Why Attend
The 2015 Rapid Excavation and Tunneling Conference (RETC) is the premier international tunneling event of the year. With a comprehensive technical program, short courses, an exhibit hall with companies from around the world, a site visit to the Permanent Canal Closures and Pumps and planned spouse trips, this conference has it all!

General Information
Hotel Reservation Deadline: May 18, 2015
Advance Registration Deadline: May 18, 2015

LOCATION INFORMATION
All technical sessions, social events, short courses and the exhibit will be conducted at:
Sheraton New Orleans Hotel
500 Canal Street
New Orleans, LA 70130
504-525-2500 / www.starwoodhotels.com

REGISTRATION INFORMATION
Please complete the Advance Registration form on the inside back cover and return no later than May 18, 2015 to:
MAIL TO: RETC Registration – SME
12999 E. Adam Aircraft Circle
Englewood, CO 80112
PHONE: 303-948-4200 / 303-948-4222
FAX: 303-979-3461
ONLINE: www.retc.org

After May 18, 2015 on-site registration fees apply. Full payment MUST accompany the completed Advance Registration Form. When registering by phone, fax or online, DO NOT SEND ANOTHER COPY BY MAIL. Confirmation will be emailed to the individual at address provided on form.

GENERAL MEETING QUESTIONS
Contact SME Meetings Department at 303-948-4200.

PURCHASING TICKETS
Attendees must register to purchase tickets for social functions and/or tours; however, one registrant may purchase more than one ticket.

REGISTRATION POLICY
All attendees and authors of the 2015 RETC are required to register. Nonmember authors may register at the member rate. Badges are required for admittance to the technical sessions, exhibit and social functions.

STUDENT REGISTRATION POLICY
Student registration for the 2015 RETC must meet eligibility requirements. SME requires that an individual must be attending a college/university/ higher education institute on a full-time basis to qualify for student registration rates. SME cannot process student registrations without evidence that you are a full-time student. Students enrolled in 12 or more semester credit hours are considered full-time. When sending your registration to SME Registration Dept., please provide confirmation from your educational institution. Acceptable confirmation includes: transcript, most recent report card, or official school registration documents. Student registration without this information will not be processed.

CANCELLATION/SUBSTITUTION POLICY
If circumstances require you to cancel your RETC registration, you must do so in writing. Written notice must be sent to RETC Registration, c/o SME, 12999 E. Adam Aircraft Circle, Englewood, CO 80112. Cancellations postmarked on or before May 4, 2015 will receive a refund, less a $100 processing fee. There are no refunds for no-shows and cancellations postmarked after May 4, 2015. Registrants are responsible for cancellation of their hotel accommodations. Substitutions will be accepted at no charge.

PASSPORT REQUIREMENTS
All international visitors, regardless of country of origin, must present a passport or secure document when entering the United States. Go to www.dhs.gov for more information.

AIRPORT INFORMATION
The Sheraton New Orleans Hotel is located approximately 15 miles from Louis Armstrong New Orleans International Airport. Please note that the Sheraton New Orleans Hotel does offer shuttle transportation.

LETTER OF INVITATION
SME will send a letter of invitation to paid registrants upon request. Invitations are intended to help potential delegates raise travel funds or obtain a visa. It is not a commitment from the Conference or the organizers to provide any financial support. Letters of invitation must include: attendee name, job title, company name, mailing addresses (Post Office Boxes are not accepted), city, state/province, country, zip/postal code, phone and fax number, and beginning and end dates of travel. Also provide the address, phone and fax number of your embassy. Send your request to: SME Meetings Dept., 12999 E. Adam Aircraft Circle, Englewood, CO 80112.
Email: meetings@smenet.org

ATTENTION EXHIBITORS
Exhibitors must register online at www.retc.org. Booth personnel of exhibiting firms should NOT use the forms contained in the conference promotion. For questions, or to obtain the exhibit forms, go to www.retc.org, click exhibitor information.

HOUSING INFORMATION
Hotel accommodations are available at the Sheraton New Orleans Hotel. Reservations must be made by May 18, 2015 and are based on availability. Please call the Sheraton at 504-525-2500 or 888-627-7033 and ask for RETC rate. Reservation can also be made online www.retc.org.
2015 RETC Calendar of Events

ALL EVENTS TAKE PLACE AT THE SHERATON NEW ORLEANS

SUNDAY, JUNE 7

SHORT COURSE
Short Course Registration  7:00 a.m. – 9:00 a.m.
Short Course Coffee Break  7:15 a.m. – 9:00 a.m.
Shaft Construction and Design  8:00 a.m. – 4:00 p.m.
Grouting in Underground Construction  8:00 a.m. – 4:00 p.m.
Underground Blasting Technology & Risk Management  8:00 a.m. – 4:00 p.m.
Short Course Coffee Break  10:00 a.m. – 10:30 a.m.
Short Course Luncheon  Noon – 1:00 p.m.
Short Course Coffee Break  2:30 p.m. – 3:00 p.m.

COMMITTEE MEETINGS
RETC Executive Committee Meeting  10:00 a.m. – 11:00 a.m.
RETC International Committee Meeting  11:00 a.m. – Noon
WTC 2016 Organizing Committee Meeting  1:00 p.m. – 3:00 p.m.

SESSION
Tunnel Safety & Other Challenges for the Industry  1:00 p.m.
Tunnel Issues Regarding Risk and Uncertainty: Comments and Panel Discussion  2:00 p.m.

REGISTRATION
9:00 a.m. – 5:00 p.m.

SOCIAL FUNCTION
Spouse/Guest Tour: New Orleans Cooking Experience  10:30 a.m. – 1:30 p.m.
UCA of SME Corporate/Sustaining Members Reception  5:00 p.m. – 6:30 p.m.

MONDAY, JUNE 8

REGISTRATION
9:00 a.m. – 5:00 p.m.
AUTHORS’ COFFEE
7:30 a.m. – 8:30 a.m.
SPEAKER READY ROOM
7:30 a.m. – 3:00 p.m.
EXHIBITS
5:00 p.m. – 7:00 p.m.

TECHNICAL SESSIONS
Design & Planning I  8:30 a.m. – 11:30 a.m.
Difficult Ground  8:30 a.m. – 11:30 a.m.
New & Innovative Technologies  8:30 a.m. – 11:30 a.m.
Pressure Face TBM Case Histories I  8:30 a.m. – 11:30 a.m.
Caverns & Large Spans  1:30 p.m. – 5:00 p.m.
Contracting Practices  1:30 p.m. – 5:00 p.m.
Design – Build Projects  1:30 p.m. – 5:00 p.m.
TBM Technology  1:30 p.m. – 5:00 p.m.

SOCIAL FUNCTIONS
Spouse/Guest Tour: Sugar & Shopping Tour  10:00 a.m. – 3:00 p.m.
Welcoming Luncheon  11:30 a.m. – 1:15 p.m.
Exhibit Hall Hosted Reception  5:00 p.m. – 7:00 p.m.

TUESDAY, JUNE 9

REGISTRATION
9:00 a.m. – 5:00 p.m.

AUTHORS’ COFFEE
7:30 a.m. – 8:30 a.m.

SPEAKER READY ROOM
7:30 a.m. – 3:00 p.m.

EXHIBITS
Luncheon  11:00 a.m. – 2:00 p.m.
Hosted Reception  4:00 p.m. – 6:00 p.m.

TECHNICAL SESSIONS
Ground Stabilization  8:30 a.m. – 11:30 a.m.
Hard Rock Tunneling  8:30 a.m. – 11:30 a.m.
Pressure Face TBM Technology  8:30 a.m. – 11:30 a.m.
Tunnel Finishing & Liner Installation  8:30 a.m. – 11:30 a.m.
Grouting: Water Control  1:30 p.m. – 5:00 p.m.
Precast Tunnel Linings  1:30 p.m. – 5:00 p.m.
SEM/NATM  1:30 p.m. – 5:00 p.m.
Shafts  1:30 p.m. – 5:00 p.m.

SOCIAL FUNCTIONS
UCA of SME Breakfast  7:00 a.m. – 8:30 a.m.
Spouse/Guest Tour: Mansions & Magnolias  10:00 a.m. – 1:00 p.m.
Exhibit Hall Luncheon  11:30 a.m. – 1:00 p.m.
Exhibit Hall Reception  4:00 p.m. – 6:00 p.m.
RETC Dinner Reception  6:00 p.m. – 6:30 p.m.
RETC Dinner  6:30 p.m. – 9:00 p.m.

A.M./P.M. Coffee Breaks
Sponsored by:

WEDNESDAY, JUNE 10

REGISTRATION
7:30 a.m. – Noon

AUTHORS’ COFFEE
7:30 a.m. – 8:30 a.m.
SPEAKER READY ROOM
7:30 a.m. – 3:00 p.m.
EXHIBITS
9:00 a.m. – Noon

COMMITTEE MEETING
UCA of SME Executive Committee Meeting  11:30 a.m. – 2:00 p.m.

TECHNICAL SESSIONS
Design & Planning II  8:30 a.m. – 11:30 a.m.
Geotechnical Considerations II  8:30 a.m. – 11:30 a.m.
Risk Management  8:30 a.m. – 11:30 a.m.
Trenchless Tunneling & Rehabilitation  8:30 a.m. – 11:30 a.m.

FIELD TRIP
Permanent Canal Closures and Pumps (PCCP)  Noon – 4:00 p.m.

SOCIAL FUNCTIONS
Spouse/Guest Tour: Mysteries of the Swamplands  8:30 a.m. – Noon

A.M./P.M. Coffee Breaks
Sponsored by:
Spouse and Guest Tours

NEW ORLEANS COOKING EXPERIENCE
Sunday, June 7, 2015 10:30 a.m. – 1:30 p.m.  Cost: $285 per person
The New Orleans Cooking Experience is dedicated to the wonders of the Louisiana kitchen and the pleasures of the table. The highly personalized classes, focusing on authentic Creole cooking, are taught on residential equipment so that students can reproduce the recipes at home. You will be able enjoy appetizers and desserts throughout the presentation.

SUGAR & SHOPPING NOLA STYLE
Monday, June 8, 2015 10:00 a.m. – 3:00 p.m.  Cost: $199 per person
Depart the Sheraton in your favorite walking shoes and walk the eight fabulous blocks of Royal Street shopping which includes antiques, boutiques and galleries! Need some Sugar? A stop at Café du Monde for some famous powder sugar covered beignets will be just what you need to keep going. Then it is on to Magazine Street, the hottest shopping destination in town! This tour will not only be informative but, most assuredly, a fun-filled experience. Guests will have the opportunity to explore the many boutiques, antique stores, galleries, and specialty shops along this interesting and famous street also known as “New Orleans’ Unique Street of Dreams.” Your tour will include lunch at the Commander’s Palace Restaurant.

MANSIONS AND MAGNOLIAS
Tuesday, June 9, 2015 10:00 a.m. – 1:00 p.m.  Cost: $85 per person
The Garden District boasts one of the best preserved collections of historic southern mansions in the United States. Its 19th century origins fashioned opulent estates built by wealthy newcomers who flocked to New Orleans after the Louisiana Purchase, a time of huge prosperity in the city. Guests will experience a knowledgeable and entertaining tour through one of these lavishly restored Garden District homes. This impressive neighborhood, dating back to the 1830s, is well known for its luxurious mansions of Greek Revival style architecture, as well as the lush semi-tropical gardens that surround the homes. Guests will also travel along beautiful St. Charles Avenue and get a glimpse of this famous thoroughfare.

MYSTERIES OF LOUISIANA SWAMPLANDS
Wednesday, June 10, 2015 8:30 a.m. – Noon  Cost: $75 per person
Tour Duration: Approximately 3.5 hours
Join us for an incredible journey into the mysterious swamps and bayous of southern Louisiana. On today’s swamp boat tour, you will be introduced to the interesting history of our Louisiana wetlands and the rich Cajun heritage of the people who inhabit this region. As your swamp boat travels into the depths of Cajun country, you will hear the tales of the Cajun folks and how they reap the bounty of their surroundings: they trap nutria, mink, otter, and muskrat; they hunt frogs, and alligators; and they fish for catfish and crabs. You will soon discover the respect and knowledge the Cajun people have for the wildlife and vegetation indigenous to the swamp.
Social Events

WELCOMING LUNCHEON
DATE: Monday, June 8, 2015
TIME: 11:30 a.m. – 1:15 p.m.
FEE: $60 per person
SPAKER: Angela DeSoto Duncan, PE.

Angela DeSoto Duncan is currently self-employed following a 24-year career with the Corps of Engineers and 3-year career at Tetra Tech. where she lead nation-wide, multi-disciplinary teams of engineers, scientists, and support staff for federal, state, and local government clients. With the Corps, Angela was chief of a multi-disciplinary branch responsible for the budget oversight, scheduling, cost estimating, design, real estate acquisition, and environmental compliance documentation of the Hurricane Protection Offices (HPO) five year, fully funded, $7B Hurricane and Storm Damage Risk Reduction (HSDRRS) program for the metropolitan New Orleans area. HSDRRS program includes approximately 50 construction contracts consisting of levees, floodwalls, sector gates, lift gates, flood control structures, pump station rehabilitation, control houses, and urban drainage projects.

UCA OF SME BREAKFAST
DATE: Tuesday, June 9, 2015
TIME: 7:00 a.m. – 8:30 a.m.
FEE: $45 per person
UCA of SME Chair, Bill Edgerton will present:
• UCA Activities
• Industry updates
• Upcoming conferences
• ITA Report
• Announcement of UCA Scholarship Recipients
  ▶ Lisa Mori, Colorado School of Mines
  ▶ Simon Prasetyo, Colorado School of Mines
  ▶ Kevin Schaeffer, Colorado School of Mines
  ▶ Yuanli Wu, Colorado School of Mines
  ▶ Hamed Zamenian, Purdue University
• Induction of incoming UCA Chair, Artie Silber

RETC DINNER
DATE: Tuesday, June 10, 2015
TIME: 6:00 p.m.: Reception,
6:30 p.m.: Dinner
FEE: $95
Spoker: Lt. General Russel L. Honoré

If anyone knows how to lead and execute a mission, it’s Lt. General Russel Honoré, USA (Ret.), who arrived in a Hurricane Katrina-battered New Orleans in 2005 and saved a city by taking swift charge of military relief efforts. Drawing on his 37 years of military experience, Gen. Honoré now brings his bold, no-nonsense leadership approach to businesses and organizations to help better prepare them for the challenges of the future. He addresses how the public and private sector can solve a broad array of issues — from jobs and energy to healthcare and technology — by emphasizing innovation, risk assessment, and social entrepreneurship.

Gen. Honoré’s experience directing military operations gives him rare insight into the “New Normal,” an era where businesses, policymakers, and the citizenry must lead the way in creating a “Culture of Preparedness” that is equipped to safeguard our economy and natural resources. He also shares how all sectors of industry can get the most out of their people in ways that optimize efficiency and effectiveness of operations — and why we need to save our best leadership for home because our children represent the next generation of problem solvers.

FIELD TRIP
Permanent Canal Closures and Pumps (PCCP)
Date: Wednesday, June 10, 2015
Time: Departs Noon, Returns 4:00 p.m.
FEE: $40 per person
Limit: 50 people
Includes: Tour, transportation and lunch

For the past year, Traylor has been hard at work on the capstone of our post-Hurricane Katrina work in New Orleans: the Permanent Canal Closures and Pumps (PCCP) Project for the U.S. Army Corps of Engineers. As part of PCCP Constructors, a joint venture of Kiewit Louisiana Co., Traylor Bros. Inc., and the M.R. Pittman Group LLC, we are building three permanent structures to block future hurricane storm surges to New Orleans from Lake Pontchartrain.

