The State of Dispute Resolution Boards in the Tunnel Industry
(The Good, the Bad and the Ugly)

Tunnelers have a long history with DRB’s, as they were born of necessity in the Tunnel Industry and used for the first time on the Eisenhower Tunnel in 1974. The Dispute Resolution Board Foundation (DRBF) was formed in 1996, dedicated to promoting the avoidance and resolution of disputes worldwide, providing guidelines for the practice as well as training for DRB practitioners and participants alike. Just recently the UCA of SME and the DRBF signed a cooperative agreement, in recognition of the close ties and shared values between the two organizations. With the DRBF turning 25 this year, what better time to pause and take stock of the state of DRBs in our industry. Where have we been, where are we now and what can we expect in the future?

To share their varied perspectives on this question, we have assembled an expert panel of highly-experienced individuals with extensive experience using, or serving on, DRBs from a wide cross section of the industry. Panelists include Mike Roach (Contractor, Traylor Brothers), David Hatem (Attorney, Donovan Hatem LLP), Joe Gildner (Owner- Sound Transit Seattle, WA) and Fred Dunham (DRB practitioner and Ex-Contractor). Session Chair Mike Vitale (Mott MacDonald) will moderate the panel as they each provide a short talk on the subject, followed by an open panel discussion and Q&A forum. Join us for what promises to be an interesting and provocative assessment of the past, present and future of DRBs; the good, the bad and the ugly.

Design-Build vs Design-Bid-Build. A Review of Canadian Recent Tunneling Experiences

Tamara Kondrachova, U of T, Engineering Department, Richmond Hill, Ontario CA; Giuseppe Gaspari, AECOM, Mississauga, Ontario CA

Contract practices affect cost and schedule of tunneling works, impacting risk allocation between Owners and Contractors. The Authors compiled a dataset of projects constructed in the Toronto Area between 1990-2020 procured either Design-Build or Design-Bid-Build. Data were analyzed identifying independent cost variables across the two methods. Overall industry’s efficiency further comparison with historical information demonstrates the costs of engineering ongoing escalation due to rising trends in environmental requirements and public consultations stirred through modern communicative platforms. These hard to predict and estimate costs need to be included in the risks evaluated and managed by Owners and not by Contractors.
9:00 am  
**Tunneling to Manage Construction Impacts for Albany’s Beaver Creek Clean River Project, Albany, New York**


Beaver Creek Clean River Project will satisfy the consent decree requirements by capturing and treating combined sewage overflows. The project consists of, approximately, 2,700 feet of 30-inch trenchless pipe installation, a new screening/disinfecting facility, an expansion of an existing diversion structure, and a 72-in internal diameter, 550-foot long mined tunnel. The tunnel portions are being progressed as early release packages. This paper presents the geotechnical exploration program and the subsurface conditions encountered; interpretation of the geotechnical conditions; and, approach to developing stand-alone packages for the tunnels to mitigate construction and schedule risks and continue to advance the project.

9:30 am  
**Coffee Break**

10:00 am  
**Case Study on Innovatively Launching a Full-size TBM in Challenging Ground**

Mahmood Khwaja, CDM Smith, Waban, Massachusetts US; Bernard Catalano, Bessac, Canonsburg, Pennsylvania US; Michael Schultz, CDM Smith, Boston, Massachusetts US; Janice McGovern, Suffolk County Department of Public Works, Yaphank, New York US

Launching a full-size pressurized-face Tunnel Boring Machine in difficult ground conditions is always challenging. Recently, few projects have innovated the process by scaling the trenchless method of pipe jacking to facilitate the launching of a full-size TBM without the need for large and deep trenches; starter/tail tunnels; or for incrementally installing supporting gear as the machine advances. This paper presents two such projects; evaluates the post-bid contractor proposed modifications; details the innovative use of pre-cast pipe segments to facilitate machine launch; and, provides an overall assessment of the benefits, challenges and lessons learned related to the modified approach.

9:30 am  
**Coffee Break**

10:00 am  
**Tea Break**
9:30 am  
**Coffee Break**

10:00 am  
**Design and Construction Challenges at the Potomac River Tunnel in Washington DC**


The Potomac River Tunnel (PRT) is the next major phase of the DC Clean Rivers Project. The PRT includes a 5.5-mile-long, 18-foot-diameter tunnel, seven shafts, and two underground connections to existing structures. Major challenges include TBM excavation through mixed-face conditions within a buried paleo-channel and a 2,000-foot-long rock/soil transition zone; construction beneath the elevated Whitehurst Freeway; tunneling beneath an existing luxury residential building and existing transit tunnels with limited clearance; and complex coordination with a variety of federal, regional, and local stakeholders. This paper describes the overall project scope, geotechnical conditions along the alignment, and primary design/construction challenges and mitigations.

10:25 am  
**Influence of Large Deep Excavations on Closely Underlying Subway Tunnels and Design of Mitigation Measures**

Shawn Wang, AECOM, Thornhill, Ontario CA; Giuseppe Gaspari, AECOM, Mississauga, Ontario CA

The pandemic emergency is forcing transit agencies to define strategies allowing social distancing, that are more challenging in underground interchange stations in crowded downtown cores. TTC’s Bloor-Yonge Station Capacity Improvement Project in Toronto was approved to meet increasing demand and represents an opportunity to fight Covid-19. This paper discusses cost-effective solutions in expanding the cut-and-cover station box over existing Toronto Subway Line 2 and connecting it through openings in the steel-plates tunnel liner. Potential uplift risks and structural damage due to minimal vertical clearance were analyzed via three-dimensional finite element analyses with advanced constitutive laws to simulate the multi-stage construction process. Based on the simulation results, a series of countermeasures, including excavation support systems, king posts, ground-consolidations, and liner reinforcements were integrated into a comprehensive design to ensure the serviceability and structural integrity of the subway tunnels.

10:25 am  
**Influence of Large Deep Excavations on Closely Underlying Subway Tunnels and Design of Mitigation Measures**

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8:30 am  
**Difficult Ground**

Chairs: Ehsan Alavi, Jay Dee Contractors, Livonia, Michigan, US  
Everett Litton, WSP, St. Louis, Missouri, US

8:35 am  
**Introductions**

8:35 am  
**Tunneling Through a Buried Valley with A Hard Rock EPB Compatible TBM**

William Hodder, Jay Dee Contractors Inc, Toronto, Ontario CA; Ehsan Alavi, Jay Dee Contractors Inc, Toronto, Ontario CA; Nader Ghasempour, Jay Dee Contractors Inc, Toronto, Ontario CA; Daniel Cressman, Black & Veatch Canada, Toronto, Ontario CA

The Coxwell Bypass Tunnel is expected to be excavated entirely through Georgian Bay shale, at 50 meters deep. The tunnel alignment runs parallel to a buried bedrock valley located adjacent to Bayview Avenue. The tunnel crosses this valley in the southern portion of the alignment, adjacent to the Don River. The risk of encountering weathered bedrock, significant ground water inflows or surficial soil deposits through this area was identified as a significant risk and the TBM has been designed with the ability to probe drill ahead of the TBM and convert to EPB mode if necessary. This paper will discuss the additional exploration that was performed by the contractor to identify the extent of this buried valley, the plan going into the zone of potential weathered shale, and the actual conditions encountered.

9:00 am  
**Transitioning from Mixed-face Conditions to Hard Rock During TBM Launch on the Reedy River Basin Sewer Tunnel Project – Greenville, SC**

Horny Parker Jr., Black & Veatch, Greenville, South Carolina US; Jason Gillespie, Renewable Water Resources, Greenville, South Carolina US; Stephen O’Connell, Black & Veatch, Greenville, South Carolina US; Justin Kolster, Super Excavators, Menomonee Falls, Wisconsin US

Construction of the 5932-ft Reedy River Basin Sewer Tunnel in Greenville, SC was marked by a critical transition from drill-and-blast mining in mixed-face conditions to TBM excavation with limited rock coverage. In this paper, we discuss the geological, geotechnical, and risk management considerations for transitioning to TBM operations in variably weathered gneissic bedrock. After construction of an unexpected 230-ft starter tunnel due to differing ground conditions, the 11-ft diameter TBM was successfully launched in December 2019 without significant ground support issues. This project highlights the effectiveness of extensive rock probing to fully characterize bedrock topography prior to the TBM launch.
9:30 am
Coffee Break

10:00 am
Under Pressure: Geotechnical Forces and Conditions at Work on The Ohio River Tunnel Project

The Ohio River Tunnel Project encountered multiple unexpected geotechnical challenges such as crown and invert instability due to the over stress condition affecting the strata above, below, and in the tunnel alignment during and after TBM excavation along with the potential for methane inflow. This paper showcases how the orientation of a tunnel alignment has a significant impact on how in-situ geological stress can impact the excavation of a tunnel from the contractor’s point of view and how geological features influence gas inflow to the alignment over time.

