t&UC®
Tunneling & Underground Construction
The Official Publication of UCA of SME
www.TUCmagazine.com
Volume 16 NO. 3 September 2022

3D tunnel assessment
Improved contracting practices
North American Tunnel Conference recap

Special Editorial Supplement from the publisher of Mining engineering

HERRENKNECHT IN CANADA

CONNECTING INNER CITIES

With 5 EPB Shields, Herrenknecht supports the extension of the Canadian metro systems by more than 25 km. The subway lines in the Greater Toronto Area will be expanded by over 20 km. In Vancouver 7 km of additional tunnels will lead to 6 new subway stops. Herrenknecht guarantees the local support with their offices in Sumner, WA and Toronto, ON.

› **herrenknecht.com**

SCARBOROUGH SUBWAY EXTENSION, TORONTO
Machine type: EPB Shield, S-1279
Diameter: 11,870 mm
Contractor: Strabag Inc.

EGLINTON CROSSTOWN WEST EXTENSION, TORONTO
Machine type: 2 x EPB Shield, S-1302, S-1303
Diameter: 6,550 mm
Contractor: WestEnd Connectors (Aecon / Dragados / Ghella GP)

BROADWAY SUBWAY PROJECT, VANCOUVER
Machine type: 2 x EPB Shield, S-1304, S-1305
Diameter: 5,980 mm
Contractor: Broadway Subway Project Corporation (Acciona / Ghella GP)

PIONEERING UNDERGROUND TOGETHER

HERRENKNECHT
Tunnelling Systems

September Contents

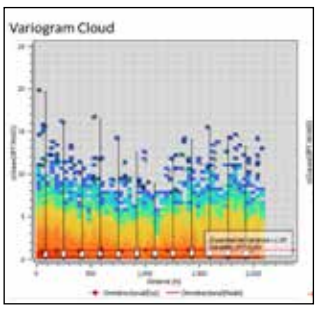
Departments

Cover Story

In This Issue

Tunnel inspection is an extremely complex and specialized process that requires forward thinking and advanced tools and technology. A team from Mott MacDonald and Dibit Measuring Technique created a detailed digital model of the interior surface of a tunnel to perform the needed assessments as a digital desktop study instead of conducting a lengthier traditional field investigation, see page 29. Cover photo courtesy of Rebecca Reeve © 2022, from the 2022 UCA Photo Contest. "A portal to the underworld - Second Narrows". North Shaft of the Second Narrows Project. North Vancouver, B.C. Canada.

Feature Articles



tucmagazine.com

AN OFFICIAL PUBLICATION OF UCA OF SME | WWW.SMENET.ORG | VOLUME 16 NO. 3 | SEPTEMBER 2022

Looking back at the year: An update on the state of the UCA

Happy New Year! … In UCA terms, that is. We've completed one year under the current administration and it's customary for the Chair's Column to address the year that was. Short of taking credit for emerging from the shroud of a pandemic, we are able nonetheless to point to signs of having returned to a semblance of normalcy, and I'm pleased to say that it has helped our Association in moving forward with its goals and objectives, all driven by our UCA Strategic Plan.

Michael Rispin
2022-2023 UCA Chair

Industry education

Building on our first return to in-person conferences, last year's RETC in Las Vegas, NV contributed to our successfully holding three conferences during the year. The Cutting Edge 2021 conference held in Dallas, TX received very strong, positive feedback, and many attendees enjoyed the single-track concept for a smaller venue. George Fox 2022, having been delayed from January to May, posted record attendance in a new venue; again, we got a lot of reinforcing comments on the Hilton New York and the program. Finally, we recently completed NAT in Philadelphia, PA with attendance just slightly shy of prepandemic levels and, from personal observations, everyone was glad to be able to get back together and maximize benefit from the time spent congregating.

Publications continued to progress in various forms: *T&UC*, books, webinars and the living document "Frequently Asked Questions" (posted on our website) and the always anticipated Tunnel Demand Forecast.

We have been successful in nominating Sanja Zlatanic of HNTB for the position of Executive Council member to the International Tunnelling Association (ITA). Her candidacy is up for election in September, and we hope to herald the addition of her experience and perspective at the international industry association level immediately thereafter.

At the time of writing this column, our domestic Working Groups (WG) are in the final stages of preparing their contributions to the upcoming international WG meetings at the World Tunneling Congress in Copenhagen (Sept. 2–8). We trust that other member nation countries of ITA will see the power and effect of having leveraged our domestic expertise as our USA leaders bring that body of work as the official USA WG representatives to the conference.

Stakeholder awareness

November 2021 marked the inaugural publication of UCA's "Tunnel Project Watch List," highlighting 20 noteworthy projects in process, and 20 that need to be built. This now becomes an annual task for our Association, the output of which we trust can be useful in our efforts to enlighten decision makers regarding the importance of tunneling.

The Owner's Forum culminated its first year with an important meeting at NAT. Ideas are being evaluated for supporting this vital cohort, and meaningful developments can be anticipated prior to next year's RETC.

(continued on page 14)

ALWAYS ADVANCING

www.terratec.co

MUMBAI'S AMAR MAHAL TUNNEL PROJECT

Two of TERRATEC's 3.2m diameter hard rock open gripper TBMs are currently being deployed by contractors Soma Enterprise Ltd. and Patel Engineering on Amar Mahal I & II water transfer tunnel contracts that will meet increased demand and ensure reliable water supply.

In recent years, TERRATEC's order book has demonstrated significant growth & diversity globally including projects in Argentina, Turkey, Thailand and India which have been the result of robust custom-made TBM designs, a readily available stock of TBM spares and consumables, and a highlyskilled team offering specialised TBM support and prompt onsite assistance throughout tunnelling operations.

TUNNELLING SOLUTIONS | UTILITIES

TERRATEC

California announces single-tunnel option for Water Fix

California Gov. Gavin Newsom's administration unveiled a 3,000-page draft version of an environmental impact report for a scaled-down version of the California Water Fix tunnel. The new plan includes a single tunnel that would divert water from California's Sacramento River and route it under the Sacramento-San Joaquin Delta to farms and cities in southern California.

The newest version of the plan, now called the Delta Conveyance — which is a trimmed-down version of tunnel scenarios proposed by the administrations of Govs. Arnold Schwarzenegger and Jerry Brown — would grab excess water delivered by big storms and divert some of those Sacramento River flows.

All along, the Metropolitan Water District of Southern California has been a major driver of this replumbing, the *Los Angeles Times* reported.

As a historic drought intensifies its grip and sea-level rises threaten to make the delta more salty, water managers in California's most populated urban areas are growing increasingly concerned about the existing system for pumping supplies through the delta. The area is not only a hub for conveying water but also an estuary that is home to rare species, some on the brink of extinction.

The *Sacramento Bee* reported that two massive, arena-sized pumping stations built in the south Delta near Tracy decades ago are so powerful they alter the currents inside the estuary and cause problems for migrating fish.

As fish numbers have dipped closer and closer to extinction, regulators have forced the pumping stations to ratchet back the amount of Delta water that gets pumped into state and federal canals. To address the growing Delta water-delivery bottleneck, both Newsom's and Brown's plans would build intakes

(continued on page 16)

A proud heritage of innovative thinking.

Moving forward, one tunnel at a time.

We're proud of the legacy that the Robbins name represents, but more importantly we're focused on the future of the underground industry and the success of our client partners today. Join us in realizing the next era of underground accomplishments.

Robbins
RELIABLE | RESPONSIVE

A GLOBAL TBM COMPANY / ROBBINSTBM.COM

San Bernardino to continue with tunnel plans to airport

In 2020 the San Bernardino County Transportation Authority voted to pursue a proposed tunnel project that would connect the Rancho Cucamonga Metrolink station with Ontario International Airport via a high-speed rail system.

The tunnel was first proposed by the Boring Co., which has since backed away from the project. The proposed subterranean path would run in one direction and cost less than $100 million — a far cry from the more than $1-billion price tag for a surface-level connection system, according to the county transportation agency's spokesperson, Tim Watkins.

"This is still a viable project, and we're moving forward," said Watkins.

The plan, which will now feature two tunnels stretching 6.9 km (4.2 miles) for travel in both directions, is estimated to cost roughly $492 million and is expected to take riders to their destination in less than 10 minutes, Watkins said.

The *Los Angeles Times* reported that three above-ground stations will be built — one at the Rancho Cucamonga train station and two at the Ontario airport at terminals 2 and 4. The San Bernardino County Transportation Authority plans to cover nearly half the cost and is looking to close financing gaps through grants, state and federal dollars. Service could start as early as 2027, officials said.

The agency decided to take on a "more traditional process for the environmental clearance" of the tunnel by having a third party assess potential impacts of the project and asking the Boring Co. to submit another proposal by the end of January 2022, Watkins said. But that deadline came and went, and Elon Musk's company didn't respond, effectively making a "business decision not to continue down that path," he said.

This is not the first time Musk has backed out of a tunnel project. In 2018, he announced plans to build two tunnels in Los Angeles: one that would run beneath Sepulveda Boulevard on the westside and another between a Metro station on Vermont Avenue and Dodger Stadium. After two groups sued over the city's proposal to exempt the Sepulveda Boulevard tunnel from an environmental review, Musk said his company was no longer pursuing the project. The Dodger Stadium tunnel also was quietly removed from the Boring Co.'s website.

"We can see there's real value to a subsurface connection. This is the fastest-growing airport in the country, and not only does [a tunnel] address the need for transit options for a growing airport, but we want to make sure we get ahead of traffic impacts for the communities that surround it," Watkins said.

Ontario International Airport chief executive officer Atif Elkadi said the tunnel is a creative solution to enhance transportation connections to the airport.

But the project still has a long way to go. The agency has to secure

(continued on page 18)

TBM breaks through at South London Power tunnel

The first of five drives by four tunnel boring machines (TBM) in London was completed in June, traveling 6.7 km (4.1 miles) underneath the capital.

A team of 'boring' National Grid workers marked the completion of its journey across south London, with the breakthrough in Eltham.

City AM reported that the London Power Tunnels (LPT) project started in July of 2021 reaching depths of 50 m (165 ft) underground, and completed the breakthrough on June 21.

It marks a key moment in the £1bn project to rewire the capital and prepare for the future's greater electricity demands, while also helping the energy sector to reach its net-zero targets.

The 140-t (154-st) Herrenknecht TBM, named Christine after Christine Townley, the former executive director of the Construction Youth Trust known for her championing of diversity and STEM careers, began its journey at the LPT site in Hurst in July of last year.

Members of the LPT project team gathered at the Eltham site to witness this major milestone and celebrate their achievement. National Grid's three other TBMs, — Edith, Grace and Caroline — continue their tunneling work deep underground across sites in South London.

Speaking at the breakthrough, Gareth Burden, project director, London Power Tunnels, National Grid, said: "The completion of Christine's journey from Hurst to Eltham represents a significant milestone for all of us working on London Power Tunnels. After close to a year of tunneling, it is exciting to see the first connection between sites.

"The team has worked so hard to make this happen, in the face of tough ground conditions. Thanks to Hochtief Murphy Joint Venture (HMJV), Herrenknecht, our engineers, fitters, miners and everyone else involved. A special thanks also goes to the Joseph Gallagher Limited gangs who put in some hard yards down in the tunnel. It's great to take a moment to celebrate with them and see the flags and kits proudly on display." ■

DERRICK

GLOBAL FAMILY.
PIONEERING TECHNOLOGY.®

BEST-IN-CLASS
SLURRY SEPARATION
TECHNOLOGY

FLO-LINE PRIMER 258™

HI-CAP™

HYPERPOOL®

HYPERPOOL® WITH MUD CLEANER

DE-7200™ CENTRIFUGE

DERRICK®

Derrick Corporation
15630 Export Plaza Drive
Houston, Texas 77032
Toll Free: (866) DERRICK
www.Derrick.com

CST CLEAN SLURRY TECHNOLOGY

Exclusive Distributor

Clean Slurry Technology, Inc.
4101 Union Ave
Bakersfield, California 93305
Toll Free: (877) 365-8396
www.CleanSlurry.com

Construction begins on one of longest lots of Brenner Base Tunnel

Construction company Webuild and its Swiss arm CSC Costruzioni will begin construction on the lot H41 Gola del Sill-Pfons of the Brenner Base Tunnel in Austria.

At 64 km (40 miles), the Brenner Base Tunnel is the world's longest railway tunnel and will connect Italy and Northern Europe.

The H41 Gola del Sill-Pfons lot is one of the largest sections of the Brenner Base Tunnel.

Railway Technology reported that BBT SE, which is overseeing the project, will be responsible for its commissioning.

The project will form part of the Scandinavian-Mediterranean corridor of the Trans-European Transport Network (TEN-T).

The scope of the contract includes building the railway from Gola del Sill near the city of Innsbruck in the north to the town of Pfons further south.

The project will cover 22.5 km (14 miles) of the two main parallel tunnels, with 38 cross passages. It also includes the construction of an underground emergency stop at Innsbruck, access tunnels, exploratory tunnels, and parts of other secondary tunnels.

Furthermore, it will include the building of a bridge over the Brennero A13 highway.

Beginning in Egypt, the collaboration is due to be rolled out across the region, with countries including Saudi Arabia, United Arab Emirates, Kuwait, Oman, Bahrain, Qatar, Lebanon, Jordan, Iraq and Syria ultimately benefitting.

The Gola del Sill-Pfons lot is expected to generate up to 400 direct jobs as well as more than 1,000 jobs for third parties.

Webuild is also involved in works of Brenner Base Tunnel's other lots, including the Isarco River underpass and Mules 2-3 in Italy. The company is also constructing the railway between Fortezza and Ponte Gardena south of the tunnel. ■

Disruption is not an option

Reliable® Tunnel Deluge Systems protect your most critical infrastructure assets

Reliable deluge systems are the perfect solution for the challenges of tunnel environments:

- The Model DDV Diaphragm Deluge Valve is simple to maintain and rated for pressures up to 400 psi (27.6 bar). Available with a remote resetting pressure regulating option, the Model DDV features a compact footprint and can be installed in any orientation.
- The industry-leading low-pressure/high density TNL280 nozzle features a corrosion-resistant Electroless Nickel PTFE (ENT) finish and anti-reflective black paint topcoat.

TNL280

Over 100 Years of Reliable Experience

Reliable Automatic Sprinkler Co., Inc. has been a trusted source for high-risk fire protection solutions since 1920. Our manufacturing headquarters are in Liberty, South Carolina, USA, while our Sales and Technical Services teams span the globe.

Reliable®

Manufacturer and Distributor of Fire Protection Equipment

Contact our Technical Services team to identify the ideal solution to your specific need—no matter what the challenge.

reliablesprinkler.com/tunnels

hyperTunnel to exhibit at World Tunnel Congress and British Tunnelling Congress

hyperTunnel, the proposed tunneling technique that combines artificial intelligence (AI) machine learning and swarm robotics will exhibit for the first time at the World Tunnel Congress (WTC) in Copenhagen, Denmark Sept. 2–8. The program will return to the British Tunnelling Society (BTS) Conference & Exhibition in London on Oct. 11–12 after having formally launched its method to transform underground construction at the same event in 2021.

