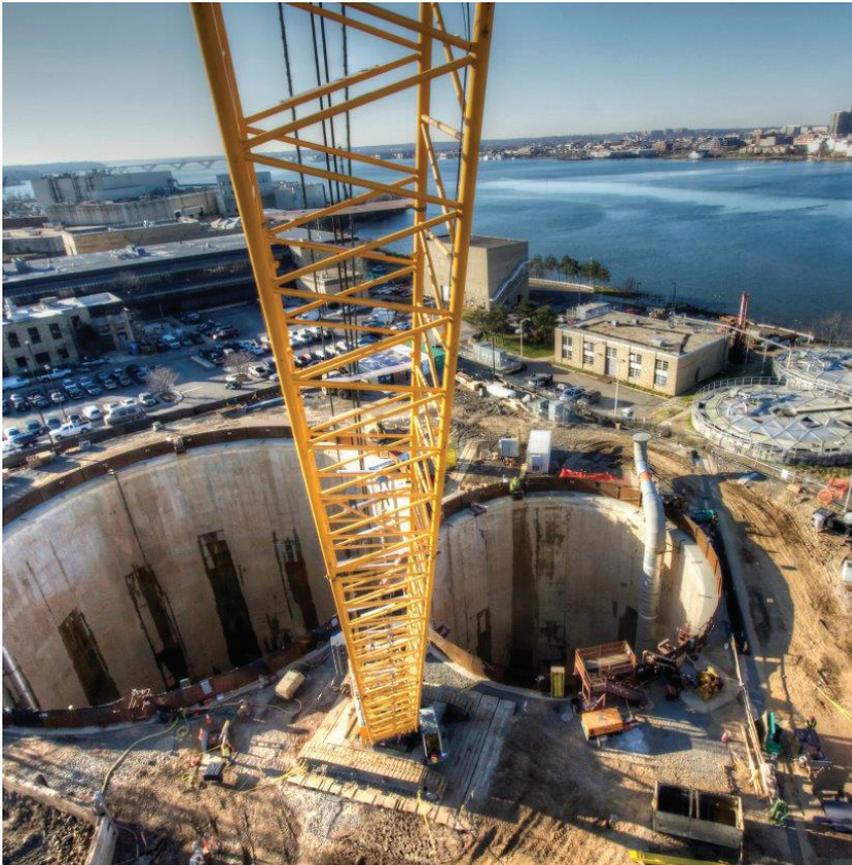


03
Erin Clarke is Professional Development Chair.



04
The UCAYM’s first webinar featured Washington DC’s Blue Plains Tunnel, which is being mined with a Herrenknecht TBM.





promotion of student chapter activities.

A challenge in the United States is the distance between members' locations. Unlike some other countries where most in the industry are within a train ride of each other, UCA Young Members are spread over 3000 miles and at least four time zones! Therefore, in February 2015 the UCAYM launched its online webinar series, which will feature speakers on the last Wednesday of every month, presenting on a variety of topics targeted to our members.

Washington DC's \$2.6 billion Combined Sewer Overflow programme was featured in the first webinar, presented by William Edgerton of McMillen Jacobs Associates, who serves as Manager of Tunnelling for the scheme. This Webinar was a resounding success and attracted over 70 attendees. The webinars are free to view; just sign up at the UCAYM website listed below. 

Our first annual networking event will be hosted at the Rapid Excavation and Tunneling Conference (RETC) in New Orleans, on June 7th – from 7pm until 9pm – and is open to anyone under the age of 35 attending the conference.

Please visit the UCAYM website to keep in touch with upcoming events and to register for the webinar series at:
<http://community.smenet.org/UCAYM>

05

The 40m diameter Dewatering Pump Station Shaft and the 23m diameter Screening Shaft at the Blue Plains Waste Water Treatment Plant, in Washington DC, were designed as a combined figure of eight diaphragm wall structure.



ITA - AITES
WTC 2016

The World Tunnel Congress
Including NAT2016

SAN FRANCISCO

MSC CANDIDATE



Gerard Quigg Donaldson Associates Masters in Tunnelling Warwick University, UK

Gerard Quigg is a Civil Structural Engineer with Donaldson Associates, in the UK. He is currently enrolled part-time in the ITA endorsed Masters course in Tunnelling at Warwick University.

Q: How did you become interested in engineering?

A: I always liked to draw and design at school, in Ireland; and my father is a builder and plumber, which gave me a practical bent in technical drawing so I went on to study engineering at the Dublin Institute of Technology. The first year was general studies and then I decided to concentrate on structural above ground stuff like bridges.

Q: What got you to into tunnelling?

A: By chance I made contact with Damien McGirr [former Chair of the British Tunnelling Society (BTS) and Chief Tunnel Engineer at Donaldson] and ended up applying for a job with him. I started in 2012, as a graduate, and began working on ground engineering and underground structures projects. Since then I have done quite a few detailed designs on shaft linings and tunnels. We have also been working on the Thames Tideway project and Crossrail. I learned a lot going on site and picking up experience from the miners, steel fixers, and others. Currently I am doing a lot on the retrofitting and upgrading of older railway tunnels.

Q: Why did you decide to do the ITA endorsed Masters in Tunnelling at Warwick?

A: It's a great fit with the work I do and relates directly to the challenges I face at work. I am doing the course part-time and the structure works really well for me, with intensive lectures and workshops for a week and then six-seven weeks back at work, with some evening and weekend homework. The lectures are very worthwhile, very hands on – if not always that easy. You also get to meet some very high level industry figures who come in to do the lectures, from companies and also from the BTS. That's what makes Warwick stand out, there are very few courses that are this relevant in the world, and Warwick has the added backing of the BTS. It's very up to date. You do a research project and thesis as well; mine is on tunnel refurbishment during live operation.

