

March 2022
VOL. 74 NO. 3

Mining[®] engineering

OFFICIAL PUBLICATION OF SME

Ronald Parratt
2022 SME President



SPECIAL INSERT:



me.smenet.org

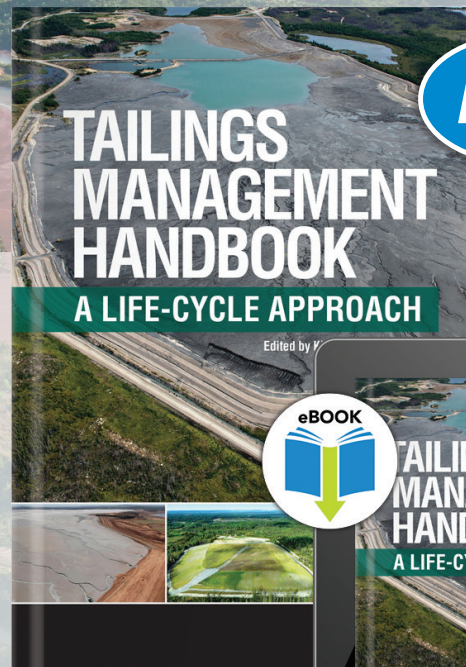
SME

Society for
Mining, Metallurgy
& Exploration

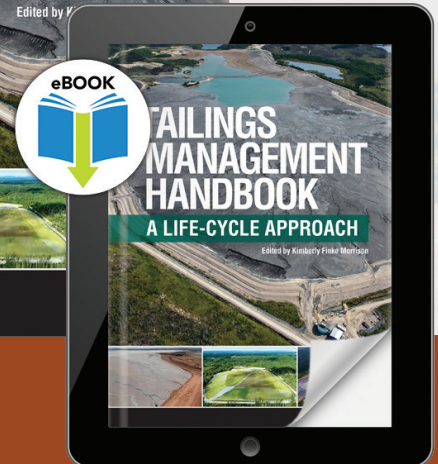
TAILINGS MANAGEMENT HANDBOOK

A Life-Cycle Approach

Edited by Kimberly Finke Morrison



NEW!



The industry's need for this resource is abundantly clear – there is no other comprehensive resource rooted in the new fundamentals and global principles for tailings management.

Contributed to by more than 100 world-renowned experts, this handbook focuses on:

- The basics,
- Life-cycle planning,
- Site and tailings characterization,
- Tailings storage facilities design and construction, and
- Systems and operations.

**Plus, learn from 42 case studies
with real-world successes and
lessons learned.**

"I expect that this Handbook will be the centerpiece in the library of all committed to tailings facility safety in the broadest sense."

Norbert Morgenstern, Distinguished Professor (Emeritus), University of Alberta, Canada, and Consulting Geotechnical Engineer



**Save 25% when you order both
the print and eBook bundle!**

Available at smenet.org/store

2022 | 1,024 pages | Print or eBook

ISBN 978-0-87335-490-5 | Book Order No. 490-5

\$179 Member | \$139 Student Member | \$299 Nonmember/List

"The knowledge sharing in this handbook is quite evident and extremely useful."

– Dr. Caius Priscu, PE, Independent Consultant and Adjunct Professor, The University of British Columbia, Vancouver, Canada

Newmont

The book was published with the support of Newmont

smenet.org

Make a Smart Career Move with the **SME Career Center**

Search a dedicated career resource specific to the mining and mineral industry.



The SME Career Center connects you with employers actively looking for professionals in the mining industry.

Interested in posting a job or internship opportunity and connecting with the talented SME membership?

Learn more at miningjobs.smenet.org or contact Laura Nelson at nelson@smenet.org.

Visit miningjobs.smenet.org to:

- ▶ Create a job seeker profile
- ▶ Post a resume
- ▶ Apply for jobs
- ▶ Get job flash emails

SME

Society for
Mining, Metallurgy
& Exploration®

smenet.org



Feature Articles

- 16** **Ronald R. Parratt;**
An interview with the 2022 SME President
William Gleason
- 19** **Adapting openpit mine design fundamentals to leverage the advantages of autonomous haulage systems**
Race Owens, Chris Roos, Scott Rosenthal and Bryce Hill
- 30** **Getting students interested in mining engineering; How can we reach them?**
Isabel Barton, Jodi Banta and Lynnette Hutson

Technical Paper Abstracts from *Mining, Metallurgy & Exploration* (peer-reviewed and approved)

- 35** **A scale model experimental study for estimating the productivity of bulk push dozer operations in hard-rock mining**
by Royal Rea, Peter Knights and Mehmet Kizil
- 37** **Usage of fly ash as binder in the micropelletization process as a partial replacement of bentonite**
by Sivalingaraju Barisetty, Rameshwar Sah, Shyam Yadav, L R Singh and P K Ghorui
- 39** **Coupled finite-difference and discrete-element method for modeling direct shear tests on combined rock-cemented rockfill specimens**
by Chong Wei, Derek Apel and Tatyana Katsaga
- 41** **Effect of bucket geometry, machine variables and fragmentation size on the performance of rubber tire loaders**
by Atta Ur Rehman and Kwame Awuah-Offei
- 43** **A discrete-event simulation and data-based framework for equipment performance evaluation in underground coal mining**
by Enver Yilmaz and Mustafa Erkayaoglu
- 44** **Effect of corn oil addition to TCMA-modified clay on ZEN removal**
by Kerri Ann A. Hue, Ayman A. El Midany and Hassan E. El Shall



tuc & Special Editorial Section

- 12** **Rehabilitation of the Tuscarora Tunnel**
Thomas Martin, Thomas Leckrone and James Stump
- 16** **Utilizing the TBM, Big Tex for the Dallas Mill Creek drainage relief tunnel**
Paul J. Smith, J. Milton Brooks, Quan D. Tran and Eudomar A. Silva
- 23** **Advances in tunneling technology discussed at Cutting Edge Conference in Dallas, TX**
Nancy Profera

Copyright 2022 by the Society for Mining, Metallurgy & Exploration, Inc. All rights reserved.

MINING ENGINEERING (ISSN 0026-5187) is published monthly by the Society for Mining, Metallurgy, and Exploration, Inc., at 12999 E. Adam Aircraft Circle, Englewood, CO, 80112 USA. Phone 1-800-763-3132 or 1-303-948-4200. Fax: 1-303-973-3845 or email: sme@smenet.org. Website: www.smenet.org. Periodicals postage paid at Englewood, CO USA and additional mailing offices. Canadian post: publications mail agreement number 0689688.

POSTMASTER: Send changes of address to MINING ENGINEERING, 12999 E. Adam Aircraft Circle, Englewood, CO, 80112 USA.
Printed by Publication Printers.



REGISTRATION OPEN

Combining Collaboration and Innovation to Advance Rockburst Seismology in Mines

Explore Innovations in Rockbursts & Seismicity in Mines

RaSiM10 provides a forum to share state-of-the-art scientific advances, to introduce technical innovations, to discuss the state-of-practice engineering and mine operations in seismically active mines experiencing rockbursts.

SHORT COURSES:
April 24-25, 2022

CONFERENCE:
April 26-28, 2022

TOUR:
April 29, 2022

This global mining event focuses on topics surrounding this vital aspect of mining, including:

- Seismic Monitoring and Data Analysis
- Mechanistic Analysis
- Risk Assessment and Mitigation
- Management and Control
- Comprehensive Industry Case Studies

Register by March 16, 2022 for best conference rates!

RaSiMsymposium.com

Overall conference sponsor:



In Partnership with



Mining engineering

OFFICIAL PUBLICATION OF SME
www.miningengineeringmagazine.com

MARCH 2022
VOL. 74 NO. 3



Editorial Staff

Editor

William M. Gleason
gleason@smenet.org

Managing Technical Editor

Chee Theng
theng@smenet.org

Associate Editor

Nancy Profera
profera@smenet.org

Production Graphic Artist

Ted Robertson
robertson@smenet.org

Business Staff

Media Manager/Advertising

Gary Garvey
garvey@smenet.org

Phone: 1-800-763-3132

Fax: 1-303-973-3845

Email: garvey@smenet.org

Society for Mining, Metallurgy & Exploration Inc. Officers

President

Ronald Parratt

President-Elect

K. Marc LeVeir

Past President

William Edgerton

Executive Director

David L. Kanagy

Mining Engineering Committee

Jeff Gillow (Chair), Tom Meuzlear (Vice Chair), Patsy Moran, Steven Schafrik, Michael Trevits, Mara Erhardt, Nicole Henderson, Javad Sattarvand, Sekhar Bhattacharyya, David Waterman, David Meadows, Jaeheon Lee, Nathan Manser, Abhishek Choudhury.

SME News

- 46 SME Foundation
- 47 Legion of Honor
- 49 Fine Grind
- 51 Rock in the Box
- 52 SME Awards
- 56 AIME Awards
- 61 SME Division Awards
- 69 Minerals Education Coalition



Departments

- 6 Politics of Mining
- 8 Industry Newswatch
- 73 Web Directory
- 74 Professional Services
- 79 Index of Advertisers
- 80 The Drift of Things

On March 3, Ron Parratt began his one-year term as the 2022 SME President. An exploration geologist with an extensive and impressive career, Parratt brings a wealth of experience to the position. On page 16 he shares his thoughts on the mining industry, on SME and what the future might hold for both. Cover design by Ted Robertson.

This month exclusively on MiningEngineeringMagazine.com:

Follow all of the recent news and developments from around the world, including:

- Legislation that affects the mining industry.
- The latest industry news.

Plus much more!

See it all at www.MiningEngineeringMagazine.com



Reproduction: More than one photocopy of an item from SME may be made for internal use, provided fees are paid directly to the Copyright Clearance Center, 222 Rosewood Dr., Danvers, MA, 01923, USA. Phone 1-978-750-8400, fax 1-978-750-4470. PDF files of articles in *Mining Engineering* are available at www.miningengineeringmagazine.com or www.onemine.org. Other forms of reproduction require special permission from, and may be subject to fees by, SME. SME is not responsible for any statements made or opinions expressed in its publications. Member subscription rate included in dues. Nonmember subscription rate, \$245; in Europe, \$275. Single copies, \$25.



2022 SME Minnesota Conference

April 11-13, 2022 | Virginia, MN

CONNECT WITH MINERAL PROFESSIONALS IN THE HEART OF THE IRON RANGE

Attend the 2022 SME Minnesota Conference

April 11–13, 2022 | Virginia, MN

SESSION TOPICS

- Processing
- Environmental – Water
- Maintenance & Mining
- Environmental
- Tailings & Safety
- Mining
- Exploration Updates



View the complete technical program on-line.
smeMNconference.org

CONFERENCE PLENARY PROGRAM

Opening Plenary

Tuesday, April 12, 2022 | 10:00 am – 11:30 am

Producing Cleaner Steel For A Sustainable Future

Jim Kochevar, Vice President, Iron Ore Operations, Cleveland-Cliffs

Closing Plenary

Wednesday, April 13, 2022 | 1:00 pm – 3:00 pm

Legislative Panel On Mining In Minnesota

Moderated by Kelsey Johnson, President, Iron Mining Association of Minnesota



Register by March 11, 2022 for best conference rates!

smeMNconference.com

Twin Metals Minnesota's mineral licences revoked

TWO MINERAL licenses held by Twin Metals Minnesota and its predecessor companies for more than 50 years have been canceled by the Biden administration.

The move to cancel the leases deals a potentially fatal blow to the company's bid to build an underground mine for copper, nickel and precious metals on the doorstep of the Boundary Waters Canoe Area Wilderness (BWCA).

Those leases, located along Birch Lake in the Superior National Forest, about 11 km (7 miles) east of Ely and just south of the BWCA, are critical to Twin Metals' plans. They're required for the company to access the valuable minerals underground.

Minnesota Public Radio reported that the Department of the Interior took the action after determining that the leases were improperly renewed by the Trump administration in 2019.

"The Department of the Interior takes seriously our obligations to steward public lands and waters on behalf of all Americans. We must be consistent in how we apply lease terms to ensure that no lessee receives special treatment," said Interior Secretary Deb Haaland in a statement. "After a careful legal review, we found the leases were improperly renewed in violation of applicable statutes and regulations, and we are taking action to cancel them."

Twin Metals responded in a statement saying the decision, "is disappointing, but not surprising given the series of actions the administration has taken to try and shut the door on copper-nickel mining in northeast Minnesota. We will challenge this attempt to stop our project and defend our valid existing mineral rights. We expect to prevail.

"This is not about law; this is a political action intended to stop the Twin Metals project without conducting the environmental review prescribed in law. We have proposed a world-class underground copper, nickel, cobalt and platinum group metals mine that deserves to be evaluated through the established environmental review process," the company said.

It is the latest in a long legal back and forth over the mineral leases that's spanned three administrations.

"Our proposal, submitted more than two years ago to state and federal agencies, was the culmination of more than a decade of engineering, hydrogeological, environmental and engagement work that maximize environmental protection," Twin Metals said in a statement. "We are confident that a full environmental review will show that the science behind this modern mine will prove that we can advance this project safely under the highest of standards."