In a release, the company said that it will present a working demonstration of a section of its robot-led swarm construction platform at both shows. Visitors will be able to see 'hyperBots' working from within an underground pipe to conduct their various programmed tasks as part of a grid. The method, via which complete structures are built according to a digital twin, is designed to be substantially faster, safer, more economical and more environmentally friendly than current techniques.

"Our attendance at both shows reflects widespread industry acceptance of and interest in hyperTunnel's solutions from around the world. There is a genuine awakening going on in relation to the use of robots, digital twins and AI in construction — it's not exclusive territory to hyperTunnel of course, but our advanced integrated package is now established as offering what the tunneling and construction industries are aiming for in many existing and new applications," said Jeremy Hammond, co-chief executive officer and co-founder of hyperTunnel.

hyperTunnel has grown significantly during the past 12 months and enjoyed a string of successes in terms of new investments, industry partnerships, talent acquisition, and the completion of a full-size pilot tunnel in the United Kingdom.

In June, hyperTunnel received a financial investment from VINCI to support business expansion and further develop the hyperTunnel method in practical situations.

(continued on page 21)

MILLER

MILLER is a family owned and operated company that was founded in 2001. We started out doing residential, light commercial, and agricultural concrete. With our location in the Illinois Coal Basin, we soon had opportunities to do projects in coal mines. Since then we have shifted our focus entirely to the industrial and mining sectors. Today we have projects across the United States, reaching 21 states but are always looking to add states and countries and are in all types of mining! This includes salt, limestone, trona, frac sand, and coal mines, as well as heavy industrial construction for aluminum plants and other manufacturing facilities.

Our high quality contracting services include: shafts, fans, hoisting, complete portals, foundations, and declines. As well as custom projects to meet each customers particular needs. We are an innovative company that approaches each project with an out-of-the box attitude aimed at efficiency, higher quality, added value, and safer job sites.

Our most important resource is our people and and we believe there is no "I" in "Team".

At MILLER, we strive to bring the best value to our customer`s projects. With fair prices, superb service and outstanding quality delivered by an honest and hard–working team of professionals, we are committed to seeing that our values are a part of every project that we do. We strive to practice the highest levels of integrity with all persons involved and praise God in every interaction.

for more information please visit our website: millercontracting.us

Chair's column

(continued from page 2)

Collaborative efforts with our various liaison associations progressed, with several MOUs being signed, defining how the UCA and the respective organizations can leverage efforts and help with mutual goals.

I'm also very pleased to share that, at the last Executive Committee meeting, we ratified a charter and initial funding for our new Government and Public Affairs Committee. As highlighted in my last column, we are becoming more structured and focused on the objective of educating stakeholders regarding the benefits and wisdom of underground infrastructure investment, and in providing tools that can assist in achieving that end.

At NAT, we celebrated industry achievements in the form of the new, expanded UCA Awards, highlighting team and individual excellence. We also had the opportunity to reflect on the passing and celebrate the excellence of industry/Association stalwarts who made an impact on underground construction and so many of us therein.

The UCA itself was also celebrated by the SME at its annual conference with Bob Goodfellow receiving recognition for his leadership with establishing the UCA Working Groups.

Association growth

It's particularly noteworthy that we have seen UCA membership grow in the last year (see Table 1).

This type of evolution becomes a virtuous cycle: more members benefit from the Association, and more members are available to contribute, as well, which provides subsequent benefit. It's what we want, what we need.

We continued our scholarships and mentoring programs this past year. The feedback from mentors and mentees alike has been very positive. Regrettably, we have not filled our conference scholarship capacities recently. We plan to start the process earlier in advance of Cutting Edge and RETC, and we are brainstorming ideas of how to get broader exposure to potential industry entrants. This is a high priority for the Student Outreach Committee and the "Down for That" initiative, to be aided and abetted by the Young Members group.

The "Teach the Professors" program was very successful at NAT, and I'm very happy that the executive committee has approved expanding that program annually. It will be held concurrent to RETCs now, as well as NATs.

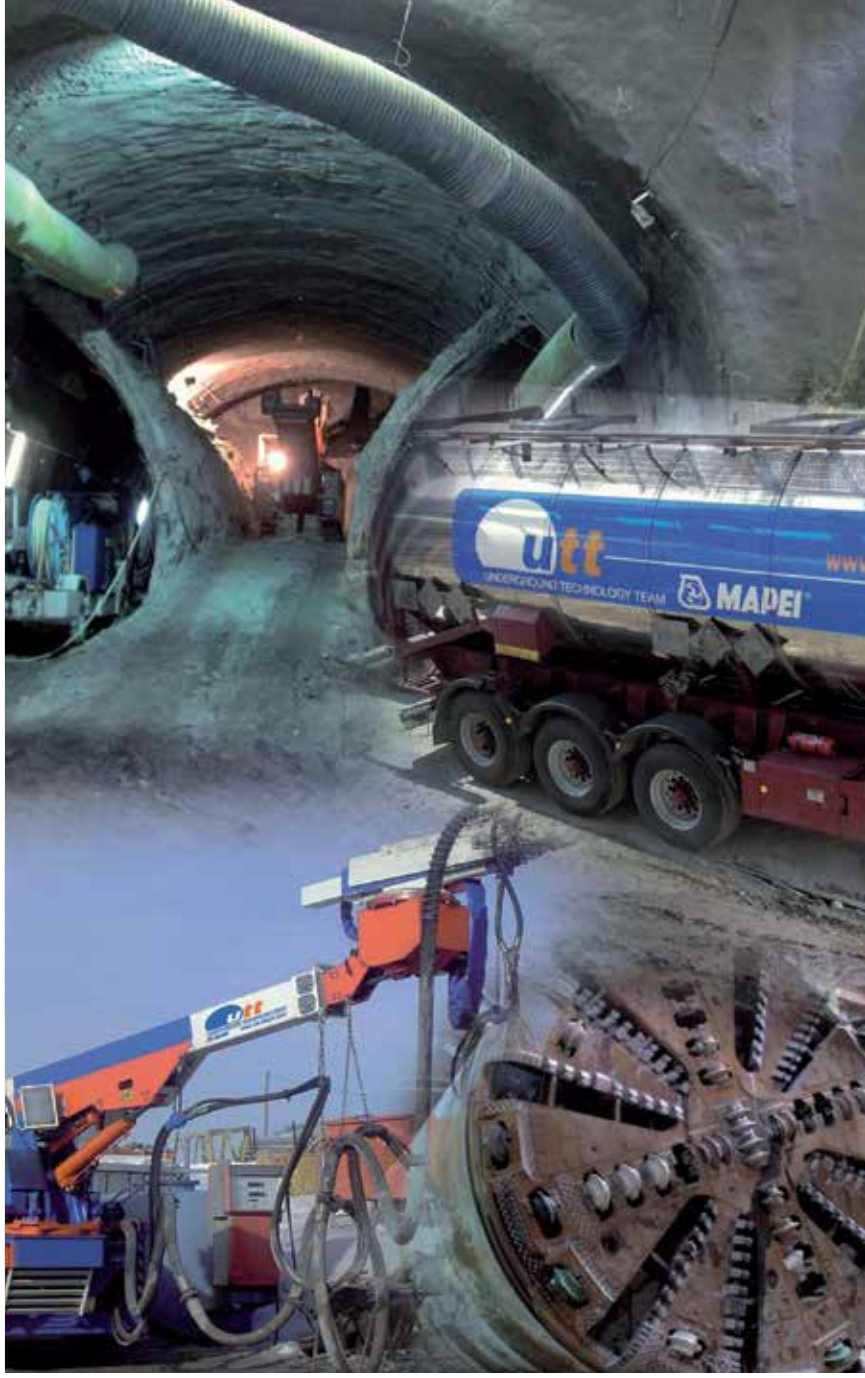
The Women in Tunneling leaders held a well-attended gathering at NAT and are in the process of reviewing their plans going forward with several events and concepts for the immediate and longer-term future.

What a year … Tunnel on! ■

TABLE 1. UCA Growth
1,558 members, up 23 percent
92.25 pecent are Professional Members; 7.75 percent are Student Members
31 Corporate Members
31 Sustaining Members
87 percent reside in the U.S.
13 percent are international
32 countries represented
6 percent women, 58 percent men, 36 percent no data
1 in 5 members (19 percent) are age 39 and under

Proven Technology for

Underground Construction



Our commitment is the detail that makes the difference.

Reliable technology and expertise for underground construction

- Alkali-free set accelerators and admixtures for shotcrete
- Products for mechanized tunneling: foaming agents for soil conditioning, polymers, sealants and lubricants
- Products for grouting and consolidation
- Products for concrete repairing, protection and coating
- Products for waterproofing: synthetic waterproofing membranes and waterproofing accessories

Discover the world of MAPEI: Visit www.utt-mapei.com or email us at hq.utt@utt.mapei.com

MAPEI USA

MAPEI®

ADHESIVES · SEALANTS · CHEMICAL PRODUCTS FOR BUILDING

Water Fix: Plans now include one tunnel

(continued from page 4)

a few miles south of Sacramento that would siphon off a portion of the Sacramento River's flows during heavy storms and route it under the Delta so that fresh, clean water could head to the southern part of the state without as many environmental harms.

The state's favored proposal outlines the construction of a tunnel — 11 m (36 ft) in diameter on the inside — crossing the eastern side of the delta, whereas an earlier version went down the middle. It would capture water from the Sacramento River, just 27 km (17 miles) south of the state capital, and deliver it to the Bethany Reservoir, northwest of Tracy, where the existing state water project pumps are located.

If constructed, it would be the state's largest infrastructure venture since the high-speed rail system, a project that has faced numerous delays, cost overruns and litigation — hurdles that could also hobble the water tunnels. It would also create thousands of jobs — one reason the state's powerful labor unions have backed versions of it for decades, along with numerous governors.

Cost estimates are running around $16 billion — $3 billion less than the previous iteration, a double-tunnel system proposed in 2018, during Brown's administration.

Large water districts, including the Metropolitan Water District and the Santa Clara Valley Water District in San Jose, have been funding the planning of the tunnel system for years. They are joined by 14 other water agencies that receive water from the state water project.

Between 2021 and 2024, that group of water agencies, known as the Delta Conveyance Design and Construction Authority, planned to spend about $360 million on the effort. The Metropolitan Water District is footing about 44 percent — roughly $160 million.

The single tunnel project is smaller than iterations proposed during the Brown and Schwarzenegger administrations. This new one has a maximum capacity of 6,000 cubic feet per second, whereas Brown's plan called for a capacity 50 percent higher. Schwarzenegger's plan was even bigger — 15,000 cubic feet per second. ■

DSI
UNDERGROUND
A SANDVIK COMPANY

Advancing The World, Safely And Efficiently

Tunnels help maximize space and improve communications – all key to helping drive human progress. And we supply key solutions that reinforce progress underground. Our products keep workers safe. Our reliability helps engineers plan ahead. And our expertise keeps tunnels advancing efficiently to bring benefits to everyone.
We are your system supplier for all consumables.

DSI Tunneling LLC
502-473-1010

dsitunneling.com
dsiunderground.ca

San Bernardino: Project moves forward

(continued from page 6)

at least $265 million from the state and $25 million in federal funding. An underground tunnel is also an unprecedented feat in an area infamous for traffic congestion. The project's design and building could take up to three years before it's ready for testing.

In April, the San Bernardino County Transportation Authority began obtaining environmental clearance and drafting a formal document for the Ontario airport tunnel, a process that typically takes around 18 months. The agency also is conducting industry outreach and courting new firms to help with financing as well as design and construction. Outside companies will be required to submit their own proposals for approval. ■

ANTRAQUIP® CORP

Experienced, Innovative & Reliable

YOUR PARTNER FOR PERFORMANCE

DRUM CUTTER ATTACHMENTS

ROADHEADERS 13 - 85 TONS

THE ULTIMATE CHOICE FOR TUNNELING APPLICATIONS!

ROADHEADERS • ROCK AND CONCRETE CUTTERS • SCALING ATTACHMENTS • TUNNEL / GROUND SUPPORT SYSTEMS

Proudly Made in the USA from Domestic Steel

GROUND SUPPORT PRODUCTS

LATTICE GIRDERS • ARCH CANOPY SYSTEM • PIPE ROOF SYSTEM
SPILES & ROCK BOLTS • STEEL RIBS & MORE

antraquip.net | info@antraquip.net | 301.665.1165

ANTRAQUIP® CORP

PROVIDING INNOVATIVE SOLUTIONS FOR TUNNELING, SCALING, TRENCHING, & SOIL REMEDIATION PROJECTS

WSP to aquire UK-based consulting firm RPS Group

WSP announced that it has reached an agreement with the board of RPS Group to acquire RPS, a UK-based consulting firm with 5,000 employees globally generating approximately $875 million in revenue.

Founded in 1970 and built on a legacy of environmental and social engagement, RPS is a diversified and well-recognized global professional services firm.

As an established technology-enabled consultancy that operates across a range of sectors, RPS provides specialist services to government and private-sector clients with a focus on front-end consulting.

RPS has been widely recognized for its strong sustainability agenda, having been ranked number one in the UK for climate change and energy consulting by the Environment Analysis for 2019/2020, a top 200 environmental firm, by *Engineering News-Record* in 2021, and was recognized in 2021 as one of the first "carbon champions" by the Institution of Civil Engineers.

"We are pleased to announce the proposed acquisition of RPS as it will enable us to rapidly deliver on our global strategic action plan and create value for all our stakeholders," said Alexandre L'Heureux, president and chief executive officer of WSP.

"RPS is a perfect fit as it adds depth to our current platform and is highly complementary, in terms of geographies and sectors, to our recently announced agreement to acquire the environmental and infrastructure (E&I) business of the John Wood Group.

"When completed, our recently announced transactions will bring our workforce to approximately 70,000 with approximately 23,000 environmental experts across the globe. We are proud that we are building a strong ESG leader with significant capabilities in water and energy, and contributing significantly towards the transition to a greener and low-carbon world," said L'Heureux. ■

hyperTunnel: New program will be on display

(continued from page 12)

As part of that deal, hyperTunnel recently joined VINCI's innovation platform Leonard as a member of its startup accelerator program, Catalyst. hyperTunnel also won the prestigious annual Construction Start-up Competition in Miami, FL last year, which Leonard co-organizes with other sector heavyweights such as Ferrovial and Cemex Ventures.