Q: What advice would you give to other graduate civil engineers?

A: Stay general and don't specialise until you get a feel for what you like; try and experience things to see if you like them or not. 



A Career in Tunnelling?

What does the tunnelling industry look like to a 15-year-old? We asked UK high school student Smith Middleton to investigate.

My only knowledge of tunnelling is using the London Underground, playing Minecraft, and (unsuccessful) childhood attempts to build tunnels through sandcastles at the beach. I've been told it could be an interesting career for me because I am good at maths and physics, but I know little about what a job in the tunnelling industry would be like. I imagine I would need a degree in engineering, but as to starting salaries, different sectors of the industry, career progression or actual day-to-day experience I'm totally ignorant. So, in order to find out more about this basic information, I head online.

Simply searching for "tunnelling" brings up five or six articles on quantum tunnelling, which although apparently of major import to the scientific community is not related to this line of enquiry. So, I try "careers in tunnelling" instead, which presents a far more fruitful yield.

One of the results, a piece by www.thamestidewaytunnel.co.uk, details how to "get the inside track on the industry now!" and "choose a career in construction". The page tells me that the industry is for those "born to build" and does genuinely convince that tunnelling is an exciting industry. But there's a problem; everyone looking at this page is presumably already interested in the tunnelling sector. On the career progression tab they need you to at least have a degree for them to be able to tell you your options. More needs to be done to get young people interested before they've already decided to spend years at university studying engineering.

This problem is made more obvious by a comment in an article by tunneltalk.com, which identifies a worrying trend of young engineers "stumbling into tunnelling". Like the Tideway Tunnel site, it contains two videos, in this case produced by the International Tunnelling and Underground Space Association (ITA), and the USA's Underground Construction Association (UCA of SME). The videos tell me a lot about the industry and the second video in particular, which gives little biopics of various workers in the underground engineering sector, is really good. One of the most interesting things about the videos is the diversity of roles in the tunnelling industry, such as geologists,



computer technicians, or graphic illustrators. In my opinion, this fact should be advertised more.

Just like the previous pages, the information is all about why people should become tunnellers, but there's nothing about how to become a tunneller. They assume the reader already knows.

I continue searching and try to develop my knowledge of the different careers in tunnelling, but searching for "tunnelling jobs" just supplies me with links to head-hunting sights. I re-watch the videos and evaluate the specific jobs outlined; the aspect that interests me most is the mechanical engineering side; designing machinery and equipment to do certain jobs.

Then I want to find out about how much a career in tunnelling might pay. Because I think searching specifically for tunnelling engineers won't give too many results, instead I search for "mechanical engineer salary," which tells me both the average salary (£29,807 per year) and the lower and upper pay limits of the industry, and www.payscale.com gives a graphic of common career routes. It would be useful if some of the tunnelling-specific websites gave information on this. In the UK, we face the prospect of student loans and other debt in order to obtain a degree, so basic facts about starting salaries are pretty important.

Although I have shown it is possible to find out about a career in tunnelling



online, for me it was anything but easy. What made the process even more difficult was the nature of the sites. Whilst most of them interested me in becoming a

tunneller, very few of them told me how to become one.

If the industry wants to make it easier for students like me to find information, I would make these suggestions: give us advice on what subjects we should study at 16, tell us about degrees and universities, and provide more information on salaries. 

Check out these career videos and more on the ITA-AITES's YouTube channel or search 'careers in tunnelling'

For tons of other interesting YouTube videos on tunnelling projects, try searching 'tunnel construction'



Career Day Success for Greek Young Members

Following the ITA's decision to establish a Young Members Group for young tunnelling professionals, the Greek Tunnelling Society (GTS) decided to create its own national Young Members Group in 2014. The main objectives of the group, as described by the GTS, are:

- To record and communicate experience and knowledge in design, construction, operation and maintenance of tunnels and underground structures in Greece, and countries where Greek industry professionals are active.
- To disseminate information relating to the development and implementation of new technologies and methods on underground projects.
- To act as a forum for young members within the GTS, to maintain a direct relationship with other YM Groups (including the ITAYM Group), and attract new members into GTS' Working Groups.
- To facilitate career opportunities in the tunnelling and underground construction industry.
- To educate school and university students about the prospects and opportunities offered by the tunnelling industry.
- To organize educational and training events for young professionals.
- To organize visits to relevant underground construction sites in Greece and abroad.

The new Young Members Group now has 30 members and it is continuously growing. The young tunnellers in Greece have been enthusiastic and have supported the idea from the beginning. In this regard, the role of the Masters

programme at the National Technical University of Athens on "Design and Construction of Underground Works" has been very important.

In the YMG-GTS we were lucky to be able to build the base of our group and cooperation between members with a specific project: Greece's first "Career Day for Tunnelling and Geotechnical Professionals". It was held as part of the 2nd Eastern European Tunnelling Conference (EETC2014), which was organized by the Greek Tunnelling Society, in September 2014.

The main objective of the Career Day was to bring young professionals specialising in the fields of tunnelling, underground works, and geotechnics together with companies with significant activity in this field.

The response was far beyond expectations. The companies that took part in the Career Day were a number of the leading companies in the industry: CH2M Hill, Dr. Sauer & Partners, Systra, GEOS Ingenieurs Conseils, Geodata, Vinci Construction, Omikronkappa Consulting, Lombardi and Pini Swiss Engineers.

On the other hand, 80 young professionals attended the event. These were mainly civil engineers (~65%), geologists (~15%) and mining and metallurgical engineers (~10%), as well as a small percentage of other professions (~10%).

Young professionals had the chance to interact with companies that interested them; and at the same time companies had access to a pool of potential employees with a broad range of professional backgrounds.