The future of those plans is in

serious doubt with this announcement from the Biden administration.

"We are firmly dedicated to bringing much-needed economic growth to our region and the opportunity to responsibly develop the critical minerals needed for our global efforts in combatting the climate crisis," Twin Metals wrote.

"The administration's decision to withdrawal Twin Metals' mineral leases — long held leases that were first issued more than five decades ago — contradicts and will obstruct the realization of the goals established in its own stated jobs, economic, climate, infrastructure and supply chain agendas," the National Mining Association said in a statement. "Our nation's supply chain vulnerabilities are significant and growing. Decisions such as this one will only deepen our heavy dependency on foreign sources for the minerals that we could be sourcing here at home, in accordance with the world's top environmental and labor standards. In fact, the Twin Metals project could supply decades worth of copper, nickel, cobalt and platinum group metals. These are the same minerals needed for the clean energy transition and severe supply constraints are forecast. This decision is disappointing and foreshadows a global economic, energy, manufacturing and overarching supply chain race where the U.S. may be watching from the sidelines." ■

Adjusted mining royalty bill introduced in Chile

AN AMENDED version of Chile's mining royalty bill that would raise tariffs on mining companies that operate in the country was pushed forward by that nation's Senate.

Reuters reported that the upper chamber's Mining Commission waved through the amended draft, which seeks to address concerns within the copper and lithium industries that higher tariffs will hit Chile's competitiveness and hurt new investment.

The adjusted bill proposes royalties based on two areas: first the value of gross copper sales and a second calculated according to profitability,

similar to the current tax model for the industry.

The commission said the bill would see an 'ad valorem' tax corresponding to 1 percent of annual sales of copper products applied to firms producing under 200 kt/a (220,000 stpy) of copper. Mines producing under 50 kt/a (55,000 stpy) would be exempt.

"For companies that produce higher levels, the royalty will be applied depending on the average annual copper price registered according to the prices of the London Metal Exchange," the commission added.

Chile's mining industry has strongly opposed plans to raise taxes, arguing

that the level is already at its limit. Lawmakers, especially from the leftist opposition, have pushed to increase taxes to bolster funds for social spending.

Leftist President-elect Gabriel Boric, 35, comes into office in March after his strong election victory last year. He does, however, face a divided Congress, which is likely to temper any reform plans.

The modified bill includes a sales tax of some 3 percent for lithium, but excludes contracts signed with a development office in the Salar de Atacama, where the two main current lithium miners Albemarle and SQM operate. ■

PROJECT MANAGEMENT FOR MINING

A Handbook for Delivering Project Success – 2nd Edition

by Robin J. Hickson and Terry L. Owen



Featuring 5 new chapters, substantial updates throughout, and 56 new or updated figures, flowcharts, and checklists that every project manager can use.

Order your copy
smenet.org/store



Save 25% when you order both
the print and eBook bundle!

2022 | 784 pages | Print or eBook
ISBN 978-0-87335-494-3 | Book Order No. 494-3
\$169 Member | \$129 Student Member | \$279 Nonmember/List

“Capital intensive industries have a terrible reputation for project overruns and delays. This book provides the step-by-step disciplined process proven to best deliver economic value from project development, execution, and start-up.”

Edward C Dowling, Jr., Distinguished Member SME,
Chairman Polyus Gold, Chairman Copper Mountain Mining,
Director Teck Resources, Director SSR-Mining



Rio Tinto reaches agreement with Mongolia; Oyu Tolgoi expansion project is back on track

THE \$6.95 BILLION expansion project for the Oyu Tolgoi underground copper mine in Mongolia is finally back on track after Rio Tinto, Turquoise Hill Resources (TRQ) and the government of Mongolia reached an agreement that will move the Oyu Tolgoi project forward.

Rio Tinto said in a statement that the agreement will reset the relationship between the partners and increase the value the project delivers for Mongolia.

Reuters reported that Rio Tinto Chief Executive Jakob Stausholm has visited Mongolia twice in recent months in an attempt to salvage the project amid mounting concerns that the economic benefits of the project for Mongolians were being eroded.

Mongolia owns 34 percent of Oyu Tolgoi, one of the world's largest-known copper and gold deposits. Rio Tinto controls the rest through its 51 percent stake in Toronto-listed Turquoise Hill Resources Ltd and operates the mine.

As part of the deal, Turquoise Hill will waive \$2.4 billion in debt owed to it by the Mongolian government.

Additionally, construction will soon start on the underground portion of Oyu Tolgoi, with first production expected in the first half of 2023.

The expansion will be paid for with cash, the rescheduling of existing debt repayments and prepaid sales of copper concentrate to Turquoise Hill.

The Oyu Tolgoi board, comprised of representatives from Rio Tinto, TRQ and Erdenes Oyu Tolgoi (EOT), which is wholly owned by the Mongolian government, has unanimously approved commencement of underground operations.

Rio Tinto and TRQ have amended the heads of agreement signed in April 2021 to ensure they appropriately fund the project. The capital forecast for it is \$6.925 billion, including \$175 million of known COVID-19 impacts through 2021. Forecasted remaining underground capital expenditure is approximately \$1.8 billion.

The project also committed to buying electricity from the Mongolian grid once it is able to meet supply. Rio said it will work to help add renewable power to the grid. In the

meantime, the government extended an agreement to import power from China through 2023.

Luvsannamsrain Oyun-Erdene, the prime minister of Mongolia said, "The commencement of Oyu Tolgoi underground mining operations demonstrates to the world that Mongolia can work together with investors in a sustainable manner and become a trusted partner. As part of our new recovery policy I am happy to express Mongolia's readiness to work actively and mutually beneficially with global investors and partners."

Stausholm said, "We would like to thank the government of Mongolia for their commitment to working productively with Rio Tinto and TRQ to reach this crucial agreement that will see one of the world's largest copper growth projects move forward and firmly establish Mongolia as a global investment destination. This agreement represents a reset of our relationship and resolves historical issues between the Oyu Tolgoi project partners. We strongly believe in the future of this country and I am

(continued on page 12)

Newswatch contents

10

MP Materials awarded processing facility contract

12

Department of Interior makes \$725 million available to clean up mines

14

i-80 launches comprehensive plan to create gold mining company

Fortescue Metals Group to purchase Williams Grand Prix Engineering

IN ITS PUSH TO decarbonize its fleet of equipment, Fortescue Metals Group announced that it will purchase William Advanced Engineering (WAE) from private equity firm EMK Capital and Williams Grand Prix Engineering Limited for US \$222.15 million.

Fortescue Metals Group said it had been working with WAE since early 2021 to build a prototype battery to power an electric haul truck and will release more details this year on plans to develop an electric train project.

This follows an aggressive push by Fortescue's billionaire-founder Andrew Forrest to turn his mining firm into one of the world's biggest green energy companies.

Fortescue, the world's fourth-largest iron ore miner, aims to work with WAE to develop battery electric solutions to cut the use of diesel in its rail, mobile-haul fleet and heavy mining equipment to decarbonize operations by 2030.

Rivals BHP Group and Rio Tinto have also made strides to bring down emissions by buying battery-powered electric trains to transport iron ore, *Reuters* reported.

Fortescue said WAE will be managed by Fortescue Future Industries, the Perth-based company's clean energy unit after the purchase from private-equity firm EMK Capital and Williams Grand Prix Engineering Ltd is complete. ■

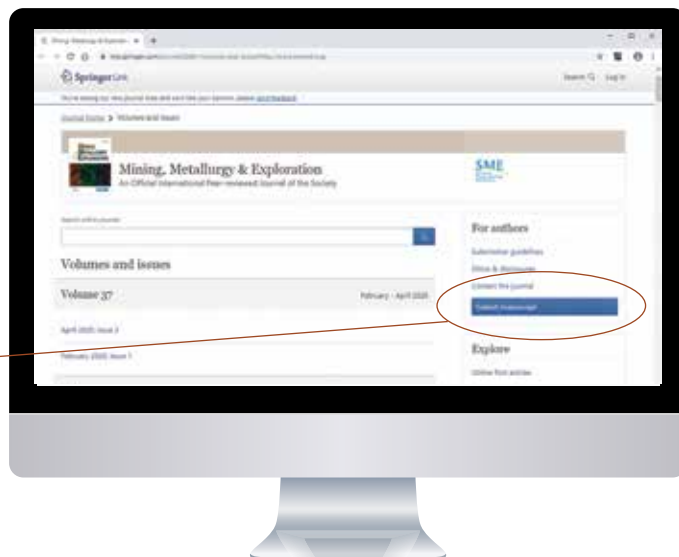
Share Your Expertise

Submit a paper to Mining, Metallurgy & Exploration

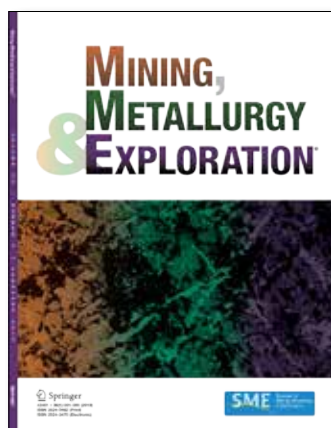
Gain maximum exposure for your research work, technologies or findings and elevate the industry.

How to Submit to SME

Go to link.springer.com/journal/42461/volumes-and-issues. Click on the blue "Submit manuscript" button.



Call for papers!



Special Focus Issue on Ground Control in Mining

Technological advances in field instrumentation and monitoring, computer modeling, laboratory testing, ground control support systems, development of deeper mines, slope stability and strict mine health and safety regulations have brought significant improvements to mine ground control engineering. This special focus issue will include papers on extreme ground conditions, bumps, rockbursts, mine case histories, in situ stress and global stability, numerical modeling applications in ground control, rockmass characterization, slope stability and monitoring, fundamental ground control studies, ground control support systems, surface subsidence, and any other aspects of ground control in mining.

Editor: Ihsan Berk Tulu, Ph.D., Assistant Professor and Wayne and Kathy Richards Faculty Fellow, West Virginia University

DEADLINE: Submit by March 30, 2022.

Email Chee Theng at theng@smenet.org if you have questions or need help.

Why publish in MME?

- Online First publication in 16-21 days of acceptance.
- No charge for publication.
- No restrictions on number of pages/figures.
- Hybrid model with Open Access option available.
- Free electronic access by all SME members.
- Extended abstract published in Mining Engineering.
- Expanded reach to up to 7,000 libraries and institutions and 20 million desktops worldwide through SpringerLink.
- Journal impact factor of 1.413 and coverage in Clarivate Analytics' Web of Science.
- Abstracted and indexed in Science Citation Index Expanded, Scopus, Ebsco, Proquest, Google Scholar and more.



MP Materials awarded processing facility contract; Department of Defense to supply \$35 million

THE U.S. DEPARTMENT of Defense (DoD) has awarded a \$35 million contract to MP Materials Corp. to design and build a facility to process heavy rare earth elements at the company's Mountain Pass Mine in California.

The contract is part of the Industrial Base Analysis and Sustainment Program that will support the construction of a commercial scale processing facility for heavy rare earth elements (HREE) at Mountain Pass.

On Feb. 22, the Biden administration actions taken by both the federal government and private industry that it says will bolster the critical mineral supply chain.

According to a White House fact sheet in addition to the contract from the DoD, MP Materials will invest \$700 million in the magnet supply chain, creating 350 jobs by 2024.

HREEs have higher atomic weights and are generally less abundant than light rare earth elements (LREEs), MP Materials said in a statement. HREEs are essential inputs to many critical defense and commercial technologies, particularly permanent magnets instrumental to the performance of electric vehicles, wind turbines, drones, and missile systems. In a separate contract

awarded in December 2020, the DoD committed \$9.6 million to MP Materials' Stage II optimization, a project underway to restore LREE processing capabilities to Mountain Pass. The ability to process HREEs alongside LREEs will enable MP Materials to extract and refine all rare earths required to manufacture high-performance permanent magnets. It will also enable the company to recycle all recoverable rare earths from end-of-life magnets and magnet production scrap, increasing the resiliency and environmental sustainability of the domestic supply base.

"The ability to mine, process, and refine rare earths at Mountain Pass is foundational to a national effort to secure the U.S. rare earth supply chain," said MP Materials Chairman and CEO, James Litinsky. "We thank the Department of Defense for its confidence and support."

In addition to its mining and processing operation at Mountain Pass, MP Materials is developing a rare earth metal, alloy and magnet manufacturing facility in Fort Worth, TX. Materials sourced from Mountain Pass will be transformed into manufactured products at this new facility, restoring a wholly domestic and vertically integrated U.S. magnetics

supply chain. In December 2021, MP Materials entered into a long-term agreement with General Motors to supply U.S.-sourced and manufactured rare earth materials, alloy, and finished magnets for the electric motors.

"The U.S. needs to continue to push the scientific envelope to develop secure, reliable, and affordable domestic source critical minerals used in defense and commercial manufacturing in order to reduce its dependence on foreign sources in a time of global economic competition," said Deborah Rosenblum who is performing the duties of Assistant Secretary of Defense for Industrial Base Policy.