"hyperTunnel's technology can be truly game-changing when it comes to improving the safety and sustainability of underground construction projects," said Guillaume Bazouin, head of start-up and intrapreneurs programs at Leonard. "It strongly aligns with our goals of rapidly responding to the climate emergency by enabling technological advances that have a substantial environmental impact. hyperTunnel also boasts exceptional leadership and engineering teams, and we are looking to support their great success in the near future."

hyperTunnel was selected by The European Innovation Council (EIC), Europe's flagship innovation program to identify, develop and scale up breakthrough technologies and game-changing innovations and will receive funding of 1.88 million euros through the EIC accelerator scheme.

hyperTunnel has been picked by Innovate UK to join its Global Business Innovation Program. It has also won startup of the year at this year's Construction Technology Awards in Dubai. In 2021, hyperTunnel was highlighted as a top 50 contech startup and was among 10 winners of a global construction startup competition.

hyperTunnel continues to attract outstanding talent to its business: Sven Asmus, formerly chief technology officer at MBCC Group, is director of chemistry and materials development; Tao Xinghui, a leader in the field of data science, and edge-to-cloud AI, has been appointed head of AI and digital twins; Sid Shaikh, an ex Ocado, GSK and Mars technology innovator, has been hired as hyperTunnel's new head of robotics. At Ocado, Sid and his team developed and delivered into production the first three generations of the Ocado smart platform, a very similar system in principle to the hyperTunnel method. ■

First TBM breakthrough at London's HS2

London's High Speed 2 (HS2) rail project celebrated its first tunnel breakthrough when a 2-kt (2,200-st) tunnel boring machine (TBM) broke through on the London to Birmingham route in July.

The TBM began boring its 1.6-km (1-mile) journey in 2021 underneath ancient Warwickshire woods and became the first project of HS2 to break through. Work is being done in a bid to preserve the ancient woodland, officials say.

Sky News reported that the TBM, Dorothy, named after Dorothy Hodgkin — the first woman to win a Nobel Prize in chemistry in 1964 — is the first tunnel breakthrough on the London to Birmingham route.

HS2 minister Trudy Harrison described it as "quite literally, a ground-breaking moment" for the scheme.

She said it demonstrated the government was "getting on with delivering on our promises and progressing our transformative plans to boost transport, bring communities together, and level up the North and Midlands."

However, the scheme is opposed by environmental activists including Stop HS2, which criticized the destruction of the woodland and argues more investment in short commuter-rail services is needed.

Long Itchington Wood is classified as a site of special scientific interest and has ecosystems that have taken hundreds of years to establish, the HS2 team behind the work said.

Nearly 400 people working for HS2's main works civils contractor Balfour Beatty VINCI (BBV JV) have delivered this important milestone on the HS2 project.

The tunneling team have been working around the clock in shifts for seven months to operate the TBM, which has put 790 concrete rings in place, with each ring made from eight 2 m (6 ft)-long segments.

HS2 Ltd's chief executive officer Mark Thurston said: "This is a historic moment for the HS2 project, and I'd like to congratulate everyone involved in delivering it. The 400-strong team, including tunneling engineers, TBM operators and construction workers at both portal sites, have pulled out all the stops to achieve this fantastic milestone.

"This milestone demonstrates the significant momentum behind Britain's new zero-carbon railway, creating thousands of jobs and apprenticeships, along with hundreds of opportunities for businesses across the country, helping fuel our economic recovery."

Over the next four months, the cutterhead and front section of the TBM will be dismantled and transferred back to the north portal, while the bulk of the machine will be brought back through the tunnel. It will be reassembled, ready to launch for the second bore of the tunnel. ■

Second TBM begins work at Eglinton Crosstown West Extension

Tunneling on the project started this past spring with the first of two tunnel boring machines (TBM) named Renny boring the roughly 6-km (3.7-mile) tunnels.

Since April, Renny has tunneled more than 650 m (2,132.6 ft), making tremendous progress in a short amount of time. The TBM averaged 10 to 15 m/d (32.8 to 49.2 ftpd).

The second TBM, Rexy, has now begun boring operations.

The launch shaft is only large enough to accommodate one TBM launch at a time, which prevented both machines from tunneling at the same time, *Mass Transit Mag* reported.

Rexy and Renny are expected to continue this pattern over the next 20 months. Renny will reach the extraction shaft just west of Scarlett Road first, with Rexy following behind.

These tunnels will form a large part of the Eglinton Crosstown West Extension, which will expand the Eglinton Crosstown light-rail transit (LRT) line another 9.2 km (5.7 ft) west, to Renforth Drive. Plans are also being explored to extend the line even further to Pearson International Airport.

After the TBMs are pulled out of the ground near Scarlett Road, the route will transition to an elevated section, passing over the Humber River before heading back underground just east of Jane Street, where the extension will connect to the Eglinton Crosstown LRT at Mount Dennis Station. ■

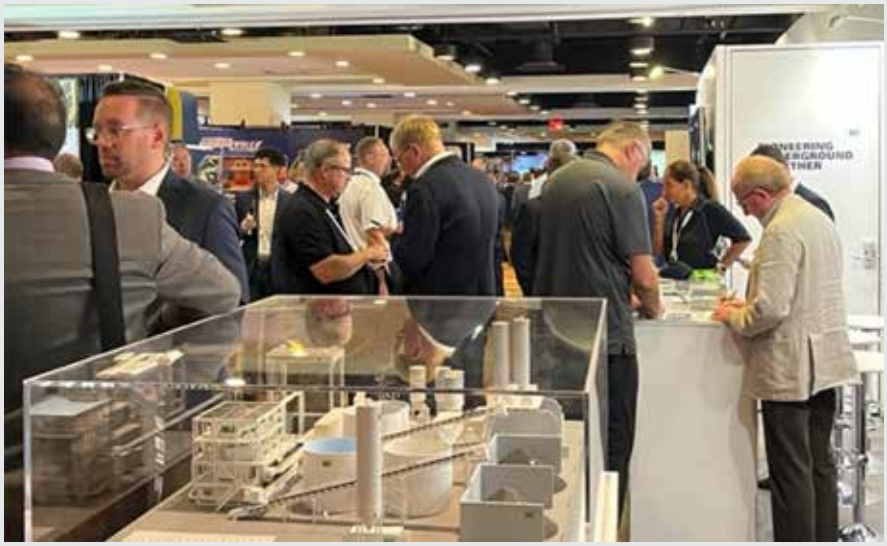
More than 1,000 attend NAT Conference in Philadelphia, PA

By William Gleason, Editor

For the first time since 2018, the North American Tunneling Conference (NAT) returned to an in-person format with more than 1,000 attendees coming together for the three-day conference in Philadelphia, PA June 20–22.

The conference began with an opening awards session in which individuals and projects were recognized for outstanding achievements and contributions to the tunneling and underground construction industry. UCA Awards chair Lonnie Jacobs explained that the UCA adjusted some of its

More than 1,000 attendees gathered at NAT 2022 in Philadelphia, PA.



Bill Edgerton was given the Lifetime Achievement award during the NAT awards breakfast.

awards criteria to better align with those presented by the International Tunnelling Association.

William Edgerton, past chair of UCA and past SME President was given the Lifetime Achievement award.

Edgerton said he was humbled by the award and thanked those close to him who have supported his career. He also spoke about ways to continue to improve the industry. In addition to developing better conflict-resolution methods, Edgerton encouraged those attending the conference to use the opportunity to learn from successes as well as mistakes. "At these conferences we do a good job of talking about the projects that we completed and the success we have had, but not all of the projects go well, and we should share stories about the jobs that didn't do so well because we learn more from mistakes," he said.

Attendees had ample opportunity to learn about success and some failures from industry experts.

Derek Penrice, vice president and principal project manager of tunnels for Mott MacDonald, was the program chair for the 2022 conference. Along with a committee of industry leaders, the three days of technical programming covered a range of topics important to the industry. "I thought this was an exceptional conference, the venue was great — it was compact and easy to transfer quickly between tracks and the exhibition hall felt intimate. The program itself was excellent, the technical sessions were well run and had strong content," said Penrice. "I was fortunate to be working with some dedicated people including program chair Paul Madsen, and track chairs Matthew Crow, Louis Falco, Amanda Morgan and Kathy Murtagh to arrive at those selections."

Technical programming tracks included: case histories; tunnel lining design; underground project delivery; construction innovation; design of underground spaces; rehabilitation/fire life-safety; TBM technology; SEM/NATM excavation techniques; challenging design issues; underground project risks; innovative solutions; shaft excavation, tunnel rehab and challenges; innovative designs; future projects; design innovations; geotechnical and contracting cases; numerical modeling; project design and digital technology.

"The process starts with a thorough review of the submitted abstracts," Penrice said of the behind-the-scenes work done to bring the conference to life. "We interrogate these to see whether they add value to the conference — is

the subject matter of interest to the audience, does it contribute to their learning experience, and has the author taken the time to submit a well-written, thoughtful abstract that suggests the paper will ultimately be of high quality."

The biennial conference has established itself as the premier event for the exchange of technical information, and while much of the programming was very technical, the conference also allowed attendees to discuss the less technical, but equally important, issues facing the industry. Among those issues is attracting and retaining a qualified workforce that will allow the industry to meet the demand for more underground infrastructure, an issue Edgerton spoke about during his acceptance speech.

As did Christophe Bragard, the Muddy Boots Award winner. This award goes to a field supervisor who has exhibited leadership in the field. Bragard also spoke about the workforce challenges and ways to retain good people. He compared the building of tunnels to climbing a mountain, saying both endeavors require team work and a shared goal. And in both, the journey, while challenging, should also be enjoyable.

"There were recurring themes that we heard time and again over the course of the conference," said Penrice. "We need more people and how do we attract younger generations to our industry? I heard that same question asked by vendors, contractors and engineers. While other industries faced massive layoffs during the COVID pandemic, we were as busy as ever, learning new ways of working. What we do is utterly fascinating. It's a very stable and rewarding career, but we're in competition for engineers with Apple, Google and Meta as well as each other. These are products and services that the younger generation is intimately familiar with through daily

use. How do we compete with that?"

In addition to the technical programming, the conference included a number of networking events including receptions of UCA corporate and sustaining members; an Owners reception and a Women in Tunneling reception as well as the NAT Welcoming Lunch and UCA Breakfast.

During the UCA Breakfast, UCA Chair Mike Rispin spoke to a crowded room about the need to support the industry by supporting the UCA's strategic plan that was built on the pillars of improved stakeholder awareness, association growth and industry education. During the breakfast, Rispin spoke about the need to increase awareness of the benefits of underground infrastructure to a wider audience. He has written about this topic in his chair's column of *T&UC* and encouraged the attendees to become involved with the education of decision makers.

Rispin noted that SME has had success educating lawmakers through the efforts of its Government and Public Affairs Committee. That committee does not lobby, but provides factual information on issues related to mining. Rispin said the UCA should have a similar committee that can educate lawmakers on the benefits of tunneling.

The tunneling and underground construction industry, after all, is healthy and positioned well for the future. The $1.2 trillion infrastructure bill that was passed in 2022 includes billions of dollars to improve the nation's transportation networks, water and power systems and internet connections.

The infrastructure bill includes about $16 billion for "major projects that are too large or complex for traditional funding programs," but that have big economic benefits, according to the White House.

In addition to new spending on highways and bridges, the broader infrastructure package includes what the White House calls the nation's biggest investment in transit and clean energy transmission in U.S. history, as well as billions for replacing lead pipes and extending broadband. It includes investments in passenger rail, electric vehicle infrastructure, and programs to address past environmental damage, reduce road deaths and improve airports and waterways.

Many of these future projects were discussed throughout the conference, and it concluded with a closing plenary session chaired by Jon Klug called the Tunnel Demand Forecast. Klug compiles the information for the Tunnel Demand Forecast in each issue of *T&UC*. In this session, future projects in the United States and Canada were discussed in detail.

In addition to the technical programming and networking events, the conference hosted a vibrant exhibit hall with 125 companies in 149 booth spaces. The latest advancements in technology were on display in the exhibit hall, which also served as an excellent venue for attendees to discuss hot topics.

"Our industry is strong, vibrant even," said Penrice. "We are continuing to see major technological advances in tunnel boring machines — both size and function in terms of how we can deliver subway projects, communications infrastructure, and advances in BIM technology, and spatial tools that will fundamentally change how contract documents are delivered and thereafter how assets are managed. Many people I spoke with at the conference mentioned how busy they were and

how they needed more people. This is a positive sign, up to a point. We have many high-profile projects underway in Los Angeles, San Jose, Virginia and Toronto that will raise the profile of our industry, many more major massive projects in the planning stages — Sepulveda Pass, ST3, California High Speed Rail, the Transbay Downtown Extension and the Delta Conveyance project on the west coast alone. With the passing of the recent infrastructure law, we hope to see further significant investment in transit. The major issue will be the competition to find resources to complete these projects."

Next up for the tunneling and underground construction industry is the Cutting Edge Conference Nov. 14–16 in Long Beach, CA. Hosted by UCA and *Tunneling Journal*, Cutting Edge is a unique technical conference focused on the advancement of tunneling technology. The conference features high-end technical sessions focused on innovation and practical knowledge. This year it also includes a site tour of the Clearwater Project currently being constructed by a tunnel boring machine.

The Clearwater Project was approved after a multiyear evaluation of the main sewer system serving nearly half of Los Angeles County. A new 11-km (7-mile) tunnel, a key component of the project, is being constructed to protect local waterways by addressing aging infrastructure.

International Tunnelling Association (ITA) vice president Arnold Dix will give a keynote presentation on sustainability goals for the tunneling industry.

Paul Madsen, engineering manager, Roundout BT-2, Kiewit-Shea Construction, is the program chair for the 2022 conference.

"Cutting Edge is a single-track conference. Meaning, everyone attends the same hand-selected, high-quality presentations, which provides great fuel for discussions during the question and answer panel sessions," said Madsen. "It is a smaller, more intimate conference, and both attendees and sponsors in the tabletop exhibit hall (where meals, coffee breaks and receptions take place) often comment on the high level of networking that goes on in the room."

This year the conference will include high-level technical discussions as well as a focus on the tunneling industry's role in the fight against climate change. ■

360-degree, 3D digital assessment of subsurface water infrastructure

Major water tunnels have the capacity to deliver several hundred million gallons of water each day. Tunnel inspection is an extremely complex and specialized process that requires forward thinking and advanced tools and technology. In an effort to minimize the time it takes to conduct inspections, and because of operational needs, tunnels are typically taken out of service for a limited window of time.

The Mott MacDonald team worked with Dibit Measuring Technique to capture the inside of a major freshwater tunnel. By building a detailed digital model of the interior surface, the engineering team could perform the needed assessments as a digital desktop study instead of conducting a lengthier traditional field investigation. The result was an inspection program that reduced the out-of-service time needed by more than 80 percent while yielding a higher-quality, more complete and precise inventory of issues that will be repaired during construction.

Advantages of water tunnel assessments based on 3D data

Some water tunnels must be capable of withstanding high pressures and flow rates. This makes it mandatory to perform conditional assessments, ensuring safe and reliable water conveyance over dozens of miles.

Severe tunnel damage, like cracks or seeping construction joints, can cause a significant loss of water. This type of damage can also contaminate the water in tunnels from surrounding areas.