10:25 am
Rock Tunnels at High Water Pressure: Non-Continuous Pressurized TBMs vs. Slurry

The choice of TBM type is never easy, but it becomes especially challenging when faced with a hard rock tunnel with expected high water pressure. While Slurry Shield tunneling has a long history of addressing this problem, this method has not always been problem-free. At recent projects around the world, another method has been proven: Shielded, Non-Continuous Pressurized (NCP)-TBM tunneling in rock with a comprehensive grouting program. In this paper, the authors will analyze the use of Shielded NCP TBMs at projects around the world as compared with slurry shield tunneling in rock under water pressure. Recommendations will be given in order to establish a clear picture of the optimal tunneling method.

HARD ROCK TBMS AND TUNNELS
Chairs: Jesse Salai, J.F. Shea, Walnut, California, US
Sponsored by: The Walsh Group

8:30 am
Introductions

8:35 am
TBM Data and Performance Monitoring on Large Diameter TBM Tunnels Lined with Shotcrete in the Himalayas – A Case Study
Gary Peach, Multiconsult AS, OXFORD, Oxfordshire GB; Peter Mason, Stantec UK Ltd, High Wycombe, Buckinghamshire GB

Planning and estimating progress rates and costs for tunnelling is always best done on the basis of experience and historic precedent. Much precedent is available but the use of data monitoring, data mining and other retrieval techniques on modern TBM machines can enable this to be further expanded and refined. Advance rates can be related much more closely to rock types as can associate rock bolt and mesh/shotcrete requirements. This in turn can lead to a further refinement in best likely combinations of equipment, such as shotcrete jumbos, better selected for the anticipated conditions, rather than the potential advance rates of the machine. Efficient and timely construction of the tunnel will also be linked to times needed for finishing work. Indeed, this in turn may affect the most preferable layout and construction details of the permanent tunnel. Considerable experience has been gained in the use of two large diameter TBM tunnel drives through the Himalayas at the Neelum-Jhelum hydropower project in Pakistan. All the above aspects will be discussed in the paper based on the considerable experience and data which came from that operation, including appropriate measures in highly stressed areas potentially subject to rock burst.
9:00 am
The Effect of TBM Diameter on Ring Installation Time

TBM performance prediction is critical for developing a reliable estimate of the construction completion time and cost of the tunnel. Machine performance is affected by machine type and specification, geological condition, site setup and logistics, and operational factors. These factors lead to scheduled and unexpected downtimes during the tunnel construction. The effect of different parameters on TBM performance was studied by many researchers; however, the effect of tunnel size was never investigated thoroughly. This paper concentrates on the effect of tunnel diameter on the type and duration of downtimes and examines the impact of machine diameter on downtimes. For this purpose, the operational parameters and their dependency on diameter are analyzed. Furthermore, two tunnels with different diameters and similar TBM type were compared as case history to evaluate the capability of the proposed analysis method for predicting TBM performance based on machine diameter.

9:30 am
Coffee Break

10:00 am
Tunneling in Toronto Shale- Construction of Coxwell Bypass Tunnel Project
Daniel Cressman, Black & Veatch, Markham, Ontario CA; Ehsan Alavi, JayDee Canada, Toronto, Ontario CA; Tatiana Chiesa, City of Toronto, Toronto, Ontario CA; Robert Mayberry, City of Toronto, Toronto, Ontario CA

The City of Toronto’s Coxwell Bypass Tunnel (CBT) is currently being constructed by North Tunnel Constructors ULC. The scope of the CBT project includes construction of approximately 10.5 km of 6.3 metre finished diameter rock tunnel, five 20 metre diameter storage shafts and eleven tunnel connection drop shafts, along with associated deaeration and addit tunnels. This paper describes progress on the CBT to date and reviews the approach taken in both design and construction of the tunnels and shafts to mitigate risks and reduce cost and schedule of construction.

10:25 am
The Bypass Tunnel: Excavation, Interliner, and Lining

The Rondout-West Branch Bypass Tunnel is being built to bypass a substantial leak in New York City’s primary water supply tunnel. The 13,500 foot long tunnel travels 600 feet under the Hudson River through the same troubled geology and high pressure water inflows that the original tunnel did in the 1940’s. A Robbins TBM traversed this geology and built gasketed segments. Nine thousand two hundred feet of 16 foot diameter interliner was installed and backfilled within the segments. Finally reinforced cast in place lining was placed. This paper addresses the challenges, and the multi-tasking approach the contractor utilized.

10:30 am
Coffee Break
1:30 pm
**DESIGN BUILD PROJECTS**

**Chairs:** Kush Chohan, McMillen Jacobs Associates, Walnut Creek, California, US

*Sponsored by: HNTB*

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1:30 pm
**Introductions**

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1:35 pm
**Construction of Ottawa’s Combined Sewage Storage Tunnel**

Andreas Feiersinger, Dr Sauer & Partners Ltd., Surbiton, Surrey GB; Juergen Laubbichler, Dr Sauer and Partners Corp, Herndon, VA, US

The Combined Sewage Storage Tunnel (CSST) is part of the Ottawa River Action Plan and will greatly reduce the frequency of sewage overflows into the Ottawa River during storms. The project consists of the design and construction of two TBM tunnels running east west and north south along 6.2 km in total, and multiple shafts and support buildings. Contractor Dragados Tomlinson JV (DTJV) was awarded the $232 million CAD contract in 2016 and the CSST will be in operation in 2020. The paper will address TBM selection, critical tunnel sections, geotechnical risk management, rock mass grouting and other aspects.

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2:00 pm
**Design of Precast Segmental Tunnel Lining in a Design-Build Environment**

Irwan Halim, AECOM, Chelmsford, Massachusetts US

Nowadays more infrastructure tunnel projects are procured using design-build method. In this environment, the Owner’s engineer would typically provide performance requirements for the design-builder, and the Contractor’s designer would work with the contractor to design the tunnel lining based on the Contractor’s means and methods for manufacturing. This paper will describe the typical requirements provided by the Owner based on its design objectives, and the means and methods by the Contractor that would significantly impact the design. Project examples and recommendations for Owner’s requirements will be provided that can optimize the design and achieve the Owner’s performance objectives.

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2:25 pm
**Design and Construction of the new I-75 Modernization Stormwater Storage and Drainage Tunnel System in the Segment 3 P3 DBFM Contract**

David Mast, AECOM, Cleveland, Ohio US; Mina Shinouda, Jay Dee Contractors, Inc., Livonia, Michigan US; Amanda Foote, AECOM, Cleveland, Ohio US; Jason Edberg, NTH Consultants, Ltd., Detroit, Michigan US

The Michigan DOT’s I-75 Modernization Project, Segment 3, is a 30-year, $1.2 Billion design-build-finance-maintain project in Southeast Michigan. The scope includes building a nearly 4-mile long, 14.5-foot ID stormwater storage tunnel. The tunnel and pump station are being built concurrent with new roads and bridges, requiring multiple levels of design and construction coordination. Underground risks include the potential for encountering granular soils, groundwater, and explosive gases. The new tunnel will be mined by a new open-face TBM and lined with a one-pass steel-fiber-reinforced precast concrete segmental lining. Shaft construction began in early 2020 and tunnel mining in July 2020.