Since the Career Day, the YMG-



YMG-GTS members gather following the highly-successful Career Day, in September last year.

GTS has been working on ways to increase its membership, with a focus on developing its social media network to encourage communication between members. Other new activities have also been planned, such as presentations from senior tunnel professionals and site visits to key underground projects.

As one of the main objectives of the YMG-GTS is to contribute to the activities of the ITAYM, as well as the activities of YM groups in other countries, a delegation of six YMG-GTS members will participate in the World Tunnel Congress, in Croatia, this May. 



For more information on the YMG-GTS and its role in the industry, please visit the GTS website: www.eesygr.gr

Or check them out on Facebook, Twitter and LinkedIn:



Wanderlust

Matias Iovine spends his time travelling the world working as a Tunnel Boring Machine (TBM) Field Service Engineer for The Robbins Company. Over the past three years, he has gone from green mechanical engineering graduate to project site manager, and worked on four continents.

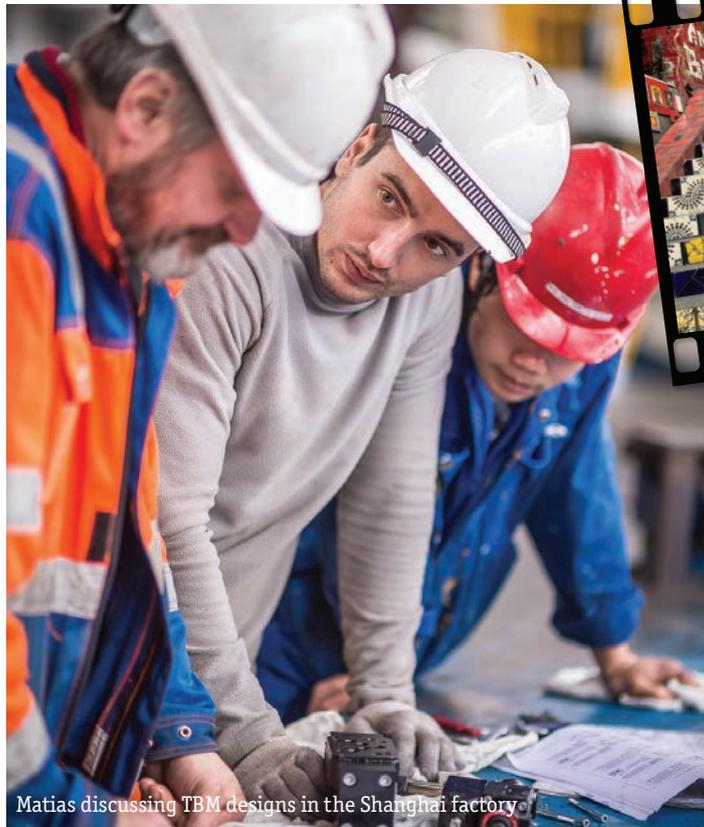
When Matias Iovine began working on his thesis for his mechanical engineering degree, he never imagined that a few months later he would be embarking on a career in tunnelling. "Honestly, if you had asked me, I would have said 'Eh? I don't even know what it is!'"

As it turned out, Matias got on well with the tutor assigned to help him with his thesis, and when he explained his desire to do something that would allow him to travel, his tutor provided an interesting response.

Ten years earlier, the same tutor had worked with Elisa Comis, who had gone on to work as a Project Engineer for TBM manufacturer Robbins. "He told me he was still in contact with her, and that she was looking for young engineers. Two weeks after my graduation I was working for the company."

"It all happened very quickly, and at first I was a bit insecure, and didn't know if I wanted to do this for a career. But Elisa told me 'look, you can come and try it out and see if you like it, and if it's not right for you, it's no problem'. And actually after two months I was in love with my job, I could never have quit."

Matias started in the Robbins' factory in Italy, where he began his trial period working on a 4.3m diameter



Matias discussing TBM designs in the Shanghai factory

double-shield TBM that was destined for the Yamanli II Hydro Project, in East Turkey. "Initially I was in the workshop, meeting the team, and learning about the company. And then a month

and a half later I was in the middle of Turkey! At the start, I have to say I didn't really know what I was doing. I just tried to understand as much as possible day by day – looking at drawings, studying, and asking questions."

After eight months in Turkey, Matias emailed Robbins' International Field Service Manager, Steve Chorley, to tell him he was going on holiday and to ask if he should buy a return ticket. Steve said no, he wanted Matias to come to the

factory in Shanghai to start learning about Earth Pressure Balance machines (EPB TBMs) for soft ground projects.

"Shanghai is like another world. As soon as you land you realise it is where everything is happening right now. I can imagine it's a bit like going to New York in the 80's. I would go back to Italy for a holiday, and when I returned things would have changed in that time."

During his time in Shanghai, Matias initially worked on a double-shield TBM for a project in Singapore, and was then assigned to one of four 6.9m diameter EPB TBMs destined for the Fortaleza Metro, in Brazil.

After this he went to Malaysia for a few months to rebuild the hydraulic units for a TBM that was being refurbished for the Carrapateena Mine, in Australia. "By then my confidence was growing, so Steve made me the supervisor of that machine. Unfortunately, it is still sitting in the middle of the desert. There



was a downturn in the mining market and they abandoned the idea of using the machine.”

One of the things Matias loves about his job, is that it fulfils its promise of letting him travel:

“Aside from work assignments, we get a few weeks off every three months and the company pays for our flights. Most people go back home to their families, but I like to travel. When I was in Asia I visited Thailand, Singapore, New Zealand, Australia, Taiwan, and Japan.