In addition to the funding for MP Materials, the Interior Department is expected to launch an interagency group pursuing "legislative and regulatory reform of mine permitting and oversight."

The Hill reported that the department will also update its list of critical minerals. Meanwhile, other agencies are expected to tout portions of the bipartisan infrastructure law, like the Energy Department, which was given \$3 billion for battery recycling facilities and refining battery materials including lithium, cobalt, nickel and graphite. ■

U.S., Japan reach deal to cut tariffs on Japanese steel; Nations will team up to fight excess output

TARIFFS ON about 1.25 Mt/a (1.37 million stpy) of Japanese steel will be removed on April 1.

According to a report by *Reuters*, the tariffs that were put in place by the Trump administration will be lifted. The new deal, which excludes aluminum, will take effect on April 1 and requires Japan to take "concrete steps" to fight global excess steel manufacturing capacity, largely centered in China, U.S. officials said.

A joint U.S.-Japan statement said Japan would start to implement within six months "appropriate domestic measures, such as

antidumping, countervailing duty, and safeguard measures or other measures of at least equivalent effect," to establish more market-oriented conditions for steel.

The agreement is similar to one reached with the European Union in October and calls for steel imported from Japan to be completely produced in the country for duty-free access, a standard known as "melted and poured," to reduce the risk of Chinese steel skirting U.S. tariffs.

"This is a step toward a solution... but we will continue to strongly urge the United States to fully eliminate

the tariff in a manner consistent with WTO rules," Japanese industry minister, Koichi Hagiuda, said.

An official at the ministry said the exclusion of aluminum reflected the U.S. position and was not a request by Japan.

U.S. Commerce Secretary Gina Raimondo said the deal "will strengthen America's steel industry and ensure its workforce stays competitive, while also providing more access to cheaper steel and addressing a major irritant between the United States and Japan, one of our most important allies." ■

Carbon storage potential at Tamarack Mine; site will be explored by DOE and Rio Tinto

THE U.S. DEPARTMENT of Energy (DOE) has awarded \$2.2 million in funding to a Rio Tinto-led team to explore carbon storage potential at the Tamarack nickel joint venture in central Minnesota.

Rio Tinto has assembled a team of climate innovation and research leaders to explore new approaches in carbon mineralization technology as a way to safely and permanently store carbon as rock. Rio Tinto will contribute \$4 million in funding for the three-year project, in addition to the funding from the DOE's ARPA-E Innovation Challenge.

Earlier this year Talon Metals entered an agreement to supply Tesla Inc. with nickel from the Tamarack Project in Aitken County, MN.

"This agreement is the start of an innovative partnership between Tesla and Talon for the responsible

production of battery materials directly from the mine to the battery cathode. Talon is committed to meeting the highest standards of responsible production that is fully traceable and that has the lowest embedded CO₂ footprint in the industry. Talon is excited to support Tesla's mission to accelerate the transition to renewable energy," said Henri van Rooyen, CEO of Talon.

Carbon mineralization uses natural chemical reactions to convert captured carbon dioxide (CO₂) into rock and store it underground. It has the potential to be an important technology in meeting global climate goals and is now being used at large scale by the world's leading carbon mineralization company Carbfix in Iceland.

Rio Tinto's technical experts will work with partners including the

DOE's Pacific Northwest National Laboratory (PNNL), which has demonstrated carbon mineralization technology in Washington state; Columbia University; Carbfix and Advantek Waste Management Services. Talon Metals, the majority owner and operator of the Tamarack Nickel Project and Rio Tinto's joint venture partner, is contributing ore body knowledge and land access for scientific field work.

Rio Tinto Chief Scientist Dr. Nigel Steward said, "Our aim is to deliver carbon storage solutions that can help to meet climate targets by reducing and offsetting emissions from our operations and in other industries, and to explore the emerging commercial opportunities carbon storage may offer at Rio Tinto sites around the world. We will be working with

(continued on page 15)



The SME Foundation (SMEF) announces the **Miners Give Back Award** for the recognition of SME Section community service and humanitarian outreach. The Miners Give Back Award program promotes community service and humanitarian outreach initiatives by SME Sections within their communities and facilitates networking between Sections.

PURPOSE

This award recognizes the outstanding efforts of an SME Section for their accomplishments in community service and humanitarian outreach to serve the mission of **Miners Give Back**. The mission of MGB is to support world-wide initiatives focused on humanitarian efforts that tangibly improved the lives of individuals and inspired a commitment to give back to the local community.

GET INVOLVED TODAY

Plan and start your community outreach.
Visit <https://community.smenet.org/smefoundation/programs/mgb>



ELIGIBILITY: SME Sections in good standing between April 1, 2020 - March 31, 2021



Nearly \$725 million to be made available in 2022; Money is for cleaning up abandoned mines

THE U.S. DEPARTMENT of the Interior announced that nearly \$725 million in federal funding will be made available to 22 states and the Navajo Nation for the reclamation of abandoned coal mines and cleanup of acid mine drainage.

The funding is part of the \$11.3 billion allocated to mine reclamation that is included in President Joe Biden's \$1 trillion infrastructure package. The money is part of a 15-year plan to address the issues of abandoned mines throughout the United States.

The funding is considered key to removing toxic metals and returning fish and wildlife to waterways that haven't been vibrant for decades.

"In community after community, this legacy pollution was left behind by industry, and it poorly impacts our quality of life, from contaminated drinking water systems to playgrounds and schoolyards," former New Orleans Mayor Mitch Landrieu, picked by Biden last year to supervise the president's infrastructure plan, said during a conference call.

"And rather than point the finger, President Biden said let's do something about it."

The *Associated Press* reported

that the funding will help pay for projects that treat acid mine drainage to improve water quality, restore mine-damaged water supplies, close dangerous mine shafts and reclaim unstable slopes. Land also can be converted for recreational and other economic redevelopment uses, such as manufacturing.

States will be required to prioritize projects that hire displaced coal workers. The funding is tied to hiring union labor, which Landrieu said is "not an absolute mandate in all circumstances, but there is a heavy recommendation."

Pennsylvania is eligible for \$245 million and West Virginia about \$141 million. Other significant amounts include \$75 million for Illinois, \$74 million for Kentucky and \$46 million for Ohio. The Interior Department will advise states in the coming weeks on how to apply for the funding.

Democratic U.S. Sen. Bob Casey said 43 of Pennsylvania's 67 counties are affected by abandoned coal mining. West Virginia, the nation's second-largest coal producer, has such sites scattered across the state. And Illinois has 590 unfunded mine reclamation projects in its inventory with an estimated cost of at least \$156 million.

The federal abandoned mine reclamation fund relied on fees paid by coal companies based on the coal tonnage produced, but that's been declining over time.

The problem is so profound in West Virginia that state lawmakers have proposed an insurance program to cover the costs of cleaning up the mines. A bill in the state Senate would establish a new private company to issue performance bonds to help companies pay for reclamation.

Wyoming, the largest U.S. coal producing state, will receive just \$9.6 million. Officials said the funding is tied to environmental degradation from before the Surface Mining Control and Reclamation Act of 1977. Though Wyoming's coal industry is over a century old and some underground mines in the state still need reclaiming, most reclamation work has occurred at the relatively new surface mines in operation after the act's passage. The funding is based on tons of coal historically produced before the legislation.

The funding follows last week's announcement that \$1.15 billion is available to states from Biden's infrastructure package to clean up orphaned U.S. oil and gas wells. ■

Oyu Tolgoi: Expansion project is back on track

(continued from page 8)
personally committed to ensuring that the people of Mongolia benefit

strongly from Oyu Tolgoi along with our shareholders." By 2030 Oyu Tolgoi is expected to be the fourth

largest copper mine in the world. It is a complex greenfield project with an underground block cave mine and copper concentrator as well as an openpit mine that has been successfully operating for almost ten years. It is also one of the most globally modern, safe, sustainable and water-efficient operations with a workforce that is more than 96 percent Mongolian. Since 2010, Oyu Tolgoi has spent a total of \$13.4 billion in the country including \$3.6 billion in taxes, fees and other payments to the state. The size and quality of this Tier 1 asset provides additional expansion options, which could see production sustained for many decades. ■

MAXIMIZE your productivity
with **TOMAMINE® M**
& **AROSURF® MG**
reverse iron and
phosphate collectors



Visit: Mining-Surfactants.com



Letter to the editor: We have been here before

Editor: I'm responding to the excellent article on "Workforce Development" that appeared in the Dec. 2021 *Mining Engineering*.

I started my career teaching mining engineering at Penn State in September, 1967; at that time the price of coal had not changed very much from its price in 1947, when the railroads changed from steam engines to diesel power in one swift move. It was depressed and the coal companies reacted by shutting mines or working short weeks. Miners would listen to the local radio station in Brownsville, PA, to learn which mines were working and on which shift: "Montour 4 will work the day shift only." Older miners left the industry, either to retirement or to other careers. Yet, by 1968, owing in part to the energy and mineral needs for the Vietnam War, the industry began to pick up particularly with the switch of steam coal from transportation to electricity generation, and the same cry went out, "where will we get new, trained miners?" The earlier training, imparted by elders, fathers and uncles, to the young, sons and nephews, and which is described realistically in the novel, "How Green Was My Valley," by Richard Llewellyn (1939), was greatly diminished by the retirement of the earlier generation. Another great book about mining culture, albeit British, is "Weekend in Dinlock," by Clancy Sigal (1960).

The 1968 disaster in Consol's Farmington Number 9, 78 deaths, brought home the need to react intelligently to mine safety and miner training. I remain deeply impressed by the multi-volume report from the Theodore Barry Consultancy in 1971, "Industrial Engineering Study of Hazards Associated with Underground Coal Mine Production - Volume I - Analysis Of Underground Hazards And Fatal Accidents (et seq.)," which was commissioned by the U. S. Bureau of Mines in response to the disaster. This report is available through SME's One Mine. The report is extensive; here, however, are several key findings and the regulatory response to them.

Who is hurt most frequently and when? The categories were defined by

the Barry study and the responses have grown over time in the regulations (www.msha.gov).

Newly hired miners in their first shifts in the mine. Parts 46 (aggregates) and 48 (coal, metal, and other nonmetal) of CFR Title 30 require that all newly hired miners be given mandatory training before being allowed in the mine.

All experienced miners, particularly older ones, who may have become carelessly overconfident. Annual retraining required in these same regulations.

Experienced miners after an extended time away from a mine. Required 8-hr specialized training. Experienced miners changing tasks. Specific job training required by these regulations.

Visitors to a mine. Mandatory hazard training.

The other thing that happened in

the 1970s, particularly in response to the energy crisis, was the development of specialized miner-training programs, both credit and noncredit, in community colleges such as Penn State's Fayette Campus, Bluefield State in WV, Belmont College in Ohio, and several western colleges. As the supply of energy became more assured and as many companies developed their own corporate training programs, many of these public programs closed but their history is available to tap for examples. If industry has regained its concern for a supply of new miners, they, either as associations or as individual companies, should work with local campuses to develop miner-training programs.

I have lived through this period and am happy to share its history.

Lee Saperstein

See *Mining Engineering's* featured advertiser in the March 2022 calendar



SRK Consulting is an independent, international consulting practice that provides focused advice and solutions to clients, mainly in the earth and water resource industries.

For mining projects, SRK offers services from exploration to mine closure, including feasibility studies, due diligence reviews, and production optimization.

Established in 1974, SRK now employs more than 1,400 professionals internationally in over 45 offices on 6 continents.

Featured advertiser:
SRK Consulting
www.srk.com

Mining
engineering
OFFICIAL PUBLICATION OF SME



i-80 launches comprehensive plan; Company looks to create Nevada-focused gold mining company

NEVADA-BASED i-80 Gold Corp. announced its development plans for 2022, which it called a catalyst-rich year as the company commences its plans to build a comprehensive Nevada mining complex. i-80 is in the process of developing multiple mining operations to achieve its objective of building a Nevada focused mining company with the goal of ultimately producing more than 500,000 ounces of gold annually.

i-80 completed multiple strategic transactions in 2021, the first year of it being a publicly traded company, which position the company to achieve its goal of becoming a prominent, stand alone, gold producer in the state of Nevada. i-80 acquired the Granite Creek, Lone Tree and Ruby Hill properties to become one of the largest holders of gold and silver resources in Nevada.

In a statement, the company said it secured the ability to process all types of gold mineralization, including refractory gold bearing mineralization, through the acquisition of the Lone Tree

processing complex and also through interim processing agreements with Nevada Gold Mines that provide i-80 with the flexibility to process material from any of the three planned underground operations until the Lone Tree autoclave is restarted. Processing of refractory mineralization remains one of the biggest barriers to entry in Nevada, and i-80 is currently one of only three companies with this capability.

To execute its “hub and spoke” development plan, i-80 intends to construct four new mining operations over the next three years, complete multiple large-scale drill programs, advance permitting, build a tier-one exploration, development and mining operations team and restart the Lone Tree autoclave.