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2:45 pm
**Coffee Break**

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3:15 pm
**Construction of the Plymouth Tunnel by SEM Based on a Permanent Shotcrete Liner for the Purple Line Project in Maryland: A Case Study**


The Plymouth Tunnel forms part of the 16-mile long route of the Purple Line Light Rail Project promoted by the Maryland Transit Administration. The tunnel is approximately 1,220 feet in length with a shallow vertical alignment located beneath a residential area. Challenging mixed ground conditions included surficial soils, decomposed Saprrolite, and highly weathered to fresh rock requiring the use of the Sequential Excavation Method (SEM) for construction. This paper discusses innovative approaches implemented during construction as well as challenges faced during planning and installation of a spray-applied permanent concrete liner.
1:30 pm
Introductions

1:35 pm
The Use of Low-Density Cellular Concrete (LDCC) in Annular Fill Applications: Kaneohe-Kailua Sewer Tunnel Case Study
Nico Sutmoller, Aerix Industries, Timberville, Virginia US; Don Painter, Brierley Associates, Honolulu, Virginia US; Brian Dorwart, Brierley Associates; Lori M.K. Kahikina, Department of Environmental Services, City and County of Honolulu

This paper will address the feasibility of using low-density cellular concrete (LDCC) in annular fill applications. In this discussion, the paper will examine the case study of the Kaneohe-Kailua Sewer Tunnel project that was constructed in 2018 to convey wastewater and provide temporary storage of peak wet weather flows entering the collection system, thereby reducing the potential for spills. Located on the island of Oahu, Hawaii, the 13’-0” excavated diameter with a 126” Hobas pipe installed as the final liner for the conveyance tunnel extends for approximately three miles from the Kaneohe Pre-Treatment Facility to the Kailua Regional Wastewater Treatment Plant. The paper will also evaluate data related to the physical properties, manufacture, and technological advances of LDCC, highlighting the material’s unique physical properties of low density, high compressive strength, environmental stability, and high fluidity during placement. In its discussion of the Kaneohe-Kailua Sewer Tunnel project, the paper will posit the effectiveness of 50 LDCC as a backfill material in annular fill projects.

2:00 pm
Lesson Learned During the EPB TBM Launch Using Umbilical and Muck Pump
Raffaele Aliberti, The Lane Construction Corporation, Washington, District of Columbia US; Daniele Nebbia, The Lane Construction Corporation; Flaviano Solesin, The Lane Construction Corporation

The launching of a Tunnel Boring Machine (TBM) is one of the most challenging parts of the construction of a tunnel. Challenges are coming from the limited space, learning curve, for the concurrence of other activities and in some cases for the geological conditions. Launching a TBM is an extraordinary and complicated operation requiring a great level of planning. An Earth Pressure Balance (EPB) TBM was successfully launched for the Northeast Boundary Tunnel, the largest component of the Clean Rivers Project in Washington, DC. Due to space and time constraints, the 8-meter diameter TBM was launched from a single 20-meter diameter shaft, with a 30-meter-long tail tunnel by means of umbilical connections. This paper presents the steps followed during the TBM assembly and launching to allow the execution of the first drive of the tunnel maintaining high level of efficiency and quality despite the space constraints. Specifically, it focuses on the methods used to extract the excavated material (muck) from the TBM and from the tunnel, to supplying consumables, precast rings and backfill grout. The paper presents results in terms of productivity, lesson learned and possible alternatives to be considered in similar conditions.

2:25 pm
Quantification of Tangible and Intangible Benefits of Digitalization in Tunnel Construction
Jacob Grasmick, Maxwell GeoSystems, Golden, Colorado US; Angus Maxwell, Maxwell GeoSystems, Golden, Colorado US

As the tunneling industry continues to adopt Tunnel 4.0, digital twins of the tunnel construction site are becoming standard requirements for tunneling projects. However, the benefits of these remain unproven to many practitioners. The paper discusses the various implementations of digitalization and describes efforts to combine all data types to analyze the relationships between influences, predictions and performance in a single digital platform. This includes data pertaining to investigations, design, construction, monitoring and post-construction asset performance and management. Based on 16 years of global tunneling projects the paper aims to quantify the tangible and intangible benefits of such systems. Using a number of real examples, the paper describes where opportunities were taken and where they went unrealized. Challenges and considerations for both procuring and developing these digital twins are also discussed.

2:45 pm
Coffee Break
3:15 pm

Design and Construction of Load Transfer System to Replace Existing 39th Street Bridge Piers with New Integral on the Track B/C Approach Structure for the East Side Access Project


The underpinning/SOE support required the construction of 16 large hand dug pits 36ft deep that were reinforced and concrete filled. In addition, an extensive steel support system was tied into the bridge superstructure. All of the underpinning/tunnel construction was done while a 110ton crane sat directly atop the heavily trafficked – 66 ft. wide bridge. The tunnel excavation, concrete lining and final bridge pier support work will also be presented. All work was done within 5ft of active mainline tracks and that required tight grouting behind all lagging to eliminate any track settlement.

1:30 pm

Introductions

1:35 pm

Slurry Treatment Plants in Mechanized Tunneling Operations – Safety, Boosting and Cost Factor for Jobsites

Gino Vogt, Herrenknecht AG, Schwanau, Baden-Wurttemberg DE

In world wide mechanized tunneling operations time, consumption figures and safety requirements are the main factors for the jobsites. These highly effect the budgets. One of the most important components, often underrated, affecting these factors especially in slurry TBM operations are Slurry Treatment Plants (STPs). Wrongly sized and designed STPs create bottle necks to the operation and finally could delay the whole schedule. Inefficiened planned STPs create huge consumption figures in power, bentonite, water and polymers, etc. which will raise the budget cost dramatically. Inaccurate designed and treated slurry properties could cause a risk potential for the whole job. This presentation will explain the key parameters for STPS to look at from the start to the end of the project and its results.

2:00 pm

Lyon Metro Line B Extension: A Variable Density TBM for an Underground Mission in Remarkably Diverse Geology

Karin Bäppler, Herrenknecht AG, Schwanau, Baden-Wurttemberg DE

Lyon Metro Line B with a length of 2.4km will support sustainable urban development for the metropolitan area of Lyon and is being built in singular diverse geology. The project sets a benchmark for the use of Variable-Density-TBM-technology in forecasting geological conditions along the tunnel route. They comprise sections of highly permeable and extremely highly abrasive alluvial deposits that will be excavated mainly above the water table and areas with fresh granite with UCS of up to 164 MPa. The paper will highlight on this special area of application and its benefits in regards of safety, quality and required space.

2:25 pm

Respirable Crystalline Silica Dust (RCS) – Practical Impacts and Solutions in Tunnelling

Rainer Antretter, BeMo Tunnelling, Innsbruck, Tyrol AT

While RCS that arises in industrial production mostly accumulates out of a point source and can be extracted well, the application of this method is much more difficult in underground construction, since dust does not only occur locally, but largely spread. Analysis of dust measurements show that RCS values are difficult to predict and effective dedusting systems are required to comply with the limit values (PEL) in breathing air. Dedusting systems are effective at the face area, while dedusting of working areas behind is difficult or even impossible. In tunnels with small cross-sections dedusting systems often cannot be accommodated and PPE must be used instead. The paper highlights problems with dedusting measures and shows possibilities to comply.

2:45 pm

Coffee Break
3:15 pm
Steady State, Groundwater Inflows in Deep Rock Tunnels
Mark Vanarelli, Colorado School of Mines, Golden, CO, US

Estimating groundwater inflows in rock deep tunnels is critical to the safety of personnel constructing the tunnel and the cost of construction. This paper presents two case studies for estimating steady-state groundwater inflows into deep rock tunnels. The case studies included the Chattahoochee and Nancy Creek tunnels. In this paper, statistical methods were applied to packer test data obtained from exploratory borings during geotechnical site investigations. A semi-empirical procedure was utilized for estimating groundwater inflows into these deep rock tunnels. The Chattahoochee and Nancy Creek tunnels are deep rock tunnels which exhibit radial flow conditions. For the radial flow condition, a statistical analysis presented in this paper indicates that the semi-empirical procedure works well; however, variations in the procedure and/or an insufficient amount of testing could lead to underestimations of the inflow quantities. Packer test data plotted in histograms were observed in all cases to be log-normally distributed for the radial flow condition. Modeling using Monte Carlo simulations was observed to be an effective tool for removing irregularities in the distribution of the data and incorporating high-end permeability data to derive reasonable groundwater inflow estimates.

3:40 pm
Dustless Hard Rock Tunneling Methods

Silica/Crystalline Quartz exposure remains a serious threat to nearly 2 million U.S. workers, including more than 100,000 workers in high risk jobs such as abrasive blasting, foundry work, stonemasonry, rock drilling, quarry work and tunneling. The primary focus of this study is to reduce dusty air (crude air) and limit/eliminate potential respirable dust (Silica/Crystalline Quartz) exposure to tunneling personnel by introducing two de-dusting methods/systems. The study is being conducted on two separate tunneling projects. The first project location in Toronto, Ontario, Canada will be utilizing a wet de-dusting system and the second project in Cleveland, Ohio will be utilizing a dry de-dusting system. The goal is to determine which de-dusting system application is best suitable to reduce/remove/capture the aspirated, dry and fine-grained dust particulates within the tunnel heading.

