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RAPID EXCAVATION AND TUNNELING CONFERENCE®

RETC2023

June 11–14, 2023
BOSTON, MA

TECHNICAL PROGRAM

Design Build Projects

MONDAY, JUNE 12

Sponsored by: HNTB

Chairs: Jay Sankar, Amtrak
Julio Martinez, Skanska, West Caldwell, NJ

Introductions

8:30 am

Designing and Constructing the Advance Tunnel for the Scarborough Subway Extension

Michael Dutton; Arup Canada, TORONTO, Ontario, Canada, Uhland Konrad; STRABAG Inc, Toronto, Ontario, Canada, Jorge Ferrero; STRABAG Inc, Toronto, Ontario, Canada

Strabag, in partnership with ARUP, is constructing the Advance Tunnel for the Scarborough Subway Extension (ATSSE). The 10.7m internal diameter single bore tunnel represents a significant departure from the traditional arrangement of twin subway tunnels in North America. ATSSE is the first-time steel fibers are used to solely reinforce a tunnel of this size in Eastern Canada. This paper discusses the challenges with design and acceptance of SFRC segments and the state-of-the-art numerical models employed to check the joint performance. The TBM's and PCTL's rapid procurement schedule is also presented.

9:00 am

Qualifications and Design of Waterproofing Systems for Underground Structures

Stefan Lemke and Tim Kearney; Renesco Inc, Chantilly, Virginia, United States, Enrico Pavese; Renesco Holding AG, Moosseedorf, BE, Switzerland

Modern underground structures are built with a design-life-expectancy of over 120 years, which means that standards for tunnel construction must be high, in particular those involving sealing and waterproofing systems. Starting with manufacture's application guidelines, the today's corresponding standards are available on the international market since the 1980s years and being constantly adapted to current issues in various committees. However, it can be observed that, especially when interpreting the application limits between SEM constructions, cut & cover structures, and buildings, these are interpreted differently, not always to the advantage of a permanent seal. The paper is giving an overview about the current available standards for waterproofing in the tunnel industry and highlights the different philosophies to allow a better technical interpretation.

9:30 am

Design and Construction of NBAQ4 Project- First Urban EPB TBM Tunnel in Metro Manila

Evan Catalan; Arup, Cebu City, Cebu, Philippines, Andrew Raine; Arup, Kowloon, Hong Kong (Greater China), Allan Patdu; Manila Water Company Inc., Quezon City, NCR, Philippines

The design and construction management of an Earth Pressure Balance TBM excavated tunnel for the Novaliches-Balara Aqueduct 4 (NBAQ4) project is the first urban tunnel in Metro Manila. The 7.3km long, 3.1m diameter tunnel is capable of delivering up to 1000MLD of raw water and connects the intake structure at the La Mesa Dam Reservoir and the outlet structure at the Balara compound while passing under the highly populated area of Commonwealth Avenue. The new intake tower required the construction of a 19.5m diameter, 30m deep cofferdam at the La Mesa Dam Reservoir and connects to the outlet structure and into the Downstream Network System which also involved a mined tunneling construction at the Balara Water Treatment Plant compound. During the entire duration of the tunnel excavation, minimal ground movements were observed and the excavation did not have any effect on the stability and integrity of adjacent existing buildings and structures.

10:00 am

A Case Study in Successful Progressive Design Build Tunneling

Leo Weiman-Benitez; Barnard Bessac Joint Venture, Bozeman, Montana, United States, Nik Sokol; Arup, Oakland, California, United States, Mike Jaeger; Tanner Pacific, Inc., San Carlos, California, United States

Silicon Valley Clean Water signed a progressive-design-build (PDB) contract with Barnard Bessac Joint Venture (BBJV) to design and construct the Gravity Pipeline Tunnel in Redwood City, CA. Owner and Design-Builder teamed with designer Arup to provide a final product: 3.3 miles of 182 in. O.D. precast concrete segmentally lined tunnel with 10 ft. & 11 ft. I.D. Fiberglass Reinforced Polymer Mortar (FRPM) carrier pipe, complete with two FRPM Drop Structures. BBJV and Arup collaborated with SVCW to evaluate alternative design concepts, negotiate an agreeable price and reduce contingencies through a transparent estimating process, and deliver the project ahead of schedule.

10:30 am

Successful Completion of LA Metro Regional Connector Transit Project

Tung Vu; VN Tunnel and Underground, Inc., Azusa, California, United States, Mike Harrington; Los Angeles County Metropolitan Transportation Authority, Los Angeles, California, United States

The Regional Connector Transit Project is a 1.9-mile long underground light rail system that will connect LA Metro's Blue, Expo and Gold Lines in downtown Los Angeles. This $1.75-billion design- build project is scheduled for revenue service in fall 2022. The project consists of 21-foot diameter twin- bored tunnels, a 300-foot long crossover SEM cavern, three new underground stations (at 1st Street/Central Avenue, 2nd Street/ Broadway Avenue, and 2nd/Hope Streets), and cut-and-cover tunnels along South Flower, Alameda, and 1st Streets. This paper, which is the continuation of our previous paper presented in RETC 2019 - LA Metro Regional Connector Transit Project: Successful Halfway-Through Completion, will provide insight into construction of major components, and system integration and testing of this complex transit project.

Difficult Ground

MONDAY, JUNE 12

Sponsored by: Stantec

Chairs: Dave Dorfman, Walsh Group, Warwick, NY
Chris Lynagh, McNally, Westlake, OH

Introductions

8:30 am

Eisenhower Memorial Tunnel – 50 Years Later

Adam Bedell; Stantec, Atlanta, Georgia, United States, Neal Retzer; Colorado Department of Transportation, Golden, Colorado, United States, Nick Ciofreddi and Mike Salamon; Stantec, Denver, Colorado, United States

The first wagon trail across Loveland Pass was built in 1869 thus starting the struggle between the Colorado Rockies and interstate travel. The 1st Pioneer Bore underneath Loveland Pass at the continental divide in Colorado was attempted between 1941 and 1943 and was abandoned due to ground conditions at the Loveland Fault. Construction on the Eisenhower Tunnel began in 1967 and was completed in 1973. Numerous challenges associated with tunneling at 11,000 ft were overcome. The purpose of this paper is to summarize the history of investigation and construction challenges associated with the Eisenhower Tunnel to celebrate its 50th anniversary.

9:00 am

Los Angeles, California JWPCP Effluent Outfall Tunnel Project – Tunneling Under Extremely Challenging Conditions

Roberto Schuerch, Paolo Perazzelli, Miriam Piemontese and Philippa Halton; Pini Group Ltd., Zurich, Zurich, Switzerland, Claudio Cimiotti and Nick Karlin; DRAGADOS USA, Wilmington, California, United States

The new Los Angeles, California JWPCP effluent outfall tunnel will transport secondary-treated effluent from the Joint Water Pollution Control Plant in Carson to White Point Manifold. The tunnel will be approximately 7 miles (11 km) long with a finished internal diameter of 18 ft (5.5 m). The TBM is designed to cope with high water pressure up to 10 bar. The geotechnical challenges are due to the heterogeneous subsurface conditions: in the first half of the alignment, the tunnel runs through soils with a low overburden under urban areas, and, in the second half, the tunnel runs through extremely weak, intensely faulted rock masses with high overburden. Following an overview of the project, this paper focuses on the northern portion of the alignment and presents a decision-making procedure developed during pre-excavation phase in order to cope with the expected heterogeneous conditions during mining. The risk assessment and the TBM operational design of the southern portion will be dealt with in a future paper.

9:30 am

Gas Extraction and In-Situ Oxidation for TBM Tunneling of the Purple Line Extension, Section 1, Los Angeles

Richard McLane; Traylor Bros., Inc., Long Beach, California, United States, Matt Neuner; Golder Associates, Calgary, Alberta, Canada, Hugh Davies; Golder Associates, Englewood, Colorado, United States, James Corcoran; Traylor Bros., Inc., Long Beach, California, United States, Joseph DeMello; Los Angeles County Metropolitan Transportation Authority, Los Angeles, California, United States

The LACMTA Purple Line Extension Phase 1 is a $3.12 billion (US) design-build, heavy rail project, connecting an existing station at Wilshire Blvd and Western Ave and extending west 3.92 miles under Wilshire Blvd and terminating approximately 550 feet west of Wilshire / La Cienega Station. The project alignment runs through the heart of the world famous La Brea Tar Pits. This paper presents a case history of the planning, design and construction efforts to achieve successful construction of the bored tunnels through Reach 3 of the alignment and outlines the pro-active partnership between Metro, Skanksa-Traylor-Shea Joint Venture, and Golder and Associates to safely manage pressurized face tunneling through a confined gas zone near the La Brea Tar Pits. Specifically, a program of in-situ oxidation and soil gas extraction was designed to test and analyze, the risks associated with pressurized face TBM tunneling and the complex subsurface geological conditions.

10:00 am

Second Narrows Water Supply Tunnel – Conventional Deep Shaft Excavation in Variable Weak Rock

Andrew McGlenn; McMillen Jacobs Associates, Mercer Island, Washington, United States, Murray Gant; Greater Vancouver Water District, Burnaby, British Columbia, Canada, Bruce Downing; WSP Golder, Burnaby, British Columbia, Canada, Brian McInnes; Traylor AECON General Partnership, North Vancouver, British Columbia, United States

The Second Narrows Water Supply Tunnel crossing beneath Burrard Inlet is an important component of the Greater Vancouver Water District's plans to increase seismic resilience and meet increasing water demands. The project included the 110 m (350 ft) deep South TBM Receival Shaft, the deepest shaft to date in the sedimentary rock unit underlying much of metro Vancouver. The shaft encountered varied sedimentary rock types including fractured rock associated with a fault underlying Burrard Inlet. This paper discusses the design and construction challenges associated with this shaft and the means necessary to complete the shaft in time for TBM arrival.

Geotechnical Consideration

MONDAY, JUNE 12

Chairs: Da Ha, STV Inc
Dan McMahon, Taylor Bros Inc, Long Beach, CA

Introductions

8:30 am

Design-Build Project Delivery Method Selection and Implementation of a GBR-B and GBR-C for the Pawtucket Tunnel

Brian Hann; CB3A, Pawtucket, Rhode Island, United States, Robin Dill; AECOM, Chelmsford, Massachusetts, United States, Julian Prada; Stantec, South Burlington, United States, Chris Feeney; Stantec, Providence, Rhode Island, United States, Kathryn Kelly; NBC, Providence, Rhode Island, United States

Narragansett Bay Commission's (NBC) Pawtucket Tunnel Project includes construction of the 11,600-ft long, 30-ft ID, deep rock tunnel. This paper presents insight into the features and benefits of lump-sum, design- build that led NBC to select it as the project delivery method. The use of a design-build contract including a GBR-B and GBR-C developed by the various stakeholders from start to finish, and how consensus was reached regarding establishment of the final baselines is described. The discussion includes features and benefits of design-build that addressed NBC's desired outcomes, and the process used by the various stakeholders in developing the final GBR.

9:00 am

Adapting to Project Needs: Frozen Cross Passages and Adits

Aaron McCain; SoilFreeze, Woodinville, Washington, United States

The use of frozen soil as ground improvement and temporary ground support for the excavation and construction of cross passages and adits has gained in popularity over the last decade. Frozen soil provides a number of advantages for this application such as being waterproof, structurally stable, and working well with any soil type. One of the greatest advantages is the ability for the system to be adaptable to the project geometry and site limitations. Multiple case histories illustrate that freezing can occur from the ground surface, from within the tunnel, or as a combination.