My favourite place is New Zealand, I would love to live there some day. Another favourite is Hong Kong. You get this feeling everywhere in Asia, that it’s the future, things are happening. In Hong Kong there is also this perfect mix between Eastern and Western cultures – the Asian food, great bars – and then there is the old Hong Kong, which not many people know about. Little fishing villages and beaches that you just don’t expect to find when you first arrive in this big modern city.”

After Malaysia, Matias

returned to Shanghai, and worked on several more TBMs. But early last year he decided it was time for a change: “I got to learn a great deal from Steve, but I’d been at the factory in Shanghai for over a year and I wanted to be back on a job site. I missed that relationship, being in a place where there is a customer and there are different challenges to face every day.”

So Matias went to work on the AMR Water Transfer Project, near Hyderabad, in India, where one of two TBMs that are mining a 44km-long tunnel was having issues. “China was amazing, but India is impressive in a totally different way – it touches you. I made a lot of friends there – on and off the job site – I also loved the food, one of my favourites.”

He was not expecting to leave India so soon, but after just six weeks, the project manager he had worked with on the Fortaleza machines requested that Matias come and help at the US factory on a TBM for a project in Chile. So Matias spent four months at the Robbins’ factory in Solon, Ohio, last summer,

working on the machine, before taking a break while it was being shipped to Chile.

“I arrived in Santiago in October. I had been back to Europe for two weeks, and then I visited Brazil and Argentina, which was amazing. But I had never heard much about Chile, and probably wouldn’t have gone if not for work. I’m really glad I did, it’s actually a great country.”

Matias was in Santiago for four months, working with the customer, taking care of the shipment of the TBM, purchasing missing parts, and organising the job site for the machine’s assembly.

At the beginning of this year, Matias was on holiday again,

this time in Costa Rica and Belize, when he got a call to tell him his next post would be in Mexico City. He is now working on the Onsite First Time Assembly (OFTA) of a new type of dual-mode TBM, called a Crossover TBM, for the Emisor Poniente project, where he is the site manager (and probably planning his next holiday).



A selection from Matias’ travel photos

1. Hanging out with locals while working in India
2. Soaking up the atmosphere in Rio de Janeiro last fall
3. Checking out the Petronas Towers in Kuala Lumpur
4. A bike ride shows off the fantastic beach in Rio
5. Visiting the Batu Caves, in Malaysia
6. A festive TBM acceptance ceremony in the Chinese factory
7. Shanghai’s ever changing skyline
8. Assembly of the Yamanli II TBM, in Turkey
9. Exploring Chile’s spectacular mountains



BTS Young Members Conference 2015



01
Charles Blamire-Brown, of Pinsent Masons, gives the crowd a “Tour of the [UK’s] New Engineering Contract”

02
Acciona’s Ander Meléndez takes part in an engaging Q&A session

03
BTSYM Chair, Eoin Ó Murchú provides some parting words at the end of the conference

The British Tunnelling Society Young Members (BTSYM) hosted their second conference on the 27 March, in Pinsent Masons’ stunning Central London law offices. The event followed on from a hugely successful conference in 2012 and was attended by over 90 delegates. Young tunnelling professionals and university students from across the United Kingdom were in attendance as well as the Chair of the British Tunnelling Society, Roger Bridge.

BTSYM Chair, Eoin Ó Murchú – who is a Chartered Tunnel Engineer with CH2M Hill – presided over the day, which included 11 presentations covering all aspects of a tunnelling project’s life-cycle. The final talks also focused on more specialised topics, such as constructing underground metro railways, and current research into composite tunnel linings.

Presenters were from a range of backgrounds including project owners, designers, contractors, and academia, as well as legal professionals. The day was also a testament to the truly exciting climate that currently exists within London for tunnelling with a number of talks on proposed road and railway tunnels as well as station upgrade projects.

The day began with varied discussions on the

proposed Hammersmith Flyunder and Crossrail 2 projects, and finished mid-afternoon with a presentation from Pinsent Masons on the role of the UK’s NEC3 contract in construction. A presentation on the feasibility study of a new particle collider, which could potentially succeed the existing Large Hadron Collider (LHC) at the CERN nuclear physics laboratory, showed how tunnelling can extend beyond trains, traffic and water and that a career in tunnelling can be as diverse as you wish.

The event also served as an important occasion in bringing young tunnelling engineers together to network and to form contacts within the industry, with time allocated specifically for this throughout the day and a drinks reception following the event.

A particular highlight was the number of graduate and student engineers in attendance. It offered a great opportunity for young tunnellers to meet their colleagues from across the industry and the spirit of collaboration was plain to see. Many of the delegates in attendance commented on how much they were looking forward to getting more involved in the BTSYM and that they would enjoy the opportunity to present at future YM events.



Roger Bridge brought the conference to a close sharing his thoughts on the importance of inspiring the next generation of tunnelling engineers, saying it is the young professionals of today who are best placed to do so. The final word was left to the BTSYM Chair Eoin Ó Murchú, who emphasised the many opportunities open to those who get involved in the BTSYM and how invaluable the networking and social aspect of the society is. Feedback from delegates was excellent and demonstrated the good work being promoted by the BTSYM and its members. 



04 Rocio Garcia Segovia (left) discusses the conference with Gala Maria Gonzalez-Cano both with CH2M

05 An impromptu reunion of Camborne School of Mines' alumni during lunch

06 Mott MacDonald's Matthew Lane (left) and London Underground's Aimi Elias

07 Sophie Payne of Atkins (left) and Gala Maria Gonzalez-Cano

08 Eoin Ó Murchú enjoying a post-conference chat with CH2M colleagues Harriet Cheaney and Benjamin Wok

09 Roger Bridge, Chair of the British Tunnelling Society, offers some words of wisdom

For more information on the BTSYM and its role in the industry, or on any of its upcoming events please visit their website: www.britishtunnelling.org.uk/btsym

 Like them on facebook: www.facebook.com/btsyounghmembers

 or follow them on twitter: www.twitter.com/btsym

All other enquiries can be made to: btsym@britishtunnelling.org.uk



Local knowledge, global expertise

A career in tunnelling with CH2M is as diverse and exciting as you want to make it. With great people, challenging projects and collaborative design, CH2M offers unrivalled opportunities to grow as an engineer - taking a leading role in the development of infrastructure and underground space solutions globally.