1:30 pm
Introductions

1:35 pm
Real Challenges of Digging a Shaft in Free Phase Oil and Hydrocarbons

The Don River & Central Waterfront Coxwell Sanitary Bypass Tunnel Project in Toronto will extend approximately 10.5 km from Ashbridges Bay Treatment Plant west under Lake Shore Boulevard, north under Bayview Avenue and east through the Don River park area to the Coxwell Ravine Park. During the installation of initial support of excavation and excavation of Shaft LDS-3(B), significant volumes of free phase oil and hydrocarbon contaminants were found in both overburden and the transition zone between rock and overburden. Due to the heavy inflows of the contaminants, excavation was stopped at the transition depth. The initial support of excavation needed to be redesigned, shaft had to be backfilled with CDF and installation of deeper secant piles are in progress to cut off contaminants. This paper outlines the initial plan for excavation as well as the design changes to the plan. The current status of the shaft excavation and lessons learned will be discussed.

2:00 pm
Deep Portal Shafts of the Annacis Island Outfall Tunnels – Building on Pacific Northwest Shaft Design Experience
Ulf Gwildis, CDM Smith, Bellevue, Washington US; John Newby, CDM Smith, Burnaby, British Columbia CA; Fred Marquis, McMillen Jacobs Associates, Vancouver, British Columbia CA

From the Brightwater Conveyance System in Seattle to the Second Narrows Water Supply Tunnel in Vancouver, B.C., the construction of deep lying tunnels in the Pacific Northwest has required the design of deep portal shafts. Alluvium overlying marine and glacial deposits combined with the high regional seismicity is the common geologic setting. The latest example illustrating the development of shaft design for this scenario are the 40-m-deep shafts of the Annacis Island Wastewater Treatment Plant New Outfall System for launching and receiving a 5-m-diameter TBM. This paper presents design considerations for these shafts against the background of past project experiences.
2:25 pm

**Mechanical vs. Manual Shotcrete Application in Underground Construction**
Lauro Lacerda, Normet Americas, Inc., Layton, Utah US

Shotcrete is a highly adaptable and widely used underground construction material at infrastructure and mining projects around the world. In fact, many projects could not have been completed without its utilization. As underground projects became larger, the use of mechanized wet-mix spraying gradually replaced manual dry-mix shotcrete applications. This paper details some of the reasons for that and provides information on the equipment and operational factors including safety and productivity required to successfully complete underground shotcrete projects.

2:45 pm

**Coffee Break**

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TUESDAY, JUNE 15

8:30 am

**GROUND SUPPORT AND FINAL LINING**

*Chairs: Martin Mancini, Jacobs Engineering, Florham Park, New Jersey, US*

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8:30 am

**Introductions**

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8:35 am

**A Comparison of Grouting Through Segment Ports vs Grouting Behind the Tailcan of Two Segmentally Lined Rock Tunnels**


The Don River & Central Waterfront Coxwell Sanitary Bypass Tunnel (CBT) Project in Toronto will extend approximately 10.5 km and lined by using a precast concrete segmental tunnel liner with an internal diameter of 6,300 mm and external diameter of 6,900 mm. The CBT liner is being grouted through ports drilled in the segments. The Westerly Storage Tunnel (WST) in Cleveland will extend approximately 2.93 km long and will be lined by using a similar precast concrete segmental tunnel liner with an internal diameter of 7,620 mm and external diameter of 8,230 mm. The WST liner was grouted using both grout ports built into the tail can of the TBM and through segments. Each tunnel was mined primarily in Shale with varying levels of weathering and both dry and wet sections. This paper will document the means and methods for grouting in each liner as well as the methods utilized to proof grout and the results found.
9:00 am

**Final Lining Construction of an SEM Cavern – Regional Connector Transit Project**

Rebecca Reeve, Traylor Bros, Inc., Long Beach, California US; Christophe Bragard, Traylor Bros, Inc., Long Beach, California US

Following the successful excavation of a 287 ft. long, 58 ft wide, and 36 ft. high SEM cavern underneath historical structures of downtown Los Angeles, an unusual three-part formwork system was used to accommodate the many unique challenges of the 18” thick cast-in-place final lining. An innovative method of hydrocarbon resistant membrane (HCR) installation was adapted using Velcro to adhere the waterproofing membrane. To further limit ground settlements, a contact grouting procedure involving grout injection to both the interior and exterior of the waterproof membrane was also implemented for the notable completion of the SEM Cavern final lining.

9:30 am

**Coffee Break**

10:00 am

**Composite Segmental Lining to Resist a Fault Rupture**


Designing and constructing tunnels in seismic prone areas present unique challenges to both designers and contractors. The Westside Purple Line Extension Project - Section 3 in Los Angeles requires crossing an active fault that may subject the tunnels to extreme structural demands. In order to guarantee that the linings will safely accommodate the fault movement, a revolutionary composite section – steel plate embedded in the intrados of the precast concrete segmental tunnel lining was finally selected. Additionally, continuous expansion steel plates over the circumferential joints will be installed to mitigate the potential opening of the circumferential joints.

10:25 am

**TBM Removal within the Busiest Passenger Interlocking in the United States**


This paper describes the surgical removal of a 24ft dia. Slurry Shield TBM entombed beneath one of the country’s busiest commuter rail interlockings, the Harold Interlocking in Queens, NY, and the construction of the interface to a cut/cover tunnel which extended the mined tunnel section. A sophisticated SOE was built around the TBM to support active track loads within 8ft. of the excavation. Once the TBM head and guts were removed, a full round CIP lining was installed connecting the existing precast tunnel liner to the C/C tunnel under construction. All this construction was done on a narrow island of land without road access nestled between 7 mainline LIRR/Amtrak rail lines.

10:50 am

**INTERNATIONAL PROJECTS**


8:30 am

**Introductions**

8:35 am

**Second Narrows Water Supply Tunnel – Final Design, Procurement and Construction**

Gregg Davidson, McMillen Jacobs Associates, Pasadena, California US; Frank Huber, Metro Vancouver, Burnaby, British Columbia CA; Andrew McGlenn, McMillen Jacobs Associates, North Vancouver, British Columbia CA

The Second Narrows Water Supply Tunnel will ensure system reliability in the event of a major earthquake and increase the Greater Vancouver Water District’s capacity to meet the long-term needs of a growing population. The tunnel will be 1,100 meters (m) long and 6.5 m in diameter (3,610 lf x 21.3 ft), constructed under Burrard Inlet between North Vancouver and Burnaby in British Columbia. It will be excavated through mixed ground conditions under high groundwater pressure, using a slurry TBM, between a 72 m (236 ft) deep shaft in soil and a 110 m (361 ft) deep shaft in rock. The completed tunnel will accommodate three large-diameter water mains that will be installed as part of the tunnel contract. This paper presents the project from planning, through design and contractor procurement, and into the current construction stage describing some of the unique challenges encountered during the project development to date.
9:00 am

**Short Startup for a High Pressure Mixshield Tunnel Boring Machine**

Matt Burdick, Traylor Bros., Inc., North Vancouver, British Columbia CA; Erica Bailey, Traylor Aecon GP, North Vancouver, British Columbia CA; Andrew Rule, Traylor Aecon GP, North Vancouver, British Columbia CA

The Second Narrows Water Supply Tunnel, Burrard Inlet Crossing project for the Greater Vancouver Water District entails deep shaft construction, subway sized pressurized face tunneling through highly variable ground conditions, installation of three permanent steel water mains and construction of elaborate valve chambers adjacent to either shaft. The paper discusses key elements of the planning and implementation of 6.69 m Ø slurry TBM assembly in a small diameter deep shaft including incorporation of a fully pressurized launch lock, preparations for saturation diving, surface support infrastructure and initial mining sequence.