9:30 am

Submerged Penetrations through a Frozen Soil Shoring System

Aaron McCain and Larry Applegate; SoilFreeze, Woodinville, Washington, United States,

Frozen soil shoring has been used for decades in the tunneling industry to provide temporary support of excavation. However, horizontal penetrations through the frozen soil can prove to be challenging. The key to creating a stable portal through frozen ground is managing and mitigating the flow of groundwater into the excavation through the annular space surrounding the drill stem or casing. This paper will review two different approaches that have been used to successfully penetrate frozen soil shoring on multiple projects.

10:00 am

Ground Improvement in Glacial Soils for the Lower Olentangy Tunnel – Columbus, OH

Horry Parker Jr.; Black & Veatch, Columbus, Ohio, United States, Jeremy Cawley; City of Columbus, Columbus, Ohio, United States, Jeff Murphy; DLZ, Columbus, Ohio, United States, Jake Keegan; McMillen Jacobs Associates, Columbus, Ohio, United States, Brock Gaspar; Schnabel Geostructural Design and Construction, Bethesda, Maryland, United States, Bob Rautenberg; Granite Construction, Columbus, Ohio, United States

The Lower Olentangy Tunnel project includes 47000 cubic yards of planned ground improvement for EPBM tunneling (3 miles) and micro-tunneling (1100 feet) in glacial soils. Jet grouting initiated in late 2021 will continue through 2023 to complete operations at 5 shafts, 14 safe havens, 5 watermain ground improvement zones, and a river crossing. Typical jet grout columns are installed at depths between 50-80 feet and discrete soil-cement blocks range from 267-8900 cubic yards in volume. This paper discusses the methodology, testing program, sequencing, and technical considerations associated with jet grouting operations in glacial overburden across an urban environment.

Hard Rock TBMs and Tunnels

MONDAY, JUNE 12

Sponsored by: WALSH

Chairs: Ben McQueen, Frontier-Kemper Constructors Inc, North Vancouver, BC, Canada
David Lacher, Traylor Bros Inc, Los Angeles, CA

Introductions

8:30 am

New Diversion Hydropower Plant – Nedre Fiskumfoss

Mads Aniksdal; Skanska Norge AS, Oslo, Kongshavn, Norway

Construction project in North Trøndelag, Namsen River. The purpose of the contract is construction of a new hydropower plant, that will phase out the existing power plant in the same waterfall. The contract consists of a tunnel system with cross sections from 16m2 to150m2, powerhouse and transformer in rock caverns, 5 shafts and major works with inlet and outlet below river level. Technical challenges consist of demanding design on rock extraction, temporary dams, solid constructions with challenging design and demanding rebar work, as well as restrictions and unpredictable waterflow in a national salmon river.

9:00 am

New Water Supply – Oslo, Norway

Ingunn Opland and Silje Marie Tinderholt; Skanska Norway AS, Oslo, Norway

The contract consists of 7 rock caverns (350-950 m2), 9.2 km tunnels and 4 shafts. With 48 blue collar and 31 white collar the project produces an average of 16-21 000 m3 hard rock per week, with a total of 19 tunnel faces, 9 grouting rounds for water control, 60 trucks pr. day, 800 m3 shotcrete and 1200 bolts. Challenges consists of blasting in densely populated areas, planning and coordination to maintain high production, obtain a CEEQUAL certification of very good, transportation of rock on Oslo's main high-way.

9:30 am

Enhanced Probe Drilling and Pre-Grouting Design and Recommendations on Hard Rock TBMs

Stryker Magnuson; Robbins, Kent, Washington, United States

Water ingress and unstable ground can be resolved before becoming a problem that results in costly delays. A hard rock TBM can be designed with an array of drill ports in the shield, matched to the ground—a setup that results in enhanced, 360-degree probe drilling and grouting capabilities. When exceptional water and instabilities are expected, additional probing locations are low-cost ways to lower risk. In this paper we look at ongoing projects including the Lower Meramec and Jefferson Barracks tunnels. We detail those probe drill arrangements, and our overall recommendations for probing/grouting systems that best suit challenging conditions.

10:00 am

Hard Rock TBMs – The Experience of Brenner Basis Tunnel, Construction lot Mules 2-3 for the Evaluation of Risk Prediction Tools

Federico Amadini; Systra Sws, Mattarello (TN), Trento, Italy

The Brenner Base high-speed rail link represents one of the most relevant long and deep tunnels under construction. This project features overburden up to 1700m, excavation length of 15km for 3 TBMs and variable geological conditions. The 6.85 m-diameter Double Shield TBM called “Serena” successfully completed the excavation of the Exploratory Tunnel, notwithstanding the challenges raised by very hard rock formations and fault zones. The twin 10.71 m-diameter Double Shield TBMs “Flavia” and “Virginia” are excavating the main tunnels. The paper focuses on the retours of experience acquired by correlating geological conditions with operative TBM data and machine learning prediction.

10:30 am

Record-Setting Tunnel Boring below Lake Ontario at the Ashbridges Bay Outfall Tunnel

Doug Harding; Robbins, Solon, Ohio, United States

The 3.5 km long Ashbridges Bay Outfall in Toronto, Ontario, Canada is a challenging drive set below Lake Ontario. After a remote machine acceptance due to the global pandemic, an 8 m diameter Single Shield machine launched in March 2021 from an 85 m deep shaft and began its bore in shale with limestone, siltstone and sandstone. During excavation, the TBM and its crew bored a city-wide record of 30 rings in one day, or 47 m of advance. This paper will cover the unique project, from TBM acceptance through to launch, tunneling in difficult conditions, and completion in 2022.

11:00 am

Construction of TBM-Mined Segments of the Sister Grove Outfall Pipeline

R Gregory Rogoff; McMillen Jacobs Associates, Mayfield Heights, Ohio, United States

The North Texas Municipal Water District’s (NTMWD) service area is experiencing rapid growth resulting in expanding wastewater collection and treatment needs in the Upper East Fork Interceptor System (UEFIS). In part to meet this demand, approximately 4.5 miles of 96-inch outfall pipeline was constructed between the proposed Sister Grove Regional Water Resource Recovery Facility (SGRWRRF) and Stiff Creek discharge Structure. Two TBM-mined tunnel segments were excavated through rock and mixed-face conditions in the Austin Chalk Formation. This paper discusses the excavation production achieved, and compares it with the performance in previously TBM-mined tunnels in the same geological formation.

11:30 am

Construction of Coxwell Bypass Tunnel Project in Toronto, ON

Ehsan Alavi; Jay Dee Contractors, Livonia, Michigan, United States, Eren Kusdogan; JayDee Canada, Toronto, Ontario, Canada

The City of Toronto’s Coxwell Bypass Tunnel is currently being constructed by North Tunnel Constructors ULC, a joint venture of Jay Dee Canada, C&M McNally Tunnel Constructors and Michels Canada. This 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 adit tunnels. This paper describes progress on the project to date and reviews the risk mitigation measures utilized on the project to move the project forward through tough geological conditions during shaft excavation and tunneling phase of the project.

Design

MONDAY, JUNE 12

Sponsored by: HNTB

Chairs: Manan Garg, Austin Transit Partnership, Austin, TX
John Yen, Skanska, Riverside, CA

Introductions

1:30 pm

Milestone Reservoir Quarry Project: Collaborative Design Development using CMAR

Stephen Miller; Schnabel Engineering, Sterling, Virginia, United States, Rob Gould; Guy F. Atkinson Construction, Austin, Texas, United States, James O’Shaughnessy; Arcadis, Arlington, Virginia, United States, Savita Schlesinger; Loudoun Water, Ashburn, Virginia, United States, Mike Hanna; Black & Veach, Gaithersburg, Maryland, United States

The Milestone Reservoir project involves conversion of a rock quarry to a billion gallon raw water reservoir. The project includes a new 40 MGD pump station, deep intake shaft with three drill and blast intake tunnels for accessing the reservoir. Due to concerns regarding constructability and construction risks, the project design was paused while a CMAR contractor was procured. The CMAR contractor was engaged collaboratively with the design team to provide risk and constructability input for refining the design. Aspects of the original design, design modifications, and benefits of the CMAR collaboration will be presented.

2:00 pm

Design Aspects of the Minneapolis Central City Parallel Tunnel

Randall Divito; HATCH, Buffalo, New York, United States, Bruce Wagener; CNA Consulting Engineers, Minneapolis, Minnesota, United States, Craig Eckdahl; CNA Consulting Engineers, Minneapolis, Minnesota, United States, Joseph Klejwa; City of Minneapolis, Minneapolis, Minnesota, United States

The existing Central City Tunnel was built in the 1930's for stormwater drainage in downtown Minneapolis. It is a 4,400-ft long tunnel located 80 feet underground. The Central City Tunnel has experienced surcharging and surface overflows during heavy rainfall events. This paper presents the details of tunnel and shaft design for the new Central City Parallel Tunnel to mitigate the overflows. The design considered hydraulics and geotechnical engineering for the structural geologic conditions including the weak Saint Peter Sandstone and overlying strong Platteville Limestone. Ground conditions resulted in tunnel designs including large flat-back box tunnels and unique cathedral-shaped tunnel sections.

2:30 pm

Gateway Program – Cut and Cover Tunnel in Manhattan

David Smith; WSP, New York, New York, United States, Drew Bazil and Matteo Ferrucci; WSP, New York, New York, United States, David Pittman; Amtrak, Philadelphia, Pennsylvania, United States

The Gateway program will provide additional rail capacity between New Jersey and Manhattan. This paper describes the how a 90-foot-deep section of cut-and-cover tunnel was designed to directly support future high-rise towers. The tunnel will link a previously completed tunnel sections under Hudson Yards to future tunnels under the Hudson River. The design aims to minimize constraints on future overbuild and future tunnels, while maximizing constructability within a small worksite. Design optimizations between Preliminary and Final Design are described. The tunnel will pass under the High Line walkway, next to an active rail yard, and close to a subway tunnel.

3:00 pm

Gravity Sewer Tunnel Liner Corrosion Protection – Part Two

Jon Kaneshiro; Parsons, San Diego, California, United States, Pooyan Asadollahi; Parsons Corporation, Centerville, Virginia, United States

This paper provides updates to the 2011 RETC paper in San Francisco with a summary of developments in technologies, products, and approaches to corrosion analyses of gravity sewer tunnels and microtunnels. This paper provides an approach in evaluating degradation of fiber reinforce concrete liners using the EPA's approach using the Pomeroy equation. Also, the carbon footprint of conventional concrete liners and alternative "green" liners are compared and their life cycle costs are considered. A few illuminating case histories since 2011 are provided indicating the latest and emerging trends in liner protection.

3:30 pm

Tunneling for High Energy Physics in Menlo Park, CA

Justin Lianides, Derek Penrice and States, Rahul Thareja; Mott MacDonald, San Ramon, California, United States, Irene Bendanillo; SLAC National Accelerator Laboratory, Menlo Park, California, United States, Canon Cheung; SLAC National Accelerator Laboratory, Menlo Park, California, United States

The SLAC National Accelerator Laboratory's 2-mile-long particle accelerator generates the world's brightest X-rays from its Linac Coherent Light Source (LCLS) that have driven ground-breaking discoveries in medicine and industry. The LCLS-II-HE project provides a significant increase in laser energy, allowing cutting-edge research in fields including biology and environmental sciences. A key project component is the Low Emittance Injector Tunnel (LEIT), a 240-ft-long tunnel to be built alongside the accelerator and connected via a 30-ft-long transfer tunnel. This paper discusses site and scientific constraints that led to the selection of the LEIT configuration— sequential excavation method driven tunnels to be constructed in mixed face conditions comprising native rock and placed backfill, and critical design considerations including protection of overlying and adjacent historic structures and structural accommodation of near fault seismic loading.