Not only must the new stations be designed to block surges from a 100-year storm, they must also take into account expected increases in the height of Lake Ponchartrain’s water level during the next 50 years to account for the rising sea level caused by global warming and local subsidence. When the surge closures are operated during storms, the pumps will move 12,500 cubic feet of water per second from the 17th Street Canal into Lake Pontchartrain; 2,700 cubic feet per second from the Orleans Avenue Canal; and 9,000 cubic feet per second from the London Avenue Canal. Temporary pumps and floodgates near the mouths of the three at-risk drainage canals (17th Street, Orleans Avenue, and London Avenue) will stay in place until our team completes the permanent structures.

The project is approximately 35 percent complete, with the preliminary site work and access roads completed. The team has also begun construction of the concrete structures. Project completion is scheduled for September 27, 2016.
Short Courses
Sunday, June 7, 2015

SHAFT CONSTRUCTION AND DESIGN
8:00 a.m. – 4:00 p.m.
$300 Member, $400 Nonmember
Includes: Coffee, lunch, course materials, 7 PDH

This short course is designed to provide a quick review of the various shaft construction methods and some of the basic design guidelines. It covers various subjects from classification and application of the shafts to excavation methods, ground support method, and special topics dealing with groundwater, hoisting, etc. The objective is to review the state of the art and common practice of shaft construction for civil and mining applications for the engineers involved in underground construction. The course will cover drilling and blasting, mechanical excavation, muck haulage, groundwater issues, ground freezing, slurry walls, steel support, shotcrete application, shaft site layout, and will review several case histories. Also, specific design issues related to main applications of shafts such as water/waste water, transportation, and mining will be addressed. With interactive environment and active participation of the attendees, engineers from entry level to more experienced staff can develop an overall view of the methods and get their questions answered by the leading experts in the field.

INSTRUCTOR:
Jamal Rostami
Pennsylvania State University, State College, PA.
He will be joined by a team of experts in the industry.

GROUTING IN UNDERGROUND CONSTRUCTION
8:00 a.m. – 4:00 p.m.
Cost: $300 member, $400 nonmember
Includes: coffee, lunch, course materials, 7 PDH

This one-day short course will present an overview of the materials, equipment and various grouting methods used in association with underground construction and tunneling in soils and rock. Subjects covered will include cements and admixtures, grouting equipment and practices, chemical and cementitious permeation grouting, jet grouting, compaction grouting, pre-excavation grouting, backfill and contact grouting, and cellular grouts. Nine industry experts will give the lectures on these various grouting subjects and techniques. The attendees will also receive a course notebook containing all presentation material by the speakers. This course is recommended for contractors, engineers, owners and consultants involved in any aspect of underground design and construction.

INSTRUCTORS:
Raymond Henn, Brierley Associates, Denver, CO
Paul Schmall, Moretrench, Rockaway, NJ

UNDERGROUND BLASTING TECHNOLOGY
& RISK MANAGEMENT SHORT COURSE SYNOPSIS
8:00 a.m. – 4:00 p.m.
$300 Member, $400 Nonmember
Includes: Coffee, lunch, course materials, 7 PDH

This course is intended to review information that engineers, managers and professionals overseeing underground shaft and tunnel construction should know regarding the safe and efficient use of conventional drilling and blasting methods. Topics include a review of modern explosive and initiation systems, blasting physics and rock breakage, principles of tunnel and shaft round blast design, control of blast-induced ground vibration and air-over-pressure, estimating drill-blast costs, and important risk management practices. Practical elements of controlled blast design and risk management will be reviewed in an interactive blast design workshop and demonstrated in case histories involving many North American tunnel projects.

INSTRUCTOR:
Gordon F. Revey of REVEY Associates, Inc.
A professional mining engineer who has specialized in controlled drill-blast tunneling work for over thirty years.

RETC Sessions At-A-Glance

SUNDAY P.M.
- Tunnel Safety and Other Challenges for the Industry
- Tunnel Issues Regarding Risk and Uncertainty—Comments and Panel Discussion

MONDAY A.M.
- Design and Planning I
- Difficult Ground
- New and Innovative Technologies
- Pressurized Face TBM Case Histories

MONDAY P.M.
- Caver and Large Spans
- TBM Technology
- Design-Build Projects
- Contracting Practices

TUESDAY A.M.
- Hard Rock Tunneling
- Future Projects
- Major Projects
- Ground Support and Final Lining

TUESDAY P.M.
- Grouting and Ground Modification SHAFTS
- Geotechnical Considerations I SEM/NATM

WEDNESDAY A.M.
- Geotechnical Considerations II
- Design and Planning II
- Risk Management
- Trenchless Tunneling and Rehabilitation
TECHNICAL PROGRAM

Tunnel Safety & Other Challenges for the Industry

SUNDAY, JUNE 7, 2015
1:00 p.m.
CHAIRS: N. JOENS, KIEWIT INFRASTRUCTURE CO, OMAHA, NE
J. Choi, PARSONS BRINCKERHOFF, LOS ANGELES, CA

Tunnel Rescue in America – A Realistic View
N. Lipski, National Tunnel Institute, Milwaukee, WI

This paper presents a view of tunnel rescue in the United States, unclouded by politics, myth or misinformation. Further, it demonstrates the critical need for documentation and a unified solidarity of purpose across agencies. The present system is broken. Most municipal Fire Chiefs are now politically appointed and serve in some cases as a revenue-generating agent for the local government. This is a stark difference from the non-electioncycle dependent lifetime appointments that effectively freed Fire Chiefs from the constraints of rapidly shifting political winds, allowing them to focus solely on life safety concerns and effective hazard mitigation. The environment within which tunnel rescue concerns are approached is one of extreme lack of (or no) experience whatsoever, causing each separate fire department, when faced with tunnel construction projects within their jurisdictions, to effectively attempt to reinvent the wheel. Having no single resource for Tunnel Rescue Team development and training, many fire departments cite the National Fire Protection Association (NFPA) as their guide. This is, of course, largely out of the desperation occurring from a complete vacuum of actual information on the matter. There is no silver bullet solution; some of the problems as well as solutions will be offered.

Cleaning Risky Behavior from the Workplace
S. Stier, Taylor Bros., Inc., Washington, DC

The Clean Rivers Project is DC Water’s program to reduce combined sewer overflows into the District’s waterways - the Anacostia and Potomac Rivers and Rock Creek. The $2.6 billion Project is designed to capture and clean water during heavy rainfalls before it ever reaches our rivers. The Blue Plains Tunnel (BPT) is one of three main tunnels being implemented for this massive infrastructure project. The technology necessary to complete this scale of work has success stories from all over the world, but it’s the safety implications, that had those involved with the planning of this work, looking for tunnel contractors who were willing to conform to the most stringent compliance in the safety community. Contractors coming into the District had to rely on the local craft workers for immediate buy-in for the Process Safety Programs that would include the new wave of Behavioral Safety and Risk Behavior safety practices.

Tale of Two Cities – Subaqueous Tunneling in London and New York City 1879 to 1910
V. Tirolo, Arup, New York, NY

Subaqueous shield tunnel construction began in London in 1828 when construction of Marc and Isambard Brunel’s Thames Tunnel began. In London, Peter Barlow, James Henry Greathead, Benjamin Baker and Charles Jacobs developed tunneling practices to include circular shields, hydraulic jacks, cast iron liners and compressed air. In New York City in 1879 DeWitt Clinton Haskins attempted to cross the Hudson River using compressed air but without a shield. A blow in 1880 caused twenty sandhog fatalities. Mining continued but the work was abandoned in 1888 for lack of funds. In London, Barlow and Greathead had successfully mined the 2.178 m diameter Tower Tunnel under the Thames using a circular shield, propelled by screw jacks reacting against a cast iron segmental initial lining. In 1889, Austin Corbin, President of the LIRR invited Charles M. Jacobs of London to come to New York. In 1890 work resumed on the Hudson River when S. Pearson & Son of London assumed the construction contract. Sir Ernest Moir designed the shield for this work and introduced the first medical lock. These events started the collaborative association of the tunneling engineering in both London and New York that would last over thirty years and culminate with the completion of the Pennsylvania Railroad Tunnels under the Hudson and East Rivers in 1910. Concurrent with this mining collaboration, Werner von Siemens in Germany, Frank J. Sprague in the USA and others were developing electric traction systems into reliable systems that would make sub-aqueous railway tunnels possible.

Engaging Future Generations for the Benefit of the Underground Industry
S. Von Stockhausen, Hatch Mott MacDonald, Pleasanton, CA
and P. Campbell, McMillen Jacobs Associates, San Francisco, CA

The field of tunnel engineering and construction is exciting and multifaceted, with unique design and construction challenges and solutions, which offers a diverse and rewarding career path. The underground industry will increasingly face the difficult task of engaging new, talented people to join its workforce. With the growing deficiency of underground academia and increased competition for careers, it is increasingly important for the industry to make a commitment to advance technology, design, and construction through education and outreach programs. This paper examines the current decline of tunnel engineering and construction curricula within educational institutions, and provides strategies to encourage growth in such a stimulating field, with help from contractors, engineers, academia, and professional organizations alike.

Tunneling Issues Regarding Risk and Uncertainty – Comments and Panel Discussion

SUNDAY, JUNE 7, 2015
2:00 p.m.
CHAIR: RUSSELL CLOUGH, PALO ALTO, CA

This session addresses events in the industry as well as recent research and books such as Predictably Irrational and The Black Swan. It will cover how to better understand uncertainties and human behavior in the planning and building of projects using models, case studies, and class exercises. In ambiguous and risky situations, how do we recognize biases, opinions, and beliefs that hinder us from making the best choices? Why do others have such different views of “logical and rational” decisions? How do we improve critical thinking skills in random and/or high risk situations? How do we minimize the cost escalations and harmful publicity that result? Specific work and teaching experiences are used to address the audience background and interests but generally speaking these topics are relevant to all.
Design & Planning I

MONDAY, JUNE 8, 2015

8:30 a.m.

CHAIRS: J. SANKAR, HNTB, NEW YORK, NY
G. FAIRCLOUGH, SCHIAVONE CONSTRUCTION CO. LLC, Secaucus, NJ

Critical Connections: Planning and Preparation Needed for the Eastside Access Project's Westbound Bypass Jacked Shield Tunnel

F. Perrone, Hatch Mott MacDonald, Lymbrook, NY;
E. Prantil, Hatch Mott MacDonald, New York, NY and A. Klag, STV

Harold Interlocking is a vital rail connection for Amtrak, the Long Island Railroad (LIRR) and New Jersey Transit traveling to and from New York City’s Pennsylvania Station, and is considered the busiest passenger rail corridor in North America. During the planning of East Side Access, the development of a conflict-free route to support Amtrak was necessary. East Side Access Contract CH057A, otherwise known as the Westbound Bypass Tunnel, will support this conflict-free route via the construction of 630 feet of soft-ground tunnel mined with a traditional jacked shield. The tunnel will be mined with extremely shallow cover beneath Harold Interlocking and a reinforced concrete track slab. This paper describes the preparatory work and extensive planning needed to facilitate construction of the protective track slab.

South Hartford CSO Tunnel and Pump Station

V. Nasri, AECOM, New York, NY; W. Bent, AECOM, Rocky Hill, CT
and W. Hogan, Hartford, CT

The South Hartford Conveyance and Storage Tunnel (SHCST) is a major component of the Hartford Metropolitan District’s Clean Water Project (CWP). This tunnel is intended to capture and store Combined Sewer Overflows (CSO) from the southern portion of Hartford, CT, and Sanitary Sewer Overflows (SSO) from West Hartford and Newington, CT. The project is estimated to cost approximately $500 MM and will be constructed in multiple construction contracts. The project components include a deep rock tunnel 21,800 feet in length with a 20 feet excavated diameter, several miles of consolidation sewers, multiple hydraulic drop shafts with deaeration chambers and a 50 MGD tunnel dewatering pump station. The TBM-bored tunnel will be excavated in shale, siltstone and basalt through several fault zones. AECOM is currently performing the final design for this project. This paper discusses the major aspects of the final design of the SHCST.

High Speed Two (HS2) – General Overview of Project with Focus on Tunneling Challenges

C. Rawlings, CH2M Hill, London, UK; J. Carroll, Skanska;
M. Leggett and B. Harland, Mott MacDonald; I. Gee, Atkins;
V. Portal Cabezuelo, INECO and H. Jung, Arup

The High Speed Two (HS2) scheme ($64 billion) will provide a high speed railway network increasing connectivity & capacity across the United Kingdom (UK). Up to 62 km of twin bore and 10 km of twin cell cut-and-cover tunnels are planned with associated cross passages and shafts. A preliminary design has been completed to define the optimum route and the associated environmental details for government approvals. The tunneling challenges have included: increasing the total tunnel length (8.5 km) approaching London to avoid a surface alignment disrupting important infrastructure; resolution with the interface with Old Oak Common Station; tunneling through Groundwater Source Protection Zones and Areas of Outstanding Natural Beauty; tunneling beneath Ancient Woodlands; an additional (2.8 km) tunnel avoiding a surface alignment through an elevated highway area near Birmingham; and the logistics associated with the supply of tunnel segments and transportation & disposal of the excavated material from the underground construction activities. This paper describes how these challenges were overcome with review of the tunnel route options, route selection, aerodynamic design, and also summarizes the work done by HS2 Ltd to explain the impacts of tunneling for use in public consultation.

Evolution of Large Diameter TBM Road Tunnel Design

H. Asche, Aurecon, Brisbane, Australia; G. Bertakis, AECOM, Melbourne, Australia and E. Taylor, John Holland, Melbourne, Australia

TBM driven road tunnels with 3 lanes or more are becoming more common, but present special difficulties with respect to optimizing the cross section. Fitting the road envelope within a circular tunnel makes for an inefficient use of space in an expensive tunnel. Constructing the road pavement can involve a large and time consuming backfilling operation. The position of the roadway in the TBM cross section for 3 lanes also affects the design of the cross passages and creates special difficulties for tunnel design and construction. The paper describes some of the issues and presents the evolution of designs that provide the owner with significant advantages during the operational phase.

Project Configuration and Design Challenges for the City of Ottawa Combined Sewage Storage Tunnel Project

A. Dean, Stantec Consulting Ltd., Walnut Creek, CA; S. Fradkin, Stantec Consulting Ltd., Orlando, FL; C. Quintero, CH2M Hill, Ontario, Toronto, Canada; R. Dempsey, City of Ottawa, Ottawa, Canada; A. Comeau, Stantec Consulting, Ottawa, Canada and D. Del Nero, Stantec Consulting Ltd., Duluth, GA

The City of Ottawa’s Combined Sewage Storage Tunnel project consists of two interconnected tunnels comprising a total length of 6.5 km with a finished diameter of 3 meters and associated access shafts and hydraulic structures. It will provide storage capacity to reduce CSOs and outlet capacity for base-ment flooding protection. Specific considerations include construction in the immediate vicinity of the Supreme Court of Canada, downtown core, and busy Highway 417 corridor; low cover beneath the Rideau Canal and Rideau River; mining through interbedded limestone and shale; and proximity of construction to underground works on the Ottawa Light Rail Transit System.

