

North American Tunneling Conference (NAT 2020)

Nashville, Tennessee, USA
7 - 10 June 2020

Editors:

**Brett Campbell
Paul Madsen
Jim Rush**

**Matthew Preedy
Dawn Dobson Markman**

ISBN: 978-1-7138-1330-9

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Copyright© (2020) by Society for Mining, Metallurgy and Exploration (SME)
All rights reserved.

Printed with permission by Curran Associates, Inc. (2020)

For permission requests, please contact Society for Mining, Metallurgy and Exploration
at the address below.

Society for Mining, Metallurgy and Exploration Inc.
12999 East Adam Aircraft Circle
Englewood, CO 80112-4167

Phone: (303) 948-4200
Fax: (303) 973-3845

cs@smenet.org

Additional copies of this publication are available from:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: 845-758-0400
Fax: 845-758-2633
Email: curran@proceedings.com
Web: www.proceedings.com

Contents

Preface	xi
TRACK 1: TECHNOLOGY	
Session 1: Ground Support	1
Union Square Market Street Station: Deep Battered Drilled Shafts as Permanent Ground Support	3
<i>David P. Abrahams, Kenneth A. Johnson, and Jane Wang</i>	
Innovative High Durability Non-Steel Fiber Reinforced Segments	12
<i>Paz Navarro, María N. Sánchez, Elena Martín, Ignacio Segura, Janill de la Cruz, and Albert de la Fuente</i>	
Jacked Pre-Cast Caisson Shaft Construction Methodologies	23
<i>Ben Ablett, John Elliott, and Joe Anderson</i>	
Session 2: TBM Technology	29
EPBM Proactive Tracking and Progressive Optimization	31
<i>E. Comis, C. Lavassar, and D. Nebbia</i>	
Project Clear: Efficient Hard Rock Tunneling Below St. Louis, Missouri	40
<i>Doug Harding</i>	
Small Diameter Tunnelling: Limitations and Machine Concepts	45
<i>P. Schmäh and M. Lübbbers</i>	
Using Predictive Modeling for TBM Process Control	54
<i>Jacob Grasmick and Angus Maxwell</i>	
TBM Hardening and Anti-Wear Implements Against Ground Abrasion	63
<i>Donald Del Nero</i>	
Session 3: Innovative Solutions	79
Altered Tunnel Start Due to Significant Surface Erosion in the Portal Area— a Creative Approach at Tunnel Herrschaftsbuck in Germany	81
<i>Norbert Fuegenschuh and Roland Arnold</i>	
Deep Shaft Sinking Through Limestone, Mudstone, and Halite	89
<i>S. Pollak, T. Mahoney, and G. Capes</i>	
An Introduction to Low-Density Cellular Concrete and Advanced Engineered Foam Technology	98
<i>Nico Sutmoller</i>	
Boring a Tunnel Under a Train Station Using Ground Freezing—Line 14-T03— Extension of a Subway Line in Paris (France)	106
<i>Marc Bouffier, Benjamin Lecomte, Louis Delmas, Christian Gilbert, and Laurent Buissart</i>	
Long-Distance Annulus Backfilling of Rehabilitated Sewer Tunnel with Limited Grouting Access	117
<i>Margaret A. (Peggy) Ganse, Ingrid A. Sandberg, Steven E. La Vallee, Keith Lemaster, Randy Parks, and Michael Lehrburger</i>	
TBMs for Norwegian Small Hydropower Projects	126
<i>Sindre Log, Rune Skjevdal, and Tobias Anderson</i>	

North American Tunneling: 2020 Proceedings

Session 4: Design Innovations	133
Unreinforced Slurry Walls as Temporary Support of Excavation for Circular Shafts	135
<i>Pooyan Asadollahi, Arash Dahi Taleghani, and Guoqiang Li</i>	
How Uncertain Are the Geological-Geotechnical Soil Transition Boundaries?	142
<i>Rajat Gangrade, Mike Mooney, and Jacob Grasmick</i>	
Designing and Implementing Risk Mitigation for Existing Critical Utilities by Means of Construction Sequencing	152
<i>Gregory Rogoff, Karrie Buxton, Josh Suffel, and Brad Murray</i>	
Reaching New Depths: Innovations in Technological Site Characterization Tools for Integrated Tunnel Design and Construction	160
<i>Erin L.D. Sibley, Amanda M. Wachenfeld, and Nicholas J. McCrossan</i>	
Advancements in Durable Segments for Utility Tunnels	169
<i>Ralf Winterberg, Michael R. Garbeth, and Brian Glynn</i>	
Session 5: Digital Technology	179
EPB Shield TBM Automation Using the Autonomous Vehicle Framework	181
<i>Mike Mooney, Hongjie Yu, and Rajat Gangrade</i>	
Innovative Tools to Control Tunnel Project Risks	191
<i>Bernard Theron, Bernard Catalano, and Florent Reysset</i>	
BIM Implementation in the Design of Underground Structures for the Réseau Express Métropolitain (REM) Project in Canada	197
<i>Theodora Vovou, KiSeok Jeon, and Verya Nasri</i>	
Settlement Monitoring During Tunneling Using Continuous InSAR and Trend Detection Analysis . . .	205
<i>Sara Del Conte, Giacomo Falorni, and Marie-Josée Banwell</i>	