Ground Control Approaches and Methods

MONDAY, JUNE 12

Chairs: Vinay Duddempudi, Traylor Bros inc, Silver Spring, MD
Luis Piek, Arup, San Francisco, CA

Introductions

1:30 pm

Evaluation and Construction Effects of a 22-Story Tower on Adjacent Metro Tunnels in Los Angeles

S. Amir Reza Beyabanaki; McMillen Jacobs Associates, Walnut Creek, California, United States, Yiming Sun; McMillen Jacobs Associates, Walnut Creek, California, United States, Stan Tang; Geotechnologies, Inc., Glendale, California, United States, Garrett Lee; Jamison Properties, LP, Los Angeles, California, United States, N. Sathi Sathialingam; LA Metro, Los Angeles, California, United States

A mixed-use development Kurve project including a 22-story tower at 2900 Wilshire Boulevard was constructed on a site consisting of a roughly rectangular-shaped lot at the intersection of Wilshire Boulevard and Hoover Street in Los Angeles. Two Metro Red Line tunnels, with depths of approximately 30 feet and 58 feet, respectively, cross below the building at distances of approximately 1 foot to over 63 feet from the site. This paper presents numerical modeling performed to evaluate the ground and tunnel behavior in response to building construction. Results of geotechnical instrumentation and monitoring undertaken during the building construction are also discussed.

2:00 pm

SVCW Gravity Pipeline – Ground Movements During Construction

Jon Hurt; Arup, New York, New York, United States, Phaidra Campbell; JCK Underground, Hawaii, United States

The Silicon Valley Clean Water Gravity Pipeline is the first Progressive Design Build tunnel completed in North America. The large diameter fiberglass reinforced polymer mortar pipeline is installed inside a 13.5 inside diameter, 3.3 mile long precast concrete segmentally lined tunnel. The tunnel was constructed using a 16-ft diameter Earth Pressure Balance tunnel boring machine through heterogenous silts, clays and sands.

Construction included two TBM launches from a centrally located access shaft, and a tunnel alignment below but in close proximity to very soft Young Bay Mud. Settlement criteria and mitigation strategies focused on protection of the existing 56-in diameter force main, and predicted and observed ground movements are discussed.

2:30 pm

Bay Park Conveyance Project, NY – Construction Update

David Smith; WSP, New York, New York, United States

Nassau County, New York, is improving the water quality in the Western Bays of Long Island. A major step forward will be the completion of the Bay Park Conveyance Project, which will divert treated effluent away from the Western Bays to an existing ocean outfall. The ongoing works include constructing 3.6 miles of microtunneling, 7 miles of sliplining, 14 shafts, and a 75 MGD pump station. This paper provides an update on construction progress, challenges and solutions. The project is a collaborative effort between Nassau County, New York State Department of Environmental Conservation, the Design-Builder and consultants.

Microtunneling and Trenchless Tunneling

MONDAY, JUNE 12

Sponsored by: Stantec

Chairs: Jay Sankar, Amtrak, New York, NY
Leah McGovern, STV Inc, Floral Park, NY

Introductions

1:30 pm

The Versatility of Tunnelling and Trenchless Methods for Sustainable Grid Construction

Peter Schmaeh and Dr. Marc Peters; Herrenknecht AG, Schwanau-Allmannsweier, Baden-Wurttemberg, Germany

The development of renewable energies and a sustainable power grid are the challenges for future energy supply. Underground cables will replace the vulnerable overhead lines, because of their safety benefits. Due to the public environmental awareness, smart tunnelling and trenchless solutions are required for inner- city and cross-country installations of underground cables, as well as for crossings and the landfall sections to connect offshore windfarms to the transmission grid. Methods from the tunnelling and pipeline industry provide a high flexibility in the planning of alignments, including versatile tunnel concepts and the installation of protective pipes with E-Power Pipe and Direct Pipe.

2:00 pm

Curved Microtunneling to Reduce Disruption in City Environment

Daniel Cressman; Black & Veatch, Markham, Ontario, Canada

The City of Toronto plans to construct a 1,350 mm consolidation sewer along the East Don Roadway (EDR). The project includes installation of approximately 260 meter of 1,350 mm diameter concrete pressure pipe through microtunneling methods. The sewer alignment crosses underneath a busy 5-lane arterial road and then follows the very narrow East Don Roadway road allowance. This paper discusses the significant challenges overcome to design and construct the Don Roadway sewer using slurry microtunneling methods through mixed face conditions below the groundwater table in a congested road allowance. A curved microtunnel was ultimately required to avoid conflicts with existing utilities, condominium tiebacks and a bridge structure.

2:30 pm

Missouri River Intake Screen Structure and Tunnel: Overcoming Underground Challenges to Build Vital Infrastructure

Ryan Ward a Michels Trenchless, Inc., Brownsville, Wisconsin

The Missouri River Intake Screen Structure and Tunnel (MRISST) is one phase of Red River Valley Water Supply Project (RRVWSP), a vital piece of infrastructure in the state of North Dakota to transport water to drought-laden communities in the eastern half of the state. The scope of work consists of constructing a cofferdam in the Missouri River, mining a 1,600-foot by 74-inch tunnel from a secant pile shaft near the riverbank into the cofferdam, and erecting a 40-foot Y-shaped vertical pipe structure in the cofferdam to support the intake screens. Construction personnel worked in the river through the North Dakota winter to construct the cofferdam and contended with high hydrostatic pressures and raveling sands, gravels, cobbles and boulders while mining the tunnel. Microtunneling was selected as the technique with the highest probability of success on this important project. Diligent planning and meticulous execution were essential to overcoming the challenges encountered below the Missouri River.

3:00 pm

Northeast Boundary Tunnel Project: First Street Connector Tunnel and Mount Olivet Road Diversion Sewer Design and Construction

Jeremiah M. Jezerski, Brierley Associates Corporation, Basilio Giurgola, The Lane Construction Corporation, Filippo Azzara, The Lane Construction Corporation, Russell H. Lutch, Brierley Associates Corporation, Federico Bonaiuti, The Lane Construction Corporation

The Northeast Boundary Tunnel Project consists of a 23 ft diameter, 27,000 ft long, CSO tunnel, multiple underground connections, and significant surface works within an urban corridor. The NEBT alignment depths range from 60 to 140 ft and includes seven shafts ranging in depth from 77 to 155 ft with diameters varying from about 19.5 to 56 ft, some as in-line connections and others required adits for connection to the main tunnel. This paper focuses on the design and construction of two major underground connections which are the First Street Connector Tunnel and the Mount Olivet Road Diversion Sewer.

RETC 2023 Owner Forum Panel

MONDAY, JUNE 12

Moderator: Moussa Wone, vice President, DC Clean Rivers Project, Washington, DC

1:30 pm

RETC 2023 Owner Forum Panel

The purpose of this Panel is to share with the audience an Owner's perspective on issues of interest to both the Consulting and Contracting communities. The Forum will be moderated by Dr. Wone, Vice President of DC Water's Clean Rivers' program, and will be comprised of four Owner panelists who are subject matter experts in their fields. The Panelists will focus on four topics to be selected; potential topics include Covid Claims, Owner Controlled Insurance Program (OCIP), Escalation, Partnering, Project Delivery Methods, Dispute Resolution Boards, Risk Management, and others. The list of the panel composition is being developed and will be soon made available to the Conference participants.

Shafts, Caverns, and Mining

MONDAY, JUNE 12

Sponsored by: WALSH

Chairs: Steve Price, Walsh Group, Little Falls, NJ
Ehsan Alavi, JayDee Contractors Inc, Livonia, MI

Introductions

1:30 pm

Project Clean Lake's First Large Diameter EPB TBM in Cleveland, Ohio

Lance Jackson and Brian Negrea; McNally Tunneling Corporation, Cleveland, Ohio, United States

There was no need for the people of Cleveland to inquire "where does the raw sewage go, we want to know" because it was clear! The raw sewage was being discharged into Lake Erie during heavy rain fall events due to the outdated design of the combined sewer system. In efforts to resolve this ongoing issue for the city of Cleveland, the Northeast Ohio Regional Sewer District (NEORSD or "District") in collaboration with the Federal government developed Project Clean Lake. Project Clean Lake is a 25-year program consisting of the construction of seven CSO storage tunnels beneath the city's existing infrastructure. The current project, the Shoreline Storage Tunnel Project, is the fifth large tunnel to be constructed as part of Project Clean Lake. This project presents unique challenges and complexities as it will be the first large diameter EPB TBM that will dig under the city of Cleveland. The project itself consists of one tunnel drive, 14,100' (2.7 miles) in length, two pipe jacking tunnels, three large slurry wall shafts, two diversion structures and three regulator reconstructions. Upon completion of this project, 12 permitted CSO locations along Lake Erie will be taken offline and will reduce overflow volumes by approximately 350 million gallons per year

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2:00 pm

Ground Freezing Deep Shaft Excavation Shaft 17B-1 New York City Water Tunnel No. 3

Andrew Chedwiggen; Keller, Hanover, Maryland, United States, Maddie Erickson; McMillen JA Engineering PLLC, Hanover,Maryland, United States, Tara Wilk; Walsh Construction, Hanover, Maryland, United States

Construction of Shaft 17B-1, a part of the New York City water supply's system Tunnel No.3, required excavating approximately 38m (123ft) of water-bearing overburden soil and 160m (527ft) of gneiss bedrock. Ground freezing was specified to provide earth support and water control for the overburdened material. The freezing process relied on a supplemental geotechnical investigation and comprehensive laboratory testing of the frozen soil to evaluate long-term creep behavior and eliminate a temporary lining system. This paper discusses that process, the ground freezing system installation methods, and the methodical approach of excavation and insulation, followed by the permanent concrete liner Installation.

2:30 pm

Large Diameter Shaft Excavation Support Design and Blasting Methods in a Dense Urban Environment for the Pawtucket Tunnel Project

Andrew R. Klaetsch, Mueser Rutledge Consulting Engineers PLLC, Frederic Souche, Civil & Building North America (CBNA), Brian Hann, Barletta Co, Nick Goodenow, Stantec Consulting

This paper describes support of excavation (SOE) design and construction for three large diameter shafts excavated through glacial soil and controlled blasting in complex sedimentary rock formations. SOE in soil consists of unreinforced secant pile rings designed to resist lateral pressure in circumferential compression, eliminating costly steel core beam reinforcing. Controlled blasting at the shafts, adits, and tunnels in densely populated neighborhoods requires managing risks to the public, buildings, and utilities. Controlled blasting approaches limited adverse impacts to receptors nearby while achieving adequate production and fragmentation. A site-specific observational approach was used to adjust blasting parameters, limiting the impact on local stakeholders while maintaining daily progress and managing overbreak.

3:00 pm

Development and Performance of Large Span Caverns at Depth for the LBNF Far Site

Seth Pollak; Arup, New York, New York, United States James Rickard; Fermi Research Alliance, LLC, Lead, South Dakota, United States

The Long Baseline Neutrino Facility Far Site in Lead, South Dakota is currently under construction and involves drill and blast excavation of some of the largest and deepest caverns in North America. This presentation will review how the geotechnical risks are being managed through careful consideration of excavation sequence, completion of exploratory pilot tunnels, implementation of a robust instrumentation and monitoring program, and validation against the design. Aside from having a cross section of 5,900 square feet and being situated at a depth of one mile, the caverns also employ a unique permanent rock bolt solution which underwent a significant pre-production pull testing program involving varying installation methods and being subject to blast vibrations. The behavior of the schistose rock mass and performance of the ground support are being continually monitored throughout the construction phase.

