## Contents

Preface............................................................................................................................... xi
Executive Committee ........................................................................................................ xiii
Session Chairs.................................................................................................................. xiv
International Committee................................................................................................. xv

### Part 1: Pressure Face TBM I

Accomplishing Extraordinary Tasks as a Machine Supplier for Metro Doha............... 2
   *Karin Bäppler, Dirk Schrader*

Innovations and Efficiency in Urban Tunnelling—A Case Study of the Eglinton Crosstown LRT in Toronto, Ontario ............................................................ 14
   *Dan Ifrim, Andre Solecki, Iqbal Hassan, Paul Cott*

Wear of Cutting Tools on an EPB TBM Tunneling Through Glacial Soils ............... 25
   *Lisa Mori, Ehsan Alavi, Brian Hagan, Michael A. DiPonio*

Impact of Conditioned Soil Parameters on Tool Wear in Soft Ground Tunneling....... 37
   *Mansour Hedayatzadeh, Jamal Rostami, Daniele Peila*

Removal of Interfering Tiebacks Using SEM in Advance of TBM Mining on the Regional Connector Project ................................................................. 45
   *Christoffer Brodbaek, Derek Penrice, Eren Kusdogan, Christophe Bragard*

Port Mann Water Supply Tunnel: Lessons for the Future .......................................... 58
   *Gregg W. Davidson, Frank Huber, Murray D. Gant*

### Part 2: Instrumentation and Monitoring

Material Flow Reconciliation: Risk Management for Pressurized Face Tunneling ....... 72
   *Ulf G. Gwildis, John E. Newby*

Managing Ground Control with Earth Pressure Balance Tunneling on the Alaskan Way Viaduct Replacement Project ......................................................... 82
   *Edward J. Cording, Jack T. Nakagawa, Justin J. McCain, Anthony F. Stirbys, David Sowers, Jorge Vazquez, Cody Z. Painter*

DC Clean Rivers Project: Geotechnical Instrumentation Programs for Protecting Critical Infrastructures in the Nation's Capital .............................................. 99
   *Lei Fu, Peter Kottke, Brad Murray, Stephen Njoloma, Rafael Castro, Moussa Wone*

A Smart Disc Cutter Monitoring System Using Cutter Instrumentation Technology....109
   *Kamyar Mosavat*
Part 3: Shafts

Dugway Storage Tunnel Ground Freezing at the Shaft DST-1: A Focus Study on the Successful Application of Ground Freezing Around an Open Shaft Excavation............. 120
  Jim Kabat, Roberto Bono, Giacomo Pini, Ryan Sullivan

Design of the Hemphill Deep Pump Station Shafts Using Blind Bore Drilling Techniques.......................................................................................................................... 131
  Yong Wu, Tao Jiang, Julian Prada, Brian Jones

Hecla Mining Lucky Friday No. 4 Shaft Challenges and Possibilities.................. 140
  George Sturgis, David Berberick, William Strickland, Matthew Swanson, Eunhye Kim, Gabriel Walton

An Overview of the SR99 TBM Access Shaft, Seattle, Washington.................. 151
  Phillip A. Burgmeier, Jacob Mitchell, Gregory Hauser

Gas Control in a Vertical Boring Machine Advanced Shaft in Shale............... 160
  Ryan P. Sullivan, Michael J. Schafer, Michael A. Piepenburg, Phil Kassouf

Large Diameter and Deep Shafts: Unique Design and Construction Challenges.... 171
  Raymond Blanchard, Edgardo Ross, Harald Leiendecker, Rodolfo Aradas

Part 4: Grouting and Ground Modification I

Cellular Backfill—A Review of Some of the Basics ........................................... 182
  Raymond Henn, David Crouthamel

Copenhagen Cityringen Project: Big Data to Manage Quality Control in Megaprojects......................................................................................................................... 190
  Livia Cicinelli, Valerio Violo, Frank Stahl, Thomas Gronbach

Copenhagen Cityringen Project: Complex Passage and Obstacle Removal Under Existing Metro Station.................................................................................................. 202
  Valerio Violo, Antonio Raschillà

Grouting and Ground Modification—Copenhagen Cityringen Project: Compensation and Jet Grouting as Mitigation Measures for TBM Operation Under Historical Building ........................................................................... 213
  Antonio Raschillà, Valerio Violo, G. Kafantaris

The Crossing Under the Alaskan Way Viaduct .................................................... 226
  Enrique Fernandez, Gregory M. Hauser, Francisco Gonzalez, Carlos Herranz, Andrew Herten

Part 5: Hard Rock TBM

Rockbursts in TBM Tunnels—Analysis and Countermeasures............................ 240
  Gary Peach, William B. Dobbs, Bruce Ashcroft