9:30 am

**Coffee Break**

10:00 am

**The Kramer Tunnel – Challenging NATM-Tunnelling in Germany’s Alps**

Richard Gradnik, BeMo Tunnelling GmbH, Innsbruck, Tyrol AT; Richard Gradnik, BeMo Tunnelling GmbH, Innsbruck, Tyrol AT; Martin Zeindl, Landesbaudirektion Bayern, München, Bavaria DE; Roland Arnold, BeMo Tunnelling GmbH, Innsbruck, Tyrol AT; Norbert Fuegenschuh, Alpine Bemo Tunnelling

The Kramer Tunnel is located in Garmisch-Partenkirchen, Bavaria in close vicinity to the Austrian border. This road tunnel project with two parallel tubes (two-lane main tunnel and separated rescue tunnel) and a length of approximately 3,600 meters passes through a rockslide area with very complicated geological and geotechnical conditions. The construction of an exploratory gallery had to be aborted in 2013 due to the difficult hydrogeological conditions in this area. SEW NATM in combination with groundwater lowering measures has been chosen to excavate the tunnels. The paper describes the challenges which will put the flexibility of the construction method on the edge.

10:30 am

**Coffee Break**

8:30 am

**Introductions**

8:35 am

**Pre-Excavation and Early Work Activities for the Long Baseline Neutrino Facility Far Site**


The Long Baseline Neutrino Facility Far Site at the Sanford Underground Research Facility in Lead, South Dakota will house four large detector tanks located one mile underground. Construction of the supporting infrastructure required for this project is already underway including installation of the waste rock handling system and preliminary drill and blast excavation of supporting drifts and chambers. This presentation will discuss the project transition from pre-excavation activity into preparatory excavation leading to mass excavation of the neutrino detector caverns.

9:00 am

**Utilizing “Big Tex” for the Dallas Mill Creek Drainage Relief Tunnel**

Paul Smith, Black & Veatch Corporation, Richardson, Texas US; Milton Brooks, City of Dallas, Dallas, Texas US; Quang Tran, Southland Holdings, LLC, Roanoke, Texas US; Euadomar Silva, Black & Veatch Corporation, Dallas, Texas US

The Dallas Mill Creek Drainage Relief Tunnel is an 8.04 km (5 mile) tunnel that will provide 100-year flood protection for impacted neighborhoods in the east Dallas area. “Big Tex” is a main beam gripper TBM capable of changing diameters in mid-tunnel to excavate 2.83 km (9,290 ft) of 11.45 m (37.58 ft) diameter tunnel and 5.21 km (17,095 LF) of 9.94 m (32.61 ft) diameter tunnel. Construction began in April 2018 and is anticipated to be completed in late 2023. This paper will discuss the challenges and lessons learned during assembly and re-assembly, start-up and mining with “Big Tex”.

9:30 am

**Coffee Break**
10:00 am  
**Design of Large Underground Near Detector Cavern for Fermilab in Batavia, Illinois**  
Irwan Halim, AECOM, Chelmsford, Massachusetts US; Seung Han Kim; AECOM, Oakland, CA, US; David Cregger, AECOM, Chelmsford, Massachusetts, US  
Fermilab is constructing a large underground cavern in Limestone to house scientific equipment. The cavern will have a complex L-shaped geometry and about 215-foot depth with relatively shallow rock cover, with service/egress shafts accesses into the cavern. Three-dimensional analytical models were developed to study the ground behavior and support performance. Multiple rock constitutive and failure models were evaluated. The models were significantly impacted by the high lateral in-situ earth pressure at the site. This paper will describe the design approaches that were taken to optimize the cavern arch geometry to allow safe construction in shallow rock, and permanent support requirements.

**NEW AND INNOVATIVE TECHNOLOGIES I**  
**Chairs:** Luis Fernandez-Deza, Traylor Bros., Inc., Alexandria, Virginia, US  
Seth Pollak, Arup, New York, New York, US  
Sponsored by: The Walsh Group

8:30 am  
**Introductions**

8:35 am  
**High-speed 3D Tunnel Inspection in Subway Tunnels – Case Study San Francisco BART**  
Heiner Kontrus, Dibit Messtechnik GmbH, Innsbruck, Tyrol AT; Jérôme Steinkühler, Dibit Messtechnik GmbH, Innsbruck, Tyrol AT; Thomas Peal, Dibit Measuring Technique USA, Inc., Bellevue, Washington US  
The Dibit high-speed 3D scanning system which is based on Photogrammetry and LiDAR technology enables data acquisition in tunnels at a speed of up to 60mph. Given the high rate of speed the system can operate, tunnel shutdowns can be drastically reduced, and tunnel safety increased. The photorealistic texturing of the 3D-model allows the identification and analysis of smallest material damage (e.g. cracks >=0.3mm wide). The publication illustrates technical details and 3D results of the innovative system from measurements that were performed in the subway tunnels of the Bay Area Rapid Transit System in San Francisco, CA (total length 66.23km).

9:00 am  
**Segment Production 4.0 – Automated Segment Production Using Robots**  
Stefan Medel, Herrenknecht Formwork Technology GmbH, Schwanau, Baden-Wurttemberg DE  
ROBOT SUPPORTED MOULDING — this is the name of Herrenknecht Formwork’s entry to the world of automated segment production. What had been considered impossible for a long time, has been achieved by Herrenknecht experts together with the Swiss company Marti AG: unmanned segment production on the working line. The moulds open and close autonomously with the help of a hydraulic system. A robot cleans and greases the moulds at one work station and inserts the injection sockets at another. The next step will include further automation and digital networking of all processes from production to installation in the tunnel.

9:30 am  
**Coffee Break**

10:00 am  
**The Variable Density TBM – Current Level Of Development**  
Werner Burger Herrenknecht AG, Schwanau, Baden-Wurttemberg DE  
After its first introduction in 2013, Variable Density TBMs have increased their application significantly in mechanized closed mode tunneling. Throughout a variety of successfully completed and ongoing projects since then, Variable Density TBM technology has demonstrated its advantages in a wide range of applications. This paper will present the developments and lessons learned from these projects as well as the future potential of Variable Density TBMs.

10:25 am  
**Performance of Tunnel Segments reinforced with Synthetic Macro Fibers**  
Ralf Winterberg, BarChip Inc., Kurashiki City, Okayama JP; Todd Clarke, BarChip Australia Pty Ltd, Penrith, New South Wales AU  
For more than a decade the tunneling industry has explored the potential and benefits of macro synthetic fiber (MSF) reinforced concrete solutions for precast tunnel segments. Parallel to industry investigations, academic research is being undertaken to better understand this material when subjected to the typical loads expected during mechanized tunneling. This paper investigates the performance of MSF reinforced precast concrete tunnel segments by means of an experimental program comprising testing of full-scale tunnel segments. The presentation of the satisfactory results of the experimental testing programme will be complemented by brief case histories from successfully executed projects, including an America’s First.
TUESDAY, JUNE 15

1:30 pm
FUTURE PROJECTS
Chairs: Tony Cicinelli, Kiewit, Omaha, Nebraska, US
David Jurich, Mott MacDonald, Lakewood, Colorado, US

Sponsored by: The Walsh Group

1:30 pm
Introductions

1:35 pm
SCMAGLEV – Innovative Mass Transportation in the Northeast Corridor (NEC)
Vojtech Gall, Gall Zeidler Consultants, Ashburn, Virginia US; Nikolaos Syrtariotis, Gall Zeidler Consultants, Ashburn, Virginia US; Timothy O'Brien, Gall Zeidler Consultants, Ashburn, Virginia US; Ian Rainey, Northeast Maglev, Baltimore, Maryland US; Mark Berger, WSP, Washington, DC, District of Columbia US

The Northeast Corridor Superconducting Maglev Project (SCMAGLEV) entails construction of a high-speed train system between Washington, D.C. and New York City, with the first leg between Washington and Baltimore, MD. This innovative project will shorten travel times between Washington D.C. and Baltimore to approximately 15 minutes, and connect Washington, DC to New York City in under an hour. In 2021 the draft EIS is expected to be issued for comment with a Final EIS/ROD anticipated by early 2022. This paper provides an update on the project as presented in Gall et al. (2020) and discusses the economic and environmental benefits, preferred alignment alternative, preliminary staging and launching of the TBM’s for construction, and preliminary station design.

2:00 pm
Design Development of the BCRUA Phase 2 Raw Water Delivery System Project
James Parkes, Schnabel Engineering, Baltimore, Maryland US; Aaron Archer, Walker Partners, Austin, Texas US; Norbert Fuegenschuh, Alpine BeMo Tunneling, Vienna, VA, US

This paper presents design considerations for the underground elements of the pending BCRUA Phase 2 Raw Water Delivery System Project. These elements include two lake taps; a 9,000-ft, minimum 10-ft OD intake tunnel; a suction chamber with 6 pump shafts with 72-inch casings; a 30-ft diameter, 300-ft deep shaft; a 2,600 LF transmission tunnel with 84-inch steel liner; and a 130-ft deep transmission riser shaft. The tunnels and shafts will be excavated through the Glen Rose limestone. The design development included consideration for technical requirements, easements, third party commitments, previous local project experience, and constructability considerations based on contractor outreach.