Ground Support and Final Lining

TUESDAY, JUNE 13

Sponsored by: HNTB

Chairs: Jean-Luc des Rivieres, JFShea
William Hodder, North Tunnel Constructors ULC, Toronto, ON, Canada

Introductions

8:30 am

Evaluation of Long Term Loads on Freight Tunnels in Chicago

Alireza Ayoubian; Parsons, New York, New York, United States, Richard Finno; Northwestern University, Evanston, Illinois, United States

The network of freight tunnels in Chicago consists of about 62 miles of horseshoe-shaped tunnels constructed typically less than 50 feet below ground surface. These tunnels serve as repositories of much infrastructure and should remain serviceable. The tunnels are often impacted by adjacent excavations and the question arises as to the existing state of stress in the final liner. This paper discusses construction of these tunnels and presents the results of finite element analyses which were used to obtain ranges for axial forces and bending moments that have developed in the final liner of the freight tunnels since their construction.

9:00 am

Direct Tensile Testing and CT-Scanning of Fiber Reinforced Shotcrete

Mark Trim; McMillen Jacobs, Mosman, New South Wales, Australia, Denis Tepavac; McMillen Jacobs, Docklands, Victoria, Australia

Structural performance of fibre reinforced concrete (FRC) depends on its ability to carry tensile forces after cracking. Australian Standards AS5100.5–2017 and AS3600–2018 are the only available design standards that establish a test procedure to determine strength, and toughness, of an FRC in direct tension. Direct testing of fibre reinforced shotcrete samples was performed to determine if the model and guidelines in AS5100/3600 were applicable to shotcrete—all previous testing was from cast samples. In addition to direct testing, CT-scanning was also performed. The paper presents tests performed, results, and how the tests could be used on future projects.

9:30 am

Various Rock Tunneling Methods Utilized on the Doan Valley Storage Tunnel Project

Collin Schroeder, Brian Negrea and Chris Lynagh; McNally Tunneling Corporation, Westlake, Ohio, United States

Determining which rock tunneling excavation method will be utilized is an important step to the successful construction of a tunnel. Several factors can dictate the rock tunneling method, such as: 1) rock characteristics, 2) tunnel size and length, 3) nearby utilities/infrastructure, and 4) contractor preferred means and methods. This paper discusses the various rock tunnel excavation methods utilized on the Doan Valley Storage Tunnel Project (DVT); a project constructed as part of the broader Project Clean Lake in Cleveland, Ohio. The differences between each methods initial/final linings, geologies, and cycle sequences will be analyzed in comparison to one another.

10:00 am

Bypass Tunnel Shafts – Steel Access Pipe Shotcrete Lining

Paul Madsen; Kiewit-Shea Constructors, AJV, Newburgh, New York, United States, Bade Sozer; McMillen Jacobs Associates, New York,New York, United States, Tom Hennings; McMillen Jacobs Associates, Burlington, Massachusetts, United States, Eileen Test; McMillen Jacobs Associates, New York, New York, United States

The Rondout Bypass Tunnel in New York has two access shafts. The upper sections of the shafts are lined with 18-foot internal diameter steel pipe to resist the 1,200 ft of internal water head. The shafts are capped with a transition piece (diameter varies from 18 ft to 9 ft) and a dome shaft cap above the access pipe. Initial design included a ¾" thick cement mortar lining (CML) for all three components. Due to concerns with CML application on large diameter pipes, the lining was redesigned to shotcrete. This paper discusses the details of design, mock-ups and shotcrete application.

10:30 am

Acclimatization: Adapting Conventional Tunnel Lining Techniques to Overstress Rock Conditions

Jean-Luc Des Rivieres; J.F. Shea Construction Inc., Indianapolis, Indiana, United States and Ross Goodman; J.F. Shea Construction Inc., Louisville, Kentucky, United States

The Ohio River Tunnel Project encountered multiple unexpected geotechnical challenges which, continuing to develop over time, hampered excavation completion and impacted the cast-in-place final lining technique and work execution sequence for the entire project. The continued degradation of the excavated hard rock tunnel conditions lead to a unique, dynamic, geologic setting that forced the project to innovate new and adaptable measures that allowed for a classic cast-in-place liner to be completed in a safe and timely manner and minimize delay.

International Projects

TUESDAY, JUNE 13

Chairs: Steve Kramer, Cowi North America, Kensington, MD
Boris Veleusic, Michels

Introductions

8:30 am

TBM Tunnel Off-shore Connection

Gary Peach; Mott MacDonald, Wheatley, Oxfordshire, United Kingdom, Hernan Vigil; PORR Qatar Construction, Doha, Qatar

The musaimeer pump station and outfall project located in Doha Qatar, was designed to collect and manage ground and stormwater and then discharge the treated waters offshore. The project constructed a long outfall tunnel using an EPB TBM with segmental lining. The diffuser structure was a 6-arm structure, measuring 280 m by 70 m connected to a central manifold in turn connected to the TBM constructed tunnel via a riser shaft constructed from an off-shore barge. This technical paper will discuss the planning, methodology and construction practices employed to connect the TBM tunnel to the diffuser structure 10.2 km offshore.

9:00 am

Formwork Solutions for the Final Lining of the Kramertunnel, Germany

Rainer Antretter; BeMo Tunnelling, Innsbruck, Tyrol, Austria

The city of Garmisch-Partenkirchen in southern Germany is located at a main transit road to Tyrol in Austria and suffers of a very dense traffic load. Therefore, the Kramertunnel as a by-pass tunnel is built to release/mitigate the traffic through the centre. The 3,600 m long single tube road tunnel is designed with cross passages to a parallel but smaller emergency tunnel and fitted with single and double emergency bays, a vent shaft, and an intermediate ceiling to separate fresh air supply from the road traffic. The entirely lined tunnel provided the challenge to find smart formwork solutions which had to be designed for quick relocation, setup and pouring.

9:30 am

Design and Construction of REM Tunnels and Underground Structures

Verya Nasri; AECOM, New York, New York, United States, Mohammad Motallebi; AECOM, Montreal, Quebec, Canada, Gary Kramer; Hatch, Mississauga, Ontario, Canada

Once completed, the Montreal Réseau Express Métropolitain (REM) will be the fourth largest automated transportation system in the world. The REM represents construction costs of approximately 7.0 billion Canadian dollars. The project consists of 67 km of twin tracks over four branches connected to downtown Montreal. The project includes 26 stations with 3 underground stations in downtown Montreal. One of the underground stations was built using the NATM method with thin permanent shotcrete initial and final liners separated by a sprayed on waterproofing membrane. The 2 other underground stations were built with the cut and cover approach including one using permanent secant pile wall with permanent walers and struts as the support of excavation and the final perimeter wall of the station. The project also includes the rehabilitation and enlargement of the Mont Royal Tunnel. This 100-year-old double track tunnel is about 5 km long. The REM also consists of 3.6 km new TBM tunnel connecting downtown to the Montreal International Airport through saturated soft ground and karstic rock. By the time of RETC, the construction of REM underground structures will be completed. This paper presents the design and construction aspects of the underground structures of this mega project.

10:00 am

Nice – Tramway T2: A Success Story in Unusual Ground Conditions

Guillaume ROUX, Bessac, Saint-Jory, France; Raoul FERNANDEZ, CBNA/ Bouygues, Miami, Fl; and Bernard CATALANO Bessac Canada / Bessac Inc, Vancouver, Canada / Canonsburg PA

The Thaumasia Joint-Venture, composed of Bouygues Travaux Publics, Soletanche-Bachy and Bessac, completed the construction of the underground section of line 2 of the Nice tramway, which comprised a 3.2 km twin track tunnel and four underground stations, in a particularly complex urban and geotechnical context. The density of the surface structures, as well as the presence of many historic buildings on its route made the construction of the tunnel even more sensitive, with a settlement threshold of Half an Inch. The joint venture faced a complex subsoil, varying from one extreme to another from highly plastic clay layers to fibrous peat and to cobbles with very high permeability, with artesian ground water, and with unforeseen anthropogenic obstacles in the tunnel section Due to the diversity of the problems encountered and their variability over short distances, the construction of the underground section of the Nice tramway, in its very sensitive urban context, undeniably constituted an unprecedented challenge.

10:30 am

Bad Bergzabern Bypass Tunnel – NATM Tunneling through Vineyards

Richard Gradnik and Pafos Busch; BeMo Tunnelling GmbH, Innsbruck, Tyrol, Austria and Ralf Plinninger, Plinninger Geotnik

This paper presents the details of the Bad Bergzabern tunnel project. This tunnel is the main part of the B427 federal road bypass, intended to improve the regional traffic infrastructure and to reduce the traffic load in the historic city centre of the health resort Bad Bergzabern. Located in the south-western part of Germany, the project area is situated at the eastern margin of the so-called Palatinate Forest, a low mountain region of mainly triassic sediments with a complex and variable geological history

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Tunnel Rehabilitation

TUESDAY, JUNE 13

Sponsored by: Stantec

Chairs: Alston Noronha, Black and Veatch, Louisville, KY
Youyou Cao, STV Inc

Introductions

8:30 am

Major Rehabilitation of the Montreal 55 years old Lafontaine Immersed Tube Highway Tunnel – Design Consideration

Jean Habimana; Hatch, Montreal, Quebec, Canada and Laurent Rus, Singular Structures

The Quebec Ministry of Transportation is undertaking major structural rehabilitation work and systems upgrade on the La Fontaine Tunnel to comply with current codes, standards and best practices in fire life safety and to extend the lifespan of this 55-year-old immersed tube tunnel for another 40 year The paper will discuss design and construction aspects of ongoing works that include structural analyses and repair strategies for the post-tensioned reinforced caissons, the scheme to repair two leaky joints between caissons, the design of passive protection boards that involved in situ and real scale laboratory tests, and other tunnel systems upgrades.

9:00 am

Corrosion and Leakage Remediation for WMATA Yellow Line Steel Tunnels

James Parkes; Schnabel Engineering, Baltimore, Maryland, United States, Matthew Goff; Schnabel Engineering, Chadds Ford, Pennsylvania, United States, Alan Kolodne Steven Kolarz; RK&K, Baltimore, United States, Tatiana Kotrikova; Washington Metropolitan Area Transit Authority (WMATA), Washington, District of Columbia, United States

The WMATA Yellow Line includes a unique section of steel segmentally lined tunnels that have experienced leakage and significant corrosion in isolated areas. A three part rehabilitation design has been developed for curtain grouting, structural repairs, and corrosion protection to provide continued performance. As WMATA's first Construction-Manager-at-Risk (CMAR) project, the design development benefitted from collaboration with the Contractor through the final design development process. Rehabilitation work is scheduled to start Fall 2022 and be completed by Summer 2023. Details of the project, the remediation design, and the process and benefits of the CMAR approach in the design development are presented.

9:30 am

Tunnel Condition Assessment: State of the Practice

Saleh Behbahani and Tom Iseley; Purdue University, West Lafayette, Indiana, United States

In the USA many tunnels were built during the 1930s and 1940s and the 1950s and 1960s. This indicates that these tunnels have exceeded their intended design service life. Based on the initial tunnel inventory conducted jointly by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA), more than 526 highway tunnels have been identified in the USA. For understanding the condition of the tunnels and risks associated with deteriorating conditions, comprehensive condition assessments are necessary to mitigate risk and remediate works as required. Monitoring the condition and rate of deterioration of tunnels is vital for timely tunnel maintenance and rehabilitation to avoid sudden tunnel collapse. This session will explain the necessary steps for tunnel inspection and review some of the state of the practice information on tunnel inspection techniques.