Large-Diameter 20-Inch Disc Cutters: A Comparison of Tool Life and Performance on Hard Rock TBMs ............................................................... 254
  Stephen Smading
Successful Excavation of Mexico City’s Emisor Poniente II Wastewater Tunnel—Use of a Dual-Mode, Crossover TBM in Challenging Geology ..................... 261
  Roberto Gonzalez, Martino Scialpi

High Cover TBM Tunneling in the Andes Mountains—
A Comparative Study of Two Challenging Tunnel Projects in Chile .................... 269
  Carlos Lang, Mark Belli, Pablo Salazar

**Part 6: Conventional Tunneling**

John Hart Generating Station Replacement Project—Underground Works:
Project Update and Challenges Encountered ............................................................. 284
  Matt Kendall

Sewer Tunnel Excavated Under and Adjacent to Treacherous Terrain,
Including Landfills, Oil Refinery, Crowded Streets, and Significantly Contaminated Material and Utilities ................................................................. 298
  Russell Vakharia, Rosann Parachuelles

Design and Construction of the Capitol Connector Pedestrian Tunnel .................. 306
  Andrew M. Stone, John Jacoby, Matt Over, Joe Schrank

Geotechnical Considerations for the ORBEEC Drumanard Tunnel .......................... 317
  David Neil

**Part 7: Large-Span Tunnel Cavern**

Design and Construction of Indianapolis Pump Station Cavern ............................. 326
  Verya Nasri, Alex Varas, Michael Miller, Jose Castillo

Admiralty Station, Hong Kong: Rock Excavation and Support Challenges to Accommodate MTR’s Two New Lines ......................................................... 336
  Harry Asche, Mike Bezzano, Scott Smith, Mark Wiltshire

Completing the Second Avenue Subway Project, New York ................................. 350
  Jonalen Chua-Protacio, Richard Giffen

Permanent Lining Design for Downtown Los Angeles Cavern ............................... 358
  Justin Lianides, Carlos Herranz, Derek Penrice

First Large-Diameter Hard Rock CSO Chamber in St. Louis ................................ 371
  Dave Frierdich, Patricia Pride, Kevin Nelson, Clay Haynes

**Part 8: Future Tunneling**

Overvaal Rail Tunnel: Securing the Economic Arteries of the Rainbow Nation .......... 378
  Jack Muir, Hennie Gouws

California High-Speed Rail—Connecting and Transforming California—Design Considerations for Tunnels ................................................................. 389
  Steve Dubnewych, Steve Klein, Ofelia Alcantara, Noopur Jain, Randy Anderson

Design of Atlanta Raw Water Supply Program ....................................................... 400
  Tao Jiang, Don Del Nero, Adam Bedell, Brian Jones, Ade Abon
Contents

Annacis Island Wastewater Treatment Plant Tunneled Outfall System........................ 409  
  John Newby, Kapila Pathirage, Ken Massé

Delivery of Design, Environmental Statement, Engineering, Construction  
Management of the UK’s New High Speed Railway for the 21st Century................. 420  
  Colin Rawlings, Nita Rabadia, Mark Howard, Richard Sturt,  
  David Soper, Alan Vardy

Planning and Design of the New Ashbridges Bay Treatment Plant Outfall for the City of Toronto................................................................................................................. 438  
  Gary J.E. Kramer, Deborah Ross, Fiona Duckett, Justyna Kempa-Teper

Planning of the San Francisco Public Utilities Commission’s Channel Tunnel ............ 453  
  R. John Caulfield, Art Hamid, Manfred Wong

Part 9: Pressure Face TBM II

EPB or Slurry TBM? Suffolk County, Long Island, NY, Outfall Replacement Tunnel ......................................................................................................................... 466  
  Michael S. Schultz, Greg Sanders, Mary Anne Taylor, John Donovan

SR99 Bored Tunnel in Seattle: Performance and Challenges of “Bertha,” the Largest TBM Ever .............................................................................................................. 472  
  Roger Escoda, Juan Luis Magro, Jorge Vazquez

Design and Implementation of a Large-Diameter, Dual-Mode “Crossover”  
TBM for the Akron Ohio Canal Interceptor Tunnel....................................................... 488  
  E. Comis, D. Chastka

Cutterhead Protection in a Boulder Field Using Real-Time Vibration Monitoring........ 498  
  Jessica Buckley, Ehsan Alavi, Brian Hagan, Michael A. DiPonio,  
  Mike Mooney, Nathan Toohey, Thomas Planes

EPB TBM Foam Generation ....................................................................................... 509  
  Mike Mooney, Nils Tilton, Dhrupad Parikh, Yuanli Wu