Modeling of Ground Deformation Control Induced by Slurry Shield Tunneling

Z. Li, J. Grasmick and M. Mooney, Colorado School of Mines, Golden, CO

Ground deformation induced by soft ground tunneling can cause consequential damage to existing infrastructure if proper controls are not achieved. Highly controlled pressurized face tunneling combined with tail-shield segment void grouting has yielded significant reduction in ground surface settlement. In some projects, such as the East Side Access Queens Bored tunnels, near zero ground surface deformation was achieved through proper control of support pressures. To investigate TBM control of ground deformation, 3D soil-fluid coupled finite element analysis was conducted with detailed modeling of the construction sequence (such as face and annulus pressure, as well as grout and segment behavior). The findings derived from finite element modeling and the comparison against field measurements identified critical ground deformation mechanisms during pressurized-faced tunneling. Results show that both the face pressure applied at the cutterhead and the slurry annulus pressure in the shield skin void control the ground deformation during the passage of TBM.
Difficult Ground

MONDAY, JUNE 8, 2015
8:30 a.m.
CHAIRS: G. HAUSER, DRAGADOS USA, SEATTLE, WA
A. SMITH, CH2M HILL, BURNABY, BC, CANADA

Challenges and Methods Utilized to Excavate Rock for an Escalator Incline Through a Luxury High Rise Building in Manhattan
A. Smith and A. Dhimarko, Skanska USA Civil NE, New York, NY
and J. Collins, AECOM, New York, NY
As part of the ongoing 2nd Avenue Subway extension program MTA Capital Construction (MTACC) has contracted with Skanska/Traylor Joint Venture (STJV) to perform mining and structural concrete work for the 86th Street Station. One of the key components, as well as one of the highest risk pieces of work, on the 86th Street Station contract was to excavate rock through an existing luxury high rise apartment building to make way for the escalator entrance. This work required temporarily supporting the building to allow for the removal and subsequent replacement of main support columns which interfered with the future escalators. This paper will discuss the successful engineering, planning, and execution phases of this critical aspect of the excavation and underpinning of the high rise building.

Combined Solution Karlsruhe, Heavy/Light Rail Tunnel and Light Rail Boulevard, Germany Inner-City Tunnel Advance at Little Overburden in Difficult Geology
H. Göhringer and M. Schimmelpfennig, BeMo Tunneling GmbH, Innsbruck, Austria and F. Nenninger, Karlsruher Schieneninfrastrukturgesellschaft mbH (KASIG), Karlsruhe, Germany
The area of Karlsruhe, Germany has a fast growing public transportation system. In the last 15 years the number of passengers increased by 45 % to approximately 178 million, and therefore requires a new light/heavy rail tunnel, which is already under construction. Design and construction processes are highly influenced by the logistical and technical challenges derived from the heart of the inner city of Karlsruhe. Beside the description of the general logistical concept and its measures to control the individual and public traffic flow under consideration of the additional movements for the construction site, the tunnel and station design is presented in the article. However, the emphasis of the article is on how to face the great challenges of inner-city tunneling at little overburden in difficult geological conditions without impacting light rail, road and pedestrian traffic.

Case History of Canopy Tubes used in Metro Expansions in Santiago, Chile and Vienna, Austria
T. Avery, Avar Construction, Fremont, CA; A. Stelke, Minroc;
C. Leigh and R. Roman, Jennninterational, Santiago, Chile
Canopy tubes are frequently used in the Sequential Excavation Method (SEM) to provide stability in bad ground ahead of a portal or tunnel face. Canopy tubes or umbrella tubes are a support element consisting of a series of small diameter pipes, ranging from 76.1 mm to 168.3 mm diameter. Two projects demonstrating the ability of canopy tubes are summarized in this paper. The first project is the Santiago Metro in Santiago, Chile, which relied heavily on canopy tubes for construction of new stations and tunnels on the new Line 6. A design methodology using canopy tubes, lattice girders and shotcrete should reduce the construction time of the stations from 17–25 months down to 9–10 months. The second project is the expansion of the U1 subway line in Vienna, Austria where telescoping canopy tubes were used to provide support going through a diaphragm wall underneath an existing highway tunnel.

Tunnels, Tiebacks and Piles: A Design Case History of Dealing with Obstructions
J. Parkes, Parsons Brinckerhoff, Baltimore, MD; H. Cordes, Parsons Brinckerhoff, Washington, DC and J. Wisniewski, Parsons Brinckerhoff, Baltimore, MD
The proposed Baltimore Red Line light rail project includes a 3-mile-long downtown tunnel with five underground stations and twin TBM mined tunnels. The vertical alignment includes the requirement for the proposed Inner Harbor Station to connect to an existing Metro station. During design, it was discovered that basements along both mined Inner Harbor Station approaches were constructed with soldier piles and tiebacks. These elements pose significant risks, including direct conflicts with TBM excavations. Mitigation options considered include frequent TBM interventions, cut-and-cover and sequential excavation method sections to remove obstructions, and alignment changes. Projects with similar precedence were evaluated, including the Central Subway in San Francisco, Regional Connector in Los Angeles, and projects in Europe and Korea. Alternatives, advantages and disadvantages, and ultimate solution are discussed.

Abu Hamour Tunnel Project in Doha, Qatar
M.R. Jafari, CDM Smith, Providence, RI; F. Barbardeau, J. Stypulowski and A. Siyam, CDM Smith, Doha, Qatar
Abu Hamour Tunnel - Phase 1 will discharge storm water from southern and western Doha via an existing tunnel to sea. The project includes 31,000 LF of 14.8 ft outside diameter (O.D.) tunnel, 27 access shafts, and 4760 ft of trenchless crossing. The tunnels shall be constructed by two EPB TBMs, launched from a shaft in the middle of the tunnel alignment, proceeding in opposite directions toward receiving shafts. The tunnel will be supported by steel fiber reinforced concrete segmental lining. The tunnel alignment passes through very complex and challenging subsurface conditions. This paper presents the design and construction aspects.
New & Innovative Technologies

MONDAY, JUNE 8, 2015

8:30 a.m.

CHAIRS: P. FINN, JF SHEA, NEW YORK, NY
N. CHEN, JACOBS ENGINEERING, OAKLAND, CA

Synthetic Fiber Reinforcement for the Cast in Place Final Tunnel Liner at the Euclid Creek Tunnel Project

J. Carlson, Kiewit Infrastructure Group, Inc., Omaha, NE; D. Wotring, Hatch Mott MacDonald, LLC, Cleveland, OH; R. Auber, Northeast Ohio Regional Sewer District, Cleveland, OH and M. Vitale, Hatch Mott MacDonald, LLC, Cleveland, OH

The Euclid Creek Tunnel is largely a precast concrete, segmentally lined, single shield driven CSO tunnel. The launch chambers, consisting of a tail and enlarged starter tunnel, were excavated by a roadheader in advance of the TBM arrival. After the TBM drive was completed, these launch chambers required a cast in place final liner that was originally designed with a single layer of circumferential and longitudinal reinforcing bars. This paper reviews the program to substitute a wholly plastic fiber-reinforced final lining in lieu of the reinforcing steel, including design, testing, construction and challenges of implementation.

A Controversial Discussion Regarding the Use of Spray-Applied Waterproofing for Tunnel Applications

S. Lemke, Sika Services AG, Zurich, Switzerland and P. Moran, Wisko America, Inc., Chantilly, VA

For some time now, spray-applied waterproofing has been reviewed and discussed as viable materials and methods for tunnel waterproofing applications. Unquestionably, these products have been applied on some underground projects, but seemingly with rather inconsistent results. The aim of this paper is to present an objective overview and to identify some potentially critical limitations of this technology and approach.

Web-based Process Controlling of Shield Tunneling

U. Maidl and J. Stascheit, MTC Maidl Tunnelconsultants, Munich, Germany

Shield machines are equipped with various sensors that provide a complete picture of the tunnelling process. These data allow assessing and steering the process to optimize safety and efficiency. We present PROCON, software capable of gathering machine and monitoring data, geotechnical information, intervention and shift reports and other data sources. Acquired information is visualized in a unified time/space reference. Thus, all data can be evaluated in terms of correlations, potential hazards or actual/target deviations. Data mining and knowledge based methods are employed for further analyses.

The capabilities are demonstrated by means of reference projects.

Design of High Head Temporary Concrete Tunnel Plug

J. Singh, M. Baishya, B. Kenny and T. Boatwright, Kiewit Infrastructure Co., Omaha, NE

The Chicagoland Underflow Plan (CUP) McCook Reservoir Project constructed by Kiewit Infrastructure Co is a $121 million project. It is a shot rock excavation, concrete lined 10.1 m (33 ft) finished diameter tunnel that ties into an existing operational sewage tunnel designed to capture and store combined sewer overflows (CSO) until it can be pumped and treated before being released to local waterways. A concrete plug was designed to facilitate tie-in work concurrent with newly constructed tunnel works and final shaft concrete. The plug was required to support 87.2 m (286 ft) of water head at 11.9 m (39 ft) diameter. Plug design optimizes reinforcement and thickness of concrete required. The paper examines plug behavior of different thicknesses and reinforcement requirements coupled with the operational problems faced during construction.

Challenges in Tunneling with a Hard Rock Slurry TBM in Columbus, Ohio

B. Rautenberg, Kenny Construction, Columbus, OH; K. Yamauchi, Obayashi Corporation, Columbus, OH; P. Smith, Black & Veatch, Columbus, OH; G. Fedner, City of Columbus Department of Public Utilities, Columbus, OH and M. Hall, H R Gray, Columbus, OH

The City of Columbus OSIS Augmentation Relief Sewer (OARS) is a major component in the City’s Long Term Control Plan (LTCP) for CSOs. The alignment passes through karstic-solution featured limestone that called for a hard rock slurry pressure balance TBM to control the large water volumes anticipated. The project is unique as it required the utilization of several innovative ideas to drive one of the longest hard rock tunnels using a slurry TBM. The paper will explore several of these ideas such as muck and slurry removal, installation of an upgraded slurry system during production mining, and several unique methods of cutterhead access.
Pressure Face TBM Case Histories I

MONDAY, JUNE 8, 2015
8:30 a.m.
CHAIRS:  B. HAGAN, JAY DEE CONTRACTORS, SEATTLE, WA
K. BANEK, FRONTIER KEMPER CONTRACTORS INC., VANCOUVER, CANADA

Lake Mead Intake No. 3 – TBM Tunneling at High Pressures
J. Nickerson, R. Bono, C. Cimiotti, Vegas Tunnel Constructors JV, Boulder City, NV and E. Moonin, Southern Nevada Water Authority, Las Vegas, NV

In response to the severe drought on the Colorado River basin and in order to preserve existing water capacity to the Las Vegas Valley, the Southern Nevada Water Authority contracted a new deep-water intake (Intake No. 3) located in Lake Mead. The current project (Contract No. 070F-01-C1) includes three miles of tunnel with very difficult geological conditions and a 650ft deep shaft and marine works. This paper will present the current status of the design-build contract being conducted by Vegas Tunnel Constructors, the challenges and problems faced, and the innovative solutions developed to handle the difficult conditions encountered during tunneling with up to 15 bars of pressure.

London Power Tunnels – 3m TBM Tunnel Drive (Evelyn)
L. Stenman, Skanska, London, UK; A. Mackenzie, Costain, London, UK and D. Green, Mott MacDonald, Croydon, UK

National Grid is one of the largest investor-owned energy companies in the world and plays a vital role in delivering gas and electricity to millions of people across Great Britain and north eastern U.S. To ensure there is sufficient transmission infrastructure available to support future energy demand, the one billion pound London Power Tunnels programme was launched by National Grid to create a 32km energy superhighway comprising 400kV cable tunnels and six sub-stations. Most of the existing high voltage circuits in London are buried in shallow trenches constructed over 40 years ago. Placing the cables in deep tunnels would avoid disruption to the road network for repair and maintenance work and additional cables can be installed in the tunnels to meet future demand.

TBM Cutterhead Interventions at Eglinton-Scarborough Crosstown Tunnel Construction (ECLC1-15)
J. Yamashita, O. Nishikokura and M. Sheehan, Obayashi Canada, Toronto, Canada and C. Stewart, Kenaidan Constructors, Ltd., Mississauga, Canada

As part of a new light rail transit system in Toronto, 6.5 km long twin tunnels are being constructed by Crosstown Transit Constructors using two Earth Pressure Balanced TBMs. Cutting tools are routinely inspected and replaced as required at each of the station headwalls. The geological condition at each intervention is carefully examined and incorporated in the planning of preparatory work to achieve safe interventions. The paper describes lessons learned from cuttinghead intervention experiences and also discusses differing cutting tool wear amount based on differing geological conditions.

Preparation for Tunneling, Northgate N125 Project in Seattle, WA

The Sound Transit Northgate Link Contract N125 Project includes 5.6 km of twin subway tunnels in the northern end of the City of Seattle, WA, USA. This project includes the excavations for two underground stations, as well as the excavation and final concrete lining for the twin tunnels, 23 cross passages, and a portal. Jay Dee Contractors, Inc., Frank Coluccio Construction Company, and Michels Corp. formed an LLC (JCM) for the construction of this project. The tunnels are expected to be driven with 2 refurbished TBMs, one of which was previously used by JCM on an earlier Sound Transit Project, while the other was previously used on a project in Singapore. A third TBM is being refurbished as a standby machine to be used if problems are encountered on either of the initial two TBMs. This paper summarizes the preparation work that has been done prior to starting the major tunneling work on the project, including the refurbishment of the initial two TBMs.

Central Subway Tunnels: Success under San Francisco

The SFMTA Central Subway Tunnels contract is wrapping up after an excellent performance by BIH driving twin 20-foot-diameter (6 m) Robbins EPB machines 1.7 miles (2.7 km) through soil and rock under the heart of San Francisco, while managing 450-foot (137 m) radius curves and stringent alignment tolerances, and crossing 12 feet (3.7 m) below active BART tunnels. Close attention to face pressure, muck volume, and annulus grouting resulted in minimal settlements, with 50 feet/day (15 m) average and 130 feet/day (40 m) maximum advance rates. This paper provides the contractor, designer, and CM/RE team’s perspectives on the $240 million project and describes how together they mitigated potential problems using thoughtful engineering, best practices and new technologies.

Rescue and Refurbishment of a TBM Inundated with Flood Waters at the New York City Harbor Siphon Project
R. Cope, The Robbins Company, Solon, OH and D. Willis, The Robbins Company, Kent, WA

In October 2012, New York City’s Harbor Siphons Project and its 3.6 m CAT EPB ground to a halt when hit by Superstorm Sandy. Despite contractor Tully/OHL JV’s best efforts to mitigate anticipated flood risks, the launch shaft was inundated with seawater, flooding the tunnel and TBM just 460 m into the 2.9 km long drive. A team of Robbins and OHL personnel were able to document, reverse engineer, and refurbish severely corroded components of the TBM while in the tunnel, resulting in a successful re-launch in April 2014. This paper will document the incredible efforts of the team to rescue and refurbish the TBM, and its performance since the restart.
Cavern & Large Spans

MONDAY, JUNE 8, 2015
1:30 p.m.
CHAIRS: S. HOFFMAN, SKANSKA USA CIVIL, NEW YORK, NY
D. MOUNT, SKANSKA, ROCKVILLE, MD

Holmestrand Underground Railway Station from Vision to Reality
S. Ilebrevkke Undrum, The Norwegian National Rail Administration, Oslo, Norway and G. Anders Kildemo, Skanska Norge AS, Oslo, Norway
A new overground railway station in Holmestrand, Norway was planned in the 1990s. The need for higher speed involved more stringent requirements and a whole range of compensatory measures, which resulted in the planned station being moved underground. The station hall is unique worldwide, with four tracks passing through the station, two of which are through-tracks, designed for trains travelling at speeds of up to 250 km/h. The other two tracks are for boarding and alighting of passengers along the platforms. The total length of the tunnel is 12.3 km, and the station hall is located near the middle. We know of no other projects of this nature elsewhere in the world, and the design and construction of the state-of-the-art solution has posed many challenges. A variety of models were used to calculate pressure/suction forces, air speeds, the fire/evacuation concept and acoustics in the station hall, and a series of site investigations were carried out to develop theoretical models for mapping the rock conditions and hydrology. During the building process, the contractor used severe high pressure grouting, shotcrete, lattice girders and up to 12 m long rock anchors to secure the station hall, which has a cross section of 550 m². The contract for the underground work in the station hall was signed with Skanska in October 2011, and the project is scheduled for completion by the end of 2016.