Lone Tree will be the hub of i-80’s Nevada operations and the central processing facility, operations office, assay lab and warehouse for all sites. Mineralization from Granite Creek, Ruby Hill and McCoy-Cove will feed the Lone Tree Autoclave once restarted, and mineralization from the Buffalo Mountain (and Brooks)

openpit will be processed at the Lone Tree heap leach facility.

“With a strong balance sheet we are concentrated on achieving our goal of becoming one of Nevada’s largest gold producers,” said Ewan Downie, chief executive officer of i-80 Gold. “2021 was a highly successful first year for i-80 where we closed multiple strategic acquisitions that position i-80 as one of the largest holders of gold and silver resources in the state.”

“Executing our aggressive growth platform is the key focus for 2022 and management is in the process of building a tier-one management team with a track record of operational excellence in Nevada,” said Matt Gili, president and chief operating officer of i-80. “We are targeting peer-best production growth through the development of our portfolio of permitted, road accessible deposits. Additionally, the company has gained a strategic advantage as one of only three companies in the state with infrastructure to process refractory mineral resources once the facility has been retrofitted to suit its deposits.” ■

Newmont named to Fortune’s 2022 list of world’s Most admired companies

NEWMONT CORP. has been recognized as one of *Fortune* magazine’s world’s most admired companies. The in-depth annual global survey of more than 3,800 executives, directors and securities analysts identifies companies that have the strongest reputations within their industries.

Newmont had strong scores in the areas of social responsibility, quality of management and global competitiveness.

“This recognition validates our commitment to our purpose, to create value through sustainable and responsible mining. ESG is woven into the fabric of our company and

is fundamental to the way in which we operate,” said Tom Palmer, president and chief executive officer of Newmont. “We are constantly learning and evolving to create a culture in which doing what is right drives how we operate. Our workforce and leadership team set high standards of accountability to deliver strong environmental and social performance whilst creating value for all our stakeholders.”

The ranking by *Fortune* follows Newmont being named by JUST Capital, in association with CNBC, as one of America’s most just companies. Newmont is included in the JUST 100 and named industry leader for

2022, ranking above industry average in the areas of workers, communities, environment, shareholders and governance. Newmont was also recently included in the Bloomberg Gender-Equality Index for the fourth successive year, which tracks public companies committed to disclosing their efforts to support gender equality.

In late 2021, Newmont was listed on the Dow Jones Sustainability World Index (DJSI World) as mining industry co-leader and was the top-ranked gold miner for the seventh consecutive year. Newmont’s inclusion on the index marked the company’s 14th consecutive year being selected by DJSI World. ■

Industry pushes back on proposal in Chile; Bill could lead to the nationalization of country's copper sector

AN EARLY STAGE proposal that could lead to the nationalization of Chile's copper industry was approved by that nation's constituent assembly.

The proposal, "for the nationalization and new social and environmental management of copper mining, lithium and other strategic assets" was greenlit by the environmental commission of the assembly, which is drafting Chile's new constitution.

The approval sparked an angry response from mining firms operating in Chile.

"The proposal adopted is barbaric, with clear and obvious legal errors," said Diego Hernández, president of

the National Mining Society, which represents companies in the sector.

He said the measure would nationalize companies themselves as well as just the metal resources and would have a major economic and legal impact.

"A nationalization would have serious consequences for our economy in a context of globalization, since the affected companies will resort to these treaties to defend their legitimate interests," he added.

The proposal would still face a vote from the full assembly to be included in the final draft text, which would itself go before a national referendum vote later this year,"

Reuters reported.

Chile is rewriting its constitution to replace a market-centric one that dates back to the military dictatorship of General Augusto Pinochet. Debate on the draft will start in earnest later this month, but proposals have already started to cause jitters in some sectors.

The mining industry has called for preserving legal protections to ensure future investments in the sector in the world's largest copper producer and the second-largest lithium producer.

Members of the constitutional assembly have pointed out that the proposal could be adjusted or even scrapped. ■

Tamarack site: Will be explored by DOE and Rio Tinto

(continued from page 11)

leading researchers and innovators to prove the carbon storage potential of the Tamarack site and develop mineralization solutions that can be used not just here but at other similar locations."

PNNL CO₂ subsurface sequestration expert Todd Schaef said, "This work will leverage the knowledge gained from PNNL's Wallula Basalt Carbon Storage Pilot Project, the only supercritical CO₂ injection in basalt demonstration in the world. We will be developing forward-looking carbon storage strategies with Rio Tinto and the broader team. PNNL stewards a suite of capabilities that allow us to look at real-time CO₂ interactions with rocks under

extreme conditions. We are proud to bring interdisciplinary expertise with computational scientists, geochemists and engineers who have been researching the subsurface mineralization of CO₂ for decades."

Talon Metals CEO Henri van Rooyen said, "Rio Tinto has assembled a uniquely qualified team of scientists and innovators to explore new approaches to harness carbon mineralization as a way to safely and permanently store carbon sourced from hard-to-abate industries and carbon removed from the atmosphere.

Tamarack is a nickel, copper and cobalt project located in central Minnesota that is currently progressing towards feasibility studies. The project is managed by Rio Tinto's joint venture partner Talon Metals,

which holds a 51 percent share and has a right to earn-in to acquire up to 60 percent. ■

Renew with

SME

Today!



www.smenet.org

Working with rich data and remote sensing methods puts us on site – virtually.

 **srk.com**



Ronald L. Parratt;

An interview with the 2022 SME President



At the conclusion of the MINEXCHANGE 2022 SME Annual Conference in Salt Lake City, UT Ron Parratt began his term as the 2022 SME President.

Parratt is the former executive chairman of Renaissance Gold Inc. He brings a wealth of experience to the role of President of the Society that has been a consistent part of his professional career since he became a member in 1974 while working for Stauffer Chemical Co. out of Richmond, CA. He was encouraged to join SME by his first boss and became a member of SME shortly after he earned a B.S. in geochemistry from Purdue University, the same university where he would later earn a M.S. in economic geology.

Unlike many past SME President's, Parratt did not begin his education with the goal of entering the mining industry. He began

his education at Purdue studying chemical engineering but a few elective classes during his junior year would change the course of his life.

"I needed some electives and I took some geology classes because I always had an interest in geology," Parratt said. "I found the geology classes to be incredibly interesting and more importantly, the chair of the geology department spoke with me for about an hour and the scene he created for me about the career sounded fascinating. I left the college of engineering and my senior year I took nothing but geology classes."

Geology can be a challenging career and for many geologists, the highlight of a long career is involvement in one, or maybe two discoveries of real value. Not so for Parratt who would go on to establish an impressive career in which he has played a significant role in the discovery of a number of deposits that have helped make Nevada the top gold producing state in the United States and one of the top gold producing jurisdictions in the world.

Among a long list of accomplishments, Parratt managed the discovery and development of the Rabbit Creek, Lone Tree and Trenton Canyon gold deposits in Nevada. He participated, via joint venture, in the discovery of the North Peak, Gold Hill and Long Canyon gold deposits as well as the Trinity silver deposit — all in Nevada.

Cumulatively, these activities resulted in the creation of more than 18 million ounces of gold reserves.

"Anytime you are associated with a discovery, which most geologists are not, you are pretty fortunate," Parratt said. "I would tell our geologists to enjoy it and savor the moment because you don't know when you will have the opportunity again."

Away from the field work, Parratt managed the consolidation of Gold Fields Mining Corp.'s U.S. exploration staff with Santa Fe's U.S. exploration staff after completion of the Hansen PLC/Santa Fe Asset Exchange in 1993 and was a member of the executive due diligence team that evaluated the Homestake Mining Co. and Newmont Gold Co. offers to acquire Santa Fe via merger in late 1996 and early 1997.

Parratt is a Distinguished member of SME, and a recipient of the William H. Dreyer Award (2016) and the William Lawrence Saunders Gold Medal from AIME (2016).

"Throughout all my years of activity with SME and traveling as an explorationist, I had the blessing of a patient wife and family who

allowed me to pursue my passion in our industry. That really made it work,” said Parratt.”

He takes the helm of SME during an interesting time in which the Society looks to a future filled with challenges and opportunities. He recently spoke with *Mining Engineering* about his career, the role SME has played through the years, his thoughts about the mining industry and his plans for his term as SME President.

Leading in a time of change

Parratt began his career in the mining industry at a time when new technologies and favorable prices for gold helped lead to many discoveries in Nevada. He has a deep knowledge of the history of gold discoveries in the United States and explained that in the late 1800s, prospectors flocked to California for the gold rush that defined the state. Many of those discoveries played out rather quickly, but interestingly, many of the prospectors walked right over millions of ounces of gold on their way to California.

From 1961 to 1963, Newmont geologists John Livermore and J. Alan Coope discovered gold at Carlin, NV. It's the world's first discovery

of submicroscopic, disseminated gold and it revolutionized the gold industry. That discovery would lead to what is known as the Carlin Trend.

“There is a saying that the best place to go look for a deposit is to look where you found it before,” Parratt said and in doing so, he helped discover much more gold in Nevada.

He now finds himself moving into a leadership role with SME during another time of change for the mining industry, and the start of a rush for critical minerals. It is also a time in which innovation will again be important to the success and growth of the industry and the Society.

“On one hand it would seem like the new green economy could be a threat to the mining industry, but in reality, there is a lot of opportunity,” said Parratt. “To do all of the things needed for the new green economy and electric vehicles — there is a great need for metals and materials that are mined. We will need more copper, rare earth elements, cobalt, nickel, lithium and others to produce the vehicles, solar cells and wind turbines needed today.

“The only producing lithium mine in the United States is in Nevada. As the need

Parratt brings a wealth of experience and success to SME

Ronald L. Parratt is the former Executive chairman of Renaissance Gold Inc., a TSX.V listed, Nevada-based junior gold/silver exploration company. Parratt has more than 40 years of exploration experience for precious metals including service with Santa Fe Pacific Gold, Homestake Mining Company, AuEx Ventures and Renaissance Gold. During his years of precious metals experience he had direct involvement in the discovery of the Rabbit Creek (now Twin Creeks), Lone Tree, Trenton Canyon, Gold Hill and Long Canyon gold deposits — all in Nevada.

Parratt is a graduate of Purdue University with degrees in geochemistry and economic geology. In 1991, he was honored with the Distinguished Alumnus Award from Purdue University's Department of Earth and Atmospheric Sciences and in 1998 he earned

the Distinguished Alumnus Award from Purdue University's School of Science.

He is a Certified Professional Geologist with the American Institute of Professional Geologists, a Registered Geologist in California and a Professional Geologist in Wyoming. He was appointed to Nevada's Commission on Mineral Resources in May, 1991. He was re-appointed in 1995, 1999, 2003 and 2007 and was vice chairman from 2003-2011.

He is a Fellow of the Society of Economic Geologists and a past president of the American Exploration and Mining Association and a past board member of the Nevada Mining Association.

Parratt is a Distinguished Member of SME. Among his past honors from SME, he won the William H. Dreyer Award in 2017, the Distinguished Member Award in 2018 and the Distinguished

Service Award from the Mining and Exploration Division in 2005. He received the William Saunders Gold Medal Award from the American Institute of Mining Engineers in 2016.

In addition to his participation in the discovery of numerous gold deposits, he managed the conversion of resource to reserve at numerous gold deposits. Cumulatively, these activities resulted in the creation of more than 18 million ounces of gold reserves.

He also managed consolidation of Gold Fields Mining Corp's U.S. exploration staff with Santa Fe's U.S. exploration staff after completion of the Hansen PLC/Santa Fe Asset Exchange in 1993.

He was a member of the Executive Due Diligence team that evaluated the Homestake Mining Co. and Newmont Gold Co. offers to acquire Santa Fe via merger in late 1996 and early 1997. ■

for lithium has exploded, there has been an exploration rush to find new lithium deposits,” Parratt said. “Over the next many years, Nevada will likely see more lithium mines in production to fill the need. The same can be said for a wide range of commodities leading to a lot of mining. I think the future is bright for the industry and for SME”.

In addition to the growing demand for critical minerals to feed the green economy, the mining industry is advancing the need for increased environmental, social and governance (ESG) standards from investors or stakeholders. As an industry leader, SME is helping to lead the way.

“SME wants to be, and needs to be, at the forefront of these issues,” Parratt said.

SME has made positive steps in regard to ESG with the creation of the ESG Toolkit, an idea put forth by Bob Schaffer (2020 SME President). “It is certainly part of SME’s Annual Meeting programming and it needs to continue to be part of our programming because it’s an issue of growing importance.”

It’s a challenge Parratt said SME is well positioned to meet.

Parratt will have a say in some of SME’s programming for the coming year and said he will focus attention on the THRIVE Conference that is held in conjunction with the SME Midyear Meeting. Innovation will merge with technology issues and other issues such as ESG at the THRIVE Conference.

“We have multiple divisions at SME representing all disciplines in our industry and innovation is common to them all. Innovation spans everything. Innovation takes place in mining technology, process technology, environmental practices, safety practices, ESG — in everything we do,” said Parratt.