10:00 am

A Novel Holistic Methodology for Tunnel Leak Rehabilitation

Lane Boyd, Thomas Martin, and Thomas Martin; Gall Zeidler Consultants, Ashburn, Virginia, United States

Modern underground leak-remediation includes a variety of methods depending on the project's characteristics and goals. In this paper, the authors propose a new framework for incorporating geologic, hydrogeologic, and as-built information with digital scans to develop a database of existing conditions to guide owners and contractors. This information is used by specialty contractors, and the completed rehabilitation is portrayed in detailed as-built drawings. This information is implemented into a "BIM Digital Twin" which can be utilized by operations and maintenance staff for long-term planning.

New and Innovative Technologies I

TUESDAY, JUNE 13

Sponsored by: WALSH

Chairs: Kevin Smyth, Frontier-Kemper Constructors Inc, Evansville, IN
Bade Sozer, McMillen Jacobs Associates, Roseland, NJ

Introductions

8:30 am

Risk Based Design Study and Innovative Ventilation Strategy for a High Gradient Short Tunnel

Daniel Fischer; ILF Consultants Inc., Seattle, Washington, United States, Juan-Carlos Rueda, Reinhard Gertl, Hans Haring and Bogdan Chystyakov; ILF Consulting Engineers, Rum bei Innsbruck, Tyrol, Austria

The first project will be the Fehmarn Belt Fixed Link. It will be one of the biggest tunnel projects in the coming years. This is an 11 mile immersed tunnel, which will connect Denmark and Germany. The paper will present an innovative approach of the fire-life-safety systems for this challenging project. As well as provide highest safety standards combined with optimizing life-cycle-costs. The second project demonstrates a fire analysis with the use of 3D CFD simulations of a metro station. It will utilize cutting edge simulation software and numerical modelling technics to correctly represent complex fluid flow and heat transfer physics. The focus of this work will be challenging regarding simulation technics and outcomes.

9:00 am

TBM Trailing Sandwich Belt High Angle Conveyor

Joseph Dos Santos; Dos Santos International LLC, Marietta, Georgia, United States

The largest TBM (Tunnel Boring Machine) tunnels are typically along modest slopes but not always. Occasionally high slope angles are required beyond the capabilities of conventional open trough trailing conveyors. A 2019 project required a large TBM to ascended to an incline angle of 25°. A Sandwich belt high angle conveyor could easily solve the high angle conveying problem but such a system must include all of the features of the conventional trailing conveyor, particularly the ability to extend with the TBM advance. The writer responded to the challenge and developed a TBM trailing Sandwich Belt high angle conveyor with all of the needed features. The invention (U.S. patent awarded October, 2021) however goes beyond the 2019 project requirements and extends to any high angle incline. This writing presents the new TBM Trailing Sandwich Belt high angle conveyor with all of its features and implications.

9:30 am

Virtual Master Rings – Replacing a Tradition

Mathias Knoll; VMT (USA) Technical Measurement Solutions, Inc., Sumner, Washington, United States, Dieter Loh; VMT GmbH, Bruchsal,Baden-Wurttemberg, Germany

When a new tunnelling project starts, it has been a vital tradition for decades to cast and erect master rings horizontally on a flat surface to demonstrate the compliance with dimensional tolerances. Some tenders ask for the erection of two or even three rings upon each other or repeated master ring erections at intervals throughout the project. Especially for large diameters, this is a challenging and risky task for the workforce in the segment factory. The concept of virtual rings has the potential to replace this tradition by assembling master rings digitally instead of physically. This is based on a best-fit approach, considering the 3D coordinates from laser tracker measurements of segments or segment moulds.

Building a virtual ring, a sub-millimetre accuracy can be achieved, the alignment of neighbouring circumferential and ring joints observed, and the fit of bolt holes checked. The traditional method, on the other hand, is discussed controversially despite the significant amount of work and risks – particularly as the horizontal position of the ring and absence of gaskets do not simulate the reality in the excavated tunnel.

10:00 am

A Case Study from India on TBM Driving Under Low Overburden

Debasis Barman; AMBERG INDIA PVT LTD, REASI, Jammu and Kashmir, India

During working in Lucknow metro project, Uttar Pradesh, India the metro authorities encountered a TBM stretch where TBM had to cross a nallah crossing of 15m length under overburden of <1m. Not only the stability of TBM due to uplift was of concern but stability of both banks of nallah during TBM driving due to possible high-volume loss (%) as the banks consisted of mostly made ground material. Also, most structures on the nallah banks were non-engineering structures whose stability due to vibration of TBM was another concern. Overall looking at all these aspects it was proposed by me to drive TBM by controlling TBM mining parameters and also adopting an cost-effective & ease to implement methodology to control all possible modes of risks. The proposed method was guaranteed in terms of providing stability to both ground & superstructures and cost effective as well as feasible in terms of construction.

10:30 am

Mobile Solid State Lidar for Construction Quality Assurance

Stephen Miller; Schnabel Engineering, Sterling, Virginia, United States, Travis Shoemaker and Adam Saylor; Schnabel Engineering, Chadds Ford, Pennsylvania, United States

Lidar scanning has become an increasingly popular tool documenting underground excavations; however, high costs of traditional mechanical electrical lidar hardware, software, and training have limited the frequently and speed at which lidar scans can be performed. With Apple's incorporation of low-cost mobile solid state lidar on select smartphones and tablets, lidar is becoming more tractable for everyday construction documentation, like construction photo collection with smartphones. Here, we describe benefits of mobile solid state lidar and describe several practical applications for use in underground construction, such as documenting the working face, over-blast, and geologic features of tunnels.

11:00 am

Remote De-tensioning of Tieback Anchors After Structural Completion

Sean Peterfreund; McMillen Jacobs Associates, Auckland, New Zealand, Grant Finn; McMillen Jacobs Associates, Seattle, Washington, United States, Ty Jahn; Condon-Johnson & Associates, Bozeman, Montana, United States

For urban underground development involving tieback anchors for excavation support, authorities having jurisdiction typically require tiebacks to be de-tensioned before project completion. De-tensioning normally involves construction of block outs in permanent concrete walls, which are labor-intensive to install and backfill, and tend to interrupt the continuity of the basement's waterproofing system. This paper updates "A Proactive Approach to Tieback Anchor De-tensioning" (by Peterfreund and Finn, published in the 2017 RETC Proceedings). Since then, over 200 tiebacks in an underground station discussed in that paper were successfully de-tensioned from the surface after completion of the structure, in under a month.

11:30 am

Using GIS Application for Inlet/Outlet Tunnel Geologic Mapping for Ground Support (CH Reservoir Case Study)

Nadav Bar-Yaakov; Stantec, Louisville, Colorado, United States, Bolen Cory Eric Zimmerman; Stantec, Boise, Idaho, United States, Greg Raines; Stantec, San Diego, California, United States

The Chimney Hollow reservoir project broke ground in August 2021, constructing the tallest Asphalt Core Dam in North America, intending to improve reliability of drinking water supply to Northern Colorado communities. In order to expedite and streamline the geological mapping process in the tunnel, Stantec's teams has developed a GIS application for mapping input and rock mass evaluation, allowing real time decision making for assigning tunnel support class and resulting in a faster more efficient process. The presentation will present and demonstrate the GIS application based process, the mapping results and review additional uses of the data base created.

Future Projects

TUESDAY, JUNE 13

Sponsored by: HNTB

Chairs: Rebecca Reeve, Traylor Bros Inc, North Vancouver, BC, Canada
Mo Magheri, Kiewit

Introductions

1:30 pm

Understanding the Subsurface Conditions for the Cemetery Brook Drain Tunnel Project

Mahmood Khwaja; CDM Smith, Waban, Massachusetts, United States, Michael Schultz; CDM Smith, Boston, Massachusetts, United States, Frederick McNeill and Timothy Clougherty; City of Manchester, Manchester, New Hampshire, United States, David Polcari; CDM Smith, Manchester, New Hampshire, United States

The City of Manchester, New Hampshire is embarking on one of its largest public works projects, to construct a 12,000 foot long, large-diameter conveyance tunnel through downtown Manchester. This area has challenging geology with an undulating bedrock (granite, schist, and gneiss) profile overlain by fluvial deposits. Understanding the subsurface conditions is key to mitigating project risks, establishing a plan and profile for the tunnel, and selecting the most cost-sensitive and technically appropriate tunneling method. This paper will share the project team's approach for conducting the ground investigation, developing the preliminary subsurface profile, and their considerations for selecting the tunneling method.

2:00 pm

Evaluating the Trade Offs Between Microtunnelling and Tunnel Boring Machines for Small Diameter Tunnels – A Case Study of the Ferry Road and Riverbend Combined Sewer Relief Project

Dani Delaoye; Mott MacDonald, Vancouver, British Columbia, Canada, Kas Zurek; City of Winnipeg, Winnipeg, Manitoba, Canada

The City of Winnipeg is in the Preliminary Design stage for the construction of 1.6-km-long 3-m-diameter tunnel within an urban environment as part of the Ferry Road and Riverbend Combined Sewer Relief project. Evaluating and selecting the appropriate construction method is a key to the success of any tunnelling project. The benefits and risks of different methods should be well understood by the designer and communicated to the project owner to select a preferred method from a technical, social and environmental impact, cost and constructability perspective. For tunnels that have an internal diameter around 3 m, depending on the tunnel purpose and ground conditions, both microtunnelling with pipe jacking and tunnel boring machine excavation with a precast or two pass lining may be feasible construction methods. Using the Ferry Road and Riverbend Combined Sewer Relief Project located in Winnipeg, MB as a case study, this paper will discuss the benefits and drawbacks of each method, reviewing the technical design, social, environmental, cost, schedule and risk considerations.

2:30 pm

Metropolitan Water Tunnel Program in Massachusetts

Rafael Castro; JCK Underground, Winchester, Massachusetts, United States, Kathy Murtagh and Paul Savard; Massachusetts Water Resources Authority, Chelsea, Massachusetts, United States

Preliminary design is underway for the Massachusetts Water Resources Authority's (MWRA) next mega tunnel program, the Metropolitan Water Tunnel Program (MWTP). The MWTP is the last part of the MWRA's ongoing efforts to achieve redundancy for its metropolitan water transmission system including its historic deep rock City Tunnel, City Tunnel Extension and Dorchester Tunnels. The MWTP comprises several approximately 10-foot finished diameter deep rock tunnels totaling just over fourteen miles and ten connections to existing large diameter surface piping. This paper will present an update on current engineering and permitting efforts, packaging schemes, and the schedule to complete the MWTP.

3:00 pm

Design of the Akron Northside Interceptor CSO Tunnel

David Mast; AECOM, Akron, Ohio, United States, Heather Ullinger; City of Akron, Akron, Ohio, United States, Amanda Foote; AECOM, Newburgh, Indiana, United States, Juan Granja; GPD Group, Cleveland, Ohio, United States Dominick Mandalari; AECOM, Akron, Ohio, United States

The City of Akron will construct the Northside Interceptor Tunnel project, a U.S. EPA / DOJ CSO Long Term Control Plan Project. The system will provide at least 10.3 million gallons of storage in a 16-foot finished ID and 6,800 foot-long rock tunnel. The system will reduce both overflow volume and number of overflow structures on the Cuyahoga River. The project includes deep drop shafts and more than 2,000 linear feet of 24 to 96-inch I.D. sewers installed by trenchless construction methods. This paper will discuss the project background, ground conditions, and other challenges overcome during the design phases.