New York City Grand Central Subway Station Planned Modifications and Improvements
A. Grigoryan, Parsons Brinckerhoff, Ridgewood, NJ and T. Jablonski and D. Haase, MTA-NYCT, New York, NY
The Metropolitan Transportation Authority—New York City Transit – anticipating an increase of ridership caused by the Long Island Railroad (LIRR) East Side Access project, the No. 7 Subway Extension project, and the proposed East Midtown rezoning – is planning Grand Central Station improvements to alleviate congestion and improve circulation. The improvements represent the following significant planning, engineering and construction challenges:

- Extensive rock excavation and construction below the operating 42nd Street Shuttle passageway.
- Underpinning and temporary support, re-framing and structural modifications, while maintaining passenger services, train operations, and street traffic.
- Reconfiguring the existing No. 7 Flushing Line station roof arch to add a new stair and passageway connection to the Lexington Avenue Line. The work would require rock excavation and new construction over the roof of operating subway station.
- Phasing the work to minimize impact on station operations.

Second Avenue Subway Project: Design and Construction of Large Cavern Final Linings and Penetrations at 86th Street Station
M. Voorwinde, AECOM, New York, NY; E. Garavito-Bruhn, Arup, New York, NY; L. Dalton, AECOM, New York, NY and R. Giffen, Arup, New York, NY
This paper focuses on the structural design and construction of final linings for large mined caverns at the new 86th Street Station as part of Phase 1 of the Second Avenue Subway Project in Manhattan. It covers the design of final linings with shallow rock cover spanning over 19m (63ft) and up to 17m (56ft) in height. Major topics include utilities challenges, site constraints, geometry, loads, modeling and structural analysis. The complexity of dual level mined ventilation adits, large liner penetrations, and the consideration of groundwater are discussed. The project background, construction contract packaging and milestones, interfaces and innovative engineering solutions are explored. Close collaboration and partnering efforts between the design and construction teams to successfully deliver the project are also presented.

Roof Displacements in Pump Station Cavern in the Chagrin Shale
B. Doyle, MWH, Milwaukee, WI; M. Djavid and M. Moridzadeh, MWH, Chicago, IL and D. Gabriel, NEORSD, Cleveland, OH
The Tunnel Dewatering Pump Station (TDPS) is part of a plan by the Northeast Ohio Regional Sewer District (NEORSD) to limit combined sewer overflows (CSOs) to Lake Erie, one of the U.S.'s Great Lakes. During wet weather, CSOs are diverted into a network of storage tunnels. Two of these tunnels, 24 feet in diameter and about 200 feet deep to invert, terminate at the TDPS site. Following a wet weather event, the TDPS will pump stored water from the tunnels up to a shallow sewer to be conveyed to NEORSD’s Easterly Wastewater Treatment Plant. The TDPS will be operated remotely from the Easterly Plant, and will be occupied only for inspection and maintenance. The TDPS Pump Room houses seven pumps with a combined capacity of 160 mgd. The Pump Room was designed as a rock cavern in shale. During excavation of the top heading, rock along the roof centerline displaced downward as much as 0.5 foot, more than was anticipated and more than is typically observed in rock cavern construction. The magnitude of the displacement and the prolonged time over which it progressed raised concerns about long-term stability. This paper summarizes evaluations performed during and after construction to identify the cause of displacement and to confirm the long-term stability of the structure.

St. Louis’ Sewer Tunnel Vision
P. Pride, Metropolitan St. Louis Sewer District, St. Louis, MO and M. Robison, J. Bergenthal and W. Klecan, Jacobs Engineering, St. Louis, MO
Metropolitan St. Louis Sewer District (MSD) manages the fourth largest sewer collection system in the United States. It has started Project Clear, a 23 year program of constructing tunnels and other improvements to control sewer overflows. The largest component of the program, the Lower and Middle River Des Peres CSO Controls System Improvements, includes four major underground projects. This paper describes challenges facing the 9 mile long x 30 ft diameter Lower and Middle River Des Peres CSO Storage Tunnel; the 17,000 ft long x 7 ft diameter Jefferson Barracks Tunnel; the 3,000 ft long x 28 ft diameter Maline Creek Cavern; and the 3,200 ft long x 8 ft diameter Lemay Redundant Force Main Tunnel. This paper will also deliver a brief overview of the remaining five tunnels in the program.
Contracting Practices
MONDAY, JUNE 8, 2015
1:30 p.m.
CHAIRS: A. DELLE, SCHIAVONE CONSTRUCTION CO., LLC, SECAUCUS, NJ
F. KLINGER, FK ENGINEERING ASSOCIATES, TROY, MI

I-70 Twin Tunnel Widening Using Drill and Blast Under CM/GC Contract
K. Shimomura, Kraemer/Obayashi JV, Burlingame, CA; M. Fowler, Parsons
Brinckerhoff, San Francisco, CA; M. Keleman, Colorado DOT, Golden, CO;
C. Fischer, Parsons Brinckerhoff, Denver, CO; M. Hogan, Kraemer/Obayashi,
Castle Rock, CO and S. Kim, Parsons Brinckerhoff, San Francisco, CA
The 700 ft-long Twin Tunnels west of Denver have been a notorious traffic
choke point on Interstate 70. As part of a program to improve reliability along
the entire I-70 mountain corridor, Colorado DOT undertook widening both
tunnels over two 9-month summer closures beginning in 2013. CDOT elect-
ed a Construction Manager/General Contractor delivery method to address
the aggressive schedule whereby the Designers and Contractor worked to-
gether with CDOT to optimize the design and specifications to maximize the
production rates while maintaining safety and quality. This paper describes
how drill-and-blast methods advanced from multiple headings were used to
widen each of the two-lane tunnels from a 32 ft width to 53 ft through vari-
ably fractured and weathered gneiss and pegmatite including how a novel,
dual form concrete lining operation was applied.

Support of Excavation for Roosevelt Station: Successful Partnering
Overcomes Challenging Construction Change
I. Banerjee, CH2M Hill Inc., Bellevue, WA; H. Habil, Case Foundation Compa-
nny, Roselle, IL; E. Lenker, McMillen Jacobs Associates, Seattle, WA; E. Shorey,
CH2M Hill Inc., Bellevue, WA and B. Cowles, Sound Transit, Seattle, WA
The Roosevelt Station is one of the 2 intermediate box excavations on the
N125 Contract of Central Puget Sound Regional Transit Authority’s Northgate
Link Extension Project in Seattle, WA. During design, the owner and designer
settled on secant piles and tie backs for support of excavation. After award
of the contract, the contractor expressed concerns about lead times for
material procurement for the secant piles and advised that they were looking
at alternative support methods. The contractor proposed a slurry diaphragm
system to address their schedule concerns and improve upon the leakage
and surface flatness requirements of the contract. This paper presents
the cooperative process undertaken by the owner, designer, construction
manager and contractor to integrate the contractor’s concept into the design,
identify and address potential concerns with the design change, proactively
engage the city’s staff to streamline the permit review process, and suc-
cessfully complete the installation of slurry diaphragm wall system. Issues
and challenges that were encountered during development and execution of
the slurry diaphragm wall work are identified along with the steps taken to
mitigate them.

Integrated Design Process for First Street Tunnel
S. Young, Skanska USA Civil, Queens, NY; D. Smith, Parsons Brinckerhoff,
New York, NY; W. Levy, DC Water, Washington, DC and S. Njoloma, McMillen
Jacobs Associates, Washington, DC
The First Street Tunnel project is part of DC Water’s Clean Rivers Program
to provide initial flood relief in the DC Northeast Boundary area. This Design
Build project has an aggressive schedule to complete design and construc-
tion of four deep shafts, 2,700 feet of 20-ft diameter tunnel, three mined
adits, and four deep diversion chambers in 30 months. The construction will
be in close proximity to homes and businesses and requires complex design
of frozen ground shafts and adits, and deep support of excavation utilizing
secant pile and slurry wall. This paper discusses the integrated design
process between the contractor, the designer and DC Water’s project team.
The result was an effective design, completed in time for construction, that
minimized the impact of construction on the community.

Partnering Through Risk Management: Lake Mead Intake No. 3 Risk
Management Approach
J. Grayson and J. Nickerson, Vegas Tunnel Constructors, Boulder City, NV and
E. Moonin, Southern Nevada Water Authority, Las Vegas, NV
This paper presents the risk management methodology that was imple-
mented by the project team, the design-builder, Vegas Tunnel Constructors
(VTC) and the owner, Southern Nevada Water Authority (SNWA), on the Lake
Mead Intake No. 3 project. Utilizing an innovative risk management approach
developed by the team and managed by VTC, all parties collaborated to
effectively develop a strong partnering approach through the risk manage-
ment process. The team met regularly and jointly prepared and managed the
project risk register throughout the duration of construction with guidance
from a third party risk facilitator. Although this technically challenging project
has experienced difficult times, because of the commitment of the project
team to engage in partnering through the risk management process many
successes were achieved.

Construction – You Need Risk-Based Cost Estimating
J. Reilly, John Reilly International, Framingham, MA;
P. Sander, RiskConsult, Innsbruck, Austria and A. Moergeli, Moergeli
Consulting LLC, Schmerikon, Switzerland
Every cost estimate is uncertain. Underestimating construction costs by
owners in the planning or design phase or by contractors in the bidding
phase, and the possibility of low probability/high impact “black swan”
events, can lead to disputes, claims, and litigation. A better understanding of
potential costs can help owners budget and secure authorization for projects
with a reduced chance of cost overruns. A better understanding of potential
costs can help contractors in determining an appropriate base cost and mar-
gin for bidding, strategies to secure the work in a low-bid environment, and
construction management strategies to maximize profit, to avoid loss, and to
better manage and recover costs of construction changes and claims. This
paper will address cost estimating methods focused on construction. It will
address the uncertainty inherent in predicting the value of any future project
element or process as well as identifying risk (threats or opportunities) that
can impact outcomes. It will address risk-based methods that can improve
our understanding of the cost of uncertainty and potential risk events.
Design- Build Projects

MONDAY, JUNE 8, 2015
1:30 p.m.
CHAIRS:  M. YOUNIS, ALDEA SERVICES, FREDRICK, MD
 J. DILLIO, TRAYLOR

Urban Challenges of the Downtown Los Angeles Regional Connector Tunnel Project
W. Hansmire, Parsons Brinckerhoff, Los Angeles, CA; G. Roy, Los Angeles County Metropolitan Transit Authority, Los Angeles, CA and F. Smithson, Skanska USA Civil, Los Angeles, CA
The Los Angeles Regional Connector tunnel project in downtown Los Angeles is in its first year of construction and has had many challenges working in the dense urban downtown environment, both political and technical. The project has special requirements for the start of tunneling, mitigation of noise and vibration during tunneling and for light rail transit operation, extensive inter agency coordination, community outreach, and special underground station design for a future high rise building. This paper will present the urban challenges of design and construction for this major urban transit tunnel project.

Concrete Operations at the 86th Street Station for the 2nd Avenue Subway Line
C. Schoch and S. Hoffman, Skanska USA Civil NE, New York, NY and A. Parikh, MTA Capital Construction Company, New York, NY
As part of the ongoing 2nd Avenue Subway extension program, which will relieve major congestion for subway riders on Manhattan’s east side, MTA Capital Construction (MTA CC) contracted Skanska/Traylor Joint Venture (STJV) to excavate and place concrete liner for the station cavern of the 86th Street Station and approximately 2,600 ft of TBM mined tunnel. Due to an aggressive schedule to meet project milestones, concrete operations began before excavation was completed and became more intense as the project proceeded. This paper will describe the means and methods employed to balance the expedited concrete operations while maintaining job safety and providing high quality work. The obstacles that were overcome include the pumping of concrete over long distances, supplying multiple operations from sometimes only one shaft, consistently working at heights, and working on inclines—while working only during the permitted hours each day for surface work. We will describe the custom form work designed specifically for this job, and also how the project was able to overcome the challenges of working in very tight staging and work areas in the cavern and on the street. This job is a great example of how good preplanning can lead to efficient execution and a job all parties can be proud of.

PPP Mode for Procurement of Lines 2 and 4 of Lima Metro
A. Lavagna and N. Ruga, Geodata Engineering, Italy and C. Garcia Gods Naveda, Proinversión, Peru
The new (and first entirely underground) lines 2 and 4 of the Metro Lima network represent a huge challenge in Peruvian infrastructure standards, even if the country is strongly committed to the Public Private Partnership (PPP) promoted by its pro-business organization Proinversión. With a whopping $6.5 billion DBFOT-type contract, co-financed by Peruvian State, the project involves 35 stations and 35 km of fully UTO underground lines, to be drilled mainly by TBMs, in a country with little or no experience in urban tunneling. The concession process was accomplished successfully in an outstanding 20-month period, from the consultancy assignment to the signing of the concession contract.

Unique Characteristics of the Design and Construction of the Second Midtown Tunnel in Hampton Roads, VA
S. Quinn, Parsons Brinckerhoff, Boston, MA; I. Chaney, Parsons Brinckerhoff, Virginia Beach, VA and D. Francis, SKW Constructors, Sparrows Point, MD
The second Midtown Tunnel is part of the Virginia Department of Transportation’s $2.1 B Elizabeth River Tunnels Project consisting of a new tunnel under the Elizabeth River between Portsmouth and Norfolk, Virginia. Parsons Brinckerhoff is serving as the lead designer for the DB Contractor, SKW Constructors, A Skanska, Kiewit, Weeks JV. The 11 Immersed Tunnel elements are constructed of reinforced concrete, containing two travel lanes, shoulders and an escape corridor. Tunnel elements are constructed in Baltimore and towed down the Chesapeake Bay to Portsmouth with placement of the elements underway.

This paper will examine the design and construction aspects of the ITT (Immersed Tube Tunnel), including challenges such as the presence of poor soils along the tunnel alignment, the 120-year design life requirement and the coordination between the “project-space” design and the “dock-space” construction.

Practical Aspects of Final Design Development Using Design-Build Procurement
This paper focuses on generating a final design within a design-build (DB) procurement structure. Experience gained from a combined sewer overflow (CSO) deep-tunnel storage program is used to highlight some benefits and drawbacks experienced using the DB method as they pertain to issues such as establishing design criteria; coping with third-party impacts and regulatory requirements; role of the engineer of record; owner’s review and approval; the process of collaborating and reconciling differing opinions and approaches to design; encouraging contractor innovation; and differences between administration of final design on DB and traditional design bid build (DBB) projects.