During his year as President-elect, and through his years of involvement with SME prior to that, Parratt helped shape SME’s strategic plans for the future. The current five-year strategic plan includes association growth, environmental stewardship, industry innovation and industry workforce.

“SME is doing very well and is financially in great shape. With that said, I want to take a look at the programs that we offer and ensure that we continue to support them so that we provide our members with the greatest value that we can. And I want to look at considering new programs that create additional value for our members.”

Parratt said he will focus primarily on association growth and its objectives, which are to:

- Increase partnerships.
- Increase the dissemination of best practices.
- Enhance opportunities for enhancing diversity and inclusion.
- Improve engagement opportunities for our members.

“I want to see membership growth,” Parratt said. “In the past, we generally had a growing industry. However, these days some Divisions are up, some are down, and we work hard to get members and to retain them. The modern workforce has evolved somewhat and is more complex. To maintain our membership and to grow it we work hard to create value in an SME membership. We’ve done that successfully for a long time and continue to do that today. But what added value can we create for our membership? What do new and existing members want from SME?” Parratt asked.

“Our staff and Association Growth committee are working on these issues. Our programming, publications and events and efforts at improving our industry are all intimately related to membership growth and retention. SME staff and the Association Growth Committee are well aware of that and are searching for ways to ensure that members benefit from our existing value drivers and to create additional value for an SME membership.”

Parratt’s first exposure to SME came from his first supervisor who encouraged him to join the Society and to get involved to advance his career. He was new to the industry at the time but quickly found the value of being able to network with industry experts and to have access to world-class technical information. He still sees that value for young members.

“For the younger members of the Society, the SME Annual Meeting is a great place to come and meet the people in this business,” Parratt said. “It is the best way to experience the full breadth of the association. Divisions are all linked and you have a chance to talk with experts in every part of the mining industry. And you never know where a contact will lead. It is very good for the members.”

As the 2022 SME President, Parratt plans to focus on keeping the Society stable and moving forward.

“A key for the Society is to keep our programs going and evolving so that we are always a leader,” he said. “We always want to demonstrate our leadership by recognizing what’s important and then focusing our efforts there through our programming and publications that follow that line of thinking. This is all part of the strategic plan so it all flows together.” ■

Adapting openpit mine design fundamentals to leverage the advantages of autonomous haulage systems

By Race Owens, Chris Roos, Scott Rosenthal and Bryce Hill

It is common practice in the mining industry, and even legally required in many jurisdictions, to design two-lane haul roads in openpit mines to three-and-a-half times the widest dimension of the haul trucks operating on the road. In openpit gold mines with high strip ratios, road width has a significant impact on the economics of design.

It is possible to minimize the flattening of the highwall if the road width is reduced, assuming the width used is not needed for geotechnical purposes to flatten slopes. With the use of autonomous haulage and pullouts, it may be possible to operate safely and efficiently on a reduced road width of two times the width of the hauling equipment.

Autonomous haulage fleets have been successfully implemented in large copper, iron ore and oil sands mines with low strip ratios; however, demand for these trucks has not been as strong in high strip ratio mines. This article proposes that the adoption of autonomous systems may offer additional economic benefits not yet accounted for in the design of mines.

Strip ratio is a ratio that expresses how much waste is mined per unit of ore. In mines with low strip ratios, maintaining a full road width for two-lane traffic is straightforward and has less of an effect on the economics of the design. In mines with less disseminated deposits and significantly higher strip ratios, road width has a more significant impact on the economics of design.

By reducing the operating road width, the overall highwall angle may be increased and ultimately, the strip ratio reduced. This reduction in width may be possible with the advent of haulage automation.

With autonomous haulage, it may be possible to safely and efficiently reduce road width to two or less times the truck width with pullouts for two-way traffic. In this article, the requirements from an autonomous fleet to operate on reduced width of in-pit ramps are examined.

Background: Automated haulage

Parreira (2013) recognized that “In mining, automation is playing an increasingly important



A Komatsu haul truck at an openpit mining operation.

role due to a scarcity of high-demand metals and skilled personnel to operate the processes. Challenging locations and harsh environments are becoming normal for new ore bodies and mines, so automated systems may become essential.”

These difficulties can be accentuated for mines located in remote areas. Currently, where there are favorable conditions in weather and infrastructure, automation is thriving. As automated mining technology progresses, it is becoming more prevalent in all environments. These technologies are becoming common in the mining industry because they bring increases in safety and operating efficiencies.

Mines are automating processes and equipment to capture the benefits of eliminating the human factor. When discussing automating machines, it is essential to specify the level of automation being used to ensure clarity. Voronov et al. (2020) describe the following four levels of automating mining equipment:

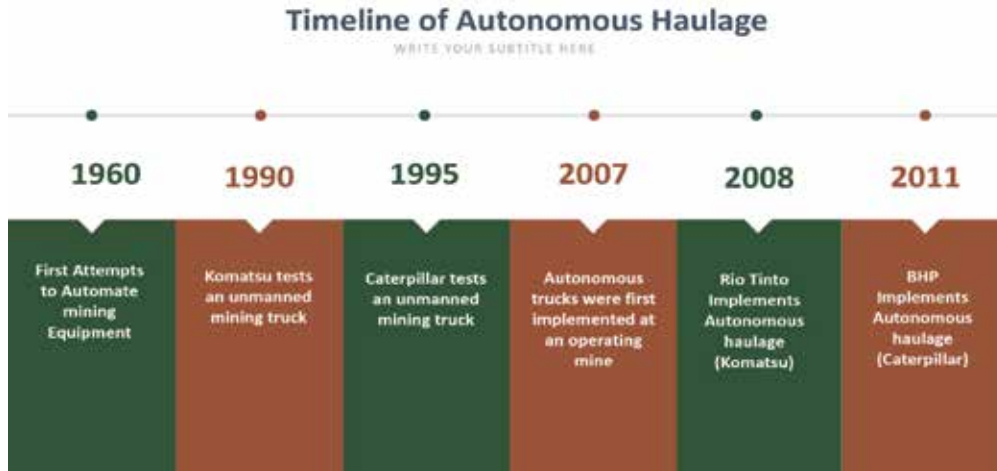
1. Remote control.
2. Telemetric control.
3. Partial automation.

Race Owens, Freeport-McMoRan, Climax, CO, Chris Roos, Montana Technological University, Butte, MT, Scott Rosenthal, Montana Technological University, Butte, MT and Bryce Hill, Montana Technological University, Butte, MT. Email: rowens1@fmi.com

Automation in Mining

Figure 1

Timeline for autonomous haulage 7 (Voronov, Voronov & Makhambayev, 2020).



hazardous areas and situations. According to Parreira (2013), at mines where autonomous haulage has been implemented, accidents from human error and poor driving habits have been eliminated.

In the last few years, autonomous mining equipment has been an unavoidable topic when mentioning technological advancements in the mining industry. Even though automated

4. Full automation.

Remote control is used to control machines where manual operation is dangerous. The machine is in the field-of-view of the operator, who uses a remotely-controlled device.

Telemetric control is similar to remote control, but the operator is located at a considerably farther distance, not allowing for line-of-sight operation. The use of cameras and sensors enables the operator to control the equipment.

Partial automation occurs when one operator regulates the activities of several units of equipment. Certain aspects of the equipment's operation move according to an algorithm, and other factors still need to be controlled by an operator.

Finally, equipment works completely independently without human participation when it is fully automated, relying on preprogrammed algorithms and artificial intelligence to control machines. This independent operation shifts the operator's job from operating equipment to managing the equipment's operation and monitoring efficiency. In this case, human intervention with fully autonomous operations is only required when serious problems arise.

The autonomous haul trucks referenced in this article are considered to be at the highest level and fully autonomous; however, other mining equipment is commonly implemented at other levels. Inputs such as dispatch, GPS, LiDAR (light detection and ranging) and proximity sensors provide data that can result in highly precise, independent operations.

The consistency and precision provided by these systems allow autonomous trucks to operate at a much higher level of safety than equivalent human-operated haul trucks. Removing manually operated haul trucks also increases consistency of operations and removes humans from potentially

mining is still at the forefront of mining technology, the first attempts to automate mining equipment were made in the 1960s, but it wasn't commercially viable until the 2000s. This timeline summarizes the steps Komatsu and Caterpillar, the main manufacturers of haul trucks investing in autonomous mining trucks, took to implement this technology.

Caterpillar and Komatsu each have their own autonomous haulage systems. Caterpillar's autonomous haulage system is called command for hauling. Trucks perform more independently within this system, with each truck routing and tracking possible interactions with other vehicles. A centralized control center is mainly responsible for the allocation of trucks between loading and dumping points. Caterpillar's system is decentralized, resulting in trucks having more complicated onboard equipment. Caterpillar's automated trucks are equipped with LiDAR and radar, which help in making complicated decisions.

Komatsu's haulage system is named FrontRunner. Komatsu's approach to an automated haulage system is to have a more centralized design with more of the decisions made at a control center. Haulage trucks are individually monitored in an autonomous zone, with the system paving each truck's route as it is assigned loading and dumping points.

While making these decisions, the system also monitors for any interactions between autonomous and human-run machines. With the need to make fewer decisions onboard, each truck is only equipped with radar and conventional rangefinders to locate the road's edge.

Although these systems are vastly different in their approach, they both fall into the highest level of automation, fully autonomous. (Voronov, Voronov and Makhambayev, 2020)



DEPENDABILITY DEFINED SANDVIK DR412i ROTARY BLASTHOLE DRILL

The Sandvik DR412i blasthole drill is designed to improve conservation and deliver dependable penetration in the world's harshest mining conditions. Constructed for rotary or down-the-hole drilling with first pass capability of 12.3m (multipass) and 18m (single pass), the DR412i is automation-ready and built to deliver reliability while bringing a new level of safety and productivity to any operation.

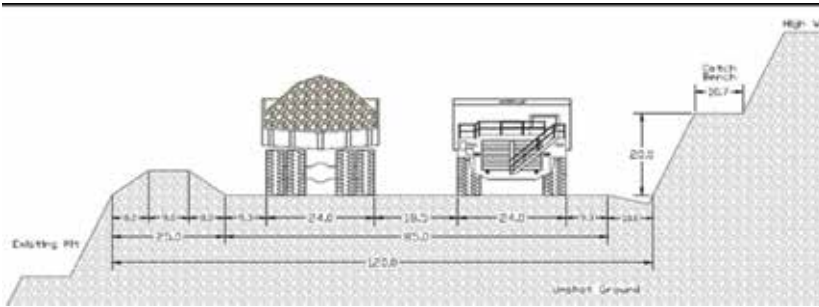
The optional Compressor Management System solves the inherent inefficiencies of rotary blasthole drills by isolating the compressor to reduce emissions and enhance durability. Reduce costs and increase safety with automated features like auto rod handling and auto leveling. Crafted to suit your needs, the DR412i is built with an open design 360-degree catwalk system for safe and easy maintenance.

To learn more, visit [ROCKTECHNOLOGY.SANDVIK/DR412i](https://rocktechnology.sandvik.com/dr412i)
or email us at SurfaceMining@Sandvik.com



Figure 2

An example of a haul road cross section (Masabattula, 2011).



As more mines turn to autonomous haulage, the benefits including reduced operating costs, increased precision and increased safety can meet or exceed an organization's expectations. Compared to manually operated trucks, autonomous haulage reduces fuel consumption, eliminates expensive operating labor, decreases maintenance costs, increases the life of equipment, reduces capital costs and reduces harmful emissions into the atmosphere (Voronov, Voronov and Makhambayev, 2020). Along with reducing costs, safety is improved, since the vehicles are operated consistently and precisely with fewer humans placed in potentially hazardous operating areas.

Current design fundamentals

Current operating widths for haulage roads are based on the principle that for improved safety, there needs to be half a vehicle width on either side of each traffic lane. Another aspect that adds to the total width of a haul road is the mandatory berm, which the electronic code of federal regulations (e-CFR, 2021) states is required on the banks of roadways where a drop-off of sufficient grade or depth exists. These mandatory "berms or guardrails shall be at least mid-axle height and of the largest self-propelled mobile equipment, which usually travels the roadway." (e-CFR, 2021). Additionally, drainage ditches and bench accesses are commonly added to a haulage ramp, contributing to the total road width.

After designing a cross-section and determining the total width of a road, factors such as the positioning of the road, the number and location of switchbacks and the intensity of the gradient will also directly affect the economics of the mine design. An example of a haul road cross section can be found in Fig. 2.

A haul road gradient of 10 percent is commonly used for haulage roads in openpit metal mines. Mine engineers must choose a road gradient that balances increased operating costs and decreased haulage distances with steeper haulage gradients. Also, for safety reasons, laws and regulations may dictate a maximum

haulage ramp gradient (Collins, Fytas and Singhal, 1987). Generally, the road gradient is based on the haul trucks' capability and what the manufacturer suggests for optimal equipment operation.