TRACK 2: PLANNING

Session 1: Tunnel Diversity	213
Recent Experience with Bond Market Investors on P3 Project with Tunnel Works	215
<i>David Mast, Amanda Foote, Tom DiPonio, Mina Shinouda, and Jason Edberg</i>	
Aged Tunnel Rehabilitation Options: Using Geotechnical Techniques to Assess Site Conditions and Provide Modeling Inputs: A Case Study from Detroit	223
<i>David M. Sackett, Russell H. Lutch, and Jon B. (Ike) Isaacson</i>	
Dugway South CSO Relief and Conveyance Sewer—Owner Flexibility and Contractor Experience Lead to Project Success	233
<i>David Mast, Amanda Foote, Richard Depew, Chris Lynagh, Tom Szaraz, and Jason Edberg</i>	
Session 2: Contracting Strategies	241
Design-Build Procurement of the Hampton Roads Bridge-Tunnel Expansion	243
<i>Martha E. Gross and James S. Utterback</i>	
CM/GC Delivery Method for Federally-Procured Projects: A Case Study on the Independent Cost Estimating Process	249
<i>Doug Pelletier, Josh Willhite, Andy Thompson, Ben DiFiore, and Jeff F. Wallace</i>	
Getting Metro Owners the Best Value from Their Major Underground Projects	256
<i>Ronald D. Drake and William H. Hansmire</i>	
Tunnel Cost Estimating—Sharing our Experience	263
<i>Dan Ifrim, Andre Solecki, Brian Garrod, Nina Dinescu, and Majid Eslami</i>	
Progressive Design Build in Silicon Valley	273
<i>Nik Sokol, Mike Jaeger, and Jack Sucilsky</i>	

Contents

Session 3: Transportation	283
Highway Connection Through Ouachita Mountains—Arkansas Tunnel Studies	285
<i>Eric Wang, Ray Sandiford, and Michael Fugett</i>	
Large Single Bore Tunnel for VTA’s BART to Silicon Valley Phase II Extension	292
<i>Anthony Bauer, Gordon Clark, Ronak Naik, and Dennis Ratcliffe</i>	
SCMAGLEV—Innovative Mass Transit in the Northeast Corridor (NEC)	298
<i>Vojtech Gall, Nikolaos Syrtariotis, Timothy O’Brien,</i> <i>Cosema (Connie) Crawford, and David Henley</i>	
Safety Challenges in Long Rail Tunnels	304
<i>Bernd Hagenah, Sean Cassady, Mala Ciancia, Sanja Zlatanic,</i> <i>and Hans-Peter Vetsch</i>	
Revisiting Whittier Tunnel 20 Years After Conversion to Dual Rail/Highway Service	312
<i>David Jurich, Paul Gabryszak, Matt Tanaka, and Carl Hall</i>	
Proposed New Tunnels for Sound Transit’s LINK Light Rail Expansion	320
<i>Matthew Preedy, Dirk Bakker, and Anthony Pooley</i>	
Session 4: Risk Management	325
Risk Mitigation Strategy for Big Walnut Sewer Extension in Columbus, Ohio	327
<i>Irwan Halim, Heather Marsh, and Jeremy Cawley</i>	
Estimating Project Contingency Reserves—Now What?	335
<i>Keith Ward, Erika Moonin, Joe O’Carroll, and Connor Langford</i>	
Tunneling in a Dense Urban Environment—The Edgewood Avenue Near Surface Collector Project	344
<i>Greg Sanders, Mike Schultz, Mahmood Khwaja, and David Kasper</i>	
Reliability, Availability, Maintainability, Safety (RAMS) Analysis for Complex Tunnel Construction Systems—Applications and Benefits	349
<i>Philip Sander, John Reilly, Jim Brady, and Markus Spiegel</i>	
Second Narrows Water Supply Tunnel—Planning Through Construction Procurement	358
<i>Frank Huber, Gregg W. Davidson, and J. Andrew McGlenn</i>	
Session 5: Water/Wastewater	367
Brushy Creek Regional Utility Authority Phase 2 Raw Water Delivery System Project	369
<i>James Parkes, Aaron Archer, and Brian Gettinger</i>	
Determining the Feasibility of Tunneling for Flood Mitigation After Hurricane Harvey	377
<i>Brian Gettinger, Hector Olmos, Scott Elmer, Michael Joye, Don Wotring, and Patrick Beecher</i>	
ALCOSAN Tunnel System Preliminary Planning	387
<i>Kim Kennedy, Mike Lichte, Tim O’Rourke, and Dan Dobbels</i>	
Assembly and Launch of the Coxwell Bypass TBM, Assessment of Complete vs. Partial TBM Assembly	395
<i>William Hodder, Brian Hesano, and Ehsan Alavi</i>	
 TRACK 3: DESIGN	
Session 1: Overcoming Design Challenges	401
Surface Water Supply Project, Segment C	403
<i>Nancy Nuttbrock, Melinda Silva, and Alan Hutson</i>	
The Three Rivers Protection and Overflow Reduction Tunnel (3RPORT)— Design Challenges of the Launching of Pressurized Slurry TBM	411
<i>Roberto Schuerch, Paolo Perazzelli, Giuseppe Moranda, Miriam Piemontese,</i> <i>Ludovica Pizzarotti, and Emidio Tamburri</i>	