The Planning and Procurement Process of the Northeast Boundary Tunnel (NEBT) Project: DC Water – District of Columbia
DC Water and Sewer Authority (DC Water) is in the planning and development stage for the Northeast Boundary Tunnel (NEBT) Design Build project. The NEBT is part of the DC Clean Rivers Project (or Combined Sewer Overflow [CSO] Long Term Control Plan) that will significantly reduce CSOs to the Anacostia River by over 98% and reduce flooding in the northeast and northwest parts of the District of Columbia. DC Water has successfully procured nearly $1 billion worth of large, soft-ground tunnel projects over the past six years including the Blue Plains, Anacostia River and First Street Tunnels. The NEBT comprises 27,000 feet of 23-foot diameter, soft-ground tunnel ranging in depth from 80 to 160 feet. The project also includes seven deep shafts, five diversion chambers, seven adits, several storm water inlets, two ventilation control vaults, and an 80,000 cfm above grade and two 3,000 cfm below grade ventilation control facilities. The purpose of this paper is to present the procurement process and the challenges of the project.
aspects related to a major infrastructure project in economic and technical
difficulties. For example, sensitive soil conditions can lead to enormous
beneath other infrastructure, such as utilities and transport routes, can cause
standards in urban areas with shallow cover, and tunnelling equipment
able a decade ago. Nowadays, tunnels have to be built under high safety
today in regions and geological conditions that would have been inconceiv-
the economic success of a construction project. Projects are implemented
reliability in construction, compliance with construction schedules, and thus
boring machines are the successful improvements in respect of certainty and
smaller construction projects. The factors driving the increased use of tunnel
the civil engineering sector for large scale infrastructure works and also for
1990s, the “15 m class” was successfully introduced in the first decade of
Now, one decade later, the “18 m class” is becoming reality. The tunnel face area has more than doubled from 115 m² to 250 m²
and passing the 20 m line is not far off in the immediate future. Besides the
technological aspects of such large face areas, TBM designers have to
face and overcome a variety of ever changing challenges arising from these
super dimensions. The paper will highlight such new challenges as well as
presenting existing and future solutions for the large diameter TBM design
developments.

Managing Data Collection for Large Tunneling Projects, a Complicated Task
K. Bäppler and M. Strässer, Herrenknecht AG, Deutschland, Germany
This paper summarizes the data collection system that is utilized to collect, monitor and analyze data between different complex data systems including two tunnel boring machines, grout plant, belt conveyor system, instrumentation data, segment handling, etc. This data collection system, which was used on the Sound Transit Northgate Link Extension Light Rail Project, consists of approximately 5.6 km of Light Rail Transit tunnel commencing at the north end of the Maple Leaf Portal in Seattle to the University of Washington (UW) Station near Husky Stadium. The project includes construction of three stations; Maple Leaf Portal (MLP), Roosevelt Station (RVS), and University District Station (UDS) in addition to construction of 23 cross passages along the tunnel alignment.

Super Diameters - Design Aspects for Very Large TBMs
W. Burger, Herrenknecht, Deutschland, Germany
The recent decades have seen tremendous changes in what is called a “large” TBM. Whereas a 12 m size was considered to be at the limit in the
parameters all influence the performance of conditioned soil.

Earth Pressure Balance Machine Cutterhead Torque Modeling: Learning from Machine Data
E. Alavi Gharahbagh and G. Frank, Jay Dee Contractors, Seattle, WA; F. Macias, NTNU, Trondheim, Norway; R. Godinez, H. Yu and M. Mooney, Colorado School of Mines, Golden, CO
This paper characterizes earth pressure balance machine (EPBM) torque within the context of a physical model using data from a recent Seattle metro-sized (6.44 m diameter) tunnel project. The paper examines the ability of relatively simple physical models to capture torque, and characterizes relative influence of geology, soil conditioning, pressure and other parameters on measured torque. The physical torque model developed for the analysis grossly overestimates the realized torque by 50 – 500%, even with assumed shear strength reductions of 50% due to disturbance and conditioning. The shear strength reduction required to fit the model with measured torque were 65-70% reduction for sand and 80-85% for silt and clay.

Understanding the influence of soil conditioning parameters on soil behavior is critical to effective EPB TBM face support and performance. A mobile field lab has been developed to conduct various tests on conditioned muck sampled of the conveyor belt. A central piece to the field lab is measuring mechanical properties under pressure. This paper investigates conditioned soil behavior under pressure (up to 5 bar), and explores the influence of key soil parameter void ratio on behavior under pressure. Shear strength and compressibility tests were carried out on granular soil in a field- portable pressurized test chamber under a variety of pressures and foam parameters. The presented results demonstrate that void ratio, pressure and foam parameters all influence the performance of conditioned soil.

Performance Prediction Assessments of a Hard Rock TBM Used in Mining Development
L. Mori, Y. Wu, M. Cha and M. Mooney, Colorado School of Mines, Golden, CO
This paper presents existing and future solutions for the large diameter TBM design developments.
Future Projects

TUESDAY, JUNE 9, 2015
8:30 a.m.

CHAIRS: D. FIELD, HATCH MOTT MACDONALD, ARLINGTON, VA
N. GARAVELLI, FRONTIER-KEMPER ULC, NORTH VANCOUVER, CANADA

Albany Park Stormwater Diversion Tunnel Connecting Chicago River and North Shore Channel

M. Djavid, MWH, Chicago, IL; V. Jurca, CDOT, Chicago, IL; N. Djavid and M. Moridzadeh, MWH, Chicago, IL.
The Chicago Department of Transportation (CDOT) and MWMD have considered a one mile 18-ft-finished diameter rock tunnel to divert 2100 cfs flood flow from North Branch Chicago River (NBCR) to North Shore Channel (NSC) as per site Detailed Watershed Plan. In addition to the tunnel, the project also includes a diversion inlet structure and drop structure at upstream NBCR site, a shaft riser and outlet structure at downstream NSC site. Various design alternatives including soft ground and rock tunnel; excavation methods; lining of one pass with precast segment, two pass CIP with steel or fiber, and fiber reinforced shotcrete; and utilization of barging from NSC/NBCR waterways for hauling material and disposal of excavated material. In addition, a pilot study is considered to harvest the tunnel geothermal energy via installation of a heat exchanger system in the tunnel liner for augmenting the heating/cooling system of an adjacent public facility. The bid package will be out for bidding in 2015 with a construction schedule of two years.

Bypass Tunnel: Bad Rock, High Water Pressures, and a Challenging Connection

E. Dowey, New York City Department of Environmental Protection, New York, NY; B. Sozer, McMillen Jacobs Associates, New York, NY and P. Brion, New York City Department of Environmental Protection, New York, NY.
The Rondout-West Branch Tunnel (RWBT), which carries 50% of New York City’s water, is leaking up to 132 million L/day (35 mgd). The only sure solution to fix the leak is a Bypass Tunnel. Minimizing the time it takes to connect the Bypass Tunnel to the RWBT is a driving force in the design, coupled with the additional challenges of designing the tunnel for high water pressures and faulted rock. The Bypass Tunnel must pass through faulted dolomitic “limestone” with alternating crush zones and anomalously high strength (UCS) intact blocks. The high external water pressure ranging up to 244 m (800 ft) and hydraulic connections to the Hudson River above add to the challenges.

Evolution of a Mega Project: Update on the Bay Delta Tunnels Project

This paper describes recent conceptual engineering developments for the proposed Bay Delta tunnels project in the Sacramento-San Joaquin Delta region of Northern California. Engineering investigations that resulted in relocating the system’s main delivery pumps from the tunnel intakes alongside the Sacramento River, to a location at the southern-most terminus of the project will be discussed. The revised concept referred to as the Clifton Court Option, includes two large-diameter, deep-shaft pump stations and surge shafts located at the terminus of the main tunnels. Instead of pumping water into the tunnel system, as conceived in previous concepts, water will now flow by gravity through each intake structure, sedimentation basins, and then through approximately 40 miles of gravity-fed tunnels to two deep-shaft pumping plants capable of diverting gravity flows up to 9,000 cfs. Advantages of the revised concept are multi-fold including: reducing the hydraulic grade line in the tunnels such that the tunnel’s segmental liner system acts in compression instead of in tension, eliminating permanent visual impacts of the pumping plants along the Sacramento River, eliminating the need for permanent high voltage power systems at the river intakes, and reducing the overall construction impacts along the environmentally sensitive river. The main twin-bore 40-foot ID tunnels will span approximately 30 miles and will include a single-pass precast concrete segmental liner. It is anticipated that the main tunnels will be constructed at depths up to approximately 150 feet in saturated soft ground conditions. Smaller diameter tunnels, approximately 28-feet ID, will collect water from individual river intakes and convey those flows to the main tunnels.

Digging to the Beach: The Final Design of the JWPCP Effluent Outfall Tunnel Project

D. Haug, Sanitation District of Los Angeles County, Los Angeles, CA; D. Yankovich, Parsons Corporation, Las Vegas, NV; J. Kaneshiro, Parsons Corporation, San Diego, CA and S. Dubnewych, Jacobs Associates, Pasadena, CA.
In March 2013, the Sanitation Districts of Los Angeles County began final design of the Joint Water Pollution Control Plant (JWPCP) Effluent Outfall Tunnel project. The new, approximately 7-mile, 18-ft internal diameter tunnel will provide additional capacity and redundancy for the existing 8- and 12-foot diameter tunnels, which were built in 1937 and 1958, respectively. Connection to an existing, active 14-foot arch force main and four existing ocean outfalls ranging from 5- to 10-foot diameter are required. This paper will present anticipated geological features for the project and details of the proposed tunnel liner and structures at the 60 percent design level.

Maryland Transit Authority Red Line (MTA RL) Project – Major Light Rail Expansion in Baltimore, MD

S. Sadek, Jacobs Associates, Boston, MA and D. Chevning, Jacobs Associates, Baltimore, MD.
The MTA RL project final design is underway and on track to start major underground construction contracts by the middle of 2016. The $2.89 billion project is approximately 14 miles of east-west LRT extension, which extends from western Baltimore County at the Centers for Medicare and Medicaid Services through downtown Baltimore to the Johns Hopkins Bayview Medical Center campus in eastern Baltimore. The project includes two major underground components. Coates Lane Tunnel is approximately 1.2 miles of TBM and cut and cover tunnels, and the Downtown Tunnel is approximately 3.4 miles of TBM, cut and cover and 5 underground stations within Baltimore Downtown. The paper discusses the project layout, project schedule and briefly covers the procurement and delivery methods to be used on the program.
Ground Support & Final Lining

TUESDAY, JUNE 9, 2015
8:30 a.m.

CHAIRS: A. MUKHERJEE, PARSONS BRINCKERHOFF, NEW YORK, NY
A. FINNEY, CH2M HILL INC., SACRAMENTO, CA

Top-Down Construction for Tunnel Portal Walls in Karstic Limestone
C. Stone, Jacobs Engineering Group, Frankfort, KY
and E. Wang, Jacobs Engineering Group, New York, NY
A critical link for the Ohio River Bridges East End Crossing project features construction of twin 1,680-foot highway tunnels. Top-down construction was employed for portal cuts through soil, shale, limestone and dolomite to access tunnel drifts. This paper discusses the design-build challenges of the permanent top-down portal walls for this highway tunnel project, advanced under a Public-Private-Partnership contract with an aggressive mining schedule. These include innovative ground-support systems for achieving a 75-year service life, structural shotcrete reinforcement, design for karstic voids in pinnacled limestone and groundwater, soil nail wall construction techniques, requirements for architectural shotcrete, and accommodating accelerated construction schedules.

A One Pass Synthetic Fibre Reinforced Shotcrete Tunnel Lining for a Very Shallow Cover Tunnel, North Strathfield Rail Underpass
T. Nye, Mott MacDonald Australia Pty Ltd., Sydney, Australia
The Northern Sydney Freeway Corridor program when fully implemented will upgrade 150 km of freight railway line. The North Strathfield Rail Underpass is the first stage of this project and has a total length of 5 km including new sections of track. The single track rail underpass consists of two dive structures and a 148 m long skewed driven tunnel to allow the freight trains to pass from one side of the rail corridor to the other. Ground cover over the tunnel varies between 2.5 m and 3.5 m. A one-pass structural synthetic fibre reinforced shotcrete lining was used without steel sets or lattice girders. Real time surface monitoring of the three railway tracks above used robotic laser scanning in addition to in-tunnel displacement monitoring. Three hundred and sixty trains per day passed over the tunnel site during the eight months of tunnel excavation without disrupting train services. Tunnel construction was completed in late August 2014.

McCook MTS Bifurcating Steel Liner Backfill Concrete
J. Morton, Kiewit Infrastructure Co., Omaha, NE
The MWRD owned USACE-Chicago managed McCook Main Tunnel System Project consists of roughly 1,600 feet of 33-foot diameter tunnel, a bifurcating gate chamber, and associated operation facilities to provide increased CSO capacity for the mainstream tunnel.

Placing concrete around a pipe has inherent risk in consolidation and encasement. Add that the pipe is 33 feet in diameter, has 10-inch T-beams every eighteen inches, over 27,000 rebar anchors, minimal access for inspection, and the challenge to provide a quality product intensifies. Developing the proper mix, placement means, and ability to witness during placement allowed for the successful completion of the operation.

Some Concepts for Segmental Linings in Squeezing Rock
F. Mezger, ETH Zurich, Switzerland; M. Ramoni, Basler & Hoffman AG, Switzerland and G. Anagnostou, ETH Zurich, Switzerland
We analyze the application limits of stiff and deformable segmental lining systems for TBM tunneling in squeezing rock, looking at the aspects of structural behavior and construction management, as well as TBM and concrete technologies. We also present practical design aids that enable different lining systems to be compared quickly so that appropriate systems can be chosen for given geotechnical situations. Comparative investigations show that deformable lining systems are preferable for very deep tunnels crossing rocks of relatively fair quality, as rock pressure can be decreased significantly by allowing small deformations to occur.

Bonded Strip Termination Using Plastic Waterproofing Sheet Membranes on Segmental Tunnel as an Effective Economic Alternative to Clamping Constructions
S. Lemke, Sika Services AG, Zurich, Switzerland; H. Schaelicke, Ingenieurbüro Prof. Dr.-Ing. Dieter Kirschke, Ettlingen, Germany and T. Gerstewitz, MAX BÖGL Bauunternehmung GmbH & Co. KG, Munich, Germany
Forming watertight terminations for connecting tunnel cross passages or other shafts onto the precast tunnel lining segments represents a technical challenge. Their design and installation in situations with complex component geometry and high hydrostatic pressures is particularly difficult. Until now, only mechanical termination systems using bolts and plates have predominantly been used for this purpose. Due to the clear and well known difficulties and disadvantages of clamped systems, a bonded connection was developed and installed in the Finnetunnel section of the German High Speed Unity Railway System, VDE Project 8.2 “New rail line from Erfurt to Halle/Leipzig.” This was used to create watertight connections between the cross passages and the main tunnel lining segments. Instead of clamping the waterproofing membrane on the outside of the segment, a plastic strip/tape was bonded directly to the surface of the concrete using epoxy resin mortar. Once the mortar had cured, the cross passage waterproofing membrane was welded onto the strip. This new form of watertight termination was developed step by step, with expensive, very detailed and large-scale testing carried out before the final installation. In the experimental design, resistance to a hydrostatic water pressure of 9 bar over a time period of approximately six weeks could be sustained. After that, the pressure was raised to 12 bar within eight hours and then maintained at this level for two weeks. Additionally, in a destruction test, the water pressure was even raised up to 55 bar before the test assembly/equipment failed. This article describes the design principles and successful installation of these new, cost-effective and efficacious bonded connections in the Finnetunnel.
Hard Rock Tunneling
TUESDAY, JUNE 9, 2015
8:30 a.m.

TBM Mining for the Deep Rock Tunnel Connector Project
Indiana, Indiana
M. Stolkin and E. Haacke, J.F. Shea Construction, Indianapolis, IN and M. Guay, AECOM, Indianapolis, IN
The Deep Rock Tunnel Connector Project is being constructed by the S-K JV, a joint venture between the J.F. Shea Construction and the Kiewit Infrastructure Co. As bid, it was a $179 million project being built to address combined sewer overflows into the White River. Currently, the project is on schedule and budget for excavating and lining of the tunnel with completion in May of 2017.