Safety is of immense concern when creating a mine road design. Many aspects of haul road design are dependent on managing or maximizing safety while operating efficiently and productively. This balance of safety and productivity is especially of concern when human-operated vehicles are on the ramps.

The vehicle operator should be able to see ahead of the vehicle at the same distance as its maximum stopping distance. (Collins, Fytas and Singhal, 1987). This fundamental gives the machine enough time to stop to avoid collision with other objects such as humans, other vehicles and large rocks. Even with fully autonomous vehicles, the onboard sensors need to see far enough to be able to stop before encountering unexpected objects.

Operator safety is the most significant concern, along with minimizing vehicle damage. For these reasons, the e-CFR (2021) states, "Water, debris or spilled material on roadways, which creates hazards to the operation of mobile equipment, shall be removed." Mining operations commonly use graders to remove obstacles such as loose rock, snow and uneven surfaces from haul roads, increasing safety and decreasing rolling resistance. (Collins, Fytas and Singhal, 1987).

Road maintenance is essential to mining operations to ensure the safety of those who travel the road, to decrease maintenance costs and to increase operating speeds. Autonomous haulage operations require consistent, quality road maintenance. Autonomous haul trucks struggle to quickly respond to an uneven road and loose rock, which can result in increased fuel consumption and tire wear. (Zhao and Bi, 2020).

For these reasons, the minimum road width must allow for enough space for the haul trucks to operate unaffected by operations such as grading. Like water trucks for dust control, certain operations may not affect the minimum road width since they operate on the same route and at similar speeds as haul trucks.

Previous work

The authors have found no previous work directly related to changing surface mine design parameters to leverage the benefits of autonomous equipment, specifically works related to autonomous haul trucks. However, there is similar work related to single-lane traffic

Table 1**Case study pit geotechnical parameters.**

Geotechnical parameter	Zone 1	Zone 2				Units
		Northeast	Southeast	Southwest	Northwest	
Interramp angle	43	42	44	50	45	°
Berm height	40	40	40	80	40	ft.
Berm width	24	25	22.8	30	17	ft.
Batter angle	65	65	65	65	60	°

in underground mines, train scheduling and the effects of road parameters on openpit designs.

Underground haulage

The work pertaining to single-lane traffic in underground mines has its own set of challenges with limited connection to machines. Even though there is better connectivity in surface mines, some of the concepts from operating two-way traffic on a single-lane road with pullouts in an underground mine are useful to study.

In papers from Andersson (2019) and Åhlén (2014), the goal was to minimize the time used in reversing to prebuilt pullouts. Andersson evaluated using an algorithm to determine which pullout to use, maximizing the distance traveled while minimizing delays and time waiting in the pullout.

Many of the underground models involve having one vehicle stopping at the pullouts and waiting for the vehicle with the higher priority to pass by unaffected by interaction between the vehicles. This interaction is not optimal but is preferred to collisions, stopping or reversing to the nearest pullout.

Train scheduling

While the concepts of pullouts are relatively common, train scheduling on a single track is more closely related to the ideas presented in this article. Similar to a single track, surface haul roads are costly and difficult to move once built.

Like a railroad, a mining road is created to minimize the capital costs required to build it while maximizing traffic and productivity on the road. The high investment and complex physical geography of railway construction may be limited by capital budgets, resulting in the frequent use of two-way traffic on single-track railways.

In recent decades, the railway industry has focused significant effort on researching train scheduling methodologies to make single-track railways work efficiently (Xu, Li, Yang and Gao, 2019). Even though the purpose of this article is to propose an efficient heuristic approach for the train scheduling problem, it also provides useful insights that relate to two-lane traffic on a single-lane road.

Xu et al. (2019) has addressed train scheduling and some of its intricacies. Note that track pullouts provide the possibility for two trains to travel parallel to each other while passing, which allows for flow from both directions at the same

time. Xu et al. assumed that the positions of individual vehicles are known.

Another similarity between train scheduling and haul truck scheduling is that the location of each is always known. Even with these similarities, efficiently operating haul trucks on reduced haul road widths is different from train scheduling.

When scheduling trains, some of the pullouts are used to store parked trains, whereas for productivity in mining the haul trucks are always traveling when they are on the haul road. A difference between the mining industry and the railroad industry is how priority is assigned to each vehicle.

Road parameters

Sakantsev et al. (2018) addresses minimizing the effect of a haul road on the overall highwall angle by increasing the pit-haul road gradient. Issues related to adjusting haul road gradients such as increased maintenance costs and the effects of weather are discussed.

This article only mentions the impact that in-pit haul roads have on the highwall angle. However, discussion related to road gradient is helpful since reducing haul road gradients can have similar beneficial effects on the overall highwall angle as decreasing the road width.

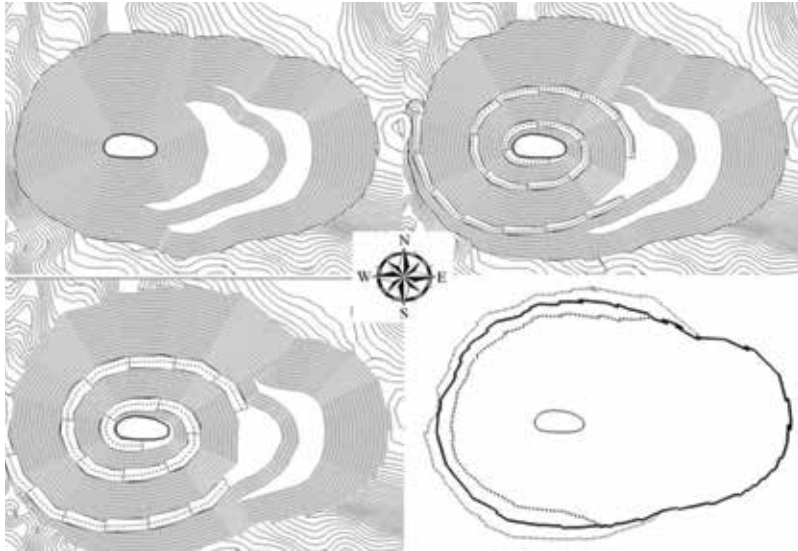
Alegre et al. (2019) also addresses the effects of haul road parameters on the strip ratio of an openpit mine. In this paper, the authors address the impact of three major parameters of haul road design; road widths, switchbacks and road gradients on strip ratio and costs in both high- and low- strip-ratio pits.

Even though increasing the gradient of the road has the largest impact of the three variables reviewed, it also results in higher maintenance costs. Sakantsev et al. (2018) also found that steeper gradients of access roads ensures reduced stripping costs, but also raises the cost of transportation.

Along with increased maintenance costs, increasing the haul road gradient may be difficult because of current rules and regulations. As

Figure 3

Case study pit designs (Upper left: no haul road, upper right: single-lane haul road, bottom left: double-lane haul road, bottom right: top and bottom polygons of all three designs.)



Collins et al. (1987) states, mine operators must choose a road gradient that balances increased operating costs and decreased haulage distances resulting from steeper haulage gradients. Laws, regulations and equipment warranties may also dictate a maximum grade of haulage ramps for safety reasons.

Case study methodology: Pit design

Multiple pits were modeled on data provided for a gold deposit in Montana to demonstrate the effects of haul road width on high strip ratio openpit mine designs. Pit limit analysis has been previously conducted for this deposit using the software program Whittle.

The pit limit analysis for this deposit would be mined in multiple phases. (See Fig. 9 in the Appendix, but only one phase was analyzed in this case study.) Pit designs for this phase were generated for the following haul road widths, zero ft (i.e., no haul road), 19.8 m (65 ft) for a traditional single-lane haul road, and 36.5 m (120 ft) for a conventional double-lane haul road.

These designs can be found in Fig. 3. The haul road widths are based on the assumption that CAT 793 (Caterpillar) trucks will be operated at this mine.

The pit was split into multiple zones that had different geotechnical design restrictions. These geotechnical parameters were coded into the block model to create a design that falls within the parameters. The design parameters can be found in Tables 1 and 2.

Cross-sections were examined at 22.5-degree angles centered on the lowest bench in the design

to work as a visual representation of how the haul-road dimensions affect the overall highwall angle and overall pit design.

As seen in Fig. 4, cross-sections and additional cross-sections in the Appendix, highwall flattening occurs when larger road widths are implemented.

The following design considerations were taken to ensure the results were only influenced by the road width parameter: The phase was designed in an isolated manner and the interaction between pits was not considered; pullouts were not included since they would result in little additional width over the entire road; switchbacks were not used; each of the ramps began at the same location on the same starting polygon at the bottom of the pit; all seed strings were kept the same to create similar pits. Seed strings determined the shape of geologically constrained areas and where widening is needed to follow the optimal pit shell more closely.

The resulting pit solids from the designs were compared against the block model for the deposit to determine the tons of ore and tons of waste. The strip ratios for these pit shells were calculated and analyzed to determine the effect of haul road width on strip ratio for a final design on this deposit. The pit without a haul road was closest to the pit shell created in Whittle and had the lowest strip ratio of 0.90. The single-lane road had a strip ratio of 1.09. As seen in the pit cross sections, the double-lane road took the most waste and was the largest design while also having the largest strip ratio of 1.32. The double-lane haul road adds 29.8 million tons of waste while only adding an extra 3.8 million tons of ore.

Figure 5 shows the total tons mined split by ore, waste and pit design. This figure also clearly shows the strip ratio for each pit. At a mining cost of \$2.5 per ton, a double-lane haul road results in an additional mining cost of \$84 million more than a single-lane haul road. Wider roads tend to increase the strip ratio in a deposit that already has a high strip ratio, thus considerably increasing the costs.

Deterministic simulation

To model interactions between trucks in the haulage cycle when using single lane haulage with and without pullouts for the unloaded trucks in the haulage cycle, a deterministic simulation was created using Python 3.8.8 and is included in the Appendix. The default inputs to this simulation are shown in Table 3 as deterministic simulation input variables and default values. The process is shown visually in the Appendix as Fig. 18¹, flow chart for Python simulation code. In this

Table 2

Case study pit design parameters.

Design parameter	Value	Unit
Truck	793	none
Truck width	27	ft.
Double lane width	120	ft.
Single lane width	65	ft.

simulation, the speed, position, direction and time-delayed for each of the haul trucks is calculated for each second that the simulation runs. The speed of each truck is determined based on the location, speed and delay values of other trucks, along with the location of the passing areas. The speed of each unloaded truck is calculated so trucks optimally reach pullouts to incur minimal delay while reducing stoppages, whereas loaded trucks always travel at the maximum possible speed to maximize production. A flowchart showing the process of the optimal speed calculation is shown in the Appendix as Fig. 19¹, flowchart for optimal speed calculation code in the simulation.

The simulation was run for three situations based on case study pit designs to understand how the trucks would interact. The simulation outputs are shown in Fig. 6.

The graph in the upper left shows an example simulation output; the rest of the graphs in this figure highlight truck 1 to show the path of a single truck in the haulage cycle and expose delays within the haulage cycle.

For each simulation, the haulage cycle was split into three segments, with segment one including the haulage road going from the waste dump to the top of the in-pit ramp, segment two running from the top of the ramp to where the toe of the ramp would be on average, and segment three running from the toe of the ramp to the center of the bench. In this simulation, position 0 ft is the location of the dump, and location approximately 2,438 m (8,000 ft) is the center of the pit where the trucks are loaded. For each of the simulations in Fig. 6, half of the trucks were started at the dump and half of the trucks were started at the center of the pit to allow haulage cycles to quickly reach a consistent cycle.

To better understand the sensitivity to the number of trucks and pullouts, the simulation for the case study was run multiple times while recording the total loads hauled in 12 hours. As shown in the top graph in Fig. 7, the inclusion of one pullout allows for production similar to implementing two-lane haulage on the in-pit ramp.

Table 4 provides production numbers for the case study simulations that ran in Fig. 6. As pullouts are added to a single-lane ramp, delays caused by adjusting speed to avoid collisions are reduced until the only major constraining factors negatively affecting production are loading and dumping delays.

Figure 7 depicts that as trucks and pullouts are added to a haulage cycle, production increases until it reaches a maximum, which in this situation is approximately 175 loads hauled in 12 hours.

This maximum appears to be caused by the

loading delay, and since this simulation was run with the assumption of the use of a single loading unit, delays from loading could not be reduced without additional loading units. The locations

of these different delays throughout the haulage cycle is clearly seen in multiple scenarios in Fig. 6.

Multiple pullout sensitivity scenarios were run with progressively increasing distances to understand how an in-pit ramp of a larger distance would affect the number of pullouts required to achieve production similar to double-lane haulage. The distances used for these scenarios were 609 m, 1,524 m, 3,048 m (2,000 ft, 5,000 ft, and 10,000 ft). As expected, the number of pull-outs required to achieve similar production to double-lane haul roads is positively correlated to increased distances of the in-pit ramp.

In evaluating the simulation results, an error in the underlying code was discovered. However, it has not been addressed in the attached code since it did not materially affect the results of the simulation. This error occurs when there is a long distance of no passing before the loading side of the haulage segment as shown in Fig. 8.