So, if designing a metro tunnel in New York, a utility tunnel in London or solving the infrastructure needs of Doha awakens your inner tunneller...what are you waiting for?

Rise to the challenge - a career in CH2M awaits.

For more information about our projects and opportunities, visit www.ch2m.com/careers



www.ch2m.com
Follow us @ch2mhill



© 2015 CH2M HILL
CH0507151026LON



Korea's Young Engineers group celebrates five years of success



Members of the Korean Tunnelling and Underground Space Association's Young Engineer's Committee at their first meeting, in Seoul, in 2010

The Korean Tunnelling and Underground Space Association's Young Engineer's Committee (KTAYE) was established in September 2010. Despite its relatively short history – and thanks to the efforts and enthusiasm of KTAYE's members – it is now a lively and important committee within the South Korean engineering industry.

Our founding meeting was held in Seoul, on September 3rd, 2010, with a number of enthusiastic KTA young members participating in the event. Following this first meeting, the YE committee has held numerous academic and practical seminars, as well as regular social gatherings and networking events.

The KTAYE also published two books between 2011 and 2013:

A translated version of "Innovation and the Rise of the Tunnelling Industry" by Graham West – which studies the historical development of the tunnelling industry; and "Mankind and Underground Space". Thanks to the dedication of our committee members, "Mankind and underground space" was awarded 'Outstanding Book of the Year' by the Korean government's Ministry of Culture, Sports and Tourism.

The KTAYE have attended many major tunnelling conferences and seminars in the last five years, and continues to play an active role in the Korean Tunnelling Association. This year, the KTAYE are planning several major events. The most significant of which is a visit to the site of the Boryung Tunnel (see page 56), which is currently under

construction. The Boryung Tunnel will not only be the country's longest subsea tunnel, but it is also the first of its kind in South Korea [where immersed tube tunnels have traditionally been built]. The committee expects a great turnout for this event, not just by the KTAYE members, but also members of the main association.

This autumn the KTAYE will also participate in an independent session of the KTA's national tunnelling conference, with several papers due to be presented and engaging discussion among KTAYE members expected.

The main aim of the Young Engineers group is to promote camaraderie and professional working relationships among the young members of the Korean Tunnelling Association.

However, another important role of the group is to reinforce ties between students and practicing engineers – and with around 60 Young Engineer members actively participating in the KTAYE, we are continuously strengthening relationships and performance.

It is great to hear that the ITA has established an International Young Members Group, and KTAYE looks forward to attending the World Tunnelling Congress, in Dubrovnik, this May, and participating in the first General Meeting. 

Changwon Kwak
KTAYE Leader



Holding Back the Water

Plans for the Boryeong Tunnel, South Korea's first mined subsea tunnel, began in 2009. When the project is completed, in 2018, it is expected to transform the tourism landscape of the country's west coast – reducing a 1.5-hour journey to 10 minutes - and serve as a catalyst to the economic development of the region.



When it opens, in 2018, the 5.1km-long twin tube Boryeong Tunnel will be South Korea's longest subsea tunnel. Currently under construction, the tunnel forms part of a link that will close a gap in the National Road No. 77 and will facilitate travel between the cities of Taean, Boryeong, and Seocheon.

The project is expected to transform the tourism landscape of the country's west coast – reducing the current 1.5-hour journey from Boryeong's Daecheon Port to Anmyeon Island to just 10 minutes – and will likely serve as a catalyst for a long-delayed project to construct a new port at Boryeong.

The tunnel itself runs from Daecheon to Wonsan Island, at depths of up to 80 metres below sea level, while a 1.7km-long cable-

stayed bridge will link Wonsan Island to Anmyeon Island and the mainland beyond.

The tunnel is the first mined subsea tunnel in South Korea, where immersed tube tunnels have previously been used for underwater crossings. This is partly due to the fact that Daecheon Port and the Daecheon strait form one of the busiest shipping channels in the country, and the construction of either a bridge or an immersed tube tunnel would have disrupted waterborne traffic.

Design Considerations

In 2009, the Daejeon Regional Construction Management Administration awarded a turnkey contract for the Boryeong Tunnel to a consortium led

by Hyundai Engineering & Construction. Following detailed design, construction for the project commenced in 2012.

As the tunnel is being excavated at depths of up to 60 metres below the seabed, the control and discharge of groundwater inflows into the tunnel are considered one of the most critical design issues on the project. Water inflows during construction can affect the stability of the tunnel and the efficiency of excavation; and during tunnel operation discharge of water by the permanent pumping system raises maintenance and operating costs.

Therefore, as part of the tunnel design process, allowable quantities of groundwater inflows were estimated; and the length of discharge by the permanent pumping system was optimised via the vertical alignment of the tunnel and the location of a catch basin.