3:30 pm

San Francisco Downtown Rail Extension (DTX) Project – Evolution of Mined Tunnel Construction Approach and Design

Kush Chohan; McMillen Jacobs Associates, San Francisco, California, United States, Yiming Sun; McMillen Jacobs Associates, Walnut Creek,California, United States, Edmund Sum; Transbay Joint Powers Authority, San Francisco, California, United States, Meghan Murphy; AECOM, San Francisco, California, United States

DTX is a 1.3-mile-long rail extension being constructed by Transbay Joint Powers Authority to extend Caltrain rail service and future California High Speed Rail service to downtown San Francisco. It includes a 3,352-foot-long mined tunnel with cross section varying from 50 to 60 feet wide and 43 feet high to accommodate two- and three-rail tracks . DTX will be excavated in mixed-face and Franciscan Formation with ground cover ranging from 40 to 85 feet. This paper discusses how mined tunnel design has evolved since the preliminary design phase over 10 years ago. Current design concept for tunnel construction is also discussed.

4:00 pm

Allegheny County Sanitary Authority – Ohio River Tunnel Project Update

Michael Lichte; ALCOSAN, Pittsburgh, Pennsylvania, United States

ALCOSAN adopted its Clean Water Plan in May 2020, as part of a federal consent decree to comply with the USEPA's CSO Control Policy. Planned improvements include constructing a new regional storage/conveyance tunnel system, promoting green infrastructure/source control, and expanding the treatment plant. Preliminary planning for the tunnel system was completed in October 2020. The Ohio River Tunnel (ORT), the first of three tunnel projects, began final design in 2021. This paper will discuss the advancements made to the ORT preliminary planning concepts considering property availability, alignment optimization, supply chain uncertainties, tunnel boring machine evaluation, contract packaging and delivery schedules.

New and Innovative Technologies II

TUESDAY, JUNE 13

Chairs: Sergio Moya, Frontier-Kemper Constructors Inc, Los Angeles, CA
Glenn Larose, Jacobs, Boston, MA

Introductions

1:30 pm

Applying Automation and Machine Learning for Tunnel Inspections

LiLing Chen; Arup, New York, New York, United States, Michael Devriendt, Yung Loo, and Noemi Roecklinger; Arup, London, United Kingdom

Tunnel inspections have traditionally been carried out manually by inspectors writing up observations and taking photos of defects. The results from the inspection and the defects observed are dependent upon the rigor of the inspectors and may be subject to repeatability and consistency issues and is often time consuming with elevated health and safety risks. This presentation will discuss work that is being carried out in developing and implementing an innovative hardware and software solution integrating machine learning to automate the process of capturing objective tunnel condition information, offering cost and programme savings as well as health and safety improvements.

2:00 pm

Wireless Optical Displacement Sensor for Convergence and Divergence Monitoring

Raphael Victor; Senceive, Port Angeles, Washington, United States, Markus Rennen; Senceive Ltd, London, Washington, United States

The construction and modification of tunnels brings a requirement for precise measurement of convergence and divergence to safeguard the structure, maintain safety and provide the assurance needed to maintain efficient progress. Established methods include manual measurement using tape extensometers and automated methods using photogrammetry and automated total stations. Drawbacks include the need for frequent access, power supply, cabling, and cost. The paper describes how the development of reliable optical displacement sensors (ODS) has changed the landscape. ODS sensors are connected to a long-range wireless mesh communications network via a solar- powered gateway outside the tunnel, with data instantly transmitted to the internet. A sensor and its reflector target can be installed in 20 minutes and is maintenance free for a decade. Tunnel movement is measured to sub-millimeter precision with repeatability of ± 0.15mm. Integration of a triaxial tilt sensor allows slope distance to be converted to horizontal and vertical changes and allows rotational movement to be determined. Applications include new-build and long-term structural health monitoring. Case studies will be given, including the refurbishment of rail tunnels in Spain where the ODS measured movement during track lowering in a situation where no other automated system was considered viable.

2:30 pm

Structural Underpinning an Airport Terminal to Mitigate Tunneling Risk – Atlanta Plane Train West Extension Project

Daniel Ebin; McMillen Jacobs Associates, Chicago, Illinois, United States, Thomas Hennings; McMillen Jacobs Associates, Burlington, Massachusetts, United States, John Murray; McMillen Jacobs Associates, New York, New York, United States, Robert Gould; Clark Atkinson Technique, Joint Venture / Guy F. Atkinson Construction, Austin, Texas, United States, Ryan Smith; Keller North America, Alpharetta, Georgia, United States

The Atlanta Plane Train Tunnel West Extension was excavated at Hartsfield-Jackson Atlanta International Airport using Sequential Excavation Methods (SEM). At its shallowest point, tunnel cover to bottom of Domestic Terminal footings was limited to 7 feet in soft ground. To mitigate risk of excessive building movement due to tunneling-related activities, the columns near the alignment were directly underpinned. Underpinning was accomplished using a combination of grouted mini-piles, installed under low headroom conditions, that supported steel framing spanning over the tunnel excavations. This paper focuses on design and construction of the underpinning system used to mitigate risk from tunneling.

3:00 pm

Mechanized Tunneling – New Trends in TBM Development

Werner Burger and Marcus Lübbers; Herrenknecht AG, Schwanau, Baden-Wurttemberg, Germany

TBM development in recent decades has been dominated by increased face pressures, larger diameters and multi-mode functionality paving the way to realize projects deemed impossible before. In addition, the trend towards digitalization does not stop at the tunnel portal. A shortage of skilled personnel and the ever-present wish to increase workplace safety, quality and system performance automation, operator assist or even autonomous systems have become key development targets. The paper will present the current state of the art in light of these special conditions.

3:30 pm

Lessons Learned: Implementing BIM for the Chiltern Tunnels for High Speed 2 in the UK

Vojtech Ernst Gall; Gall Zeidler Consultants, New York, New York, United States, Kurt Zeidler; Gall Zeidler Consultants, Croydon, Surrey, United Kingdom, Tomasz Kecerski; Gall Zeidler Consultants, Croydon, Surrey, SubmissionForm. coAuthor2MailingAddress.CountryName}, Dominic Reda; Gall Zeidler Consultants, New York, New York, United States

High Speed 2 (HS2) mandated that Building Information Modelling (BIM) processes be implemented during design and construction. Gall Zeidler Consultants (GZ) was responsible for developing the BIM Models for the portals, tunnels, and crosspassages of the of the 16km-long Chiltern twin-bore Tunnel. In addition, GZ developed the GBR for the Chiltern Tunnels and incorporated the relevant information into the Project's BIM framework. This paper presents the implemented BIM framework, describes the modelling approach, and discusses the advantages and challenges of implementing BIM, particularly how BIM improved interface coordination and how BIM was used in feasibility assessments of different construction options.

4:00 pm

Installation of America's First Post-Tensioned Precast Tunnel Liner

Andrea Garoz, Rosmar Gonzalez and Nick Bowerman; Dragados USA, Wilmington, California, United States

The LA Effluent Outfall Tunnel for the Sanitation District of LA is a 7-mile-long-tunnel secondary effluent tunnel designed for peak weather flows of up to 670MGD and net-operating-pressures that are anticipated to approach 3 bar. These high anticipated flows and pressures necessitated the integration of a multi-tendon post-tensioning-system within the SFRC-PCTL to reduce the possibility of seepage and ensure water tightness for the 100-year-design-life. This paper will focus on the installation process of the PT (threading, stressing and grout injection) within the tunnel and how the project team overcame numerous new logistical challenges for a TBM tunnel drive.

4:30 pm

The Woodsmith Project: Construction of the Access Shaft at Lockwood Beck Using Innovative Blind Boring Technique

Andrew Raine; ARUP, Kowloon Tong, Kowloon, Hong Honk, Peter Stakne; Strabag UK, Cleveland, United Kingdom, Carmen Hu; ARUP, Kowloon Tong, Kowloon, Hong Kong Callum Fryer; Strabag UK, Cleveland, United Kingdom

STRABAG were appointed to design and construct the 37km long Mineral Transport System (MTS) for the new tunnel to transport mineral from the new Anglo American's new Woodsmith mine in the NE of England to Wilton site for processing into fertiliser and subsequent worldwide distribution. Two Intermediate deep shafts are required for access, ventilation, and emergency egress, the first is at Lockwood Beck, 12.5km south from Wilton. This paper will detail the innovative Blind Boring technique and associated technical risk management, highlighting advantages in design (by ARUP), programme, cost and health and safety when compared to conventional shaft sinking techniques and will also detail the challenges encountered and the solutions implemented including, ground treatment pre-grouting works for water cut off and installation of the steel casing.

Pressurized Face Tunneling

TUESDAY, JUNE 13

Sponsored by: Stantec

Chairs: Veronica Monaco, Jacobs, Florham Park, NJ
Dan Dreyfus, McMillen Jacobs Associates, Seattle, WA

Introductions

1:30 pm

Innovative TBM Launching in Urban Areas

Fabrizio Fara; Lane Construction Corporation, Seattle, Washington, United States, Daniele Nebbia; Lane Construction Corporation, Cos Cob, Connecticut, United States

The Ship Canal Water Quality Project (SCWQP) includes a 2.7-mile long, 18'-10" ID tunnel located in West Seattle. Tunneling in urban areas and soft ground conditions (Till and Till-like soils in Seattle) is associated with the risk of settlements , especially in presence of groundwater above the alignment. The Designer foresaw the use of soil improvement (jet grouting) outside of the launch shaft to mitigate the risk of flowing ground and to provide a redundant sealing. The Contractor proposed and ultimately successfully executed a different approach by using a "Steel Bell System" or Pressurized Can as described in this paper.

2:00 pm

Unique Umbilical Launch of a Slurry TBM in Los Angeles

Nick Karlin; Dragados USA, Wilmington, California, United States

Dragados USA is constructing the LA Effluent Outfall Tunnel, a 7-mile, 18ft internal diameter effluent discharge tunnel, utilizing a 21.6ft (6.585m) Herrenknecht Mixshield TBM. This paper highlights the means and methods used for TBM launch from a 55ft diameter shaft excavated in wet with diaphragm wall support of excavation. This included SEM excavation of jet grout blocks for starter and tail tunnels, temporary concrete structures and steel installations, TBM sealing system, umbilical management for TBM hydraulic, electric and bentonite circuits as well as complex segment delivery logistics. The many launching challenges were overcome thanks to the innovative approaches from the project team.

2:30 pm

Cohesive Soil Conditioning Practice for Earth Pressure Balance Tunneling

Mike Mooney and Rakshith Shetty; Colorado School of Mines, Golden, Colorado, United States

Cohesive clay soil poses a significant EPB TBM tunneling risk due to clogging, poor muck flow, slow production, etc. This paper details the performance measures required when EPB tunneling in clay soil, and the proven conditioning methods to transform in-situ clay to a muck with such characteristics, giving particular attention to TBM size, soil cutting characteristics and ground conditions. The paper then examines TBM data from multiple clay soil projects in the context of these performance measures to demonstrate good and poor clay soil conditioning.