For seven trucks operating on segment lengths of 1,524 m, 3,048 m, 365 m (5,000 ft, 10,000 ft, and 1,200 ft) with no passing on segment two, the error occurred approximately 14 times in 12 hours. In this scenario, and in the first interaction in Fig. 8, the calculated speed of truck 2 is set to the maximum speed after truck 1 reaches the end of segment two. It is not until truck 1 finishes loading that truck 2 calculates optimal speed. By the

Figure 4

Case study pit design results.

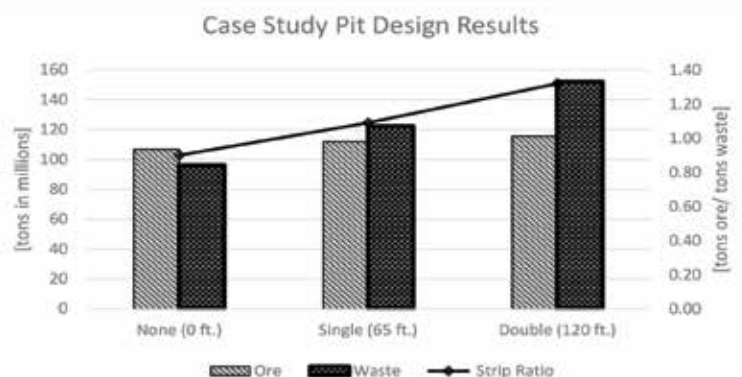
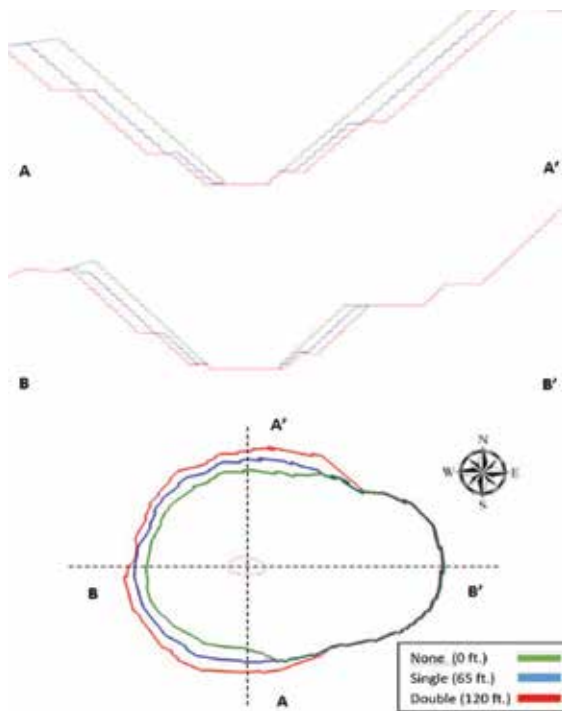


Figure 5

Cross sections and cross sections on the pit plan view.



time truck 2 considers truck 1, a collision is imminent. This error is only present when there is a large area where trucks cannot pass before the end of the segment. Also, this error explains why the one pullouts and two pullouts line cross in the bottom pullout sensitivity graph for the 3,048 m (10,000 ft)

ramp in Fig. 7.

Discussion

As shown in the methodology pit design section, reducing the road to a single-lane width results in a 17 percent decrease in the strip ratio, similar to what was found by Alegre et al. (2019). Both results show the strip ratio of the pit is significantly reduced when the road width is reduced. The case study deterministic haulage simulations showed that by using two pullouts, a single-lane road could achieve similar

production and a 4 percent decrease to a double-lane, in-pit ramp. The research into single-track train scheduling provides insights into how automation can help unlock the benefits of reducing haul road widths.

By its very nature, automation means a fundamental change in how the overall mining process will operate (Parreira, 2013). Even though autonomous vehicles operate differently from manually operated vehicles, traditional parameters, rules of thumb and laws continue to be used and go unquestioned in modern-day mine designs.

Mine designs will need to be altered and optimized to play to the strengths of autonomous haulage and minimize the effects of any downsides introduced by this technology. One significant benefit of autonomous haulage is increased accuracy and consistency. This benefit can be exploited, and designs for automated machines need less room for error. Reducing this room for error in haul roads can reduce the overall width of the haul road, which has a significant effect on the economics of the pit.

Pullouts could be added to the design to operate two-way traffic on a single-lane haul road with efficient vehicle interactions. When scheduling haul trucks, priorities are assigned to each truck to help determine which trucks yield to other trucks to maximize the system's productivity.

Generally, loaded haul trucks are going uphill and the empty trucks are traveling downhill. In mining, the priority is given to the loaded vehicle, so the unloaded vehicle will have to adjust its speed to reach the pullout before or preferably at the same time as an approaching loaded haul truck to minimize total delays incurred.

It is of utmost importance that fully loaded trucks heading up and out of the mine never stop since they might stall and be unable to restart if stopped. Resolving such a situation can take time that would negatively affect costs, production time and resources (Andersson, 2019). Furthermore, coming to a complete stop is not optimal as stopping increases the wear and tear on the trucks from brake use and accelerating back to operating speed.

Using the simulation, the number and placement of pullouts on a haulage ramp can be determined if the mine's desired productivity and number of trucks,

Figure 6

Case study deterministic simulation position by time.

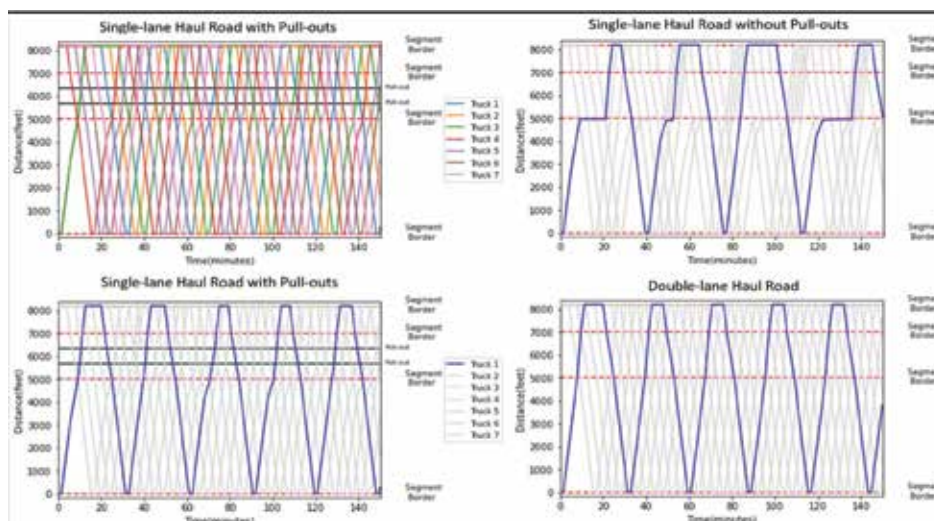


Table 3**Deterministic simulation input variables and default values.**

along with the simulation inputs, are known. The pullouts should be approximately equally spaced; however, these passing areas can be adjusted to places where the pit design requires widening for geological reasons.

Although the pullouts need to offer ample room for trucks to pass, the additional width provided by a pullout does not need to equal the full width of the truck, especially if the road is already two times the width of the haul trucks.

The pullout length needs to account for the speed of traffic and the size of the equipment operated on the ramp. If these areas are designed too short, the trucks would have to stop. On the other hand, excess ground is excavated if these pullouts are designed too long or too wide.

An artificial intelligence system or complex algorithm would need to be added to the current navigation systems to avoid collisions and adjust speeds for trucks to pass at pullouts. The most optimal interaction would allow the higher priority truck to be unaffected by the interaction and the lower priority truck would have minimal delay. A successful interaction would require the artificial intelligence or complex algorithm system knowing the locations, direction and speed of all the trucks, at all times, along with the locations of the available passing areas. This system could be added to the current navigation system that determines what the truck does and how it interacts with its environment, regardless of whether it is on board the truck or centrally located.

Due to the precision and accuracy of the autonomous systems, cluster formation and shock wave propagation seen with human operation (i.e., the grouping of trucks at various points in the cycle) should be reduced. This distribution is optimal since most interactions will only involve two vehicles and as mentioned in a paper by Andersson, the complications that result from multivehicle interactions can lead to collisions or inefficiencies.

For example, when multiple vehicles are traveling together, the first vehicle will occupy the pullout at the right time, but the second vehicle is left without any pullout to use. This situation would result in a collision or one

vehicle having to stop or reverse to the nearest available pullout. Therefore, the autonomous system must consider the vehicles around them and determine how to avoid collisions and situations like this (Andersson, 2019).

Interactions between manually operated equipment, such as support equipment and light vehicles and autonomous vehicles, need to be considered when creating a haulage design. As mentioned by Andersson (2019), “Small personnel transports might have entirely different driving patterns to heavy trucks or machinery, and as such might present entirely different problems that need to be dealt with.”

Mines that run fully autonomous haul fleets have different protocols to ensure the safety of operators while ensuring consistent production—some even address this by creating additional roads for light vehicles. Voronov (2019) documents that mines operating fully autonomous haulage (as of 2019) will divide the mine into separate working areas for human operated and unmanned vehicles. All vehicles entering the unmanned zone are equipped with satellite transceivers that provide tracking and

Variable name	Default input values	Units	Notes
Run time length	150	minutes	
Truck start positions	[0, 0, 0, 8200, 8200, 8200, 8200]	feet	Distance from the start position 0
Truck start directions	[0, 0, 0, 0, 0, 0, 0]		Position along grade from WasteDump, direction of truck 1=unloaded (away from dump), -1 loaded (to dump), 0=delay
Pullouts Seg 1	[-999]	feet	If the first value =-999=free to pass in segment, if the first value=None=No passing in segment
Pullouts Seg 2	[970]	feet	
Pullouts Seg 3	[-999]	feet	
Loading time	4	minutes	Assumed that only one truck can load at a time
Dumping time	1.5	minutes	Assumed that multiple trucks can dump at a time
Length of segments	[5000, 2000, 1200]	feet	
Loaded speeds by segment	[9, 6.5, 9]	miles per hour	
Unloaded speeds by segment	[9, 15, 9]	miles per hour	

Table 4

Production based on case study scenarios.

Scenario descriptor	Loads hauled in 12 hours	Percentage production decrease from double-lane haulage
Double lane	177	zero percent
2 pullout	170	4 percent
1 pullout	163	8 percent
Single lane	125	29 percent

communication with the autonomous system.

Two-way traffic on a decreased road width may also require increased road maintenance to ensure smooth roads and adequate dust control. A road at the width of two times the largest piece of equipment would allow for support equipment to maintain in-pit haul roads while reducing inefficient interactions with haulage vehicles. Along with support equipment, the potential for equipment to fail also needs to be considered, especially since autonomous haulage vehicles will stop in place if there are any issues with the vehicle.

For example, if the communications network is not working correctly and an autonomous truck loses contact, the truck ceases to operate, stopping in place. In addition to network problems, the obstacle detection systems of unmanned trucks sometimes operate falsely, mistaking road bumps or small pieces of rock for obstacles, resulting in truck stoppage. In each of these situations, a manual visual inspection is required for the truck to resume operation. (Voronov, Voronov & Makhambayev, 2020). This stoppage could be problematic when operating where there is no space to navigate around the

equipment. Consideration of failed equipment needs to be accounted for in the design to allow for optimal operation. If this space is not accounted for, risk for increased delays is introduced, since manually restarting the truck requires extra time and personnel oversight.

Connection issues are of great importance for large automation projects since autonomous vehicles rely on wireless communication and GPS. Even internet latency issues can have a significant impact on the operation of a mine. When considering implementing autonomous haulage for its many benefits, communication complexity problems are vitally important, and need to be considered.

Conclusion

As the case study in this article shows, road width can significantly affect strip ratio in an open pit mine. The wider the road is, the more flattening occurs to the highwall.

In a deposit that already has a high strip ratio, this extra material mined will likely increase the strip ratio further, ultimately increasing the mining cost. The benefit of narrower haul roads could be unlocked with the use of autonomous haulage while keeping similar production rates to traditional two-lane roads. The advantages of this technology promote safer and more efficient hauling.

There are many considerations when contemplating operating autonomous haulage, especially when changing design fundamentals. When implementing autonomous haulage, the communication network needs to be carefully considered. If the communication network is lacking at a mine, then an attempt to operate autonomous haulage may fail. Along with an adequate network, understanding how autonomous haulage systems operate is necessary before implementing or specializing designs.

To use unmanned haul trucks to their highest potential, one must take advantage of narrower haul roads. This article brings up some considerations that need to be made when contemplating operating autonomous haulage on a specialized design, such as reducing road width with pullouts. Current design fundamentals will continue to be questioned with the advent of new technologies.

Future work

Although this article does not attempt to prove that haul road widths should be reduced simply because of automation, it does present an opportunity for future research and analysis. A survey of professionals with experience and knowledge of autonomous haulage in the

Figure 7

Deterministic simulation pullout sensitivity.