The complete drainage of a water tunnel is difficult to execute, and even more challenging if the tunnel needs to be drained for a long period of time. Traditional water tunnel assessment requires a tunnel shutdown of several weeks per mile to accomplish detailed manual and visual documentation. It also requires a large team of highly qualified personnel to accelerate the assessment, which can result in additional costs.

Jérôme Steinkühler, Michael Mett, Heiner Kontrus, Cory Dippold and Kristi Latimer

Jérôme Steinkühler is engineering director, Dibit Measuring Technique USA, Inc., while Michael Mett is head of research and quality management and Heiner Kontrus is president, Dibit USA. Cory Dippold is vice president and Kristi Latimer is senior project manager, Mott MacDonald. Email: jerome.steinkuehler@dibit-scanner.com.

FIG. 1

The team performed scanning of a noncircular tunnel using the scanning system, which is mounted onto a cart and pushed along the alignment. Each measurement photo is fully illuminated. The system covers 360° of the tunnel surface, including a water covered invert.

Water tunnel assessment based on 3D data is a highly beneficial method to significantly reduce tunnel shutdown time. In this effort, the time spent in the tunnel is reduced to a minimum and the work is mostly concentrated on the tunnel scanning itself. The actual assessment is performed later, offsite.

This approach to tunnel scanning is faster than traditional assessments and requires less resources (Kontrus and Mett, 2019). It leads to a cost decrease, and the work can be performed within the safety and convenience of an office without the pressure of a limited time window to complete the work.

The approach involves scans of water tunnels to determine the condition of the tunnel surface (Fig. 1). It is important to capture significant damage and leaks to get a reliable state of the tunnel. Modern scanning systems offer the possibility to reproduce tunnel surfaces in the form of a 5 mm (0.196 in.) geometry accuracy combined with a high-resolution photo texture of 1 × 1 mm (0.039 × 0.039 in.) per pixel. It ensures recognizable damages and cracks down to a size of 0.3 mm (0.011 in.) crack width (Mett et al., 2019b).

360-degree scanning system

The Dibit "Altira" (Greek for dumbbell) is a light, compact and variable measuring system for the 3D

measurement of tunnels. As a hybrid measuring platform, it is equipped with a laser scanner and a photo unit and can be upgraded with a thermal unit. The laser scanner enables precise measurements of the tunnel geometry (Mett et al., 2019b). The photo unit delivers high-resolution photos for true-color texturing of the 3D data. With the help of thermal cameras (also known as infrared, or IR, cameras), additional information about the temperature behavior of the tunnels can be derived.

The system contains several high-resolution industrial cameras according to the latest standard, which are arranged on a horizontal axis in a helical structure. Due to sufficient overlap of the individual cameras, the entire interior of the tunnel is covered. Specially developed high-performance light-emitting diode (LED) flashes illuminate every measurement photo, even in tunnels without any interior lighting.

The manually pushed system reaches a speed of approximately 2 to 3 mph. With an attached control computer, the measurement can be continuously tracked, and the quality of the measurement data can be verified (Fig. 2).

The Altira measuring trolley can be used in water, road and rail tunnels. By manual rerailing, short mobilization times can also be achieved during its use. Narrow time windows can be used for the measurement: for example, in railway networks with continuous operation.

With high-resolution photos, cracks with opening widths down to 0.3 mm (0.011 in.) can be detected and measured in the 3D model. Geometric features can be detected with a 5 mm (0.196 in.) accuracy and temperature differences on the tunnel surface of 40 mK. The measurement unit is competing with other scanners like the Leica Pegasus Two and Riegl VMX (Leica-Geosystems, 2021, Riegl, 2021) and established tunnel measurement systems like the SPACETEC TS 4 (Spacetec, 2021).

FIG. 2

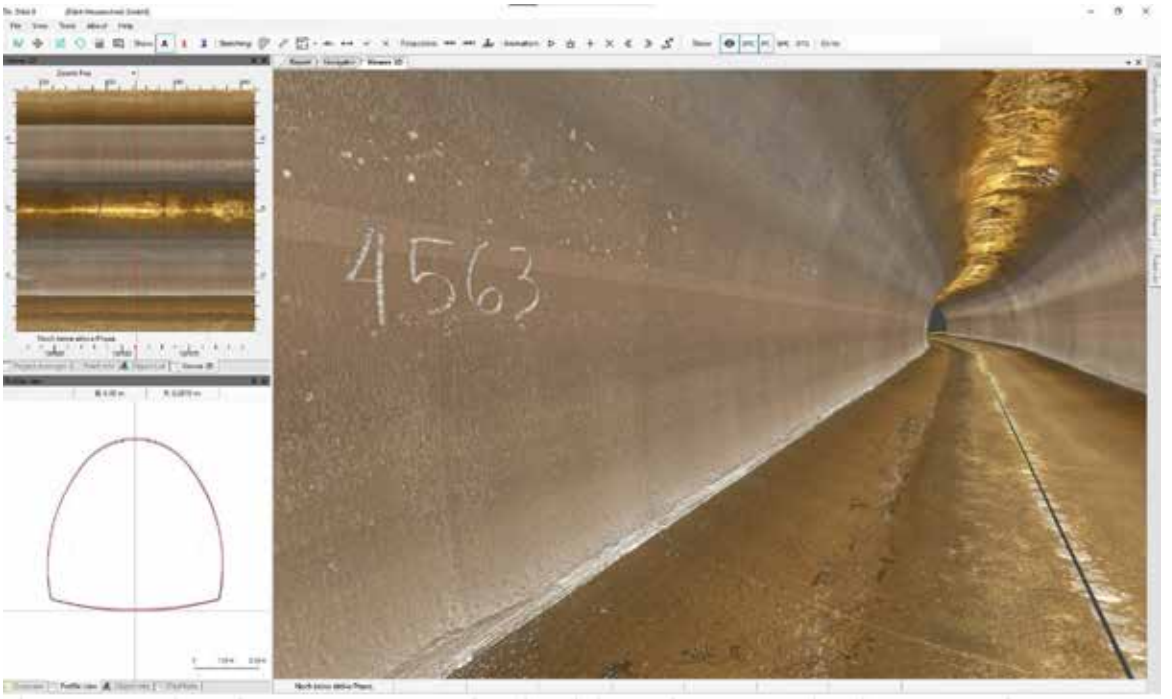
The assembled Altira shortly before its use for a water tunnel scan. The measuring system is supported by robust aluminum construction with special tires for use in standing water. The system consists of an LED lighting unit (white), cameras and the laser (gray puck).

Scan data and assessment of tunnel conditions in computer software

The scan data collected in water tunnels and the assessment of the tunnel conditions can be processed and performed in Dibit's proprietary software Dibit-8.

FIG. 3

3D view of a water tunnel surface in Dibit-8 software. A 2D view is in the top left corner and a profile view in the bottom left corner.



This software is specially, but not exclusively, designed for processing and analyzing 3D data captured in cylindrical structures like tunnels.

It supplies software standards to handle a huge amount of measurement data in the form of measurement photos (for example, RGB photos, infrared photos) and laser point clouds that are captured by the scanning device.

The viewer visualizes scan data in a fast and smooth manner, which allows for a professional analysis of tunnel conditions. It can be illustrated in a 3D viewer as well as a 2D viewer showing the unwrapped tunnel surface (Fig. 3).

A tunnel condition assessment includes a documentary of all significant damages and tunnel components like blocks (Kontrus et al., 2021).

All analyzed tunnel damages and components are stored in a database by a manual drawing of the objects,

either in the 2D orthophoto or the 3D tunnel data (Fig. 4).

Furthermore, approaches based on artificial intelligence (AI) enable automated detection of tunnel objects and cracks. Each detected object has specific coordinates and can have a linkage to an inspection or measurement photo, or even a remediation protocol. The shapes of the objects can be selected in the form of a point, an open 3D polyline, or a closed polyline (planar annotation). The objects that have individually selectable names and attributes can be categorized in classes that allow a filtering and evaluation of the different classes. All important information like positions, lengths and attributes can be exported to a tabular format for further analyses.

A final step of finishing a tunnel assessment is the printout of a plot of the 2D orthophoto. This tunnel map includes the high-resolution photo-textured unwrapped tunnel surface (orthoimage), as well as all the drawn tunnel objects and classes.

3D point clouds and 3D-textured mesh models can be exported to other data formats like ASCII, E57, LAS, OBJ and many others. Ortho image data like TIFF and JPEG can be exported for further analyses in computer-aided design or BIM software (Mett et al., 2019a).

Many tunnel objects and surface damages can be recorded in the 3D data (Fig. 4). This includes construction joints, cracks with several thicknesses, seeping holes or corrosions. Each object is cumulated in a specific class that has certain geometric information, like an open or closed colored polyline a point or a plane. Each class can have several objects indicated by numbering.

Conclusion

During the processing and analysis of measurement results, it turns out that 3D data is an excellent basis for detecting and measuring damages and cracks down to the submillimeter range.

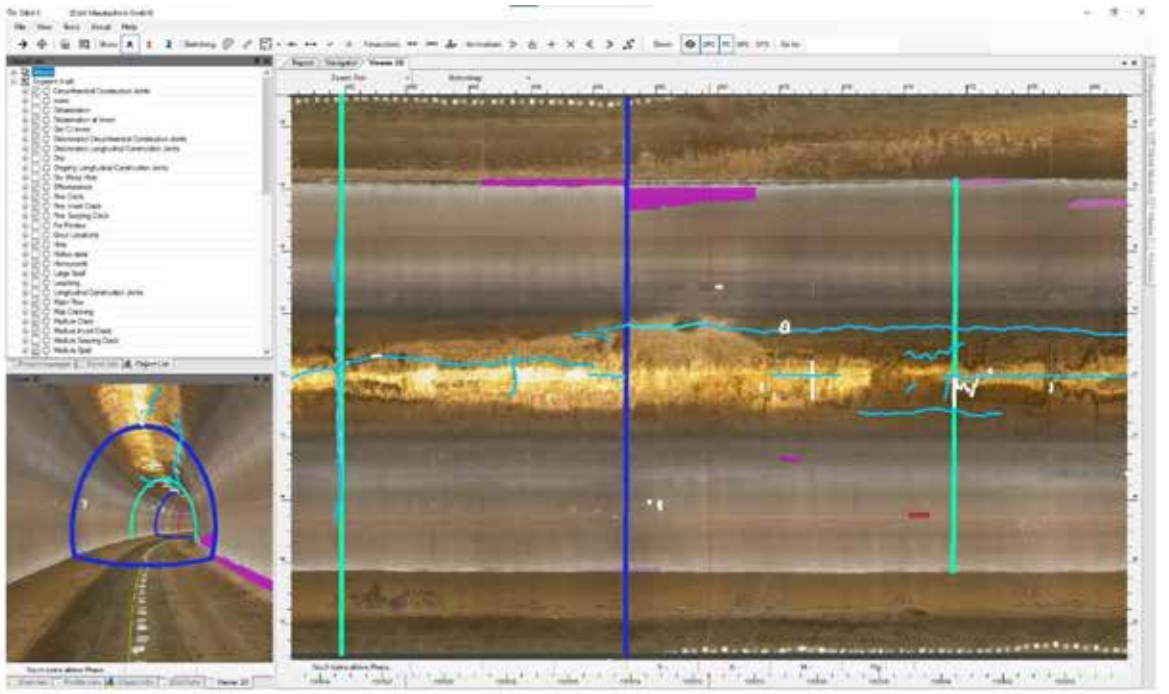
Tunnel-specific conditions, such as the absolute darkness, are a challenge. The walls of water tunnels are usually covered with organic matter, which can lead to reflections on the measurement photos. A water-covered invert (up to 4 to 5 in.) can be fully processed and analyzed showing that hybrid LiDAR and photogrammetric Altira can scan areas where comparable scanners may not deliver reliable results.

The Dibit-8 software helps to perform the tunnel assessment with its unique combination of fast performance and display of high-resolution 3D data with a built-in database structure to classify the different tunnel objects and damages.

Each digital tunnel assessment delivers a snapshot of the conditions of a tunnel. By comparing the measured data with future scans, changes can be detected (for example, growth of cracks). It is a base for future maintenance that ensures safe water flow delivery to millions of people in the United States. ■

FIG. 4

2D view of a water tunnel surface in Dibit-8 software. TIS-objects and classes are included as colored polylines and points.



References

Kontrus, H., Mett, M. (2019). High-speed 3D tunnel inspection. 7 S. Proceedings of the Rapid Excavation and Tunneling Conference (RETC) 2019. 16.06.-19.06.2019, Chicago, IL. SOC FOR MINING METALLURGY. ISBN: 978-0-87335-470-7.

Kontrus, H., Steinkühler, J., Peal, T. (2021). High-speed 3D tunnel inspection in subway tunnels – Case study San Francisco BART. 6 S. Proceedings of the Rapid Excavation and Tunneling Conference (RETC) 2021. 13.06.-16.06.2021, Las Vegas, Nev. SOC FOR MINING METALLURGY. ISBN: 0873354923.

Leica-Geosystems (2021). https://leica-geosystems.com/de-at/products/mobile-sensor-platforms/capture-platforms/leica-pegasus_two. Website accessed on 10/6/2021.

Mett, M., Kontrus, H., and Holzer, S., (2019a). Dibit TIS – Das „Proto"- BIM für den Tunnelbau. Proceedings of the 20th international geodetical week Obergurgl. 10.02.-16.02.2019 Obergurgl, Austria. Edited by K. Hanke and T. Weinold. Arbeitsbereich für Vermessung und GEOinformation. Universität Innsbruck.

Mett, M., Kontrus, H., Eder, S. (2019b): 3D tunnel inspection with photogrammetric and hybrid systems. 10 S. Proceedings of the 14th International Conference on Shotcrete for Underground Support (ECI SUS XIV), Nong Nooch Gardens – Pattaya, November 17-20, 2019. Thailand.

Riegl (2021). http://www.riegl.com/nc/products/mobile-scanning/. Website accessed on 10/6/2021.

Spacetec (2021). https://www.spacetec.de/en/products/ts4/. Website accessed on 10/6/2021.

Improved contracting practices and ground risk management using geostatistics

Tunneling projects face uncertainty in terms of the differences between simplified models described in tender documents and the reality of full-scale construction. It is not easy to document intrinsic geological variability and stratigraphy, the spatial variation in geotechnical parameters, the differences between laboratory sampling and testing and in situ behavior, ground water variations, rock mass quality variations, and the existence of anomalies, such as boulders or voids.

There are considerable pressures on drafters of geotechnical interpretative documents, such as geotechnical baseline reports (GBRs), to get it 'right,' and this can lead to ambiguous representations and give rise to disputes should those topics identified turn out to be more adverse than originally assumed.

In fact, they can be counterproductive to the owner's interests given the widely accepted doctrine of 'contra proferentum,' a rule of contract interpretation that states an ambiguous contract term should be construed against the drafter of the contract.

Most interpretations of project geology are deterministic in that they derive a single interpretation. There is no measure of accuracy or bias. The uncertainty in the interpretation is seldom quantified in a meaningful manner, and this can lead to overconfidence in the model (especially if presented in colorful 3D).