2:25 pm
Upgrading the Coal Creek Trunk Sewer
Joseph Clare, Tetra Tech, Seattle, Washington US; Ron Bard, Brown & Caldwell, Seattle, Washington US; Elizabeth Matson, King County Wastewater Treatment Division, Seattle, Washington US; Norbert Fuegenschuh, Alpine BeMo Tunneling, Vienna, VA, US

It’s not the 60’s anymore. Upgrading wastewater pipelines in the current era demands the latest trenchless technology to minimize impacts. King County Wastewater Treatment Division in Seattle, Washington is designing a nearly mile long Direct Pipe® influent sewer combined with microtunneling to replace a 60’s era trunk sewer constructed along and within Coal Creek and its natural area. Direct Pipe® and trenchless installation was chosen due to the challenges of suburban neighborhoods, natural creek environment, topography, and geology. A collaborative effort between owner, designer, and construction manager provide the foundation for success.

2:45 pm
Coffee Break
3:15 pm

**Tunnel Design Aspects the New Haven Downtown Storm Sewer Infrastructure Improvement Project**

Gregory Sanders, CDM Smith, Kansas City, Massachusetts US; Michael Schultz, CDM Smith Inc, Boston, Massachusetts US

The City of New Haven is proposing to construct Downtown Storm Sewer Infrastructure Improvement Project to mitigate on-going stormwater flooding in the Long Wharf District. The proposed project includes a 200-cfs stormwater pump station; and a 914 meter (3,000 linear feet) long tunnel segment with an internal diameter of 2.1 meters (84-inch). The tunnel alignment will cross under the Long Warf railyard and then continue parallel to the US 34. This paper presents the local geology and subsurface conditions, as well as discusses the major project challenges and risks including construction in soft marine soils.

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**NEW AND INNOVATIVE TECHNOLOGIES II**

Chairs: Kaveh Talebi, Jay Dee Contractors, Livonia, Michigan, US
Soto Vardakos, WSP, New York, New York, US

1:30 pm

**Introductions**

1:35 pm

**NEBT Project: The Application of Artificial Intelligence (AI) to Improve TBM Operations**


The application of artificial intelligence (AI) to improve tunnel boring machine (TBM) operations requires a significant amount of information to train robust performance prediction models, e.g., for tunneling-induced settlement, productivity, tool wear, etc. This data is collected by a multitude of sensors that continuously record operational parameters and by geotechnical instrumentation that monitor soil and groundwater response to tunneling. This paper presents the AI framework for applied to the Northeast Boundary Tunnel (NEBT), the largest component of the Clean Rivers Project in Washington, DC. The paper focuses on required elements for real-time AI use to estimate the aforementioned operational elements, namely tunneling-induced ground and building deformation as well as tool wear. Keys to the framework include defining the necessary quantities of data required as well as the process of windowed training, validation and model testing. The paper presents results from AI application to the NEBT project performed in collaboration between the Colorado School of Mines team and the Contractor Lane. Both advantages/successes and disadvantages/ failures of AI applied to NEBT are discussed.

2:00 pm

**Review of Measured Activity Times and Their Impacts on Machine Utilization in Operation of Selected**


Tunnel boring machine (TBM) system utilization is a critical factor for predicting machine performance. The process of estimating machine performance, including rate of penetration (ROP) and machine utilization (U) must incorporate an understanding of site geology, TBM specifications and site management. The study herein presents a preliminary analysis of the different activity time and downtime components from hard rock TBMs at two project sites to evaluate their impact on machine utilization. A comparison of crew experience, first between shifts and then between projects is included to analyze its effect on utilization and downtime. This work presents the sensitivity of the utilization factor to selected activities in the projects and the impact of geology and site set-up/logistics on machine performance.

2:25 pm

**Emerging Data Processing Technologies for TBM Projects – State of the Art and Outlook**


Automatically acquired machine data during TBM advance is typically processed by specialty software to offer the project team data visualization and evaluation options. Interfacing with GIS, CAD, 3-D geologic model, and instrumentation data bases allows Building Information Modeling (BIM) of the tunnel as-built condition. Application of Artificial Intelligence (AI) processes such as Machine Learning (ML) have already been used for hard rock TBM performance prediction and exhibited the potential of big data analytics. This paper outlines anticipated disruptive technological advances with implications on geotechnical exploration, TBM operation, face condition tracking, subsoil risk allocation, and claims management in the future.

2:45 pm

**Coffee Break**
3:15 pm

**Remote Vein Miner - Uncovering an Opportunity for Tunneling Projects**


In the past two decades, many major equipment manufacturers have ventured into developing new technology for underground hard rock excavation. A redesigned mobile miner, called the “Remote Vein Miner”, or RVM, has been developed by Epiroc for underground hard rock mining in Hecla’s Lucky Friday Mine. This equipment potentially opens numerous opportunities for innovation in civil tunneling projects, where the operational flexibility and accessibility of a TBM’s limited tunnel path, design and cost are limiting factors. This paper explores the application of the RVM in tunneling projects, its advantages and possible areas of innovation in tunnel planning and design.

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1:30 pm

**PRESSURIZED FACE TUNNELING**

Chairs: Peter Raleigh, McMillen Jacobs Associates, Pasadena, California, US; Anton Huptaat, Frontier Kemper

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1:35 pm

**Segment Design for Exceptional Circumstances: Post Tensioning & Squeezing Ground**

Nick Karlin, Dragados USA, Wilmington, California US; Claudio Cimiotti, Dragados USA, Wilmington, California US; Alfonso Navarro, Sener, Madrid, Tres Cantos ES; Eduardo Velasco, Sener, Madrid, Tres Cantos ES; Alejandro Sanz Garrote, gGravity, Madrid, Madrid ES; Paz Navarro, gGravity, Madrid, Madrid ES

Dragados is currently constructing the Effluent Outfall Tunnel for the Sanitation Districts of Los Angeles; a 7 mile long effluent conveyance tunnel designed for peak flows of up to 340MGD. The contract scope includes final design of the pre-cast concrete tunnel lining, a complicated task for the two distinctive project geologies. The northern 20,000’ of the tunnel is in alluvial sands with low ground cover requiring the integration of a PCPL post tensioning system to guarantee tunnel compression. The latter 16,000’ of the tunnel will be constructed in a zone which is historically known to exhibit extreme squeezing.

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2:00 pm

**Management of the Water Inflows During Construction of the Three Rivers Protection & Overflow Reduction Tunnel (3RPORT)**

Paolo Perazzelli, Pini Swiss Engineers, Zurich, Zurich CH; Roberto Schuerch, Pini Swiss Engineers, Zurich, Zurich CH; Miriam Piemontese, Pini Swiss Engineers, Zurich, Zurich CH; Emidio Tamburri, Lane-Salini Impregilo, Fort Wayne, Indiana US; Francesco Chiappalone, Lane-Salini Impregilo, Fort Wayne, Indiana US; Lance Wadell, Lane-Salini Impregilo, Fort Wayne, Indiana US

The Three Rivers Protection & Overflow Reduction Tunnel is part of the Long-Term Control Plan of the City of Fort Wayne, Indiana (USA). The 7.5 km, 4.87 m internal diameter tunnel is excavated through carbonate rocks by means of a slurry TBM. Due to the high hydraulic conductivity of the rock mass and the high in situ ground water pressure (up to 6.5 bar), the management of the water inflow during TBM advance and standstills represents the major challenge of the project. The paper outlines the hazards related to the large water inflows and discusses the experience gained during construction.