3:30 pm

Design and Construction Considerations for the Pawtucket CSO Tunnel

Kathryn Kelly and Greg Waugh (Narragansett Bay Commission); Victor Despointes and Stephane Polycarpe (CBNA); Vojtech Ernst Gall (Gall Zeidler Consultants); Chris Feeney (Stantec); Brian Hann (Barletta Engineering)

The Pawtucket Tunnel is a 2.2-mi, 30.2-ft diameter CSO storage tunnel in Rhode Island. The primary tunnel is built using a dual-mode open-EPB TBM capable of sealing the face within 120 seconds to manage poor ground and water ingress which is launched from within a SEM starter tunnel. The main tunnel connects to four adits along its alignment, three of which are SEM tunnels and one being a MTBM tunnel. This contribution describes the selection process, potential risks, and requirements for the TBM, as well as the design of the main tunnel, the adits, and the adit-bored tunnel connections

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4:00 pm

Launch of an Earth Pressure Balance Tunnel Boring Machine in Short-Mode on a Congested Site from Narrow Deep Shafts for the Alexrenew Project in Alexandria, Virginia: A Case Study

Jean-Marc Wehrli; Traylor Bros., Inc., Forest Hills, New York, United States, Joshua Jonason; Traylor Bros., Inc., Long Beach, California, United States, Steve Short; Traylor Bros., Inc., Normandy Park, Washington, United States, Luis Fernandez and James Hawn; Traylor Bros., Inc., Alexandria, Virginia, United States

The RiverRenew Tunnel System project in Alexandria, VA forms part of a CSO scheme aimed at reducing overflows of combined stormwater and sewage into the Potomac River during storm events. The major piece of the project is a 12-foot internal diameter tunnel of approximately 12,000 feet length lined with a single-pass precast concrete segmental liner and excavated by Earth-Pressure Balanced Shield TBM. The tunnel lies between 120 to 140 feet below grade in the clays of the Upper Potomac Formation with occasional dips of more granular, saturated soils of the Terrace Formation and the Alluvium. The TBM is launched from a figure-8 configuration Pumping/Screening Shaft located within Alex Renew's operational Water Resource Recovery Facility. This paper discusses the challenges encountered during the launch of the TBM in short- mode within a highly congested site and from narrow deep shafts.

SEM Applications and Projects

TUESDAY, JUNE 13

Sponsored by: WALSH

Chairs: Lisa Smiley, JayDee Obayashi JV, Cleveland, OH
Zeph Varley, WSP USA, Los Angeles, CA

Introductions

1:30 pm

Pipe Canopy Pre-Support with SEM Tunneling Under Active Rail Tracks

Ryan O'Connell and Todd Kilduff; Kilduff Underground Engineering, Denver, Colorado, United States

A pedestrian tunnel in Utah, beneath active UPRR tracks, required pipe canopy pre-support coupled with SEM. Given challenging ground and low-cover between tunnel and surface, pipe canopy pre-support was designed, requiring the placement of 24-inch-diameter steel pipes driven the extent of the tunnel length. The pre-support method together with SEM to advance the tunnel, offered a low-impact method to install the underpass by adding stiffness to the subgrade to mitigate surface settlement during tunneling. This paper describes how the tunneling methodology utilized was a viable solution to mitigate surface settlement below railroad tracks and define future risk for similar projects.

2:00 pm

Kramer Tunnel – Construction of the Ventilation Shaft Project in Germany's Southern Alps

Lukas Walder, Richard Gradnik, and Roland Arnold; Bemo Tunnelling, Innsbruck, Tirol, Austria, Raphael Zuber; Staatliches Bauamt Weilheim, Weilheim, Bavaria, Germany

The Kramertunnel project in Garmisch-Partenkirchen, Germany was started in January 2020 and includes the construction of the 3,600 m long 2-lane tunnel, the rehabilitation of the exploration tunnel (escape gallery) and the construction of an intermediate ventilation shaft with a depth of approximately 90 m and an inner diameter of 4.5 m. All tunnels and ducts are excavated according to the principles of the New Austrian Tunnelling Method (NATM). The paper gives an overview about the progress on the project and focuses on the geological and logistical challenges during shaft construction.

2:30 pm

Construction of the Bypass Tunnel for the Upper Llagas Creek Protection Project

Clayton Williams; Mott MacDonald, San Ramon, California, United States, Glenn Boyce, Brian H; McMillen Jacobs Associates, Walnut Creek, California, United States, Dale Hata, Brian Harris, and Brett Mainer; Drill Tech Drilling & Shoring, Antioch, California, United States

The Upper Llagas Creek Flood Protection Project is in Northern California, encompassing portions the communities within Santa Clara County. This paper describes Phase 2A, which consists of approximately 2040 linear feet of sequentially excavated 14 feet by 12 feet lined horseshoe-shaped bypass tunnel to be excavated using a combination of blasting and roadheader methods. This case study discusses the bypass tunnel, the progress of tunnel construction to date, employed construction management procedures, challenges, as well as a discussion of actual conditions compared to the Geotechnical Baseline Report and how that impacted progress.

3:00 pm

Excavation and Support of Cross Passages on Westside I

Jeff Brandt; Traylor Bros., Inc, Los Angeles, California, United States, Kerwin Hirro; Traylor Bros., Inc, Los Angeles, California, United States, Peter Rolf Dietrich and Norbert Fuegenschuh; BeMo USA, Inc., Vienna, Virginia, United States, Michael Cole; Metro/Santec, Highland, California, United States

This paper presents a case history of the ground improvement efforts and excavation of the twenty-three cross passages between twin bore tunnels driven by EPB tunneling machines. Unique and complicated ground conditions local to the tunnel alignment include San Pedro sands, siltstone/claystone Fernando Formation, and zones of "asphalt impacted soils". To provide water cut-off and stabilize soils, jet grouting was performed prior to TBM excavation at the location of many of the cross passages. However, upon investigating the cross passages prior to excavation, the subsurface conditions required additional measures and SEM tools to be utilized to ensure successful excavation.

3:30 pm

Design and Planning of New Passageway Tunnel for Circulation Improvements at Grand Central – 42nd Street Station, New York City

Dominic Reda; Gall Zeidler Consultants, LLC, New York, New York, United States, Alfredo Valdivia; Gall Zeidler Consultants, New York, New York, United States, Vojtech Gall; Gall Zeidler Consultants, Ashburn, Virginia, United States

The design and planning for the construction of a new passageway to improve access and circulation to better accommodate anticipated increased passenger flow within Grand Central Station. The passageway includes the break-in of an over 100-year-old station cavern with an innovative design implementing a protective structure above the existing track to allow for safe train operations and passenger circulation during construction. Construction of the new passageway follows the Sequential Excavation Method. This paper will present the innovative solutions that went into design and planning considering construction access, site logistics, risk management, structural retrofitting, detailed instrumentation and monitoring, and impact assessments.

Contract Practices

WEDNESDAY, JUNE 14

Sponsored by: HNTB

Chairs: David Smith, WSP, New York, NY
Seth Pollak, Arup, Cranbury, NJ

Introductions

8:30 am

Packaging and Contract Delivery Methods for the Horizon Lateral

Robin Rockey; Southern Nevada Water Authority, Las Vegas, Nevada, US, Adriana Ventimiglia; Southern Nevada Water Authority, Las Vegas, Nevada, United States, Ray Brainard; Black & Veatch, Kansas City, Missouri, United States, Amanda Kerr; Black & Veatch, Denver, Colorado, United States

The $2 billion Horizon Lateral includes over 30 miles of trenched and tunneled pipeline with diameters up to 120 inches. Related infrastructure includes pumping stations, booster pumping stations, reservoirs, and rate of flow control facilities. This paper will discuss the strategy and processes used to determine contract packaging and contracting delivery methods for the various project elements with an emphasis on the tunnels and trenchless crossings. Prior Southern Nevada Water Authority experience and the rigorous risk-based approach to develop the preferred alignments played a large role in determining the outcomes along with schedule concerns and permitting and easement acquisition.

9:00 am

Progressive Design-Build in the Tunneling/ Underground Construction Industry – Perspective from the Private Sector

Carlos Tarazaga; AZTEC-TYPSA, Irvine, California, United States

Progressive Design-Build (PDB) is an emerging variation of alternative delivery programs in the underground construction industry. PDB refers to the way a construction project design is developed by the Owner and the Design-Builder in a step-by-step process. According to the Design-Build Institute of America (DBIA), Progressive Design-Build allows the design and construction team to collaborate during the earliest stages of project development. This enables engagement between the three key players in a construction contract: the owner, the designer, and the contractor. Is the PDB the best alternative program delivery for large contracts? What is the perspective of the private sector? This paper will provide an overview of the different alternative delivery programs used in the underground industry, pros and cons of each of programs, and the perspective of the designers and contractors. The paper will focus on how the PDB works, reasons why owners should consider PDB for their projects, best collaboration strategies among owners, designers, and contractors to deliver a successful project, and how to manage the project risks using a PDB method.

9:30 am

CMGC Delivery of the I35W SSF Project – Fostering Collaboration to Meet Stormwater System Resiliency Challenges

Michael Haggerty; Barr Engineering Co., St Louis Park, Minnesota, United States, Joe Welna; Barr Engineering Co., Minneapolis, Minnesota, United States

The Minnesota Department of Transportation is constructing a stormwater storage facility along I35W south of Minneapolis, MN. The project will provide storm surge capacity reducing the frequency with which major precipitation events result in flooding of I35W. The design consists of six, 90-foot deep, adjacent underground shafts providing 14-acre feet of storage. The construction is in high groundwater with variable glacial outwash deposits. Constructability and ground variability were managed using construction manager general contractor (CMGC) project delivery. CMGC provides an environment for collaboration and innovation. This paper provides an overview of key efficiencies and collaboration examples aided by CMGC delivery.

10:00 am

Atlanta – Plane Train Tunnel West Extension Project: Progressive Design Build Risk Management Approach

Dominic Reda; Gall Zeidler Consultants, LLC, New York, New York, United States, Walter Klary and Vojtech Gall; Gall Zeidler Consultants, LLC, Ashburn, Virginia, United States

Progressive Design Build has become a common delivery method in the tunneling industry. This approach allows the Owner to select a design-builder primarily based on qualification instead of lowest price. The delivery method promotes flexibility and collaboration at all levels from the initial design stage through construction. Using the example of the Atlanta Airport Plane Train Tunnel West Extension, value-added risk management was added during the initial design phase with an independent reviewer. This paper presents the independent reviewer transitioning from constructibility review in the very early stages of design to independent design verification to on-site supervision during construction.

Health and Safety & Sustainability

WEDNESDAY, JUNE 14

Chairs: Keveh Talebi, JayDee Contractors Inc, Livonia, MI
Michael Lang, Frontier-Kemper Constructors Inc, Evansville, IN

Introductions

8:30 am

Carbon Footprint Reduction in Montreal Blue Line Extension

Pegah Jarast; AECOM, Andover, Massachusetts, United States, Mehdi Bakhshi and Verya Nasri; AECOM, New York, New York, United States

The Montreal metro Blue Line Extension toward the northeast consists of construction of five new underground stations. The project includes 6 kilometres of tunnel which will be constructed using Tunnel Boring Machine (TBM). In line with commitment to integrating sustainability best practices, Envision verification is pursued for this project. The Envision reference framework was developed to cover all the sustainable development aspects of an infrastructure project and each phase of its life cycle (planning, design, construction, operations and maintenance, and end-of-life). As a part of this endeavor, low-carbon concrete and shotcrete mixtures are proposed for the linings of TBM and SEM tunnels as well as stations and auxiliary structures. The CO2 emission of the low carbon concrete and shotcrete mixtures were compared with their typical mixtures and the total CO2 emissions reduction of the project is determined. In addition, the CO2 emissions of all other materials and construction activities in the project is quantified to have an estimate of the total CO2 emission due to the underground structures construction. The study is of strategic significance for achieving emission reduction in the tunnel industry.

9:00 am

Steep TBM Challenge for the Limberg III Pump Storage Power Plant Project

Patrick Billian; Herrenknecht AG, Schwanau, Baden-Wurttemberg, Germany

Hydropower produces almost two-thirds of the world's renewable electricity generation and delivers a major contribution on the ambition of the Paris Agreement and Sustainable Development Goals with a range of benefits to society and environment. These include clean and flexible generation and storage as well as reduced dependence on fossil fuels and avoidance of pollutants. The Limberg III PSP is one of the European projects that addresses the implementation of the UN SDGs. The challenge of the project is the construction of an approx. 770m long pressure shaft to be excavated with a TBM and an inclination of 42°.