Challenges Encountered During Tunneling on the First Street Tunnel Project............ 521  
  Mina M. Shinouda, Thomas Costabile, Abdul-Ghani Mekkaoui,  
  William P. Levy

Part 10: Risk Management

Tunneling Risk Is Down, Uncertainty Is Up—Fifty Years of Experience and  
Case Studies .............................................................................................................. 534  
  Russell Clough

Contract Packaging and Formation—Risk Informed or Ignored? ............................... 540  
  Andy Thompson

DigIndy Tunnel System—Pleasant Run Deep Tunnel Optimization Yields  
Cost Savings and Improved Level of Service ............................................................ 546  
  Nick Maynard, Leo Gentile, Maceo Lewis IV

Reduce Urban Tunnel Utility Relocation Risk Through Early Relocation by  
Specialty Contractor ................................................................................................. 555  
  Gordon Evans, Carlton Ray, Tom DiLego, Justin Carl,  
  Steven Bealby, Aliuddin Mohammad
The Importance of Collective Safety Buy-In from Project Mobilization ........................................ 566
Christina Lindstrom, Arthur Musisi

Part 11: Major Projects
Procurement and Delivery Strategies to Increase Competitiveness on Tunnel Projects .......................................................... 574
Steven R. Kramer, Paul Nicholas
Design-Build Project Delivery: The Importance of Successful Coordination Between Designer and Contractor .............................................. 584
Mark Johnson, Martin Ellis
Construction of the Longest Road Tunnel in Mexico ................................................... 594
Hector Canseco Aragon, Miguel Angel Banuet Rodriguez
Semmering Base Tunnel: 17 Miles of SEM and TBM Tunneling Under Challenging Conditions in Austria ..................................................... 604
Michael Proprenter, Oliver K. Wagner
Boston’s Central Artery/Tunnel Project—Lessons Learned ........................................ 614
John Reilly, Fred Salvucci, David Hatem
Tunneling Challenges on the Auckland City Rail Link, New Zealand ...................... 624
Tom Ireland, Bill Newns, Shu Fan Chau, Steve Hawkins

Part 12: Innovation and Technology
Game-Changing Technology for Overhead Ventilation Duct Construction in Large-Diameter Railway Tunnel .................................................. 638
Tse-Hung Lee, Li-Ling Chen
The Use of Saturation Diving Techniques in Support of Pressurized Tunnels ............. 647
Justin Costello
Use of Infrared Technology to Detect Backfill Voids Behind Steel Lining in Tunnels ................................................................. 655
Alexander MacKinnon, Bruce Harland
Use of “Command Chair” Simulator Technology to Optimize Modern TBM Performance ........................................................................ 665
Steve Chorley
Metro Doha—Continuous Tunnel Belt Application for One of the World’s Largest Infrastructural Projects (A Challenge) .................................. 673
Marco Sonnenschein, Georg Butsch

Part 13: Tunnel Lining I
Load-Bearing Capacity of Fiber-Reinforced Concrete Tunnel Linings Under Combined Moment-Normal Force Loading Conditions .......................... 680
Axel G. Nitschke, Erik S. Bernard
Engineered and Safe Approach to Tunnel Segment Lining Installation with Dowelled-In Connectors on the First TBM Tunnel in Qatar .................. 694
Francois G. Bernardeau, Jacek B. Stypulkowski
Design of Steel Fiber-Reinforced Concrete Segmental Lining for the South Hartford CSO Tunnel ................................................................. 706
  *Mehdi Bakhshi, Verya Nasri*

Final Lining Design of the Ohio River Bridges East End Crossing Tunnel ........................... 718
  *Wern-ping Chen, Mohammad Tughral Shaikh, Sharma Narasimharajan, Clement Uhring*

Construction Logistics for East Side Access CM006 Manhattan North Structures—A Study from Queens to Manhattan ........................................... 731
  *Sam Lo Grasso, Roberto Adames, Lonnie Jacobs*

Cost-Effective Seismic Station-Tunnel Connections on Westside Subway Extension Project Section 1 ................................................................. 741
  *Anthony Harding, Hisham Nofal*

**Part 14: Stations and Cross Passages**

Cross-Passage Mining Using Different Supports in Different Grounds........................ 754
  *Satoshi Akai, Kenji Yamauchi, Hiroyoshi Kawasaki, Darrell Liebno, Guido Venturini*

Systematic Cross-Passage Design and Construction Planning for Transit Tunnels ................................................................. 764
  *Peter Chou, Yue Shi, Matthew Burdick, Patrick Nicholson*