This article presents a framework for how geotechnical uncertainty can be quantified using geostatistics, and translation into practical tools for ground risk management throughout planning, procurement and construction, and enable a more objective basis for interpretation. The sources and types of uncertainty, the impact these uncertainties can have on construction risks, and approaches for managing risks associated with uncertainty are described.

The approach, if adopted, should give more clarity to the degree of uncertainty present to enable resources to either reduce the uncertainty or mitigate the risk as necessary. Clear communication of risks is vital to achieving a common understanding, and to enable proper risk management.

Tunneling projects that go wrong are usually the result of key risks not being anticipated and priced at tender; they start wrong. Relying on geotechnical interpretations and baselines without considering uncertainties in and variations from the interpretation/baseline can lead to the project team (owner, designer and contractor) being unprepared. Therefore, assessing and quantifying the range of uncertainty in ground properties and behavior will help to inform the project team of what to anticipate, and through such risk awareness, minimize commercial losses.

Jacob Grasmick and Bill Newns

Jacob Grasmick, member UCA, is principal, Emprise Concepts LLC and **Bill Newns**, member UCA, is director, NovoConsult Ltd. Email: jacobg@empriseconcepts.com.

Geotechnical uncertainty in tunneling

Geotechnical uncertainty types and sources. Uncertainties related to subsurface conditions generally fall under into two categories (Phoon and Kulhawy, 1999; Baecher and Christian, 2003):

- Natural or aleatory variability – The inherent spatial and temporal randomness in geologic materials. In principle, this cannot be reduced; however, the degree of variability can be estimated more accurately by collecting more data.
- Knowledge or epistemic uncertainty – Includes: (i) statistical estimation and site characterization uncertainty, (ii) model uncertainty and (iii) parameter (or measurement) uncertainty. This type of uncertainty is related to the lack of sufficient information.

While it is generally accepted that these uncertainties will exist, too seldomly are they properly quantified and their implications on risks assessed for a project. Inadequate assessment of subsurface variability and uncertainty on a project basis can lead to critical errors in geological and geotechnical interpretations.

Impact of uncertainties on tunnel construction risks. The lack of a proper understanding of the associated uncertainty in geotechnical interpretations is considered one of the main reasons behind commercial losses, and even catastrophic geotechnical failures. A study of 110 geotechnical failure case studies by Tonks et al. (2017) identified the top two main causes of those failures as selected construction means/methods and poor geotechnical interpretation (Fig. 1).

Several case studies of geotechnical challenges or failures in tunnel construction linked, partially or entirely, to inadequate geotechnical interpretation can be referenced. For example, the Lausanne M2 metro experienced a sinkhole collapse when ground conditions were found to deviate significantly from the initial interpretation (Fig. 2). Relying on a single deterministic interpretation of the subsurface geology, without any

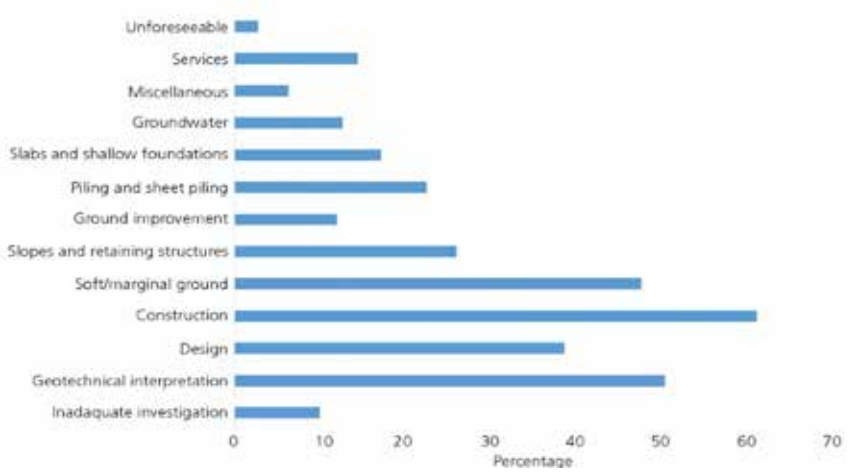
representation or quantification of interpretation uncertainty, gave a misguided belief that the excavated tunnel would encounter full-face Molasse. However, a mixed face condition with Moraine deposits in the upper half of the tunnel was encountered, causing face instability when the contractor was not prepared for this condition.

It is often said "that the client pays for sufficient site investigation, whether it does one or not," and with limitations of access and with typically less than 1 percent of the ground investigated for a tunneling works project, there is often severe limitations on the data available for interpretation, and a high degree of uncertainty associated with the interpretation of ground conditions that follow. The significance of this uncertainty is usually unknown, as it is not quantified nor communicated in advance of an adverse event.

Therefore, it is recommended to quantify the uncertainty of the conditions from site investigations to determine a measure of the sufficiency of the ground investigation along the alignment. This can also make clear the need for more site investigation. Such an approach of quantifying uncertainty should be valuable to any client organization that is committed to the efficient management of risk in underground construction, and in determining and allocating resources to manage such uncertainty.

FIG. 1

Main geotechnical issues (percentage identified in 110 cases) (Tonks et al., 2017).



Communicating the risk. The degree to which the parties to a contract understand the project risks at the time of forming the contract is considered a fundamental success factor for any tunnel project. This understanding is essential so that:

- Risks (not just geotechnical risks) are clearly allocated; and
- Financial provisions are made accordingly, and
- The parties understand the basis for changed conditions (from reference conditions created by the GBR baselines) should they arise and thereby minimize the potential for disputes.

Therefore, it is most important to define the basis of geotechnical forseeability (along with the communication of other project risks) and provide mechanisms within the contract such as a differing site conditions clause to vary the contract. These concepts are widely accepted (even

FIG. 2

Initial interpretation (left) and revised interpretation with addition of post-accident boreholes (right) (modified from Saousa and Einstein, 2021).

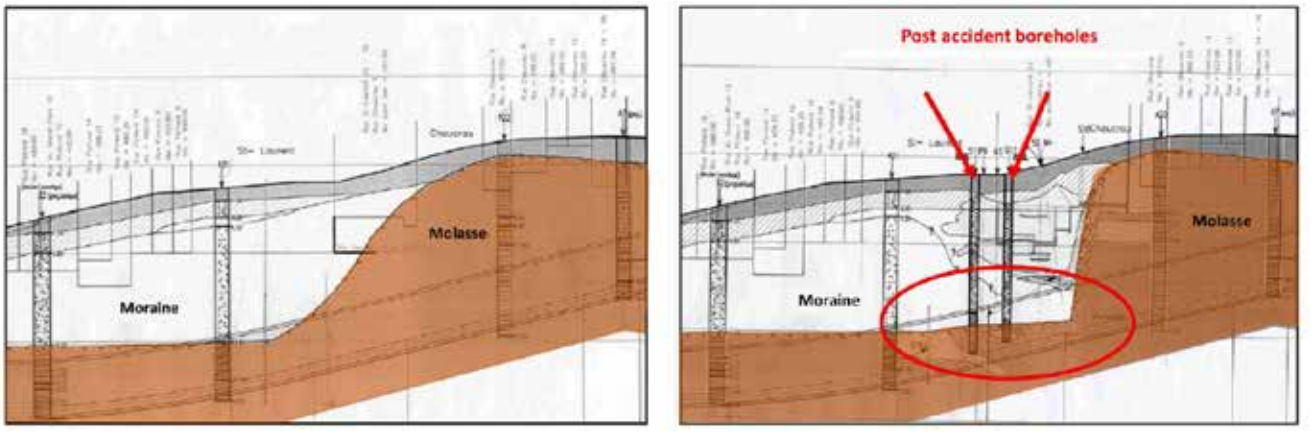
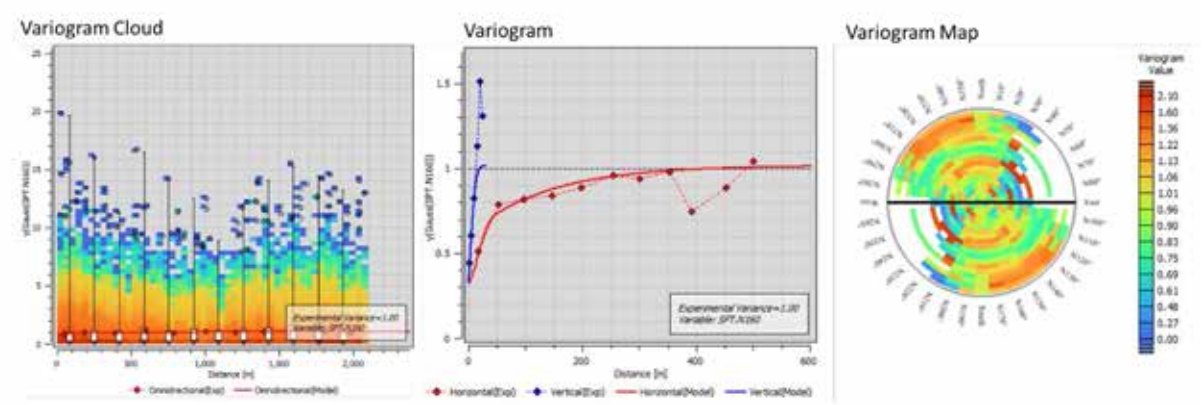


FIG. 3

Examples of visualizing the variogram, which describes the variability in the data as a function of distance and direction.



if practices may fall short) and have been the focus of industry since an Organisation for Economic Co-operation and Development conference held in Washington, D.C. in 1970 that led to the formation of the International Tunneling Association (ITA).

Quantifying uncertainties using geostatistical methods

This section introduces some approaches for quantifying uncertainty in geotechnical interpretations using geostatistical methods. Readers should refer to other references for a more detailed discussion of the theory and methods (e.g., Chilès and Delfiner, 2012; Pyrcz and Deutsch, 2014).

Overview of geostatistics. Geostatistics is a class of applied statistics used to analyze the spatial relationship of data to make predictions at unsampled locations. Widely adopted in industries such as natural resources, mining and hydrogeology, it is considered the best approach to model the spatial distribution and variability of geological and geotechnical properties. It provides a framework to integrate data from many sources (for example, geological interpretation, direct measurements and secondary measurements/information). The method is practical (consistent with the data), repeatable and can be easily updated with new information.

The spatial variability of geological and geotechnical properties is generally described by the variogram, which quantifies the degree of variability of the parameter as a function of distance and direction according to the data. A variogram is generated by computing the semivariance one-half the squared difference of all pairs of data.

Figure 3 presents example visualizations of the measure including the variogram cloud (semivariance of all data pairs versus distance), the variogram (mean semivariance versus distance) and variogram map (mean semivariance versus distance for specific direction angles).

The variogram is used for estimating properties at unsampled locations. At any unsampled location, the variogram and nearby known data (referred to as conditioning data in geostatistics) are used to derive a distribution of estimated values at that location, using an interpolator function such as kriging. In a simulation framework, multiple equally probable realizations of subsurface parameters based on geostatistical and geological rules or constraints can be generated. This offers users information on subsurface conditions consistent with the known data, alleviating the geologist or engineer of having to determine a single interpretation of the model, which can often be difficult to rigorously defend against any other expert opinion.

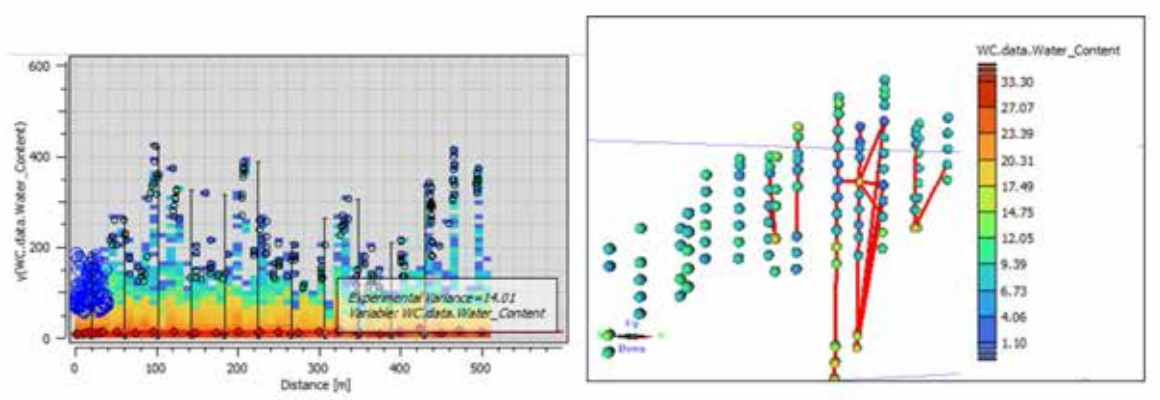
Using geostatistics to address reporting/measurement uncertainty. Since the variogram is a measure of the difference between data points as a function of distance and direction, it can serve as a powerful tool to identify potential outliers in a spatial context with respect to nearby measurements. In Fig. 4, for example, the highest water content semivariance values at each (binned) distance are identified via the variogram cloud (highlighted in blue). These points are then further reviewed (for example, 3D visualization, laboratory testing records) to allow a more rigorous assessment of the data points: whether the geological data classification is correct or whether they should be removed as outliers, or otherwise described in the process of determining baselines. Such a method is useful to more effectively identify samples and parameter values that require further verification during the data review process.

When constructing the variogram to model parameter variability, measurement errors can be incorporated such that the model reflects the uncertainty associated with the error. The semivariance value at a distance of 0 is referred to as the nugget of the variogram and reflects the microscale variability and measurement error of the parameter. This is an intuitive and effective way of incorporating measurement error into the geostatistical models to assess its impact on interpretation uncertainty.

There are several geostatistical tools available to perform exploratory data analysis and address parameter measurement/reporting uncertainty. These are useful for not only assessing the uncertainty in the sampled data, but also for accounting for uncertainty in the simulation

FIG. 4

Use of variogram techniques to identify spatial outliers of reported geotechnical parameters.



process to develop the subsurface models of geological/geotechnical conditions. Furthermore, the exploratory data analysis undertaken can reveal outliers and/or anomalies that should be disclosed in the geotechnical data reports and considered when establishing baselines.

Quantifying uncertainty at unsampled locations. Geostatistical methods are useful for estimating geology and geotechnical parameters at unsampled locations. In a simulation framework, multiple equally probable realizations of the estimation can be generated. Each of these equally probable realizations conform to the input data (for example, borehole data) and spatial correlation model (for example, the variogram). Other constraints, or geological rules, such as contacts, ranges and faulting can also be included in the simulation process.

From the multiple realizations, uncertainty can be quantified spatially at each simulated location based on the variability in estimates across all realizations. For example, the uncertainty in transition boundaries such as sand/clay interface or intact rockhead surface is quantified by the height/width of the 90 percent (or other percentile) confidence interval (Fig. 5). This can be incorporated into baseline statements such as: 'The uncertainty in the rockhead surface elevation interpretation ranges from 0-15 m (0-50 ft), depending on the chainage location (provide table of +/- variation from estimate).'