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2:25 pm

**Tailskin Brushes Replacement Under Difficult Ground Conditions – 3RPORT Project**

Francesco Chiappalone, LANE, Fort Wayne, Indiana US; Daniele Nebbia, LANE, Washington, District of Columbia US; Lance Wadell, LANE, Fort Wayne, Indiana US; Emidio Tamburri, LANE, Fort Wayne, Indiana US

As part of the 3RPORT Project, a 5-mile tunnel is being excavated underneath the three rivers of Fort Wayne using a 19-foot diameter Slurry Tunnel Boring Machine. The groundwater pressure at the tunnel axis ranges from 4.5 to 5.3 bar. The rock mass hydraulic conductivity is very high with water inflows up to 10,000GPM imposing significant challenges to the project. After excavating 1,550-feet of the TBM tunnel, major leaks between the tailskin and the segmental lining were observed, indicating the potential deterioration of the tailskin brushes and the need for inspection and eventual replacement. The first part of the paper describes the planning of the intervention, including the design of the polyurethane grouting campaign, the procedures developed for the execution and the controls established during construction to timely assess the presence of potential hazards. The second part of the paper focuses on the experience gained during execution and lesson learned to prevent future occurrences of this nature.

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2:45 pm

**Coffee Break**
3:15 pm

**Two-Component Backfill Grouting at the Three Rivers Protection and Overflow Reduction Tunnel: Above and Below Ground Challenges and Solutions**

Cristina Gabriela Oñate Salazar, MAPEI Corporation, Naperville, Illinois US; Tanner Murt, MAPEI Corporation, Pittsburgh, Pennsylvania US; Francesco Chiappalone, LANE, Fort Wayne, Indiana US; Lance Waddell, LANE, Fort Wayne, Indiana US; Norbert Fuegenschuh; Alpine BeMo Tunneling, Vienna, VA, US

The 3RPORT project is a 5-mile-long, 16-foot-diameter tunnel excavated in hard rock by slurry TBM in Fort Wayne, Indiana. Two-component grouting can be separated into two core areas of operation: batching and underground operations. This paper addresses the challenges faced and solutions implemented in these fundamental areas. The effects of external factors and their impacts on mix design and batching of grout will be explored. Underground, challenges of monitoring parameters and ensuring a proper mix between the two-components will be discussed, focusing on the adopted technical solutions and considerations to be taken in the design stage of tailskin grout ports.

1:35 pm

**Tunneling Beneath Downtown Bellevue on Time and Under Budget**


Downtown Bellevue Tunnel (DBT) is part of Sound Transit’s $3.7 billion, 14-mile light rail transit system from downtown Seattle, across Lake Washington, to the cities of Mercer Island, Bellevue, and Redmond. The tunnel was the first Sound Transit East Link project and posed significant construction risk. This paper discusses implementation of design changes to the soft ground tunneling method, implementation of several technologies such as the use macro-synthetic fiber initial shotcrete lining, use of spray-applied waterproofing, and use of shotcrete for the final tunnel lining. These efforts allowed for significant time and cost savings to the project.

2:00 pm

**Tunnel Spitzenberg – Tunnel Drive Hits a Historic Quarry**

Pafos Busch, BeMo Tunnelling, Austria, Innsbruck, Tyrol AT; Johannes Jaeger, BeMo Tunnelling GmbH, Innsbruck, Tirol AT; Martin Fischer, BeMo Tunnelling GmbH, Innsbruck, Tirol AT

The tunnel Spitzenberg is a 600 m (1,970 ft) long twin tube motorway tunnel on Germany’s autobahn A44 between Kassel and Eisenach. Since flexibility was considered to be very important in the continuously changing geological conditions NATM was chosen as construction method. When passing an old quarry with only 1,80 m (6 ft) of overburden the excavation works became extraordinarily challenging. The paper not only describes the special methods, like double side wall drifts and pipe umbrellas, applied in this zone but highlights also the cooperation between the parties involved which in combination made the project a joint success.
2:25 pm

Application of Surrogate Modeling for SEM Tunneling Simulation

The sequential excavation method (SEM) is one of the most complex tunneling approaches, usually featured with irregular excavation profile and multi-drift configuration. The evaluation of SEM design is commonly achieved by computational simulations either by finite element method (FEM) or finite difference method (FDM). Conventional 2D plane-strain numerical analysis is inadequate to capture the three-dimensional effects from multiple tunneling advances, whereas longer running time and highly expensive computational efforts required by three-dimensional step-by-step simulations hinder its application in probabilistic analysis and real-time prediction. This fuels the desire to harness surrogate modeling methods that use cheap “surrogates” to reliably represent the expensive, simulation-based model. This paper proposes a framework for applying surrogate-based approaches to evaluate SEM construction, which can both benefit the uncertainty analysis in the design stage and real-time calibration during the construction process. The performances of several surrogate modeling approaches were tested and compared. A variance-based global sensitivity analysis (GSA) was performed on surrogate models to quantify the impacts of geotechnical parameters on the deformation responses induced by SEM construction. The Regional Connector Crossover Cavern project constructed in Downtown Los Angeles was set as the benchmark problem to demonstrate the efficiency and reliability of the proposed procedure.

2:45 pm

Coffee Break

3:15 pm

Construction of the Newell Creek Dam Inlet/Outlet Replacement Project
Shawna Von Stockhausen, Mott MacDonald, San Jose, California US; Isidro Rivera, City of Santa Cruz, Santa Cruz, California US; Idit Zarchi, AECOM, Oakland, California US; Koichi Shimomura, Obayashi, California US

The City of Santa Cruz Water Department is replacing the existing Newell Creek Dam (NCD) inlet/outlet works at Loch Lomond Reservoir in the San Lorenzo Valley as required by the California Division of Safety of Dams. The project is comprised of new inlet works (three new inlets that control and convey flows and an intake control building), a new outlet structure for energy dissipation and beneficial releases into Newell Creek, a new dam seepage collection and monitoring system, and new 48inch and 10inch outlet pipelines. Notable complex project components include the integration of the new outlet pipes to the new inlets to be constructed via marine works in the wet. This paper will discuss how the project configuration met the Owner’s objectives, the progress of construction to date and plans to complete the work, and the tools being used to manage the project and risks through construction which include ProjectWise Construction Management software, partnering, and a dispute resolution board.
9:30 am
Coffee Break

10:00 am
Abrasivity and Cutter Life Assessment for TBM Tunneling in Cobbles and Boulders
Steven Hunt, Black & Veatch, Las Vegas, Nevada US; Glen Frank, Lane Construction, Seattle, Washington US

Maximizing cutter life when tunneling in mixed face ground that includes cobbles and boulders requires 1) assessment of abrasivity and strength parameters for soil matrix and rock clasts, 2) methods of combining both, 3) proper selection of cutters and 4) modified TBM operation. This paper presents approaches for addressing these factors sufficiently to improve tunneling success in mixed ground with cobbles and boulders. Current laboratory abrasivity testing will be assessed along with equivalent quartz content correlations to soil matrix and rock clast abrasivity. New approaches to combining abrasivity testing of both the soil matrix and rock clasts for various cobble and boulder volume ratios will be suggested to estimate cutter life and intervention intervals.

10:25 am
Geotechnical Investigation and Tunnel Design for the Sister Grove Outfall Tunnels
Gregory Sanders, CDM Smith, Kansas City, Massachusetts US; Micheal Schultz, CDM Smith Inc, Boston, Massachusetts US

In 2017, the North Texas Municipal Water District (NTMWD) initiated the design of the Sister Grove Regional Water Resource Recovery Facility (SGRWRFF) to provide additional treatment capacity for future population growth within the Lavon Lake watershed. To provide a discharge location for SGRWRFF approximately 4.5 miles of 2.4 meter (96-inch) internal diameter pipeline will be constructed, including 2.3-kilometer (7800) feet and 487 meter (1600 foot) long tunnel segments. This paper will discuss the anticipated geology of the two tunnel segments, selection of the tunnel alignment, the anticipated initial tunnel support requirements and other aspects of the project design.

10:25 am
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9:00 am
The Role of Small Diameter Tunneling for Pipeline Installations
Peter Schmäh, Herrenknecht AG, Schwarnau-Allmannsweier, Baden-Württemberg DE

Nowadays, small diameter tunnels are increasingly considered in pipeline projects as an alternative for sensitive crossings or when soil conditions limit the use of conventional pipeline installation methods like HDD. Safety concerns play a key role, especially for inner-city installations. Pipe jacked microtunnels and small segment lining tunnels can serve as casing tunnels if access is required, e.g. during construction for the change of cutting tools in challenging ground conditions or for maintenance of the pipeline in operation. Small diameter tunneling solutions offer a high degree of flexibility for alignment design in terms of geology, length and radius.