Design of the Headrace Tunnel Segmental Lining for the Kishanganga Hydroelectric Project
L. Ariza and Mullerova, CH2M Hill, Sydney, Australia; M. Palmer and N. Swannell, CH2M Hill, Swindon, UK and A. de Blase, Seli, Rome, Italy
This paper describes the segmental lining design for the 15 km long, 1,400 m deep TBM tunnel constructed as part of the Headrace tunnel for the 330MW Kishanganga Hydroelectric Project in India. The double-shield TBM erected a 5.2 m diameter, 350 mm thick hexagonal precast concrete segmental lining with concave-convex radial joints. Challenges for severe loading and joint geometry selection are discussed.

Critical squeezing conditions, anticipated in particular areas of the tunnel, required a risk management approach to design and construction with contingency procedures and criteria developed to allow the risks to the TBM and the lining to be managed effectively. The tunnel, completed in May 2014, represents the first segmentally lined TBM tunnel to be successfully constructed in the Himalaya.

Blue Lake Hydroelectric Expansion Project – Tunnel Excavations
K. Osborne, T. Schulze and B. Roberds, Blue Lake Tunnelers, Sparks, NV
Conventional drill and blast methods were used to successfully excavate three new tunnels and two new shafts, using rubber tired equipment and a mechanized raise climber (MRC), at the Blue Lake Expansion Project. The underground excavations were one phase of the $88 million Blue Lake Expansion Project owned by the city and borough of Sitka, Alaska, a primarily fishing and tourism based community of approximately 10,000 residents located in southeast Alaska. Working in a remote island community accessible only by plane or boat presented many challenges. Underground excavations consisted of a 42.67 m (140 ft) long exploratory tunnel located 60.96 m (200 ft) from the base of the existing Blue Lake Dam, accessible only by crane or by foot travel; a 143.26 m (470 ft) long access adit developed to facilitate excavation of a 99.67 m (327 ft) surge shaft driven from the bottom up, using an MRC breaking through in a remote surface location accessible by helicopter or by foot travel; a 256.03 m (840 ft) long intake tunnel which portaled in 9.14 m (30 ft) above Blue Lake, the city of Sitka’s fresh drinking water supply; and a 33.22 m (109 ft) gate shaft driven from the new intake tunnel, also excavated using an MRC. This paper will provide a description of the logistical and engineering challenges involved with performing underground excavations in this isolated and demanding environment. Work areas accessible by crane and helicopter only, working directly above Sitka’s drinking water supply, and excavating to within 9.14 m (30 ft) of the Blue Lake Dam and existing penstock tunnel are a few of the many factors which challenged this critical project.

Drill and Blast Excavation in Congested, High-Visibility Area
C. Purcell, Hatch Mott MacDonald, New York, NY
Midtown New York is one of the most congested neighborhoods in the developed world, and as such, all construction in the area inherits a high level of complexity. In addition to the engineering necessitated by the construction itself, a project team must also allow for New York City’s overcrowded sidewalks and streets, high cost of union labor, congested array of utilities beneath the pavement, and the close proximity of structures in varying degrees of structural integrity. Blasting operations are no exception. This paper discusses these unique challenges as experienced through the blasting operations on a federally-funded, public transportation project for New York City’s Metropolitan Transit Authority’s Capital Construction division (MTACC).

Black River Tunnel Phase 1: A Case Study in Construction of an Underground Combined Sanitary Storage Tunnel in Ohio Shale
J. Edberg and J. Brown, NTH Consultants, Ltd, Northville, MI; S. Pearson, ARCADIS US, Inc., Columbus, OH; M. Hedrick, Walsh Construction Company II, LLC, Detroit, MI and G. Rehak, Super Excavators, Inc., Menomonee Falls, WI
This paper presents a case study of the unique construction aspects of the Black River Tunnel: Phase 1 Project, a 5,600-foot long, 23-foot diameter rock tunnel located in Lorain, OH, which is intended to reduce sanitary sewer overflows to the Black River and Lake Erie. The paper discusses construction challenges and successes during tunnel excavation and installation of the primary tunnel liner systems, and portions of the secondary liner system. The paper also compares the shaft construction techniques that were utilized for each of the two shafts, highlighting advantages and drawbacks based on experience during construction.

Planning, Design and Construction Considerations for a Drill and Blast Utility Tunnel Underneath the Montreal Neurologic Institute with Highly Sensitive Equipment at McGill University Campus
J. Habimana and G. Kramer, Hatch Mott MacDonald, Mississauga, Canada and G. Revey, Revey Associates Inc., Parker, CO
The construction of a new utility tunnel associated with its hospital operations at the McGill University’s downtown Montreal campus was carried out by drill and blast. The tunnel passes within 6 meters directly beneath and adjacent to buildings that house sensitive facilities, equipment, research laboratories, medical treatment rooms and patients. In order to maintain all hospital activities during tunnel construction, certain constraints related to peak particle velocities and blast overpressure, and audible blast noise measured at selected locations were imposed on the contractor. The paper provides planning and design considerations that were used in the alignment selection, evaluation of applicable construction methods, the process used to set baseline parameters and the monitoring program, and the results of their implementation during construction.
The $1.4B Waterview Connection Motorway Tunnels – Outcomes and Progress from a Client’s Perspective

P. Spies and S. Eratne, New Zealand Transport Agency, Auckland, New Zealand and T. Ireland, Aurecon, Auckland, New Zealand

The New Zealand Transport Agency (TA) commenced its procurement process in 2010 and awarded a Design and Build with subsequent Maintain and Operate Alliance contract in November 2011 to a consortia of local and international designers and contractors. The project comprises twin 14 m OD tunnels with associated motorway-to-motorway connections, and is currently the largest tunneling project underway in the Southern hemisphere. With completion of the Design and Build phase scheduled for late 2016, this paper will describe the challenges and achievements to date from a client perspective operating within a collaborative contract model (Project Alliancing).

Blue Plains Tunnel Case History

B. Zernich, M. Jatczak, J. Dilulio, N. Tabor and J. Jonasen, Traylor Bros., Inc., Washington, DC

The Blue Plains Tunnel Project is being constructed in Washington, DC and will provide one section of an overall “World Class” combined sewer overflow system that will significantly reduce pollution throughout the city’s suffering waterways. The Design-Build contract is being constructed by Traylor/Skanska/Jay Dee (TSJD) for the District of Columbia, Water and Sewer Authority (DC Water). The first of several large tunneling projects for the DC Clean River Program, the Blue Plains Tunnel includes 5 large diaphragm wall shafts, including the treatment plant de-watering shaft, intake structures, and a 24,000-feet final lined 23-foot. ID segmentally lined tunnel. The tunnel was bored using an Earth Pressure Balance TBM with a state of the art mucking system, predominantly through sands and clays. The need to make program milestones included strict schedule constraints which were part of the overall Consent Decree between DC Water and the EPA. This paper will highlight many of the challenges encountered with planning and construction of this Design-Build tunnel contract.

Extreme Excavation in Fractured Rock and Squeezing Ground at Turkey’s Kargi Hydroelectric Project: A comparison of TBM and Drill and Blast Methods

J. Clark, The Robbins Company, New Delhi, India

In 2014, a 10 m diameter Double Shield TBM broke through in Turkey after surmounting innumerable obstacles. With limited geological information, contractor Gülemak and machine supplier Robbins overcame extreme faulted conditions that resulted in seven bypass tunnels within the first 2 km. Working together, the teams developed an efficient bypass tunneling method, and proceeded to refurbish and redesign the machine in the tunnel to better excavate unexpected conditions. The newly designed machine reached rates of over 700 m per month, outperforming a drill and blast operation initiated from the other end of the tunnel. This paper will detail the incredible conditions overcome, machine modifications, and performance. A discussion and comparison of drill and blast operations in similarly difficult geology will also be included.

Delivery of Crossrail Western Tunnels

A. Alder and D. Callaghan, CH2M Hill, Pinner, UK

The Crossrail project is building a new railway for London and the southeast of England, and is Europe’s largest construction project. The construction of Crossrail has been split into a number of contracts, each tasked with delivering a section of the project. This paper specifically reviews the works undertaken on the C300/410 Western Tunnels contract, which involved the construction of 6.8 km of twin-bore running tunnels constructed with a tunnel boring machine (TBM), and nearly 2 km of shotcrete lined (SCL) tunnels. The TBMs traveled from Royal Oak Portal in the west to Farrington in the east, with SCL works undertaken at Bond Street and Tottenham Court Road Stations, at Fisher Street Shaft, and at the cross passages between the running tunnels.

Auckland City Rail Link – The First 100 Years

B. Newns, Aurecon, Auckland, New Zealand; S. Hawkins, Auckland Transport, Auckland, New Zealand and T. Ireland, Aurecon, Auckland, New Zealand

The City Rail Link (CRL) will be a 3.4 km underground passenger railway and has been proposed in various forms over the last 100 years. The project will relieve a significant constraint on Auckland’s suburban passenger rail network by connecting the existing underground station at Britomart with Mt. Eden. Three new underground stations are proposed using cut and cover and sequential tunneling methods linked by TBM and cut and cover running tunnels. The paper describes the engineering challenges and provisions of the project in relation to the alignment, interaction with existing and proposed buildings and developments, underpinning of heritage structures, utility infrastructure, ground conditions, fire and life safety, management of traffic disruption, and the current status of project delivery.
Geotechnical Considerations I
TUESDAY, JUNE 9, 2015
1:30 p.m.
CHAIRS: R. GOODFELLOW, ALDEA SERVICES, ROCKVILLE, MD
K. ROTUNNO, NORTHEASTERN OHIO REGIONAL SEWER DISTRICT, CLEVELAND, OH

Contractor’s Approach for WTP4 S-101 Intake, Tunnels and Shafts Construction
S. Akai, Obayashi Canada, Toronto, Canada; S. Mino, Obayashi Japan, Tokyo, Japan; T. Kobayashi, Obayashi USA and D. Liebno, Obayashi USA, Atlanta, GA

Many papers and articles have been issued regarding Water Treatment Plant No.4 (WTP4) and duplication should be avoided to save trees. This paper describes how to approach the S-101 Intake, Tunnels and Shafts construction from the contractor’s prospective. The contract has one intake shaft, four tunnels and seven shafts construction, and it was key to manage each activity efficiently so that the construction could be finished on time. To meet this goal, several changes and improvements were executed throughout the project.

Controlling Ground Movement on the SR 99 Alaskan Way Viaduct Replacement Tunnel
E. Cording, University of Illinois at Urbana-Champaign, Champaign, IL.; J. Nakagawa, Tutor Perini Civil West, Seattle, WA; C. Painter, Parsons Brinckerhoff, Kenmore, WA; J. McCain, Tutor Perini Civil West, Seattle, WA; J. Vazquez, Dragados USA, Seattle, WA and A. Stirbys, Tutor Perini Civil West, Seattle, WA

Seattle Tunnel Partners established a 1,500-foot long test section prior to advancing the 57.4-foot diameter EPBM beneath the Alaskan Way Viaduct, Pioneer Square Historic District and downtown Seattle. A comprehensive ground monitoring program has been conducted in the first 1,000 feet using inclinometers, deep extensometers and piezometers to continuously monitor ground movements around the advancing TBM. The results, correlated with machine data, allow sources of ground movement to be identified and adjusted. The EPBM operation is limiting surface settlements, even in the low cover test section, and the monitoring data confirms its capability to control ground movements beneath structures in downtown Seattle.

Construction Challenges of the Central Subway’s TBM Launch Shaft and Station’s Headwalls
M. Calando and B. Caro Vargas, Nicholson Construction Company, Cuddy, PA

San Francisco’s growth requires additional transit solutions, which is why the San Francisco Municipal Transportation Agency (SFMTA) is building the Muni Metro T Third-Line Extension: Central Subway. This $1.6 billion capital investment project features a 1.7-mile long, 21-ft. internal diameter twin bored tunnel. This paper describes the geotechnical conditions, urban constraints and the novel approaches adopted for the TBM Launch Shaft and the stations’ headwalls that the TBMs mined through. In particular, it will emphasize the specificities of building a slurry wall with 16-ft. headroom below an existing highway in service.

Calculation of Volume Loss Using Machine Data from Two Slurry TBMs During the Excavation of the Queens Bored Tunnels
B. Rydahl, M. Mooney and J. Grasmick, Colorado School of Mines, Golden, CO

This paper presents a detailed analysis of volume loss estimation (more specifically excavated volume) during slurry shield TBM tunneling. The analysis includes a formal treatment of measurement uncertainty using all of the pertinent sensors involved as well as analytical modeling of the slurry circuit itself, including feed and return flow, slurry loss, and slurry membrane models. The study is based on data from the four Queens bored tunnels mined using two slurry shield TBMs, where very small surface deformations correspond to anticipated volume losses less than 0.2%. The main conclusion from this study is that volume losses on the order of 0.2-0.5% cannot be estimated based on slurry TBM measurements. The combined influence of sensor inaccuracy and imprecision, error propagation, and assumptions required about slurry infiltration and pore water excavation render it impossible to estimate volume loss with the certainty required to serve as quality control for ground deformation.

Key Features Influencing the Design, the Performance and the Cost-Efficiency of an Instrumentation and Monitoring Program
L. Galisson, Soldata Inc., Seattle, WA and Z. Birsen, CH2M Hill Inc., Seattle, WA

Instrumentation and Monitoring (I&M) scope is generally rather invisible in most conventional construction activities on large urban infrastructure projects. It does not involve heavy equipment and a large part of its materialization often happens outside of construction sites. It is nevertheless proven that the added value of this activity is considerable in several aspects for both the owner and for the general contractor. It provides the information not only to guide but to mitigate geotechnical, structural and environmental risks, but also helps for more aggressive designs and operational schedules. The monitoring also constitutes a powerful communication tool with third parties affected directly or indirectly by the project as well as with the public opinion. The monitoring program can be viewed by the pertinent individuals of the project, as a means to keep a high level of awareness of their respective potential impact and liability all along the life of the project. This article intends to describe some of the main key features of a monitoring program, which will promote understanding of the essence of the information generated, while ensuring its cost efficiency.
Grouting & Ground Modification
TUESDAY, JUNE 9, 2015
1:30 p.m.
CHAIRS:  J. SOPKO, MORETRENCH AMERICAN CORP., ROCKAWAY, NJ  
        J. FREITAS, MCMILLEN JACOBS ASSOCIATES, NEW YORK, NY

Compensation Grouting for the East Side Access Northern Boulevard Crossing
P. Schmall and A. Curry, Moretrench, Rockaway, NJ; F. Perrone, Hatch Mott MacDonald, New York, NY; and J. Rice Parsons Brinckerhoff, New York, NY

The East Side Access Northern Boulevard Crossing was completed with a 38-m (125-ft) long sequentially excavated (SEM) tunnel beneath a frozen ground arch serving as earth support and groundwater cut-off. Tunneling was accomplished in very close proximity to the overlying, active subway and foundations of an elevated transit line. Heave of the ground and overlying subway structure occurred during operation of the freeze, followed by settlement during the period through which the frozen arch thawed. Compensation grouting was implemented concurrent with the thawing of the frozen arch to correct for differential movements of the overlying 5-track subway structure. An innovative approach was utilized which included the injection of sanded grouts through sleeve port pipes. This paper describes grouting system design, grout pipe installation, the specially developed grout, and the overall results of the grouting.