Station Excavation and TBM Tunnel on Los Angeles Crenshaw Project ..................... 775
  *Ran Chen, Jesse Salai, Ben Schatz*

Third Street Light Rail Phase 2, Central Subway Stations, San Francisco, CA—Utilization of Multiple Foundation Techniques ........................................... 786
  *Albert Neumann, Kevin Bolton, Jeffrey J. Bean*

Risk Reduction, Management, and Mitigation from Experience-Based Learning During Construction of Cross Passages, Seattle, Washington ............... 796
  *Sandeep Pyakurel, Walter Klary, Vojtech Gall, Nate Long, Anthony Pooley*

Closing the Gap for Bogotá River Sanitation System Tunnels (Colombia) ..................... 809
  *Michael B. Gilbert, Harlem Suarez, Mahmood Khwaja*

**Part 15: Grouting and Ground Modification II**

Leak Mitigation Grouting for New York Subway Tunnels ........................................... 822
  *Paul M. Gancarz, John E. Minturn, Nico J. Grobler, Deon Van Dyk*

Complex Inner-City Tunnel Excavation by Means of the New Austrian Tunnel Method in Combination with a Hyperbaric Atmosphere.................. 831
  *Thomas Wechner*

Geologically Targeted Pre-Excavation Grouting Along the WestConnex M5 Tunnel, Sydney, Australia ................................................................. 839
  *Ulrike Pelz, Joan Casado, Harry Asche, Jack Raymer, David Crouthamel, Scott Fidler*

A Proactive Approach to Tieback Anchor De-tensioning ........................................... 852
  *Sean Peterfreund, Grant Finn*
Part 16: Trenchless Tunneling

Paradise Raw Water Intake: Fighting the Green River .......................................................... 874
Nicholas Joens, Matt Roberts

Dugway South CSO Relief and Conveyance Sewer, A Critical Connector ......................... 881
David Mast, Karrie Buxton, Amanda Foote, Irwan Halim, Alison Schreiber

Long-Distance Microtunnelling at Toronto Pearson International Airport ......................... 891
Robert Ofori, Jordan Schreiner, Marc Gelinas, Ajay Puri, Walter Trisi, Joe Mulville

Upper Limit Microtunneling Application to Meet Dam Safety and Operational Longevity ................................................................................................. 900
Babs Marquis, Everette Knight, Emory Chase, John Vickers, John Arciszewski

Microtunneling in Georgian Bay Shale: Rebecca Trunk Wastewater Main, Oakville, Ontario ......................................................................................................... 909
Paul Headland, Guadalupe Monge Fabian, Rajab Ali, Kanchan Mohammed, Mark Bajor

Part 17: SEM/NATM

Steep Inclined SEM Excavation—The “Uphill Machine”—at London Crossrail:
Development and Application of a Safe Excavation System in Soft Ground ....................... 928
Rainer Antretter

Downtown Bellevue Tunnel—Concept Optimization Through Team Collaboration ......... 937
Derek Penrice, Hong Yang, Chad Frederick, Jacob Coibion

Comparative Application of NATM, TBM, and RBM Technologies .............................. 949
Pedro Pino Véliz, Patricia Kong Diaz

Sequential Excavation Method with Ground Freezing for DC Water’s First Street Tunnel ...............................................................................................................960
Ivan Hee, William Bracken, Harald Cordes, Stephen Njoloma

Part 18: Difficult Ground

Design of the Fort Wayne CSO Tunnel Through Complex/Wet Rock......................... 970
Aswathy Sivaram, Mark H. Bradford, T.J. Short

Rondout West Branch Bypass Tunnel—TBM Boring in Hard Rock Against High Water Pressure and High Water Inflows Beneath the Hudson River in New York ..............................................................................................................980
David Terbovic, Martino Scialpi

Innovations on West Trunk Sewer Contract 2 ............................................................. 989
Jon Hurt, Jörg Riechers, Mike Ghasemi, Tony DiMillo, Vanessa DiMillo, Ajay Puri
Part 19: Tunnel Rehabilitation

Sumner Tunnel Rehabilitation ................................................................. 1010
   S.C. Quinn, J. Rigney

The Arlberg Tunnel Project—A Milestone in the Austrian Efforts to Increase Safety of the Road Tunnel Network .................................................. 1019
   Michael Hoellrigl, Norbert Fuegenschuh, Christoph Wanker

Large-Diameter Sliplining Under Extreme Conditions: Rehabilitating the Oakland-Macomb Interceptor While Maintaining Service to 830,000 Customers ......1027
   Curtis Rozelle, Abdul-Ghani Mekkaoui, Fritz Klingler, Saju Sachidanandan, Sid Lockhart

Index .............................................................................................................. 1039