Generally, subsurface models of the spatial variability of geotechnical parameters are not developed for tunneling projects. However, there are several reasons why developing such a model would be advantageous. First, the distribution of geotechnical parameter values may differ on a local scale compared to the full-project scale. This local variation can be captured in a geostatistical model (Fig. 6).

Second, estimated geotechnical parameters at unsampled locations are dependent on the estimated geology. Geostatistics enables a framework where geology and geotechnical parameters can be simulated jointly such that the uncertainty in geology is carried forward to the uncertainty quantification of geotechnical parameters spatially.

Translating uncertainty to ground risk management

Quantified metrics of uncertainty in geotechnical interpretations can be used for the assessment and management of risks including clogging, cutter-tool wear, groundwater inrush, and face instability (Fig. 7). This would be advantageous for assessing the spatial variation

FIG. 5

Simulating multiple equally probable transition surfaces to derive confidence intervals of the true transition location.

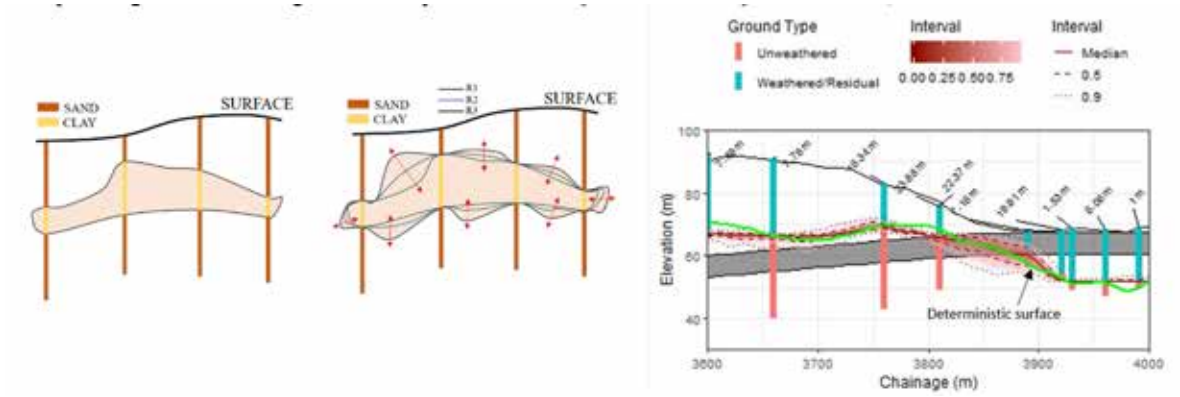
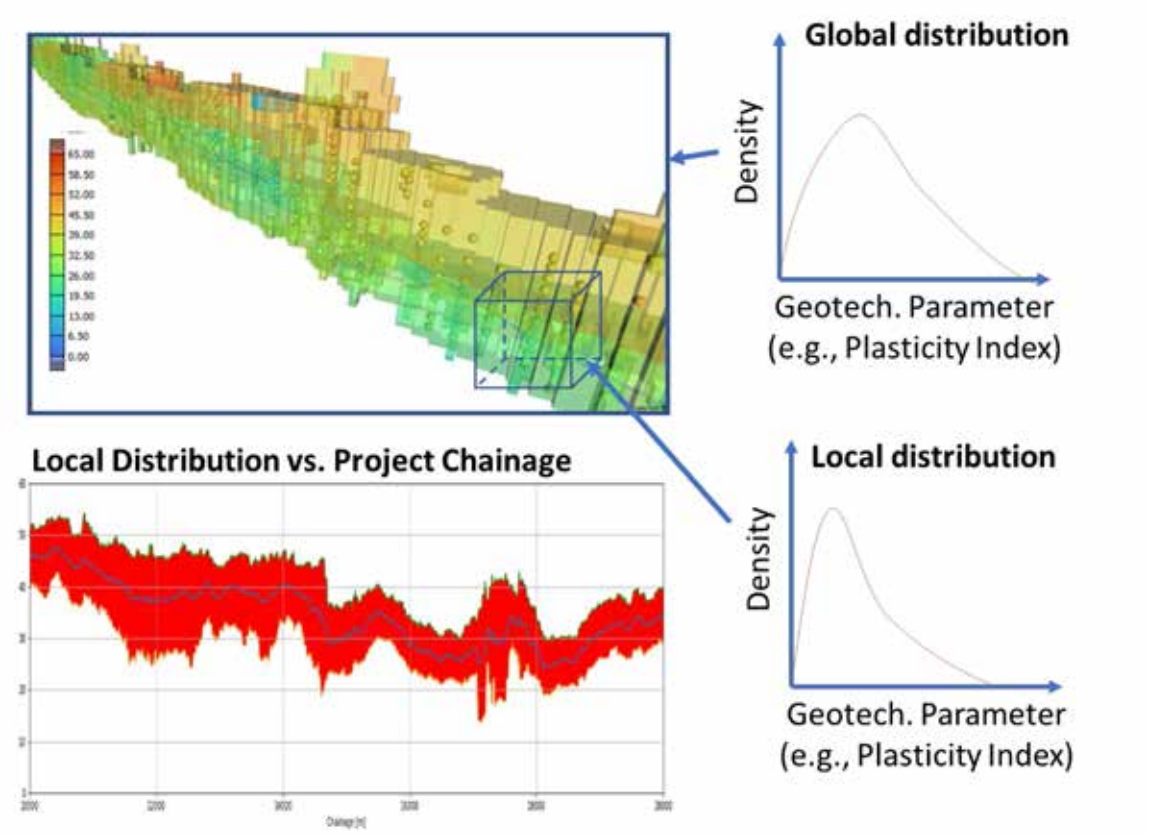


FIG. 6

Assessment of the local variation and uncertainty of a geotechnical parameter. Outputs of the geostatistical model can be used to derive confidence intervals around an estimated parameter magnitude versus project chainage.



in such types of risks, which is not conveyed in typical risk registers. The uncertainty in geological/geotechnical conditions can be directly carried forward to the risk metric and provide a common basis for understanding the risk between the owner and contractor.

Currently, many risk registers are qualitatively assessed and rely on subjective engineering judgement and experience. In a geostatistics-based approach, levels of risk in the risk register can be improved with the inclusion of quantified uncertainty to allow objective comparison. Mitigations can also be developed to reduce the risk to an acceptable level in accordance with the adopted risk criteria established by the owner in terms of contractual risk allocation, and by the contractor for internal enterprise risk management.

Proposed framework

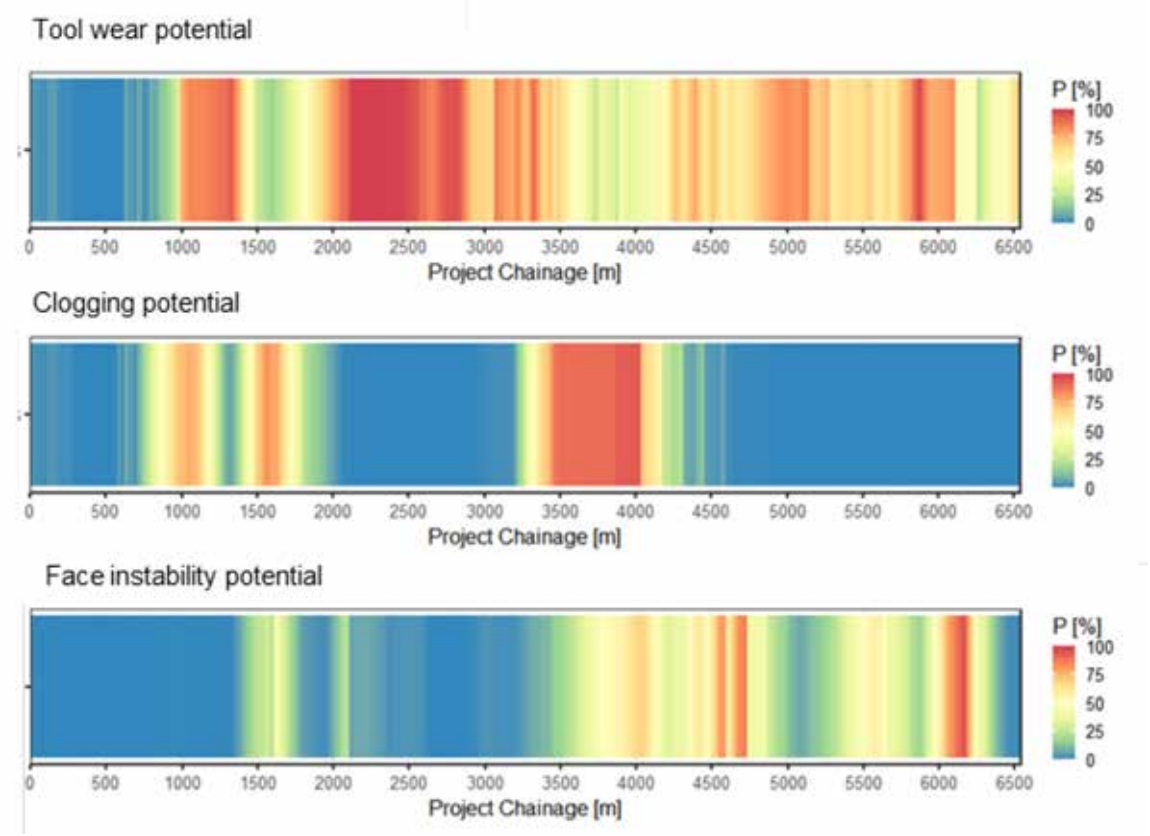
A geostatistics-based approach for quantifying uncertainty can be implemented at all stages of the project: planning and GBR preparation, bidding at tender, procurement and GBR negotiations, and construction. Figure 8 presents a general framework for this approach at each stage of a project.

Under this framework, the following risk management principles are suggested for the purpose of drafting better geotechnical baselines and GBRs:

- The owner should be liable for ground risks and differing site conditions, unless they are allocated by the GBR baselines.
- Baselines should be measurable or quantifiable during construction, and these methods of measurement or observation should also be defined under the baselines. It is important that the methodology to quantify the baseline parameters or observations is clearly stated in the originally agreed baselines. This is recommended to avoid possible disputes about how to establish if a baseline has been exceeded.
- Geotechnical baselines are the basis of foreseeability, and not a basis for design, per se. This is often confused and can give rise to disputes. The GBR should describe the anticipated subsurface conditions and the likely ground behavior for a given design and construction methodology for the purposes of establishing the commercial risks allocated with using baseline statements. To also provide a design basis, many more parameters need to be defined, and these can end up in artful interpretations of the data and unnecessary argument.
- GBR baselines should also define limits of geotechnical properties, and behavior noting that

FIG. 7

Example of quantified risk versus chainage.



geotechnical behavior or response baselines are influenced by works and methods, particularly the timing of installation, and the strength and stiffness characteristics of the support.

- Baselines that deviate from the GDR dataset should be explained, as well as the reasoning behind the difference. Data ranges should not be presented without a baseline because otherwise, there is no baseline — one may as well revert (and it is not recommended) to full-risk transfer approaches and not increase the ambiguity in the GBR.
- The owner can incorporate measures of uncertainty as part of the baseline definition process to report the relative quality and limitations of the subsurface data along the alignment. The quantified uncertainty in geological and geotechnical interpretations from the geostatistical interpretation of data can be reported with confidence intervals (for example, see rockhead surface example in Fig. 5).
- Not all geotechnical parameters that can be derived need to be baselined. However, for the purposes of risk management transparency, the reasoning behind this should be stated.
- Give plenty of time for tender interaction regarding the GBR. It is recommended to define forward-priced variations during the tender stage (for foreseeable scenarios outside of the baseline limits) and then agree the monitoring/response mechanisms that trigger the variation. This should focus all parties on project risk management at an early stage and improve the administration of any events as they are planned and costed in advance.

With the increasing adoption of digitalization in tunnel construction, the delivery of geotechnical baseline and data reports should also move toward a digital format (as opposed to conventional PDF). Some benefits to adopting digitalization for GBR and GDR delivery are:

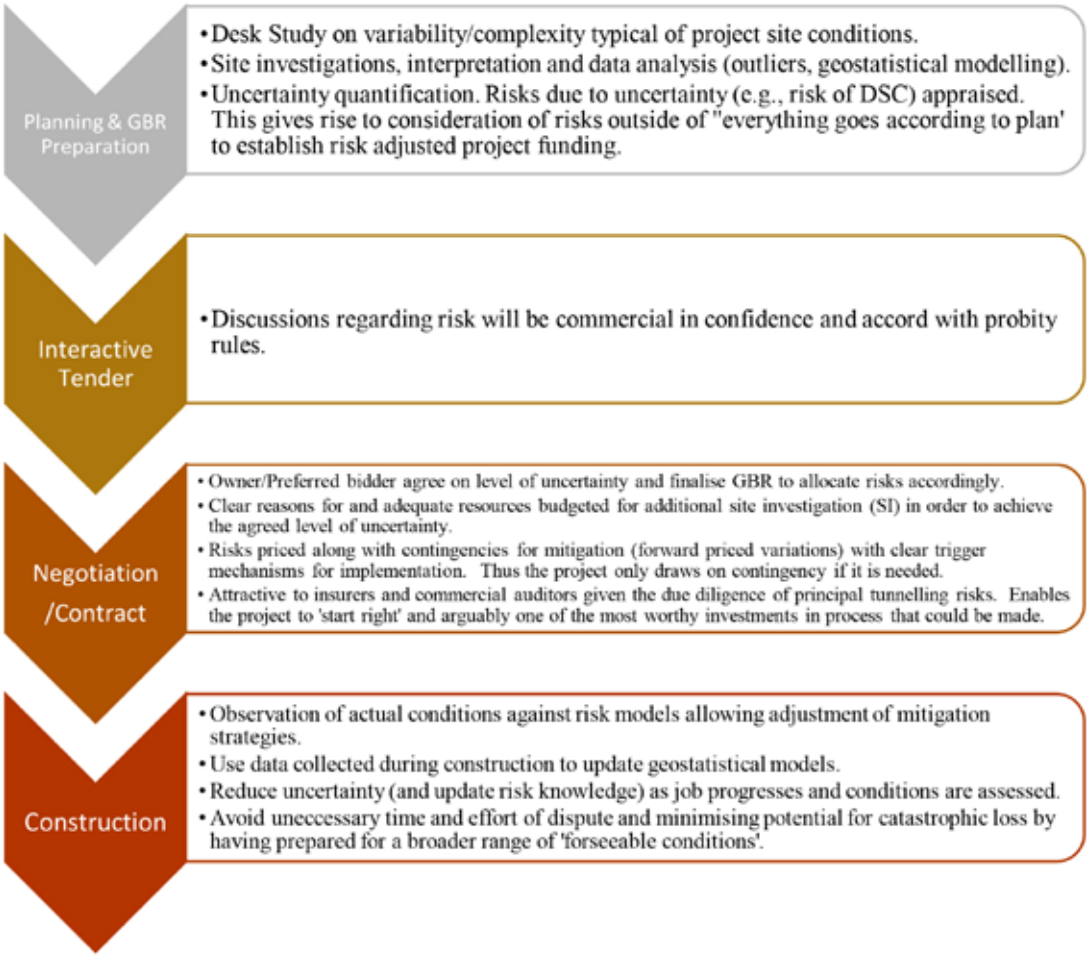
- Immediate access to the data so bidding parties can quickly begin analysis.
- Clear communication of georeferenced risks including geotechnical, sensitive structures, environmental, etc.
- BIM integration.
- The GIS-based GBR can be extended to use after the award for risk management; incorporate instrumentation and monitoring data, construction records and design, etc.