North American Tunneling: 2020 Proceedings

Nose Hill Water Supply Tunnel Design	423
<i>Dan Ifrim, Reza Shobayry, Shawn Pillai, Anwar Majid, and David Lagore</i>	
Session 2: Tunnel and Shaft Linings	433
Design, Manufacturing, Construction and Durability of Precast Tunnel Segments According to New ACI 533.5R Guide	435
<i>Mehdi Bakhshi and Verya Nasri</i>	
Cross-Passage Openings in TBM Tunnels with Shear Keys	447
<i>Cetin Sahin, Mert Gunduz, and Nicola Della Valle</i>	
Analysis of Large Side Openings in Deep Shaft Under Improved Ground Condition by Soil Freeze	459
<i>Sobhan Bhattacharya and Mohamed Gamal</i>	
Montreal Express Link (REM) Airport Tunnel—Design of Segmental Tunnel Lining	476
<i>Mehdi Bakhshi and Verya Nasri</i>	
Experimental Behavior of Large Diameter Segmental Lining Systems: A Review	488
<i>Mike Mooney, Tamir Epel, Ashley Wilson, Haotian Zheng, and Axel G. Nitschke</i>	
Session 3: Risk Management Through Effective Design	499
Setting Face Pressures for Settlement Control During EPB and Slurry Tunnelling	501
<i>S.J. Boone, J. N. Shirlaw, and S. Barrett</i>	
Challenges to Urban Excavation Through Chalk Formations	509
<i>E.C. Wang, C.K. Moon, and C.A. Stone</i>	
Everything Is Deeper in Texas SAWS Tunneling in the Navarro Claystone	518
<i>Daniel R. Maine, Melody Clay, Kevin Mandeville, Gail Hamrick-Pigg, and Jeff Farnsworth</i>	
Hard Rock Tunnel Rehabilitation: Small Demonstration Project Informs Design of Complete Tunnel Rehabilitation Project	529
<i>Kushwant S. Chohan, Rachel L. Martin, Glenn M. Boyce, and David F. Tsztoo</i>	
Addressing Project Challenges and Integrating Construction Method Flexibility for the Rand Park Stormwater Diversion Tunnel, Keokuk, Iowa	540
<i>Mahmood Khwaja, Gregory Sanders, Michael S. Schultz, Michael Odrowski, Mark Boussetot, David R. Schechinger, and Daniel Boggs</i>	
Supporting Post-Bid Changes in Segment Design and Machine Launching Philosophies for the Bergen Point Outfall Tunnel, Suffolk County, New York	549
<i>Mahmood Khwaja, Michael S. Schultz, Keith Kelly, and Janice McGovern</i>	
Session 4: Resiliency	559
LED Lighting for Hazardous and Gassy Locations	561
<i>Brian Astl and Jacob Hunter</i>	
Tunnel Rehabilitation and Structural Modifications in Transportation Structures from the Early 1900s	566
<i>Peter Torres, Daniel Garcia, and Ravi Jain</i>	
New Aspects in Tunnel Ventilation	577
<i>Petr Pospisil</i>	
Investment and Operation Cost Savings with Innovative Fire Life Safety Systems Design	585
<i>Reinhard Gertl, Hubert Heis, and Hans Haring</i>	
Rock Burst Due to High In Situ Horizontal Stress Adjacent to Tunnel and Shaft	592
<i>Bill Zietlow and Anna Crockford</i>	