Risk Management

WEDNESDAY, JUNE 14

Sponsored by: Stantec

Chairs: Marvin Ko, JFShea, Indianapolis, IN
Joe Rigney, Parsons, Boston, MA

Introductions

8:30 am

Overexcavation Risk Management During Pressurized Face Tunneling in the Pacific Northwest

Ulf Gwildis; CDM Smith, Bellevue, Washington, United States

Overexcavation and ground loss events during pressurized-face TBM advance can result in unplanned deformations above the tunnel and damage to existing infrastructure. Successfully managing the risk of this occurring is crucial for any project in an urban area to proceed. Common risk management approaches include a combination of establishing suitable ranges of TBM operational parameters and using geotechnical instrumentation for deformation monitoring. Another risk management tool is material flow reconciliation, which varies based on the specified mining method and the equipment choices by the contractor. This paper compares recent and on-going projects in the Pacific Northwest regarding overexcavation risk management.

9:00 am

Ashbridges Bay Treatment Plant Outfall TBM Risk Mitigation – Prescriptiveness and Verification of TBM Fabrication

Dan Ifrim and Andre Solecki; Hatch, Oakville, Ontario, Canada

Tunneling could be a major challenge to tunneling contractors as tunneling operations can be seriously affected by the Tunnel Boring Machine (TBM) performance. Specifying the appropriate TBM methodology, selection of systems and features, is critical for managing tunnel risks and contribute to successful tunneling project. The paper analyzes tunneling records from the recently completed City of Toronto's Ashbridges Bay Treatment Outfall tunnel project and underlines the righteous selection of the TBM type and associated TBM systems in achieving good advance rates during tunnelling and managing project risks. The paper intends to draw attention of a few aspects of TBM technical specification importance and highlight the lessons learned from this process.

9:30 am

Fire Damage Assessment of Reinforced Concrete Tunnel Linings

Nan Hua; Mott Macdonald, Pasadena, California, United States, Anthony Tessari and Negar Elhami-Khorasani; University at Buffalo, Buffalo, New York, United States

Fire hazards can cause severe and irrecoverable damage to reinforced concrete (RC) tunnel linings, threatening the serviceability and resilience of transportation networks. This presentation focuses on fire damage assessment of reinforced concrete tunnel linings. In doing so, fire damage classifications in existing guidelines are first presented. Existing approaches are supplemented with results of advanced modeling and inputs from industry experts to propose new fire damage/repair classifications with the associated thresholds. The results of the presented research can be used to guide fire risk assessment as well as the performance- based design of tunnel fire protection.

10:00 am

Risk Mitigation of Natural Gas in Louisville MSD's Deep Bedrock Ohio River Tunnel

Reese True; Black & Veatch, La Grange, Kentucky, United States, Todd Tharpe and Jonathan Steflik; Black & Veatch, Louisville, Kentucky, United States, Jacob Mathis; Louisville & Jefferson County MSD, Louisville, Kentucky, United States

In mid-2022 Louisville MSD completed a 6.5 km (4-mile), 6.1 m (20-foot) diameter CSO conveyance and storage tunnel system located along the Ohio River in downtown Louisville, Kentucky. During construction, the Ohio River Tunnel alignment was expanded 2.4 km (1.5 miles) into areas where natural gas was detected. Without delaying construction, the project team developed and implemented a natural gas risk mitigation plan to safely excavate the remaining tunnel section via TBM and install concrete lining. The mitigation plan included the installation of gas-vent borings, increased tunnel ventilation, retrofitting tunneling equipment for "gassy" operations, and modifying the project specific HASP.

10:30 am

Risk Baseline Report: An Innovative Risk Management Approach for a Complex Underground Project

Kumar Bhattarai; HNTB Corporation, Frisco, Texas, United States, David Hatem; Donovan Hatem LLP, Boston, Massachusetts, United States

The increasing popularity of alternative project delivery methods in delivery of underground infrastructure projects has given rise to innovative contracting strategies to manage the unique risks associated with the work. This paper presents recent examples of how risk has been dealt with using various alternative delivery methods, including Construction Manager General Contractor (CMGC), Progressive Design Build, and standard Design-Build (DB). Based on the experience gained from these examples, recommendations for an innovative risk baselining approach using contingency sharing are presented that should advance the overall goal of equitable risk sharing and compensation.

11:00 am

30 Years of Advances in Risk Management for Underground Projects

John Reilly; JOHN REILLY Consulting, Framingham, Massachusetts, United States, Philip Sander; Institute of Construction Management, University of the Bundeswehr Munich, Neubiberg, Bavaria, Germany, Kevin Lundberg; RiskConsult GmbH, Innsbruck, Tyrol, Austria

Since the early days of risk management, advances in technology and guidelines (ITA, ITIG, OGG, UCA), have advanced risk management and probable cost estimating, which are now widely recognized. WSDOT's CEVP is now established at 20 years. This paper traces those developments, summarizes advanced techniques and presents case studies of US and International projects with risk profiles and results. The particular case of using advanced risk evaluation to allow enhanced capability TBMs to be considered in a competitive bid process will be presented. Further advances including the use of digital twin risk-based representation of complex projects will be described.

Project Planning

WEDNESDAY, JUNE 14

Sponsored by: WALSH

Chairs: Tony Cicinelli, Kiewit, Omaha, NE
Colin Sessions, Jacobs, Atlanta, GA

Introductions

8:30 am

Digital Work Preparation Tool for Underground Construction Tasks – Planning and Optimizing Projects

Julia Herhold; Hochschule RheinMain, Wiesbaden, Hesse, Germany

The demand for sustainable and profitable/efficient projects within the tunneling and other underground engineering sectors grows rapidly. Construction task play a key role within the project conduction, whether as primary (tunneling), secondary (e. g. mine securing) or tertiary processes (e. g. workshops). The construction tasks of primary processes create the main structures, such as tunnels, which resemble the main project goal. For the secondary and tertiary processes, the purpose of the task shifts. The main goal is to provide structures, such as the securing of the cavity and workshops, that enable the project and enhance the efficiency of the primary

conduction underground. To plan and optimize the conduction of construction tasks underground, whether they are identified as primary, secondary or tertiary tasks, the work preparation can be used. This method, known from the above ground construction, can be adapted and used underground. The approach of a digital work preparation tool combines, connects and adapts the main tasks "choice of procedure", "logistics" and "site planning". In addition, the digital tool is connected with digital models (construction, site, surroundings). With the adaption and forward projection of the work preparation, underground constructions (e. g. tunneling) can provide a more sustainable and efficient outcome.

9:00 am

Flood Resilience for San Francisco

Renee Fippin; McMillen Jacobs Associates, Walnut Creek, California, United States, Eva Ferndandez; McMillen Jacobs Associates, San Francisco, California, United States, Paul Louie; San Francisco Public Utilities Commission, San Francisco, California, United States

The Folsom Area Stormwater Improvement Project's Alameda Street Wet Weather Conveyance Tunnel is part of San Francisco's flood resilience efforts under the Sewer System Improvement Program. This 4,000- linear-foot-long, 12-foot-inside-diameter tunnel will help minimize flooding in a low-lying neighborhoods.

The project is in a high seismic zone extending through a complex geologic corridor including full-face soft, compressible Bay Mud, sands, and full-face rock with stretches of mixed-face conditions. Additional challenges include removal of 99 piles beneath an existing large box sewer, tunneling under commuter rail tracks, and an underground tie-in. This paper examines these challenges and how they are being addressed.

9:30 am

Planning for State-of-Good Repair, Hazard Mitigation, and Resiliency for San Diego County Water Authority's 2nd Aqueduct Water Supply Infrastructure

Mahmood Khwaja; CDM Smith, Waban, Massachusetts, United States, Nathan Faber and Anjuli Corcovelos; San Diego County Water Authority, San Diego, California, United States, William Brick; CDM Smith, Concord, California, United States, Thomas Falk; CDM Smith, Carlsbad, California, United States, Paul Taurasi; CDM Smith, Phoenix, Arizona, United States

California's San Diego County Water Authority provides safe and reliable water supply to more than 3.3 million residents through twenty-four member agencies. The 2nd Aqueduct pipelines, a critical infrastructure consisting of three large-diameter pipelines, are susceptible to natural threats including streambed erosion, channel migration, and seismic hazards within the 3,840-ft long Moosa Canyon segment of the alignment. A state-of-good repair, hazard mitigation, and resiliency project is progressing to ensure uninterrupted water supply. For each pipeline, a segment will be replaced by tunneling. A high-level project development approach is presented, focusing on alternative selection, environmental/geotechnical considerations, and operations and maintenance constraints.

10:00 am

Developing Project Cost Estimates in Volatile Markets

Connor Langford; Mott MacDonald, Vancouver, British Columbia, Canada, Murray Gant; Metro Vancouver, Burnaby, British Columbia, Canada

Preparing accurate project cost estimates is a critical component in capital project planning. As design often occurs years before construction contracts are awarded, estimates need to make reasonable assumptions about how the work may be executed and potential future market trends. This process is challenging enough during stable markets, as historic trends can often be misleading and require a firm understanding of economics.

When you add market volatility, developing accurate cost estimates becomes even more challenging. This paper explores historic and recent market trends that impact project cost estimates and presents guidance on capturing volatility by using a risk-based contingency.

10:30 am

Planning the Black Creek Tunnel Project

Daniel Cressman; Black & Veatch, Markham, Ontario, Canada

The City of Toronto is currently undertaking the design of the Black Creek Project (BCP). The BCP Project involves the design and construction of approximately 20 kilometres of tunnel through shale rock of the Georgian Bay Formation and soft ground soil consisting of glacial till, glaciolacustrine and glaciofluvial sand, silt and clay deposits. The BCP consists of three sections of tunnel 1) the approximately 11.6 km, 3.0 metre diameter Keele Relief Trunk Sewer, 2) the 4.2 km mictrotunnel Keele Relief Trunk Sewer and 3) the 3.4 km microtunnel Jane-Wilson Relief Trunk Sewer. Additionally one 40,000 m3 wet weather flow (WWF) storage tank and numerous WWF connection shafts are to be constructed and connected to the BCP tunnel to pick up WWF from existing outfalls currently discharging to Black Creek. The anticipated cost of the project is $600 million with construction of the first project stage, the Keele TRS, scheduled to commence in 2025. This paper provides an overview of the project in terms of the expected geotechnical conditions, the scheme developed for design and construction of the tunnel system and the associated schedule and procurement strategy. The consideration for planning of the tunnel system, the risk-based analysis and decision-making process are presented and form the basis for selection of a precast tunnel lining support method in the rock and soft ground.

11:00 am

Planning for Sound Transit's Proposed LINK Light Rail Expansion in Seattle Washington

Raghu Bhargava; HNTB Corporation, Bellevue, Washington, United States, Matthew Preedy, Dirk Bakke, and Anthony Pooley; Sound Transit, Seattle, Washington, United States, Mike Wongkaew; HNTB Corporation, BELLEVUE, Washington, United States

Sound Transit's ST3 program will add 62 miles of light rail to the Puget Sound area, including connections to the neighborhoods of West Seattle and Ballard. These connections include considerations for both elevated and tunnel alternatives in West Seattle and Ballard, as well as a new tunnel and six underground stations in the densely developed parts of downtown Seattle. This paper describes the conditions and constraints along the corridor, and the latest developments in the ongoing process to plan the underground guideways and stations.