Ground Freezing for Tunnel Cross Passages First Application in North America
D. Mueller and J. Sopko, Moretrench American Corporation, Rockaway, NJ; R. Storey, Bouygues Travaux Publics, and R. Chamberland, Moretrench American Corporation

Ground freezing was used for the first time in North America to freeze two 2.8 m diameter cross passages for the Port of Miami Tunnel. While ground freezing has been used for similar construction in Europe and Asia, this was the first application in North America. This project was complicated by the extremely porous subsea soils. To reduce the permeability of these soils and rock, an initial grouting program was implemented from the ground and channel surfaces. Two rows of horizontal freeze pipes were drilled and installed to form the frozen cylinders for excavation support and groundwater control for cross passage construction. The refrigeration system used to circulate the cooling medium was located at the ground surface and supplied to the cross passages via supply and return manifolds and a specially designed pumping system. An extensive system of instrumentation was installed to monitor ground temperatures, soil and rock water pressures, coolant flow rates and pressures, and process information from the refrigeration plants. This paper will discuss the grouting approach, freezing system drilling and installation, freeze monitoring, and the excavation and completion process of a very successful project. Guidelines and recommendations for frozen cross passage construction are summarized.

Pre-Excavation Grouting for the OARS Relief Sewer, Phase 2 Shafts and Adits, Columbus, Ohio
L. Spiteri, Moretrench, Rockaway, NJ; A. Zeni, Black & Veatch, Columbus, OH; M. Nuhfer, Aldea Services LLC, Columbus, OH, and R. Pesina, City of Columbus Department of Public Utilities, Columbus, OH

The OARS Project in Columbus, Ohio, is situated along the Scioto River in extremely permeable karstic geology. Completion was divided into two phases, with the Phase 2 Contract including construction of three shafts and adits to depths of between 45 and 54 m (150 and 180 ft) below ground level. Rock conditions at these shaft locations varied from fine fractures to cavernous voids, raising significant concern for groundwater control during drill-and-blast excavation. The initial remediation program involved grouting of the shafts in incremental depths from interim interior excavation levels. However, an alternate approach was adopted to perform the grouting from the surface to minimize drilling and schedule risks. This paper discusses the challenges involved in successfully addressing the highly variable solution features encountered through the karstic geology.

Jet Grout Ground Improvement for Tunnel Launch and Retrieval Locations on Sound Transit's Northgate Link Extension Project
C. Lavassar and J. Reeves, McMillen Jacobs Associates, Seattle, WA; A. Gerondale and M. Blanding, Hayward Baker Inc., Tukwila, WA; B. Cowles, Sound Transit, Seattle, WA; and J. Sailey, CH2M Hill, Seattle, WA

The N125 contract for Sound Transit’s Northgate Link Extension Project in Seattle includes three zones of jet grout ground improvement at tunnel launch and retrieval locations. This paper focuses on the geotechnical conditions and jet grouting parameters at each zone, as well as the quality control data obtained during construction (e.g., specific gravity measurements of jet grout spoils, horizontal and vertical coring, and groundwater infiltration monitoring). The effectiveness of the quality control program is discussed as well as the means of presenting the available data so that the results of the jet grouting program can be assessed by all stakeholders.

Performance Analysis of Fly Ash in Two-Component Grouts
P. Antunes, Team Mixing Technologies, Abbotsford, Canada

While fly ash is often used as a partial substitute for cement in civil construction, its usage in two-component grouts for TBM annulus grouting is varied. Opinions on the benefits of fly ash vary from person to person and project to project as do the economics. While most tunneling projects use fly ash in two-component grouts, a significant number of projects do not. The purpose of this paper is to quantify the performance of fly ash in two-component grouts by testing the compressive strength, bleed, gel time and viscosity, and also comparing these same parameters with fly ash from different geographic sources.
Mined Tunnels to Solve Urban Problems Ottawa’s Choice

E. Fernandez, Dragados, Madrid, Spain and H. Ferrer, Dragados, Ottawa, Canada

In the XXI century new infrastructures are still being designed/built in an aerial or cut and cover way, despite disrupting the daily activities of citizens and generating high social cost in terms of business and property loss, longer journeys, carbon footprint, noise, etc. Mined tunnels, traditionally or using tunnel boring machines (TBM), provide the tools to deliver complex underground infrastructures while minimizing the disturbance to the surroundings. For the Confederation Line, Ottawa’s Light Rail Transit (LRT) project which includes 1.6 miles of running tunnel and three cavern stations, the city chose the mined option to develop the LRT through the downtown core. This paper gives the conceptual approach and solutions of this megaproject.

Shallow Cover Tunnel Below “Pop’s Fig,” a World’s First, Soft-Ground Tunnel Driven Above the Largest Highway Caverns to Date in the Southern Hemisphere Mined Caverns

H. Lagger, Arup, San Francisco, CA; T. Aydogmus, HOCHTIEF Engineering GmbH, Essen, Germany; M. Scrogings, THIERS Consultants, Brisbane, Australia and T. Marcher, SKAVA Consulting ZT GmbH, Innsbruck, Austria

This paper describes a number of aspects of the design and construction of the Northern Busway (NB) Tunnel, part of a major infrastructure project ($4.8 billion) in Brisbane, Australia. The NB Mined Tunnel is approximately 495 m long with an excavated width of 15 m and a full tunnel excavation height of 8 m. Tunnel portals and adjacent tunnel construction are below a major urban arterial road. Ground cover over the tunnel beneath the road varies from 3.5 m to 12.5 m. The Airport Link (AL) Mainline Tunnels run in close proximity below the Northern Busway tunnel with a minimum separation of 5 m between the extrados of the AL and the NB tunnels. At the Southern Portal the ground and an area above the tunnel is occupied by a large Pop’s Fig Tree, which is required to be preserved. Key challenges are the low ground cover over the tunnel beneath a major urban environment, and the very variable geology along the tunnel alignment, providing mixed face tunneling conditions and ranging from surface residual soils to high strength rock at depth. As a consequence, the predicted settlement values and their potential to cause damage to the buildings were critical to determining and obtaining approval for the selected tunnel alignment. The paper presents the design challenges and tunnel design methodology of this successfully completed project.

SEM Tunnelling in Toronto – Construction

R. Divito, Hatch Mott MacDonald, Buffalo, NY; G. Kramer, Hatch Mott MacDonald, Mississauga, Canada; E. Fernandez Iglasias, OHL/FCC JV, Mississauga, Canada and E. Poon, Toronto Transit Commission, Toronto, Canada

A portion of the recently constructed Toronto-York Spadina Subway Extension (TYSSE) Northern Tunnels includes the first tunnels in Toronto to be mined in soft ground using the Sequential Excavation Method (SEM). This portion of the extension is a 381-meter long special trackwork tunnel with crossovers, and is referred to as the Double-Ended Pocket Track Housing Structure (DEPTHS). The DEPTHS includes a 221-meter long triple-cell tunnel, referred to as the SEM Tunnels, which was excavated and supported using SEM. A unique excavation and support sequence was developed and employed during construction to avoid surface constraints and address the narrow pillar widths necessary for the triple-cell configuration. This paper summarizes the results of the construction of the DEPTHS SEM Tunnels including comparisons of ground response to design predictions.

East Link – Final Design of the Downtown Bellevue Tunnel

M. Wongkaew, Seattle, WA; D. Penrice, Hatch Mott MacDonald, Pleasanton, CA and J. Theodore and B. Patton, Sound Transit, Seattle, WA

Sound Transit’s East Link Project, a $2.8 billion, 14-mile light rail (LRT) extension, will connect downtown Seattle with the cities of Bellevue and Redmond. Among the most technically challenging aspects of the project is the 2,000-foot long tunnel through downtown Bellevue, to be constructed using Sequential Excavation Methods (SEM) in glacially over-consolidated soil deposits at shallow depth and in close proximity to the basements of high rise buildings. The paper describes the final design of the SEM tunnel, shaft and connecting adit, including the evaluation of the interaction between the tunnel and adjacent building basements, and the simultaneous planning for project implementation to address identified and otherwise anticipated risks based upon both site and project constraints.

Crossrail Western Tunnels Technical Aspects

A. Kendall, Sound Transit, Seattle, WA

Crossrail is among the most significant infrastructure projects ever undertaken in the UK. From improving journey times across London to easing congestion and offering better connections, Crossrail will change the way people travel around the capital. Crossrail will deliver a high frequency, high capacity service to 38 stations, linking Maidenhead and Heathrow in the west to Shenfield and Abbey Wood in the east via 21 km of new twin-bore tunnels under central London. It will bring an additional 1.5 million people within 45 minutes commuting distance of London’s key business districts. Around 200 million passengers will travel on Crossrail each year and the route will provide a 10% increase in rail capacity in the capital. Crossrail will make travelling in the region easier and quicker and will reduce crowding on London’s transport network, operating with main line size trains carrying more than 1,500 passengers in each train during peak periods. This makes it currently the most internationally significant project in Europe because this is a UK first of tunneling through the heart of London with tunnels for Mainline size trains.

Ground Freezing Support for SEM Tunnel Excavation in the Kansas City West Bottoms

G. Sanders, CDM Smith, Kansas City, MO; M. Gilbert, Cambridge, MA; S. Carpenter, CDM Smith, Kansas City, MO and B. Gardner, KCMO Water Services, Kansas City, MO

Improvements to the Turkey Creek Wastewater Pump Station for Kansas City, MO included many challenges to keep the pump station in operation during construction. One of the many modifications included an excavation for the installation of a Debris Control Structure below a 17 foot by 19 foot twin box culvert constructed in 1919. Further complicating the construction was the requirement to maintain flows within the box culvert of up to 4,542,000 m³/ day (1,200 mgd) during construction. Sequential Excavation Methods (SEM) using ground freezing was selected for the construction of the 12.19 m (40 feet) soft-ground tunnel below the culvert. This paper presents a practical discussion of the critical factors for the design of the ground freezing system during construction and a summary of the ground freezing activities.
Shafts
TUESDAY, JUNE 9, 2015
1:30 p.m.
CHAIRS: F. ESMAIL, FRONTIER KEMPER, NORTH VANCOUVER, CANADA
G. MILLENER, KIEWIT CONSTRUCTION CO., PORTLAND, OR

Construction of the NYCDEP Bypass Tunnel Shafts
E. Jordan, Parsons Corporation, Wappinger Falls, NY; G. Schmidt, New York City Department of Environmental Transportation, Wappinger Falls, NY and V. Sambrato, Schiavone Construction Co., Secaucus, NJ

The New York City Department of Environmental Protection (NYCDEP) is presently constructing two deep shafts, 700 to 900 feet deep in rock, to facilitate a new bypass tunnel along a 2.5 mile section of the Delaware Aqueduct. The aqueduct is New York City’s primary drinking water conveyance tunnel that brings approximately 50 percent of NYC’s drinking water from the Catskill Mountains to New York City. Significant groundwater inflows in challenging geological conditions are expected during construction of the shafts. This paper will describe project setting and background, construction constraints and risk, work progress, project geology, and groundwater and grouting techniques used to mitigate inflows to manageable rates.

Complex Solutions for Simple Problems – A Case Study on High Head Underwater Base Slab Pours

The Blue Plains Tunnel is a design build project for the District of Columbia Water and Sewer Authority. The project required construction of three drop shafts with finished diameters of 50 and 55 feet, and finished depths ranging from 110 to 133 feet. The final design required excavation as deep as 123 feet below the local groundwater table, while mitigating the risk of damage to nearby sensitive structures. The shafts were excavated in the wet, and tremie concrete placement methods were chosen to complete the construction of three permanent structural base slabs, ranging from 10 to 11 feet in thickness. Construction of the slabs presented numerous challenges including the implementation of a mass concrete temperature control plan with cooling pipes, and the suspension of heavy steel reinforcement 100 feet underwater. Careful planning, field management and coordination were essential to the successful completion of all three structures.

Anacostia River Tunnel Project: Engineering During CSO 019 Shafts and Connector Tunnel Construction

Construction of the DC Water’s Anacostia River Tunnel project commenced with twin slurry-wall Drop Shafts connected by an SEM-excavated Inter Shaft Connector Tunnel (ISCT). Both drop shafts have an internal diameter of 70 feet and are excavated to 105 feet final depth. Since subsurface conditions consist of very stiff to hard clay of the Potomac Formation, underlain by a granular deposit with high artesian water pressure, depressurization of the granular layer is required during excavation of the shafts and connector tunnel. This paper discusses the Design-Builder’s ground support and monitoring design, the mitigations measured assigned for the associated risks, and the design and construction approaches taken by the Design-Builder for the construction of CSO 019 Shafts and ISCT.

The First 8 Meter Diameter Raise Drilled Shaft in North America

Walter Energy is developing a series of shafts to support deep coal mining near Brookwood, Alabama. Most are unlined, raisebored ventilation shafts, typically 6.1 m x (425m to 700m) deep. Raisebor, Inc. was asked to construct a service shaft mechanically excavated (raised) at 8 m and concrete lined back to 7.3 m diameter including a total horizontal tolerance of +/- 2.5 cm over the entire depth of 460 m. This required directional pilot hole drilling and reaming at a diameter and depth which has expanded the boarders of what is possible with today’s raiseboring equipment. Adverse geologic conditions also contributed to a challenging project.

Euclid Creek Tunnel Secant Pile Shaft
D. Worting, Hatch Mott MacDonald, Cleveland, OH; R. Sullivan, Northeastern Ohio Regional Sewer District, Cleveland, OH; J. Suffel, McNally Corporation, Cleveland, OH and N. Willig, Case Foundation Company, Roselle, IL

As part of recent combined sewer overflow control upgrades for Northeast Ohio Regional Sewer District, Cleveland, OH, the 24-foot Euclid Creek Tunnel was constructed. Shaft 3-1 was constructed as a baffle drop shaft connecting near-surface combined sewer flows with the storage tunnel. Shaft 3-1 initial support consists of a series of 1,180 mm diameter, 105-foot long secant piles, in a 20-feet 9-inch I.D. array through clayey overburden and socketed into shale bedrock. Standard rock support was utilized extending the total depth to approximately 181 feet. This paper presents the design, construction, and performance of the Shaft 3-1 secant pile wall shaft.
Design & Planning II

WEDNESDAY, JUNE 10, 2015
8:30 a.m.

CHAIRS: D. DEERE, DEERE & AULT CONSULTING INC., LONGMONT, CO
M. LANG, FRONTIER KEMPER

Continuing a Legacy of Large Diameter Hard Rock Tunneling in Chicago
– The Des Plaines Inflow Tunnel
C. Hriner, Black & Veatch, Kansas City, MO; K. Fitzpatrick and C. Scalise, Metropolitan Water Reclamation District of Greater Chicago, Chicago, IL; F. Oksuz, Black & Veatch, Chicago, IL and B. Gettinger and B. Glynn, Black & Veatch, Kansas City, MO

The Metropolitan Water Reclamation District of Greater Chicago’s Des Plaines Inflow Tunnel will provide direct conveyance of 317 cubic meters per second (11,200 cubic feet per second) of water from the Des Plaines Tunnel System to the McCook Reservoir. The project will alleviate a bottleneck in the Tunnel and Reservoir Plan (TARP) system by creating a second major tunnel connection to the 38-billion liter (10-billion gallon) McCook Reservoir. The 1.6-kilometer (1-mile) long, 6.1-meter (20-foot) diameter hard rock tunnel will include live connections to the existing Des Plaines Tunnel System and to the operating McCook Reservoir as well as a gate shaft and an energy dissipation structure in the reservoir with low clearance crossings of other existing TARP tunnels. The project will bid for construction in mid-2015.