Conclusions

Usually when projects suffer commercial losses it is because key aspects of risk have not been anticipated and priced at the tender, but have been accepted due to an

FIG. 8

Proposed framework for applying geostatistical analysis for geotechnical baseline reports and risk mitigation.



attractively low (or sufficiently low) price. As a result of such underresourcing, the project team (owner, contractor and designer) may be unprepared for situations they encounter.

Insurers have an increasingly difficult role to play as what is technically possible encompasses a broader range of increasingly extreme geotechnical environments with ever-increasing potential for calamity. It is often overlooked that insurers also seek sustainable commercial returns, and so if claims are too large, then market coverage must be reduced (for the next job) and/or insurance costs must rise.

In this way, improved visibility of risk management (that precipitated the ITIG Guide in 2011), helps industry stakeholders and partners.

A focus on effective risk management may enable projects to differentiate themselves, and a mature and sophisticated risk management approach should be reflected in the number and quality of tenderers. By moving away from purely deterministic geotechnical interpretations and emphasizing uncertainty quantification, all parties will be better informed and prepared.

This article presents a methodology for improving the management of geotechnical risk using well-established techniques. When the methods are applied in a systematic way, the uncertainty (adequacy) associated with the preconstruction geotechnical model used to define forseeability (via the GBR) for a tunneling contract can be determined. This should enable a project team (owner, contractor and designer) to commence the project with sufficient resources and the knowledge that anything unforeseen can be efficiently and equitably dealt with. ■

References

Barcher, G.B. and Christian, J.T. (2003). Reliability and Statistics in Geotechnical Engineering

Chilès, J.P., and Delfiner, P. (2012). Geostatistics: Modeling Spatial Uncertainty. 2nd Edition. John Wiley & Sons.

Phoon, K-K. and Kulhawy, F.H. (1999). 'Characterization of geotechnical variability.' Canadian Geotechnical Journal. November 1999

Pyrcz, M. J., and Deutsch, C. V. (2014). Geostatistical Reservoir Modeling. Oxford University Press.

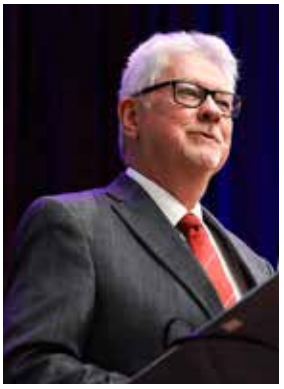
Sousa, R.L. and Einstein, H.H. (2021). 'Lessons from accidents during tunnel construction.' Tunnelling and Underground Space Technology 113

Tonks, D. et al. (2017). 'Grounds for concern: geotechnical issues from some recent construction cases.' Forensic Engineering 170(FE4). https://www.coffeygeotechnics.co.uk/wp-content/uploads/2019/01/jfoen.17.00008-GFC-Tonks-Gallagher-Nettleton-2017.pdf.

2022 UCA award winners announced at NAT

During the North American Tunneling (NAT) conference held June 20-22 in Philadelphia, PA, the UCA, a Division of SME, announced its award winners.

Lifetime Achievement Award – William "Bill" Edgerton


William "Bill" Edgerton

William W. "Bill" Edgerton, P.E. is a principal with the firm of McMillen Jacobs Associates, headquartered in San Francisco, CA. From 1999 through 2011 he served as president, directing strategic planning, business development and administration, while acting as the principal-in-charge and working in a technical capacity on underground projects.

Over the last 12 years Edgerton has served as the manager of Tunneling for DC Water's $2.6 billion Clean Rivers Project in Washington, D.C., and as the construction manager for LA Metro's $1.4 billion Purple Line Extension, Segment 2.

In addition to service as the UCA's Chair, he has served on the SME Board and was the 2021 SME President. Since 2002 he has served as an ASCE program evaluator for civil and construction engineering programs for ABET.

In 2008, he edited "Recommended Contract practices for Underground Construction," and has authored numerous technical articles on procurement practices. In 2012, he received the Golden Beaver Award for Engineering, and was inducted into the National Academy of Construction in 2015. A member of the Moles, he earned a B.S. in civil engineering from Tufts University, an MBA in procurement and contracting from George Washington University, and has PE licenses in seven states.

Muddy Boots Award – Christophe Bragard

Christophe Bragard is a tunnel manager for Traylor Brothers. Over 25 years, he has gained international experience on major tunnel construction jobs on four continents on diverse projects: TBM and mined tunnels, soft ground to hard rock, slurry or EPB, remote and urban settings; design-bid-build, design build and PPP projects from $100 million to $4.5 billion. He worked for the contractor on the field, for its technical department and for the designer.


Christophe Bragard

Bragard and his team recently completed the Regional Connector TBM drives, cross passages and a large underground cavern in soft rock in Los Angeles, CA. The hard and challenging work of the team in an urban setting, an exceptional safety record and strong cooperation with the owner resulted in several project awards (ITA 2019, UCA 2020).

Outstanding Educator – Jamal Rostami

Jamal Rostami is a professor at the Colorado School of Mines (CSM) and the Hadden/Alacer Gold Endowed Chair and director of the Excavation Engineering and Earth Mechanics Institute (EMI). He has a B.Sc. in mining engineering from the University of Tehran, Iran, and an M.Sc. and Ph.D. in mining engineering earned in 1992 and 1997 from CSM, respectively. He was a faculty member at the University of Tehran from 1988 through 2002, a full-time consultant with major A&E companies from 2002 until 2007, when he joined the Pennsylvania State University (PSU) as Centennial Chair of Career Development in Mining.


Jamal Rostami

Rostami has more than 30 years of experience in design, management, research and teaching in the field of mining, tunneling and underground construction. He is a registered professional engineer (PE) in Maryland, Pennsylvania and Virginia.

He has published more than 100 peer-reviewed journal articles and 160 conference papers and many technical reports. He is a member of SME, ASCE, ARMA, ISEE and the TRB tunneling committee. He is the editor-in-chief of "Tunneling and Underground Space Technology," and a member of the editorial board of several rock mechanics and mining journals.

Rostami is also a member of the executive committee of the International Tunneling Association (ITA). Rostami was the recipient of the 2014 Pittsburgh Coal Mining Institute of America (PCMIA) Stephen McCann Memorial Educational Excellence Award. He has chaired and coordinated the UCA of SME sessions at SME annual conferences since 2015.

Person of the Year – Leonard A. Worden

Leonard "Len" A. Worden is the chief executive officer/principal of the CSI Group of Co., headquartered in Hudson, NH. For the past 30 years he has been leading CSI Tunnel Sys-

tems, a specialist in the manufacture of precision precast concrete tunnel liners (PCTL). Worden is a self-taught professional in all phases of business, plant and equipment design with keen mechanical skills. During his tenure in the precast concrete industry, he has contributed his expertise in various leadership positions with the National Precast Concrete Association, American Concrete Pipe Association, ASTM C-13 Committee and the UCA.


Leonard "Len" A. Worden

With a committed CSI staff of professionals, Worden oversees his vertically integrated companies' activities from engineering to mobilizing dedicated segment factories, using state-of-the-art deployable carousel and material handling systems technology, CLECO molds, and concrete batch/mix plants for precise control of high-performance concrete within North America. CSI Tunnel Systems has undertaken 39 projects to date; 22 of those projects within the last decade. Worden's most treasured honor is the special and lasting relationships forged over the years with tunnel client professionals, engineers, vendors and owner representatives.

Young Member – Aswathy Sivaram

Aswathy Sivaram joined Black & Veatch after earning a master's degree in geotechnical engineering from Georgia Institute of Technology. Prior to starting her career in the consulting industry, she spent time in academia in various research-oriented roles. Her total experience is just over 12 years.

Sivaram's expertise lies in engineering design and construction management, proposal development, the preparation of contract documents, and conformance reviews of heavy civil infrastructure projects. She has worked on all aspects of tunnel projects, including prepositioning with clients, chasing pursuits, technical innovation and value add, and project execution, including planning, preliminary and detailed design, and construction contract administration and inspection services. She has successfully delivered dozens of projects adding up to construction contract values of more than $1 billion.

Her responsibilities outside of the technical realm include building resilient teams, strategizing for the growth of the heavy civil business, understanding industry trends and positioning for success. Sivaram has authored various technical papers and presented at premier industry conferences to a variety of audiences (NAT, RETC and NASTT No-Dig Show). She is a program committee member and session chair for the 2021 NASTT No-Dig Show.


Aswathy (Ash) Sivaram

Since 2018, she has served on the board of the UCA Young Members Executive Committee. Under her leadership, a forum called the "Tunnel Vision" series was initiated to provide a space for tunnelers to get together and discuss projects, challenges and successes in a safe and informal environment. This forum has continued with tremendous success.

She is licensed as a professional engineer in several states in the United States and in multiple provinces in Canada. She served as a member of the board of directors of the daVinci Pursuit, a nonprofit in Indianapolis, IN, where her love for all things art and science came to fruition. She has also served as president of ASCE, Northeast Indiana Branch.

Project of the Year – $50 million-$500 million (tie) – Atlanta Raw Water Supply Program

The $321 million construction management-at-risk project — which is the largest water supply project the state of Georgia has ever undertaken — will provide the city with a reliable supply of drinking water for the next 100 years, increasing the emergency raw water reserve from three days to more than 30 days.

According to representatives from the city of Atlanta, the five-year project is the most logistically challenging project executed by the city's Department of Watershed Management. The results put the city in a position of strength and allow for a significant expansion of its water reserves.

The project, which broke ground in August 2015, began with the conversion of an existing 122 m (400 ft)-deep rock quarry to a 2.4 billion-gal raw water storage system. From there, the team used a Robbins tunnel boring machine, nicknamed "Driller Mike," to dig, bore and install an 8-km (5-mile), 3 m (10 ft)-diameter tunnel. That tunnel connected the quarry to two new pumping stations and 11 deep shafts, all of which will work together to ensure residents and businesses have access to clean, safe drinking water, especially during drought conditions and emergencies.

Project of the Year – $50 million-$500 million (tie) – Bergen Point Outfall Replacement Project

OHL USA Inc./Posillico Civil Inc./SELI Overseas USA Inc. Joint Venture was awarded the $187 million contract by the Suffolk County (NY) Department of Public Works to replace an existing outfall pipe at the Bergen Point Waste Water Treatment Plant (WWTP) in Babylon, NY. This is the largest construction project in Suffolk County in several decades. Construction started on Feb. 8, 2018.

The project includes the construction of a 4,330-m (14,200-ft), 304 cm (120 in.)-ID tunnel through a mixture of soft soil materials under the Great South Bay with the use of a tunnel

boring machine (TBM). The tunnel replaces the existing prestressed concrete cylinder pipe (PCCP) outfall, which carries millions of gallons of treated wastewater, connecting the WWTP to Barrier Island under the Great South Bay. The new tunnel will address concerns about a potential failure of the current pipe, as well as have a longer lifespan.

The tunnel was excavated and concurrently lined using precast concrete segment rings. The joint venture selected a slurry TBM as the most effective and efficient means of tunnel excavation, and elected to use 121 cm (48 in.)-wide precast segment liners. The shaft construction was divided into major work phases including site preparation, excavation of the launch shaft, and installation of the slurry TBM.

Once the TBM was installed, tunnel excavation proceeded in 1.2-m (4-ft) pushes, followed by the installation of the permanent tunnel lining. Additionally, the team was able to complete ancillary work within the tunnel, including the installation of new piping and valving, associated plumbing, HVAC and electrical work.

Project of the Year – Less than $50 million – Greenville (SC) Reedy River Basin Sewer Tunnel Project

The Reedy River Basin Sewer Tunnel for Renewable Water Resources (ReWA) in Greenville, SC included construction of 6,000 linear ft of 330 cm (130 in.)-ID rock tunnel with 213-cm (84-in.) carrier pipe (Hobas CCFRPM pipe) grouted in place. Tunnel depth ranges from 12 to 40 m (40 to 130 ft) below ground surface and was mined in intact gneiss bedrock using a double-shielded rock gripper TBM manufactured by Lovsuns Canada. Tunneling required construction of a 12 m (40 ft)-ID by 120 m (40 ft)-deep launch shaft and 9 m (30 ft)-ID by 40 m (130 ft)-deep receiving shaft. Shaft construction consists of liner plate and rock dowels with wire mesh. The contractor was Super Excavators Inc./CMCRA Joint Venture, and Black & Veatch was the engineer. Tunneling was completed between March 2018 and September 2020.

Technical Innovation of the Year – Mill Creek Tunnel TBM Conversion

The first successful conversion of an 11.5-m (37 ft, 7-in.) TBM to a 10-m (32 ft, 6-in.) TBM from completely within the confines of the tunnel bore was achieved by Southland Mole Joint Venture in conjunction with Aldea Services and the Robbins Co.

The city of Dallas (project owner) originally designed 3,050 m (10,000 linear ft) of the downstream end of the Mill Creek Tunnel (8,300 m (27,000 linear ft) total tunnel length) to be a horseshoe shape 11.7 m × 9.9 m (38 ft, 3 in. × 32 ft, 6 in.) excavation to provide a larger capacity in this stretch, and to use only one size TBM for the entire tunnel excavation. The design called for a 9.9 m (32 ft, 6 in.) circular cross-section excavation, then utilizing conventional heavy civil equipment to bench the 3,050 m (10,000 linear ft) reach. Partnering with the Robbins Co. and Aldea Services, Southland Mole Joint Venture was able to work with the city of Dallas and their consultants to use a TBM that could excavate a larger diameter for the downstream end and be converted to the original 9.9 m (32 ft, 6 in.)-diameter for the remaining 5,181 m (17,000 linear ft). Each entity played a key role in the successful completion of this TBM conversion. ■

Three new members join UCA Executive Committee

The UCA Executive Committee welcomed three new members during the North American Tunneling (NAT) conference held June 19-22 in Philadelphia, PA. Joining the leadership committee of the UCA, a Division of SME, are Matthew Crow (owner representative), John T. DiPonio (contractor representative) and Jay Arabshahi (owner representative).

"The UCA Executive Committee is structured such that some incumbents conclude their terms and new members join the group annually," said UCA chair Mike Rispin. "This is a great, ongoing process that ensures we get fresh ideas and new perspectives into the team, which steers our Underground Construction Association. I'm delighted as chair to welcome Jay, Matthew and John and look forward to their participation and contributions."