Due to the limitations of geotechnical investigation of the seabed, a plan for additional investigation during excavation, as well as grouting to reduce groundwater

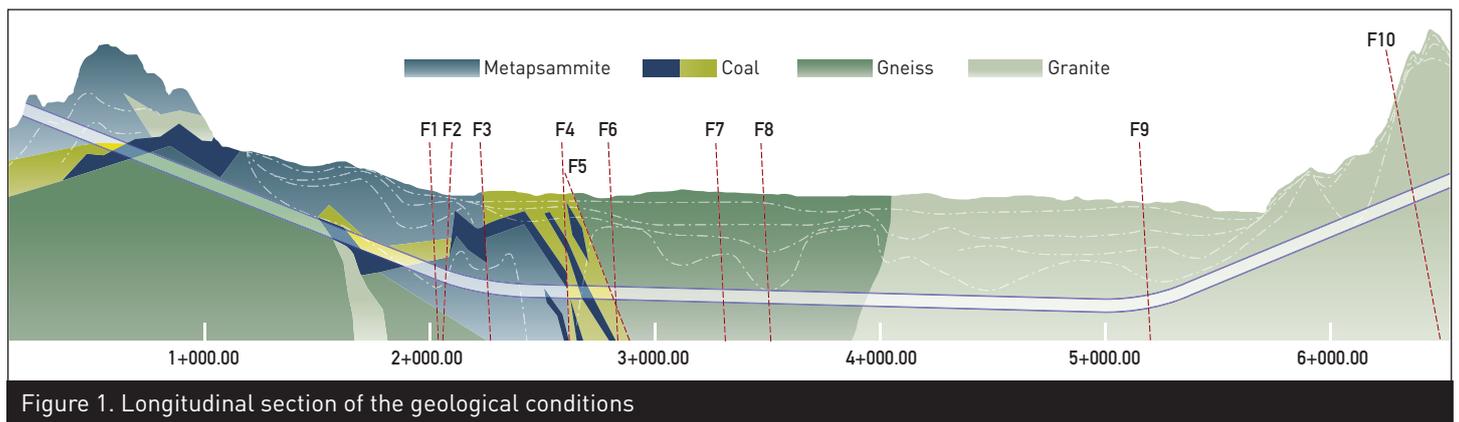


Figure 1. Longitudinal section of the geological conditions

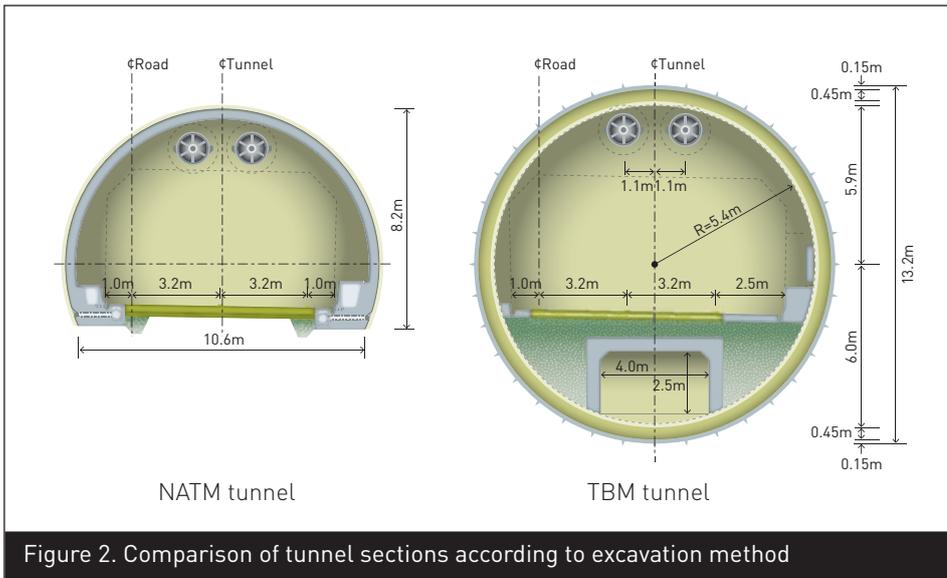


Figure 2. Comparison of tunnel sections according to excavation method

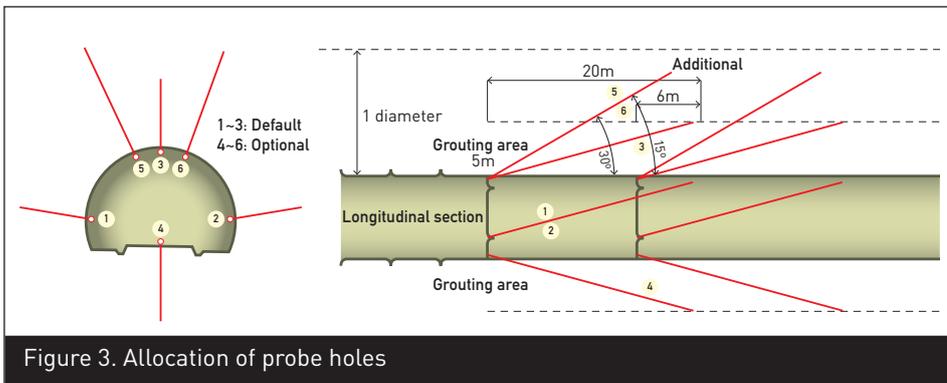


Figure 3. Allocation of probe holes

inflows was developed. A risk register of geotechnical hazards was also compiled in order to respond to any scenario met.

Site Conditions

There are mountains at either end of the tunnel and the surface of the seabed is almost flat (see Figure 1). At the start of the alignment the tunnel passes under Local Road 36 and the final section traverses an ocean ridge at a shallow depth. The tunnel initially passes through granite, gneiss and metapsammite, with a gneiss layer in the mid section, and granite dominating the final portion of the route.

Sedimentary rock layers can also be found in the initial section, and while the physical properties of the gneiss and granite are stable and favourable, the properties of the sedimentary layers demonstrate a complicated composition of sandstone, mudstone, shale, and coal layers. These geological conditions significantly affected the planning of the vertical alignment.

Construction Plan

A water control plan is very important in a subsea tunnel as it directly affects the

stability of the tunnel. In this case, inflow water will be collected in a catch basin and discharged into the sea by a pump system. A unified catch basin, with a redundancy for 10 hours of retention (in case of emergencies, such as the breakdown of pumping system, excess inflows, etc.), has been designed to collect inflows during the tunnel's operation.