TRACK 4: CASE HISTORIES

Session 1: Conventional Tunneling	599
Anticipated vs Actual Behavior of Shallow SEM Tunnel Under a Residential Area— Construction Impacts and Contractor/Designer Solutions	601
<i>Zhibo Chen, Philip Lloyd, Rafael Villarreal, David Watson, and Richard Taylor</i>	
SEM Huge Mined Cavern Stations Beat Cut and Cover in Crosslinx Megaproject	621
<i>Alejandro Sanz, Paz Navarro, Francisco Soto, and Juan Azofra</i>	
Performance-Based Classification of Fiber Reinforced Concrete for Tunnel Linings Based on Model Code 2010.	634
<i>Axel G. Nitschke</i>	
Session 2: Tunnel Boring Machines	647
Metro Singapore—Lot T219: Orchard Station and Tunnels Innovative Tunneling Techniques.	649
<i>Bernard Theron, Estelle Claeys, and Bernard Catalano</i>	
Mechanized Excavation in Shale Formation—Performances Comparison Between the Main Beam TBM Tunnels, the Single Shield TBM Tunnel and the Roadheader Tunnels at the Doan Valley Project	659
<i>Martino Scialpi, Karrie Buxton, and Brian Negrea</i>	
The Dallas Mill Creek Drainage Relief Tunnel—Changing TBM Cutterhead Diameters in Mid-Tunnel	670
<i>Paul J. Smith, J. Milton Brooks, Quang D. Tran, and Eudomar A. Silva</i>	
Completing Mexico City’s Mixed Ground Mega Tunnel: Emisor Oriente	676
<i>Roberto Gonzalez</i>	
Use of Multiple TBMs for Singapore’s Ground Breaking Deep Tunnel Sewerage System Phase 2	686
<i>Karin B�ppler</i>	
Session 3: Shafts and Rehabilitation	693
Innovative SOE Solutions for Shaft Construction: Getting to Depth with Diaphragm Walls at Westerly Storage Tunnel	695
<i>Jewels Stover, Lisa Smiley, and Ryan Sullivan</i>	
Pre-Excavation Activities for the Long Baseline Neutrino Facility Far Site	701
<i>Seth Pollak, Jon Hurt, Foteini Vasilikou, Ben Seling, Doug Pelletier, and Josh Willhite</i>	
Laguna Beach Rehab Tunnel - Solutions for Unique Tunnel Rehabilitation Challenges	711
<i>Kevin Kilby, Scott Zylstra, Trenton Cohen, Joseph Sinacori, and Marc Serna</i>	
Rehabilitation of Teck Coal Conveyor Tunnel in Elkview Mine, BC.....	719
<i>Irwan Halim, David Forrester, Brian Wong, and Bilal Butt</i>	
Digging a Shaft in Free Phase Oil and Hydrocarbons, Reality vs. Fantasy	730
<i>John Teahen, Sanjeer Yogendran, Ehsan Alavi, and Abdul-Ghani Mekkaoui</i>	
Modern Mining: Engineered Tunneling Approach for Mine Access Tunnels.....	738
<i>Timothy O’Brien, Nikolaos Syrtariotis, Vojtech Gall, and Kyle Wooton</i>	
Session 4: Planning and Overcoming Challenges	745
Case Study—Start-Up and Operation of Deep Rock Connector Tunnel and Pump Station, Indianapolis, Indiana	747
<i>Alexander J. Varas and John Morgan</i>	
Lake Mead Intake Nos. 1, 2 and 3: Fifty Years in the Making	754
<i>Erika Moonin and Robin Rockey</i>	
Design and Construction Considerations for Long Distance Small Diameter Tunnels	759
<i>Jim Buckley, Konner Horton, Adam Bedell, and Don Del Nero</i>	

North American Tunneling: 2020 Proceedings

Semmering Base Tunnel—A Challenge in Tunneling. 765
E. Neugebauer and M. Proprenter

Construction of the Albany Park Stormwater Diversion Tunnel. 775
Sotirios Vardakos and Mark J. Stephani

Session 5: Microtunneling and Trenchless Technology. 783

Sur de Texas-Tuxpan Project: World Record Microtunneling Drive with an
Underwater Recovery 785
Darrell Wilder, Marc Martí Cardona, and Hector Trigal

A Tale of Two Tunnels: The Cooksville Creek Trunk Sanitary Sewer 791
Alex Burnett, Marc Gelinis, and Grace Krasowski

How Do You Eat an Elephant? Hand Mining in the 21st Century 799
Ben Ablett and Ed Gillard

Index 811