The new members join officers Rispin (supplier representative), Erika Moonin, vice chair (owner), Bob Goodfellow, past chair (engineer representative), and members Tony O'Donnell (contractor), Matthew Preedy (owner), Red Robinson (engineer), Jon Klug (supplier), Sarah Wilson (engineer), Grover Vargas (supplier), Shane Yanagisawa (contractor), John Huh (supplier), Moussa Wone (owner), Paul Schmall (contractor), Michael Vitale (engineer), Mike Bruen (supplier and member at large) and Mark Johnson (engineer).

Jay Arabshahi

Jay Arabshahi has been a practicing professional civil engineer for 40 years and has extensive experience in organizing, planning, design and construction of waterworks projects. He earned a bachelor of science in civil engineering from Loyola Marymount University in 1982 and completed a master of science in civil/environmental engineering at Loyola in 1985. He is an engineering program manager with Metropolitan Water District of Southern California, where he has worked for the last 32 years.

Arabshahi has overseen the planning, design and construction phases of several large conveyance projects including the Inland Feeder project, California Water Fix and the Regional Recycled Water Program. As deputy program manager for the Inland Feeder project, he oversaw day-to-day activities including interface with consultants, internal staff and outside agencies. He led the project management team's

activities to achieve budget and scheduling objectives,while identifying and resolving critical project management issues.

He enjoys the outdoors, and his hobbies include playing golf, hiking, motorcycle riding and reading.

John T. DiPonio

John T. DiPonio is executive vice president of Jay Dee Contractors, Inc., a heavy civil underground construction firm located in Livonia, MI. Jay Dee was founded in 1965 by DiPonio's grandfather, John DiPonio, and specializes in the construction of tunnels, underground structures, and tunnel rehabilitation throughout the United States and Canada.

DiPonio has been employed by Jay Dee for nearly his entire working life starting in 1992. In 2003, he earned a bachelor of science degree in civil engineering from Lawrence Technological University in Southfield, MI. Over the next 10 years, he traveled the country working on projects, starting as field engineer and going on to project engineer and eventually project manager. During this time, he worked on tunnel projects in Chicago, IL; Minneapolis, MN; Philadelphia, PA and Davenport, IA. In 2018, DiPonio was appointed executive vice president of Jay Dee and has since served in that capacity. Jay Dee continues to build on its impressive project portfolio throughout the United States and Canada. To date, Jay Dee has constructed and/or rehabilitated more than 386 km (240 miles) of tunnels and underground structures.

DiPonio is also actively involved in the construction industry, serving as a board member for the Michigan Infrastructure and Transportation Association (MITA) since 2021.

John T DiPonio

Matthew Crow

Matthew Crow

Matthew Crow was introduced to the art of tunneling by Martin Knights, who is still one of his mentors. With Brown and Root, he was involved from its infancy with London Electricity in the development and implementation of using tunnels for electricity cables in London in place of digging up streets for direct burial of cables, or replacement of overhead lines. Before moving to the United States, Crow was engineering manager for the integrated owner/contractor partnering team for the Ramsgate Road Tunnel. In the United States, he worked as a resident engineer on ECIS Sewer Tunnels in Los Angeles and LNWI/UNWI sewer tunnels in Sacramento, CA. He was also project manager for the Waller Creek flood alleviation tunnel in downtown Austin, TX. More recently, Crow has been involved with the massive program of tunneling at LA Metro and is currently the deputy executive officer for Section 3 of the Westside Purple (D) Line Extension heavy rail transit subway. Since 2006, Crow has served on the organizing committee of the North American Tunneling Conference and as track chair for the 2022 conference. He champions the bridge between academia and the workplace by serving as a member of the Dean's Advisory Board for the College of Engineering, Computer Science, and Technology at Cal State LA.■

John Alvin Bischoff, 1945-2021

John Alvin Bischoff, 75, died Jan. 10, 2021 in San Rafael, CA. He was born in San Francisco, CA on June 30, 1945 to Elizabeth and Hermann Bischoff.

Just before he passed away, Bischoff celebrated 50 years of employment as a dedicated and talented licensed civil and geotechnical engineer working for Leeds, Hill, and Jewett, Woodward-Clyde, URS, and AECOM. His colleagues considered him a great leader and coach. He was well known for his care, consideration and mentorship of every person he met throughout his career. He freely shared his knowledge of tunnels, water treatment, wastewater, levees, dams and much more. He was widely respected by clients and colleagues alike.

Over the course of his long career, he led, managed and served in key roles on numerous tunnel projects, including but not limited to the New Irvington Tunnel Project, California; Manapouri Second Tailrace Tunnel Hydroelectric Project, New Zealand; Lower Northwest Interceptor Sacramento Force Main Project, Sacramento, CA; Inland Feeder Tunnel Project, southern California; Riverside Badlands Tunnel Project, southern California; Interstate 70 Glenwood Canyon Tunnels Project, Colorado; Big Walnut and Rickenbacker Interceptor Project, Ohio; Lake Thistle Emergency Drainage Project, Utah; Crosstown Wastewater Interceptor Project, Austin, TX; Stanley Canyon Project, Colorado Springs and the Eisenhower Memorial Tunnel Project, Colorado.

He is survived by his beloved bride of 49 years Stacy, and their children David Bischoff (Bridget Bischoff), and Jillian Restivo (Brent Restivo), and his grandchildren Lincoln Restivo and Madeline Bischoff, many beloved cousins, nieces, nephews, in-laws and friends. He was an exceptional husband, father, grandfather, son, brother, uncle, cousin and friend. ■

Make an Exciting Career Move with the UCA Career Center

Search a dedicated career resource specific to the underground construction industry.

The UCA Career Center connects you with employers actively looking for professionals in the tunneling and underground construction industry.

Interested in posting a job or internship opportunity and connecting with the talented UCA membership?

Learn more at **uca.careerwebsite.com** or contact Laura Nelson at nelson@smenet.org.

Visit tunnelingjobs.org to:

- Create a job seeker profile
- Post a resume
- Apply for jobs
- Get job flash emails

UCA Underground Construction Association
A Division of SME

ucaofsme.org

COMPILED BY JONATHAN KLUG, DAVID R. KLUG & ASSOCIATES

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Gateway Tunnel	Amtrak	Newark/NYC	NJ/NY	Subway	14,600	24.5	2023	Under design
2nd Ave. Phase 2	NYC-MTA	New York	NY	Subway	16,000	20	2023	Under design
2nd Ave. Phase 3-4	NYC-MTA	New York	NY	Subway	89,600	20	2024-29	Under study
Kensico-Eastview Connection Tunnel	NYC-DEP	New York	NY	Water	11,000	27	2024	Under study
Flushing Bay CSO	NYC_DEP	New York	NY	CSO	16,500	22	2026	Under study
Cross Harbor Freight Tunnel	NYC Reg. Develop. Authority	New York	NY	Rail	25,000	30	2026	Under study
Metro Tunnel Program - Northern	Boston MRWA	Boston	MA	Water	23,760	10	2027	Under study
Metro Tunnel Program - Southern	Boston MRWA	Boston	MA	CSO	50,160	10	2028	Under study
Silver Line Extension	Boston Transit Authority	Boston	MA	Subway	8,400	22	2024	Under design
Narragansett Bay CSO Phase III - Conveyance Tunnel	Narragansett Bay Commission	Providence	RI	CSO	8,800	10	2024	Under design
Amtrak B&P Tunnel	Amtrak	Baltimore	MD	Rail	40,000	32	2023	Under design
Ellicott City North Tunnel	Howard County	Ellicott City	MD	CSO	5,800	15	2022	Kiewit awarded
Potomac River CSO Tunnel	DC Water and Sewer Authority	Washington	DC	CSO	24,000	18	2022	Shortlist announced
Superconducting Maglev Project - Northeast Corridor	TNEM/BWRR	Washington	DC	Rail	146,520	43	2024	Under design
Alum Creek Relief Tunnel Phase 1 Phase 2	City of Columbus	Columbus	OH	Sewer	 30,000 21,000	 18 14	 2023 2024	 Under design Under design
Southerly Storage Tunnel	NEORSD	Cleveland	OH	CSO	18,000	23	2023	Under design
Big Creek Storage	NEORSD	Cleveland	OH	CSO	22.450	20	2026	Under design
Northside Interceptor Tunnel	City of Akron	Akron	OH	CSO	6,850	24	2025	Under design
ALCOSAN CSO Ohio River Allegheny River Monongahela River	Allegheny Co. Sanitary Authority	Pittsburgh	PA	CSO	 20,000 28,000 28,000	 18 18 18	 2024 2028 2030	 Under design Under design Under design
DELORCA Wastewater Tunnel	DELORCA	Chester	PA	CSO	45,500	13	2023	Under Design
Enbridge Line 5 Tunnel	Enbridge	Traverse City	MI	Oil	23,760	12	2023	Shortlist announced
Minneapolis Central City Parallel Tunnel	City of Minneapolis	Minneapolis	MN	CSO	4,200	10-19	2022	Final planning

To have your major tunnel project added to the Tunnel Demand Forecast, or to update information on a listed project, please contact Jonathan Klug at jklug@drklug.com.

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Stormwater Control Program	Harris Co. Flood Control District	Houston	TX	CSO	52,800	25-40	2022	Under design
Project Connect Subway Program	City of Austin	Austin	TX	Subway	8,500	20	2023	Under design
D2 Subway - 2nd Light Rail Alignment	Dallas Area Rapid Transit	Dallas	TX	Highway	7,230	22	2023	Delayed
Mill Creek Trunk Improvements	City of Nashville	Nashville	TN	CSO	13,800	10	2023	Under design
I-70 Floyd Hill Highway Tunnel	Colorado Dept. of Transportation	Denver	CO	Highway	15,840	60x25	2022	Under design
Horizon Lateral Tunnel	Southern Nevada Water Authority	Las Vegas	NV	Water	42,000	12	2024	Under design
West Seattle to Ballard Extension	Sound Transit	Seattle	WA	Transit	10,500	18	2025	Under design
LA Metro Speulvada Pass Corridor	Los Angeles MTA	Los Angeles	CA	High/Trans.	55,500	60	2024	LOI received
Ontario Airport Tunnel	San Bernardino Co. Trans. Authority	San Bernardino	CA	Subway	22,000	24	2023	Under design
Folsom Area Storm Water Improvement	SFPUC	San Francisco	CA	CSO	4,000	12	2022	Under design
BART Silicon Valley Phase 2 Tunnel	Santa Clara Valley Transit Authority	San Jose	CA	Subway	26,400	43	2022	Kiewit/Traylor/ Shea awarded
Delta Conveyance #1 Delta Conveyance #2	California Dept. of Water Resources	Sacramento	CA	Water	39,905 200,000	28 40	2025+ 2025+	Delayed Delayed
Ontario Line North Extenstion	Toronto Transit Commission	Toronto	ON	Subway	29,500	20	2022	RFQ Q3 2022
Ontario Line South Extension	Toronto Transit Commissiton	Toronto	ON	Subway	29,500	20	2022	Shortlist announced
Taylor Massey Tunnel	City of Toronto	Toronto	ON	CSO	20,000	15	2025	Under design
Inner Harbour West	City of Toronto	Toronto	ON	CSO	18,400	20	2027	Under design
Yonge North Subway Extension	Toronto Transit Commission	Toronto	ON	Subway	40,000	20	2024	Under design
West Vaughn Sewage Servicing Project	York Region	Toronto	ON	Sewer	36,000	10	2022	RFP Q3 2022
East West Tunnel - Contract 2	Region of Peel	Toronto	ON	Sewer	5,200	12	2022	Bid date 8/8/2022
Blue Line Extension	Societe de transport de Montreal	Montreal	QC	Subway	19,000	33	2022	Under design
REM-S Project	Societe de transport de Montreal	Montreal	QC	Subway	23,000	33	2023	Under design
Quebec City - Levis Tunnel	Quebec Trans. Ministry	Quebec City	QC	Highway/ Transit	27,230	60	2025	Under design
Green Line LRT	City of Calgary	Calgary	AB	Transit	9,000	40	2022	RFQ submitted
Nose Hill Project	City of Calgary	Calgary	AB	CSO	10,800	10	2023	Under design
Stanley Park Water Supply Tunnel	City of Vancouver	Vancouver	BC	Water	5,000	15	2022	Under design

t&uc CLASSIFIEDS

Ad Index

OneTunnel.org

UCA | TJ

Cutting Edge Conference

10TH ANNIVERSARY

NOVEMBER 14-16, 2022 | LONG BEACH, CA

MAKE PLANS TO ATTEND AND REGISTER TODAY

Participate in a conference that explores the innovation and sustainability of the industry.

KEYNOTE SESSION:

Underground Innovations Benefiting Social and Climate Change

Featured Program Includes:

- Research & Development
- Blueprint for Sustainability & Carbon Neutrality
- Panel Session: Sustainability & Carbon Neutrality
- Advances in Materials & Equipment
- Developments in Digitalization & Automation
- Major Projects
- West Coast Project Updates
- Owner Panel Session: Funding & Procurement of Major Projects

Find more details about the program and register online at **ucaofsmecuttingedge.org**

Where Innovation Meets Practical Experience

ucaofsmecuttingedge.org

Thanks to our sponsors:

HERRENKNECHT Tunnelling Systems

HNTB

acciona

JENNMAR CIVIL

PCS Kiewit

MASTER BUILDERS SOLUTIONS

TURNSTONE INDUSTRIAL SOLUTIONS, LLC

SAFETY, SERVICE, AND INNOVATION

JENNMAR MINING · INFRASTRUCTURE · MANUFACTURING | JENNMAR SERVICES | JENNMAR ENGINEERING | XCAL | JENNCHEM

JENNMAR CIVIL






JENNMAR Civil is committed to supplying goods and services to the Civil Construction and Tunneling industries. We have integrated JENNMAR mining products into our civil, tunneling, and geotechnical services. We manufacture goods in over twenty strategically located manufacturing facilities, ideally positioning us to satisfy our clients' industrial fabrication demands. In addition, we have formed strategic alliances that enable us to provide turn-key ground support solutions in the civil and geo-tech industries.

SUPPORTING SPACE UNDERGROUND

We offer Steel Tunnel Ribs, Shaft Rings, Steel Sets, Lattice Girders, Rock Bolts, Liner Plate, Resins, Rail, Rail Ties, Rail Hardware, Ventilation, Cementitious, Chemical Grouts, and more. Whether mining, rehabbing, or re-supporting transportation, water, wastewater, or infrastructure tunnels, JENNMAR Civil is backed by experienced engineers and technicians who are with you every step of the way, from initial consultation to qualified instruction and ongoing technical support to make your project a success!

GLOBAL HEADQUARTERS • PITTSBURGH, PA USA • (412)-963-9071

For more information on our portfolio of diverse and complementary brands visit us at www.jennmar.com.