9:30 am
Coffee Break
10:00 am
Crossing an Environmentally Sensitive Shore Area – Micro-tunneling in the Australian Outback
Taner AYDOGMUS, Flatiron Constructors, Inc., Broomfield, Colorado US

The A$29 billion Chevron-operated Wheatstone Project is one of Australia’s largest resource projects. Located at Ashburton North, 12 kilometers west of Onslow in Western Australia, the project will consist of two LNG trains with a combined capacity of 8.9 million tons per annum and a domestic gas plant. The LNG Plant will serve the offshore gas fields, which are situated some 250 km off the coast of Onslow in Western Australia. Once operational and on-stream, the Wheatstone Project will contribute to Australia becoming the world’s second largest exporter of LNG. For crossing the environmentally sensitive shore area a micro-tunnel with an internal diameter of 2 m and approx. 1,242 m in length has been constructed by means of the pipe-jacking method. The micro-tunnel will accommodate a 1.1 m diameter pipeline (trunkline) to deliver gas from the offshore fields LNG Plant. The Wheatstone shore crossing design involves a number of unique challenges owing to its coastal location, where the alignment crosses through a shore area and terminates in a marine environment. This paper provides an overview of the Wheatstone Shore Crossing Project, presents the key features, and discusses the main aspects of the micro-tunneling design.

10:25 am
Challenges to Tunneling in Abrasive Alluvial Material Above the Water Table using a SMTBM and an EPBTBM
Donald Arthur, Frontier-Kemper Constructors, Inc., Sylmar, California US; Derek Lynn, Frontier-Kemper Constructors, Inc., Sylmar, California US

Infrastructures continue to age and drinking water supplies are becoming scarce in the San Fernando Valley of Los Angeles, California (LA). Frontier-Kemper Constructors, Inc. (FKCI) was engaged by Los Angeles Department of Water and Power (LADWP) to complete the River Supply Conduit Improvement Upper Reach – Unit 7 (RSC7) Project. Two tunnel sections were bored using an 8.66-foot diameter Slurry Microtunnel Boring Machine (SMTBM) and a 13.50-foot diameter Earth Pressure Balance Tunnel Boring Machine (EPBTBM) to excavate approximately 12,150-linear feet (2.3 miles) of tunnels through highly abrasive late-Pleistocene-age Quaternary alluvial deposits (Old Alluvium) above the water table. The paper will discuss the challenges managing the TBM’s equipment degradation, use of soil conditioners, torque and advance rate while maintaining the necessary face pressures and parameters to limit over excavation and ground settlement.

9:00 am
Tunnel Vision: Planning a Resilient 21st Century Wastewater System for Houston

During Hurricane Harvey over 60% of the 39 WWTPs, including the low-lying 25 MGD Sims North WWTP, and one third of the 382 lift stations owned and operated by the City of Houston were flooded resulting in extensive facility damage, loss of service and uncontrolled release of untreated wastewater into bayous and creeks. In response the City has embarked on an effort to improve system resiliency by consolidating at-risk facilities with a network of deep sewer tunnels to augment the capacity of the existing 6,000 miles of sewer mains. Investigations on the cost to mitigate the flood damages by raising the plant at Sims North WWTP is estimated at nearly $450 million. Instead of spending $450 million to raise the plant, the funds will be directed to eliminating Sims North WWTP, along with the Scott Wet Weather Facility and providing a more robust and resilient wastewater system for the Sims basin area of Houston. The backbone of this new system is a 4.5-mile-long, 110 inch diameter deep gravity sewer tunnel that will convert a system heavily reliant on distributed lift stations to a majority gravity system with a deep consolidated lift station at the WWTP.
9:30 am
Coffee Break

10:00 am
Methodologies for Sound Transit’s Proposed New Tunnels for LINK Light Rail Expansion

Sound Transit will add 62 miles of light rail to the Puget Sound area, including connections to the neighborhoods of West Seattle by 2030 and Ballard by 2035. These connections include considerations for both elevated and tunnel alternatives, as well as a new downtown tunnel for which different configurations are being considered with potentially very different construction logistics and risk profiles. This paper describes the latest developments in the ongoing evaluation process that will inform the consideration of different tunnel and station construction methods, technical and operational challenges and contracting methodologies, including construction of deep stations in dense urban environments.

10:25 am
Back on Track: The Downtown Rail Extension
Derek Penrice, Mott MacDonald, Pleasanton, California US; Meghan Murphy, Hatch Mott MacDonald, San Francisco, CA, US

The Downtown Rail Extension (DTX) is a regionally critical project, extending Caltrain commuter and future high speed rail service from its northern terminus at the 4th and King Station via a 1.3-mile tunnel to the completed Salesforce Transit Center in downtown San Francisco. Studied since the 1970's, DTX’s EIS/EIR has been approved, and key stakeholders are aligned on the projects configuration and its expedited delivery. The paper describes efforts to optimize the DTX configuration, to develop an informed project delivery strategy which incorporates construction industry feedback on project phasing, contract packaging and procurement methods that accomplishes the projects budget goals.

8:30 am
Introductions

8:35 am
Accelerated Rehabilitation of the White Rock Tunnel
David Jurich, Mott MacDonald, Lakewood, Colorado US; Nathan Bowersox, Sacramento Municipal Utility District, Sacramento, California US; Zuzana Skovajsova, COWI North America Inc., Florham Park, New Jersey US; Brian Harris, Drill Tech Drilling and Shoring, Antioch, California US

When unwatered after nearly 60 years of operation, the White Rock Tunnel of the Upper American River Project in the foothills of the Sierra Mountains exhibited failing rockbolts and ground falls. Repairs designed for the 5 mile-long, 24-foot horseshoe unlined hydropower tunnel included pattern rock bolts, shotcrete, and cleanout of the rock trap. The work, originally scheduled for two 3-month winter outages, was completed under challenging conditions in a single 4-month outage following a carefully sequenced work plan using robotic shotcrete and rockbolter machines. Flexibility, creative solutions, and collaboration by all parties were key to project success.

9:00 am
Verification and Update on High Pressure Concrete Plug Leakage Remediation
Seung Han Kim, AECOM, Oakland, California US; Jay Lin, AECOM, Oakland, California US; Carlos Jaramillo, Marsh Wagner, San Francisco, California US; Jeremy Yager, PG&E, San Francisco, California US; Bob McManus, PG&E, San Francisco, California US; Andrew Yu, PG&E, San Francisco, California US

The concrete plug separating the pressure tunnels from the open-air tunnels has leaked since the first filling at the Helms Pumped Storage Plant located in California. A grouting program was successfully implemented in 2009 to reduce the leakage from 1,000 gpm to 25 gpm. Recent observations indicated increasing water leakage through new pathways, leading to a decision to execute a high-pressure grouting and waterproof membrane installation program in 2017. The grouting and membrane installation program was successfully executed in the areas adjacent to the plug and the largest hydraulic gradients are suspected to present.
9:30 am
Coffee Break

10:00 am
**Best Practice for Comprehensive Condition Assessments of Remote Tunnels**
Dani Delaoye, Mott MacDonald, Vancouver, British Columbia CA; Herman Gill, Mott MacDonald, Vancouver, British Columbia CA; Madelyn Rubin, San Francisco Public Utilities Commission, Moccasin, California US

The Foothill Tunnel is a remote 16-mile-long untreated drinking water tunnel in the San Francisco Public Utilities Commission’s (SFPUC) Hetch Hetchy Water and Power system. The 14-foot horseshoe shaped tunnel, constructed in the 1920s, is lined intermittently with concrete over approximately 53% of its length, with the balance being unlined rock. After detailed planning, in January of 2020 Mott MacDonald and SFPUC staff completed a visual inspection and documented the condition of the tunnel with electronic data collection, photographs, and video with audio recording. The result was a comprehensive condition assessment that identified key areas of the tunnel to monitor.

10:25 am
**Rehabilitation of an 1880s Limestone Block Tunnel Below an Active Railroad Corridor**

Constructed by stonemasons over 120 years ago, the Trout Brook storm sewer was in need of rehabilitation. A routine inspection of the 10-ft. limestone block tunnel revealed degraded and missing mortar between the blocks allowing significant infiltration and soil migration through the tunnel joints. Conditions including damaged and missing blocks were considerably worse in a 250-ft long segment beneath a busy mainline railroad corridor. Barr’s solution included tuck-pointing to repair the mortar joints, shotcrete overlay, and construction of a hybrid cast-in-place/shotcrete “tunnel within a tunnel” to support the mainline railroad loads.