Typically, there are two main methods



Horizontal drilling at the tunnel face

used to construct a subsea tunnel. The first is an immersed tube tunnel and the other is mined. In this case, it was decided that a mined tunnel was more appropriate based on the project conditions. Therefore, NATM tunnelling (Drill & Blast) and Tunnel Boring Machines (TBMs), the two main methods of tunnel construction in hard rock, were compared with each other.

Figure 2 demonstrates a comparison of tunnel sections relating to these two excavation methods. In the case of a TBM tunnel, the section is much larger due to subsidiary facilities, such as services and emergency parking, etc. In addition, the shape of the tunnel section is not uniform, due to the need for the catch basin. These factors result in raised construction costs. Therefore, it was decided that NATM excavation was the more appropriate method for the Boryeong Tunnel.

The total width of the two-lane roadway in each tunnel tube is 8.5 meters and the excavation area is approximately 80m². Jet fans will be utilised for ventilation during the operation of the tunnel.

The final thickness of the tunnel's steel fibre reinforced sprayed concrete lining is 400mm, to resist external water



Drilling probe holes at the face of the tunnel

pressures. Silica fume is added to the shotcrete (sprayed concrete) to enhance watertightness and minimize corrosion of the steel-fibres in the shotcrete.

Probe drilling during construction

The design of the Boryeong Tunnel was based on various in-situ tests such as offshore boring, offshore seismic reflection tests, etc. to detect weak sections of rock. However, despite this intensive site investigation programme, weak or fractured zones of rock could remain undetected. If encountered, such conditions could have a major impact on the amount of water inflow encountered during construction and, in a worst case scenario, could lead to serious structural damage or even collapse.

Therefore, further geotechnical investigation in the form of probe drilling was prescribed during construction to detect possible weak or fractured zones in advance of the excavation. The results of these investigations are promptly applied to the rock classification and the level of support applied in the tunnel.

Additional longitudinal probe holes are drilled to monitor the quantity of water inflows. This data is analysed to determine the quantity of grouting undertaken.

Controlling water inflows

The quantity of water entering the tunnel decreases with the amount of grouting undertaken, but this has to be balanced against increased costs. Therefore, estimation of allowable water inflows and the installation of grouting for dewatering are both required in order to optimise the cost. For example, 0.3m³/min-km of allowable water inflow is prescribed in Norway, based on past experience and

Table 1. Grade of grouting for water control

Grade of grouting	Joint conditions			Lugeon	Rock and wet joint
	Spacing (m)	Gap (mm)	Infilling material		
TYPE A	≥ 0.2	≤ 1.0	-	≤ 5	Good to Excellent Wet joint
TYPE B	0.06~0.2	1.0 ~ 2.5	-	5 ~ 10	Fair Partial wet joint
TYPE C	≥ 0.06	2.5 ~ 10	Partial clay	10 ~ 20	Poor Frequent wet joint
TYPE D	≥ 0.06	≤ 10	Partial clay Coal seam	≤ 20	Very poor Very frequent wet joint

practical data. Whereas, 0.069 to 0.694m³/min-km of water inflow is allowed in the Xiang-an Tunnel, in China, depending on the geotechnical conditions encountered. For the Boryeong Tunnel 0.5m³/min-km of allowable water inflow was estimated based on the characteristics of the seabed and the tunnel alignment. Previous experience, pumping costs, and design margins were also considered in this estimation.

The amount of grouting for groundwater control is decided once the quantity of water inflow at the probe holes is analysed (see Figure 3). This grouting prevents excess water inflows, strengthens the stability of the rock, and allows the quantity of water inflow to be maintained within prescribed limits. The threshold of water inflow is four litres per minute at one hole, or an average of five litres per minute at three holes. If the threshold is met, grouting is applied.

The level of grouting determined is based on joint conditions (displayed in Table 1). Joint conditions are estimated according to the investigation results and the designated

International Society for Rock Mechanics (ISRM) rock classification.

Risk Scenarios

Various risk scenarios for geotechnical hazards were also established in order to respond to any possible events arising from the seabed conditions. Risk scenarios can be classified into general, specific, and accident response scenarios.

The "general scenario" is a standardised procedure led by the geotechnical investigation results. The "specific scenario" is a procedure that can detect weak or hazardous zones in advance of the excavation and establishes solutions. The "accident response scenario" is the response procedure in case of an emergency such as collapse, leakage, etc.

The Boryeong Tunnel is the first subsea tunnel to be excavated in South Korea. This massive project is expected to go into service in 2018, with invaluable engineering and practical experience having been gained during its design and construction. The authors expect this experience will drive the future development of underground space in South Korea and promote further subsea tunnel projects. 