Elements of the Istanbul Strait Highway Tunnel
G. Clark, Parsons Brinckerhoff, New York, NY; R. Castelli, Parsons Brinckerhoff, Seattle, WA; D. Richards and T. Togan, Parsons Brinckerhoff; B. Anıoğlu and O. Gönenç, Yapı Merkezi İnşaat A.Ş.

The first road tunnel crossing of the Istanbul Strait (also known as the Bosporus) in Istanbul, Turkey, presented unique challenges, including very poor ground conditions, high water pressures, and severe seismic loads. The first constructed element was a 10-story deep and 180 m long TBM launch box located on the Asian side of the Strait. Other project elements for the 2-lane over-2-lane, stacked roadway include a 12-m inside diameter, 3.4-km long bored tunnel using a mixed slurry TBM through highly fractured rock, mixed face and soft ground, with up to 11 bars of water pressure; a single pass segmental liner that incorporates two massive seismic joints; retrieval shaft on the European side of the crossing; twin NATM tunnels east of the launch box; and open cut approaches. This paper discusses design and constructability issues and the solutions to these challenges.

Design and Construction Considerations for the Blacklick Creek Sanitary Interceptor Sewer Project in Franklin County, Ohio
I. Halim, AECOM, Boston, MA; N. Domenick, City of Columbus DOSD, Columbus, OH and M. Nuhfer and J. Goldsberry, AECOM, Columbus, OH

The Blacklick Creek Sanitary Interceptor Sewer will extend the City of Columbus service to the City of New Albany and Jefferson Water and Sewer District, and facilitate connection of the Rocky Fork diversion. The tunnel will be 23,000 feet long, 10-foot finished diameter, and will be mined through challenging mixed ground consisting of glacial soils and sedimentary rocks. This paper will focus on the considerations for the selection of appropriate tunneling and shaft construction methods, tunnel size and support liner, and corrosion protection scheme. A comprehensive geotechnical investigation program will be described, including characterization and baselining of the subsurface conditions for the contract procurement. The selected tunneling method is precast segmental concrete lining with an EPBM which can be driven open mode in the rock tunnel portion.

Indianapolis Deep Tunnel Pump Station – Design/Construction
M. Miller and J. Morgan, Citizens Energy Group, Indianapolis, IN

The need for a Deep Tunnel Pump Station in Indianapolis was driven by an amendment to the Consent Decree held by the city of Indianapolis and Citizens Energy Group. The amendment allowed for collection of combined sewer overflows (CSOs) via a deep tunnel storage system. This cursory overview of the design and update of the construction related to the Deep Tunnel Pump Station is intended to convey to the reader the complexities involved with the 340 MLD (90 MGD) facility. The contractor awarded the project is a joint venture between Oscar Renda Contracting and Southland Contracting (RS, JV). Both companies have primary offices in Fort Worth, Texas.

Decision Process and Criteria for Selection of a Preferred Tunneling Method
B. Fulcher, Kenney Construction Company, Northbrook, IL; L. Home, The Robbins Company, Solon, OH and E. Hudson-Smith, Geosite Pty, Ltd., WAS, Australia

In recent years, there has been considerable discussion on the subject of the early selection of the tunneling construction method – at the design concept stage, and again later, in the detailed design development stage. It was apparent from these discussions that a rationale was needed to become the basis for initial and subsequent discussions, as well as to be the basis for reevaluation of the original construction concept as more information, factors, criteria and critical influences were revealed as the early design development progresses. This paper describes a decision criteria and a methodology for early determination of a preferred tunnel construction method(s) in conjunction with known, unknown and other factors that would not only influence the tunnel design but also the preferred final construction method(s). Specifically, this paper will address the tunnel construction method selection process between mechanized tunneling (TBM) and conventional tunneling (drill and blast) wherever conditions allow for a selection.
Central Subway Tunnel Construction Instrumentation:
Lessons Learned, San Francisco, California
Construction of the SFMTA Central Subway twin tunnels was completed in mid-2014 through one of San Francisco’s most densely populated areas. Potential impacts to historic buildings, active transit systems, and utilities were anticipated in the design. An integrated system of real-time construction monitoring provided tunnel- and excavation-related deformation and was important in evaluating TBM performance and the extensive compensation grouting program. The web-based system included automated building-settlement prisms, liquid-level sensors, multiple point borehole extensometers, inclinometers, tilt beams, tiltmeters, load cells, and piezometers. Convention-al survey methods were used for monitoring potential movement of build-ings, tunnels, surface points and utilities. Acoustic leak detection technology was used to monitor water distribution systems. The key instrumentation systems employed and lessons learned during this successful project are reviewed.

Old Vs. New: Comparing the Construction of the Existing and New Irvington Tunnels
A. Wirthlin, Jacobs Associates, San Francisco, CA; R. Fusee, Hatch Mott MacDonald, Pleasanton, CA; D. Tsztoo, San Francisco Public Utilities Commission, San Francisco, CA and T. Feldsher, URS Corporation
The New Irvington Tunnel (NIT) was excavated adjacent to the in-service 83-year-old Existing Irvington Tunnel (EIT). The historic EIT construction records were combined with an extensive geotechnical investigation to characterize and anticipate ground conditions for the NIT. Detailed geologic mapping and thorough documentation during NIT excavation provide a unique opportunity to compare the ground conditions and construction of the approximately parallel EIT and NIT alignments. The in-depth comparison provided herein incorporates geotechnical and construction considerations during NIT design and observed ground conditions during NIT excavation.

Characterizing and Baselining Faults for Tunneling
S. Hunt, CH2M Hill, Henderson, NV; E. Smith, UNLV, Henderson, NV and E. Moonin, SNWA, Las Vegas, NV
Fault zones and related features often increase tunneling risks requiring proper assessment, characterization and baselining. Complex geologic conditions and site access often make site investigation, ground characterization and baselining very difficult, but a thorough valuation of geologic and fault condition complexity and use of well-defined fault zone terminology is essential to manage fault related risks. Experiences with fault conditions at Lake Mead Intakes 1, 2 and 3 within extremely faulted rock are discussed. Some suggestions for baselining fault zones are given.
**Risk Management**

**WEDNESDAY, JUNE 10, 2015**

**8:30 a.m.**

**CHAIRS:** E. FREDRICKSON, TRAYLOR, LOS ANGELES, CA

M. PREDDY, WASHINGTON STATE DEPARTMENT OF TRANSPORTATION, SEATTLE, WA

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**Risk Management in Capital Improvement Projects – The DC Clean Rivers Project Approach**


Communities with combined sewer systems are required to prepare Long Term Control Plans (LTCP) for the control of Combined Sewer Overflows (CSOs) in accordance with Section 402(q) of the Clean Water Act enacted in 2001 (P.L. 106-554). DC Water’s (Authority) LTCP, also known as the DC Clean Rivers Project (DCCR), was completed in July 2002 and is currently being implemented. DCCR is a massive infrastructure program that relies on a system of storage tunnels to reduce Combined Sewer Overflows (CSOs) into the District’s waterways (i.e., Anacostia and Potomac Rivers and Rock Creek). About one-third of the district sewer system is a combined system and annual discharges into local waterways are estimated at 2 billion gallons. The Anacostia River receives 1.3 billion gallons, the Potomac River receives 640 million gallons, and Rock Creek receives 50 million gallons of overflow each year. The schedule for completing the LTCP is included in a federal court consent decree among the United States Government, the District Government, and DC Water. The Anacostia River Project’s (ARP) portion of the LTCP is the highest priority in the court ordered schedule and its level of complexity puts it at high risk for cost overruns and schedule delays, thereby triggering costly penalties to the Authority. The objective of this paper is to describe the DCCR risk management approach for ARP, the methodologies used for the different types of procurement, and the various project stages.

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**The Seattle Fire Department’s Approach to Tunnel Rescue**

F. Brennan, Seattle Fire Department, Seattle, WA

For over a decade the Seattle Fire Department has successfully partnered with other public agencies, labor organizations and private contractors to develop an emergency response structure tailored to the specific conditions of the various tunneling and underground projects in Seattle. This cooperative process has allowed the agency to develop a model and build a system for effective delivery of fire, rescue and emergency medical services into the underground environment that shares the burden of providing such resource-intensive services. This paper will outline the process the Seattle Fire Department undertook to establish those relationships as well as the roles of its partners, development of its emergency response model, and the supporting training program.

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**Emergency and Rescue: A New Safety Concept for the Construction of “La Maddalena” Exploratory Adit – High Capacity Rail Line Between Turin (Italy) and Lyon (France)**

A. Sorlini, Geodata Engineering S.p.A. Turin, Italy and P. Gilli, Lyon Turin Ferroviaire S.a.S Turin, Italy

“La Maddalena,” (Chiomonte, Susa Valley, Western Alps, Italy) is the location from which the Italian exploratory adit for the Turin-Lyon HSR base tunnel is excavated. The adit is a large “borehole” 7.5 km-long, drilled using a 6.30 m-diameter open TBM, to investigate the Ambin rock mass, with a cover which reaches 2000 m, where part of the 57.5 km-long twin-tube base tunnel is to be excavated. The organization for dealing with emergencies in the project is an application of a PtD (Prevention through Design) approach. This case history presents a risk analysis based approach, together with application of modern information technology with the use of specific equipment, to produce an original and innovative comprehensive solution, ensuring effective management of risks and rescue operations in a particularly long single adit without escapeways.

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**Controlling Risks in Alternate Delivery Methods of Tunnels and Underground Projects**

D. Halem, Donovan Hatem LLP, Boston, MA and N. Munfah, HNTB Corporation, New York, NY

The unpredictable aspects inherent in tunnels or underground projects and the accelerated pace of the Design-Build (D-B) and Public-Private Partnership (P3) can result in additional risks, added costs, construction delays and potentially expensive litigations if risk-management strategies are not put in place and implemented early. This paper discusses contractual and management risks of tunnel and underground projects being delivered in the design-build or P3 procurement methods focusing on subsurface conditions.

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**Risk and Contingency Management on Toronto’s Rapid Transit Implementation Program**

B. Hamilton, CH2M Hill, Indianapolis, IN; C. Murphy, CH2M Hill, Toronto, Canada and I. Hassan, Metrolinx, Toronto, Canada

The Big Move is a 25 year, $50 billion ($-CAD) plan for coordinated and integrated transportation in the Greater Toronto and Hamilton Area (GTHA) in Ontario, Canada. This plan has been initiated by Metrolinx, a division of the provincial government of Ontario, and its vision, goals and objectives are rooted in creating a high quality of life, a thriving, sustainable and protected environment, and a strong, prosperous and competitive economy for the GTHA. The Big Move will triple the length of rapid transit service in the GTHA to 1,725 km; significantly increase the percentage of the GTHA population living within two kilometers of rapid transit; reduce commute times to an average of 77 minutes per person per day; and decrease greenhouse gas emissions from passenger transportation per person by 29%. Work is currently underway on several projects and more than $16 billion ($-CAD) of the planned investment has already been committed. A key project that forms part of this commitment is the Eglinton Crosstown Light Rail Transit (LRT) project which is being delivered in the city of Toronto under Metrolinx’s Rapid Transit (RT) Program. This sizeable project has been divided into a number of separate contracts comprising: LRT Vehicles, two tunnel contracts and a $5.3 billion ($-CAD) Public-Private Partnership (PPP) contract. The PPP contract, which is currently in the tendering phase, includes delivery of the remaining infrastructure for the LRT including subway and at-grade stations, maintenance facilities, tracks, intersections, systems, etc.
The New and Old Bebenroth Tunnel Project in Germany — Tunnelling as Part of the Deutsche Bahn Tunnel Infrastructure Safety Upgrade Program

M. Fischer and J. Jaeger, BeMo Tunneling GmbH, Innsbruck, Austria

A few years ago the Deutsche Bahn (German Federal Railways) launched its extensive tunnel safety upgrade program for its existing, partially more than 140-year-old, double-track tunnel infrastructure. To maintain the maximum operation capacity during the construction phase, the general concept includes construction of new single-track tunnels next to the existing structures, followed by the refurbishment of the old tunnels once the new tunnels are completed. The whole construction activities, ranging from standard sequential excavation for the newly-built tunnel and cross passages to the refurbishment of the old tunnel, requires a vast variety of tunnelling tasks which will be explained based on the case study of the New and Old Bebenroth Tunnel.

Surface Deformation Control Based on High-Speed Laser Scanning Systems

P. Matter and O. Schneider, Amberg Technologies AG, Regensdorf, Switzerland

Modern tunneling is subject to numerous demands: Tunneling companies must keep costs low, finish projects in a time as short as possible and still maintain the highest quality standards. The means for this include shortening the preparation time, the uncomplicated transfer of planning data, the flexible operational capability of system solutions, and the use of high-performance instruments. This all saves time, reduces downtimes in the tunneling process, and has a positive impact on the project costs. The exactness of the measuring instruments provides a high-level of set-out precision as well as profile precision. Seamless profile monitoring, layer-thickness determination, surface quality monitoring, as well as true-to-scale image documentation of tunnel installations are among the outstanding advantages of laser scanning technologies. In addition, laser scanning systems provide information about the condition of structures and calculate detailed masses for optimized logistics and account settling. The paper explains tunnel surveying based on a high-speed laser scanning system, the typical concepts of tunnel analysis, surface deformation control, and reporting functionalities based on various projects carried out in Switzerland and Austria over the past years.

Pipe Jacking Big Time!

K. Rieker, Wyas & Freytag Ingenieurbau AG, Frankfurt am Main, Germany

Since the mid-19th century the River Emscher in the German Ruhr District has been used for disposing of wastewater. In the early 1990s, it was decided to replace the existing open wastewater system with a sewer system and to restore the River Emscher to its natural state. The major Emscher conversion project is divided into a large number of individual schemes, with construction phase 30 being the largest. By applying the pipe jacking method, interlinking tunnels with section lengths in excess of 1,100 m are constructed.

Tunneling for the Paradise Whitney Interceptor, Project 669, Las Vegas, NV


Project No. 669 of the Paradise Whitney Interceptor Project for the Clark County Water Reclamation District includes construction of a new sanitary sewer interceptor utilizing trenchless methods for eight reaches totaling 13,481 linear ft and open cut methods for 13,483 linear ft. The gravity sewer ranges in inside diameter from 60- to 84-in., some with 76-in. steel casing. The project presented numerous design challenges including complicated geology, close proximity to existing underground utilities, limited surface access, and other factors forcing trenchless drive lengths up to 1,500 ft. The tunnels will be constructed utilizing trenchless methods that include earth pressure balance machines and micro-tunnel machines; ground improvement is required on many of the drives. Construction of this project began in late 2014 and is expected to take over two years to complete with a total construction budget of $62.3M.

Dugway West Interceptor Relief Sewer Microtunneling CSO Project in Cleveland, Ohio

D. Lopata, Northeastern Ohio Regional Sewer District, Cleveland, OH and D. Mast, S. Benton, B. Budzilek and R. Dill, AECOM Technologies, Cleveland, OH

The Dugway West Interceptor Relief Sewer Project is a combined sewer overflow (CSO) control project being built for the Northeast Ohio Regional Sewer District in a dense, urban Cleveland, Ohio residential neighborhood. The project includes 7,000 linear feet of 72-inch diameter relief sewer installed using a micro-tunnel boring machine (MTBM) through soft ground conditions. Design challenges included providing hydraulic relief points for the system, optimizing shaft hydraulics, and balancing constructability and alignment needs against potential neighborhood impacts. Contractor is a joint venture of Walsh Construction and Super Excavators. Construction aspects have included utilities prevalent in project areas, new connections to a large storm-water box culvert, secant shafts for temporary earth support systems, micro-tunneling system work area, contract constraint changes, and a contractor-proposed curved micro-tunnel segment.
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### RETC 2015 Exhibitors

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