Emergency Watertight gate in case of flooding

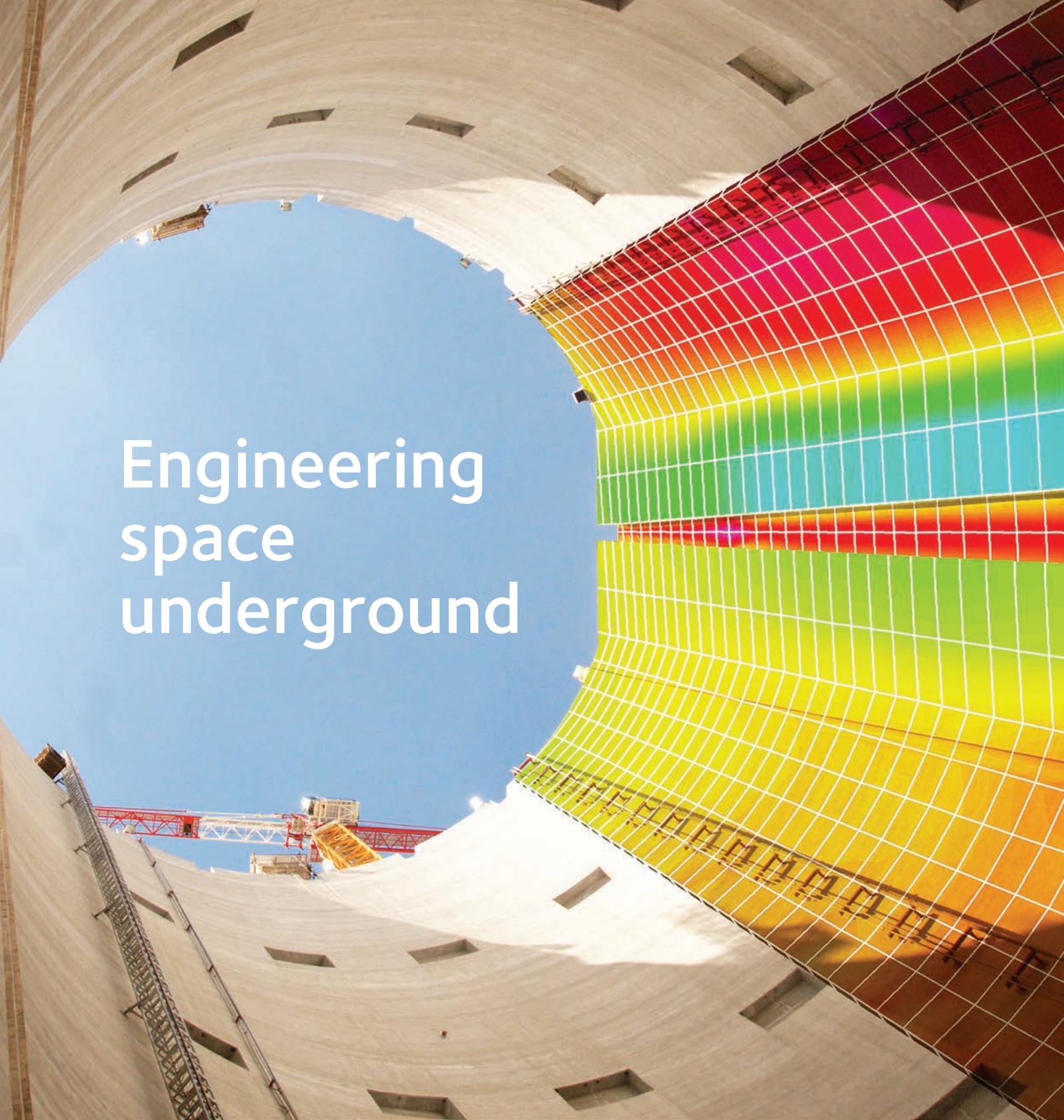
Authors

Changwon Kwak, PhD, PE

Changwon is the Leader of the Korean Tunnelling and Underground Space Association's Young Engineers Committee (KTAYE) and works for the Korea District Heating Engineering Company.

Dohoon Kim, PhD

Dohoon is a member of Korean Tunnelling and Underground Space Association's Young Engineers Committee (KTAYE) and works for Hyundai E&C.



Engineering space underground

Lee Tunnel: As lead designer responsible for the detailed design of this project's shafts and tunnels, our innovations SmartShell™ and SlipStress™ saved 19,000 tonnes of steel and reduced the carbon footprint of the project by 35 per cent.

UnPS is a specialist tunnelling and underground space consultancy with a world-class record of innovation. We have been responsible for the detailed design of more than £2 billion of the most prestigious tunnelling projects in the UK.

Our team can demonstrate an unparalleled achievement in bringing new ideas to market, and we pride ourselves on seamless interfaces between design and construction that have helped deliver more than £100 million of value engineering savings to our customers.

**Boundless
possibilities**

UnPS Limited
Corporation Street, Rugby, Warwickshire CV21 2DW
T 01788 534500, F 01788 534579
unps.co.uk

A MORGAN SINDALL GROUP COMPANY

UnPS
**UNDERGROUND
PROFESSIONAL
SERVICES**

SAFE, EFFICIENT, RELIABLE, DURABLE, PERFORMING
SUSTAINABLE, ECONOMICAL, GROUND SUPPORTING
GROUND CONSOLIDATING, WATERPROOFING, DESIGN
OPTIMIZING, FLEXIBLE, STRONG, WORKABLE, LOW
REBOUND, WATER STOPPING, GROUND SUPPORTING
SAFE, PERFORMING, EFFICIENT, STRONG, WORKABLE
RELIABLE, FLEXIBLE, DESIGN OPTIMIZING, DURABLE
ECONOMICAL, GROUND CONSOLIDATING, WATERPROOFING
SUSTAINABLE, FLEXIBLE, DESIGN OPTIMIZING, LOW
REBOUND, WATER STOPPING, WATERPROOFING
ECONOMICAL, GROUND CONSOLIDATING, WATERPROOFING
SUSTAINABLE, FLEXIBLE, DESIGN OPTIMIZING, LOW



**I NEED SAFE AND
EFFICIENT TUNNELING.**

Safety and performance are BASF's first priorities in tunneling. This calls for specialized engineering support, application know-how and state of the art chemistry. BASF can fulfill your needs with its Master Builders Solutions. Whether you are looking for ground support & consolidation, an efficient TBM or waterproofing, our leading global expertise in sprayed concrete, injection, mechanized tunneling solutions and membrane technology will help you build your tunnel safely and economically.

For more information please visit www.ugc.basf.com

 **BASF**

The Chemical Company