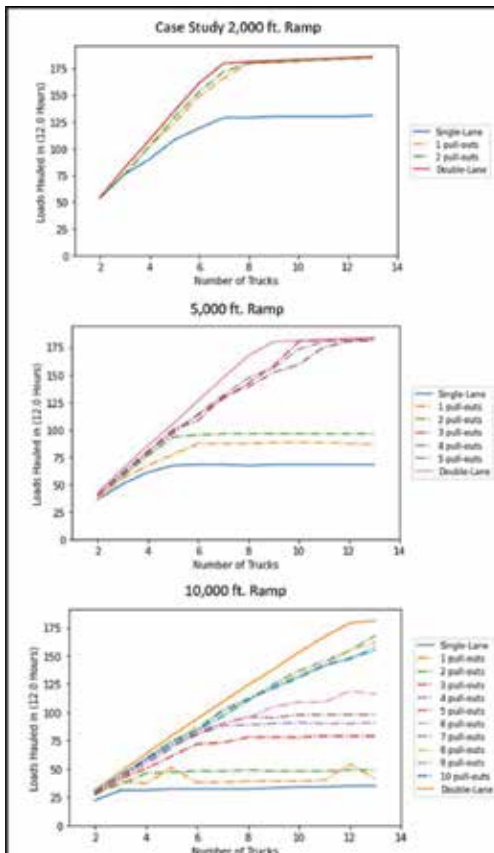
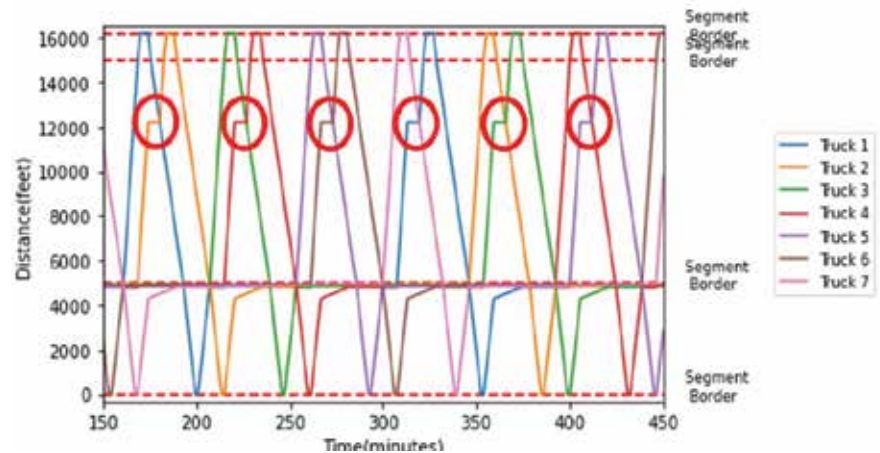


Figure 8
Simulation error example.



mining industry should be conducted to gather helpful information about the intricacies of automated haulage. Ideally, these surveys would result in offering current information on autonomous vehicles' capabilities from multiple manufacturers.

A detailed haulage simulation could show how production would be affected by adapting openpit mine haulage road widths for autonomous operations. The deterministic simulation in this article attempts to expose how the trucks would interact while operating on different road designs. For a more detailed simulation, data from manual and autonomous haulage fleets could be used to run a more extensive haulage simulation.

In deterministic simulation, the error presented earlier should be fixed to provide a more accurate simulation of a mine's haulage cycle. In the code, it is possible for loaded trucks to calculate and consider possible collisions with trucks already on the ramp. If a collision is predicted, the truck will stop at the bottom of the ramp to avoid these collisions. Currently, the issue with this solution is stopping the unloaded trucks at the top of the ramp from traveling down the ramp while loaded trucks wait until all loaded trucks have traveled from the dump to the bottom of the ramp. In the future, a solution to this issue should be found and implemented in this simulation.

Other future research should focus on developing an algorithm or artificial intelligence system that controls the speed of an autonomous truck to ensure it reaches the pullout at the correct time to maximize productivity. This article has mentioned some, but not all of the many considerations that should be considered when creating this system to ensure the truck can operate on a reduced haul road width.

In the future, designs will be altered to leverage other technological advancements in the mining industry. Advances in haulage technology such as Komatsu's cableless haulage truck concept could also affect mine designs to leverage its benefits. Voronov et al. (2020) describes this as an autonomous mining truck concept with a payload of 250 tons without a driver's cab. The machine has the ability to move forward and reverse at the same speed. Since all the wheels can turn independently, the turning radius is reduced. This reduction in turning radius will significantly decrease the time for placing, loading and dumping, and the area required for loading and dumping zones.

References

- Ählén, M. (2014). A framework for traffic management and collision avoidance in underground mines.
- Alegre, D., Peroni, R. and Aquino, E. (2019). The impact of haulroad geometric parameters on openpit mine strip ratio. *REM-International Engineering Journal*, 72(1), 25–31.
- Andersson, C. (2019). Predictive Model for Traffic Control in Underground Mines.
- Brundrett, S. (2014). Industry analysis of autonomous mine haul truck. Simon Fraser University.
- Collins, J. L., Fytas, K. and Singhal, R. K. (1987). Design, construction and maintenance of surface mine haulage roads. *International Journal of Surface Mining, Reclamation and Environment*, 1:2, 137–145.
- e-CFR. (2021, February 11). Retrieved from Electronic Code of Federal Regulations: <https://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=7434e67c01d3aea69d5dd560ec3d6491&mc=true&n=pt30.1.56&r=PART&ty=HTML#sg30.1.56.h.sg22>
- Masabattula, V. (2011, Feb. 11). Haul road design. Retrieved from slideshare: <https://www.slideshare.net/venkoos/haul-road-design>
- Michaud, D. (2018, February 25). Open Pit Mining. Retrieved from 911Metallurgist: <https://www.citationmachine.net/apaf6/cite-a-website/new>
- Parreira, J. (2013). An interactive simulation model to compare an autonomous haulage truck system with a manually-operated system (T). University of British Columbia. Retrieved from <https://open.library.ubc.ca/collections/ubctheses/24/items/1.0074111>
- Sakantsev, G. G., Cheskidov, V. I., Zyryanov, I. V. and Akishev, A. N. (2018). Validation of Slopes of Access Roads in Deep Open Pit Mining. *Journal of Mining Science*, 54(1), 77–84.
- Voronov, Y., Voronov, A. and Makhambayev, D. (2020). Current State and Development Prospects of Autonomous Haulage at Surface Mines. In *E3S Web of Conferences* (Vol. 174, p. 01028). EDP Sciences.
- Xu, X., Li, K., Yang, L. and Gao, Z. (2019). An efficient train scheduling algorithm on a single-track railway system. *Journal of Scheduling*, 22(1), 85–105.
- Zhao, Z. and Bi, L. (2020). A New Challenge: Path Planning for Autonomous Truck of Open-Pit Mines in The Last Transport Section. *Applied Sciences*, 10(18), 6622.

Appendix

Note that several sections of this article reference additional figures that can be found in the appendix. To reduce the length of this paper, the Appendix has been removed, however it is available in Montana Technological University's Digital Commons at this link: https://digitalcommons.mtech.edu/grad_rschn/270/

Getting students interested in mining engineering: How can we reach them?

By Isabel Barton, Jodi Banta and Lynnette Hutson



How do we attract more students to mining engineering majors? In two previous articles (*Mining Engineering*, Feb. and Oct. 2021), we identified the main problem: Students arrive in college knowing less about mining engineering than they do about any other engineering major, and they are not interested in subjects they do not know much about. Remedy that disparity in background knowledge, even by a little bit, and there's a large upward swing in interest.

Jodi Banta, Isabel Barton and Lynnette Hutson, members SME, are program manager, Lowell Institute for Mineral Resources, assistant professor of Mining and Geological Engineering, and Ph.D. student in the Mining and Geological Engineering Department, respectively, at the University of Arizona in Tucson, AZ. Email, jhbanta@arizona.edu.

But to be effective, information has to arrive early. Even starting freshmen have strong pre-formed interests, opinions and plans, and they harden fast (Barton et al., 2021). Three weeks into their freshmen semester, about 80 percent of the students we surveyed had already decided on a major. Three months later, a mere five to seven percent still listed

their major as “undecided.” Less than a third of the students — including those who began as undecided — reported changing their planned majors over the course of the semester. That does not leave much time or space to change minds.

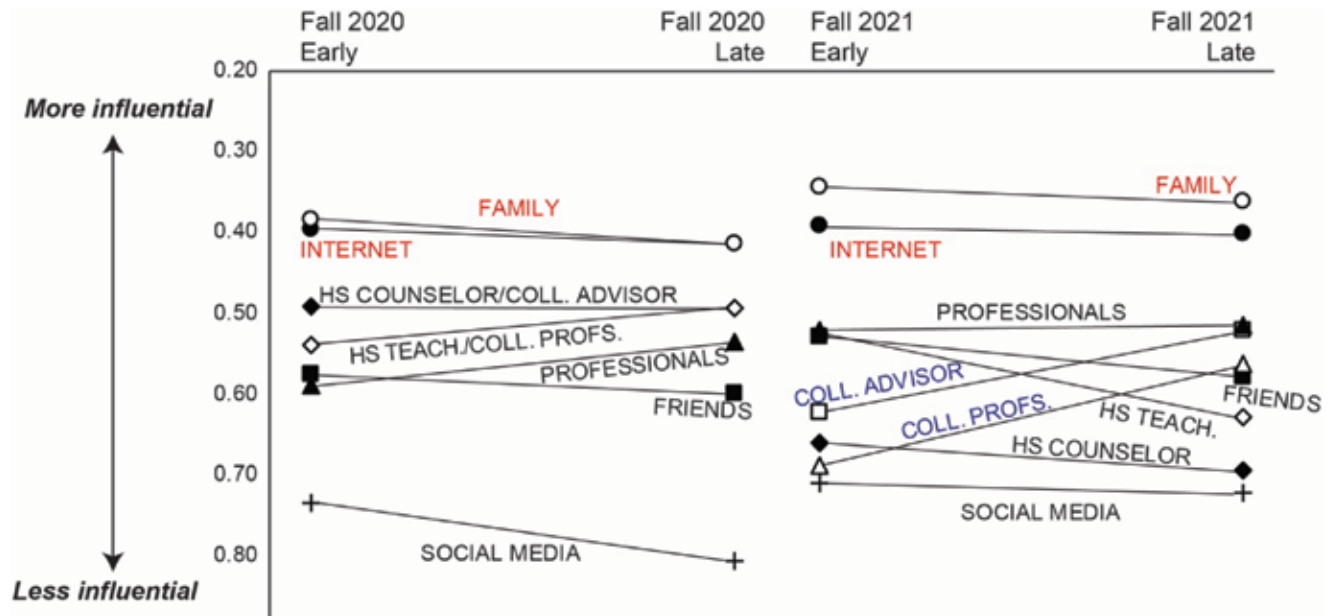
So what are the most effective channels of information? Where should university mining engineering departments focus their limited resources? What kinds of communications matter, and which do not change minds? This article uses additional data from our fall 2020 and fall 2021 surveys of the University of Arizona (UArizona) freshmen engineering class to identify where students look for information about potential majors, what does not influence them so much, and what motivates them to change their major. We conclude with some lessons learned and recommendations about where to focus recruitment efforts for the greatest impact.

Background information

A few words first about the freshmen engineering class at UArizona and our study.

Figure 1

X-axis: time of survey. Y-axis: relative strength of influence, calculated as an average ranking by students (1 = most important, higher numbers = less important) divided by number of options available to rank (seven in fall 2020; nine in fall 2021).



All incoming (nontransfer) freshmen students planning any engineering major are required to take the same engineering design course in their first semester. The course has two components: focused design work in smaller class sections and a large, combined weekly lecture that exposes students to material about majors and careers in engineering.

Throughout the middle eight weeks of the course, the material in this combined lecture class is given by designated representatives of each of UArizona's 15 different engineering majors. Each representative/group provides an approximately 20-minute video introduction to the major. All students are required to watch the video before class, take a quiz on its essential points and then attend a 20-minute class-time question and answer session with the representatives.

In the final two weeks of the semester, representatives from each major arrange for an open house that consists of a longer (one-hour) information session on the major and the careers it opens up. These commonly include hands-on activities when done in person, and a question and answer session with a broader range of faculty for both in-person and virtual open houses. The organization of the open house is up to each department housing the major. Students in the freshmen class must attend at least two open houses of their choice for engineering majors.

We administered two online surveys each semester in the fall of 2020 and 2021, one at the beginning and one at the end of the course. The

surveys included demographic information, levels of knowledge and interest in different engineering majors, planned major, sources of information, career goals and desired career attributes (Banta et al., 2021; Barton et al., 2021). After excluding incomplete responses and responses from students under the age of 18, all surveys had a confidence level of 95 percent with a ± 3 percent margin of error.

Among other questions, we asked students to rank, in order from most to least influential, the following sources of information about potential majors: family, friends, internet search, social media, high school teachers, college professors, high school and college counselors and professionals working in a related field. The same question was also on the end-of-semester survey and we compared the results.

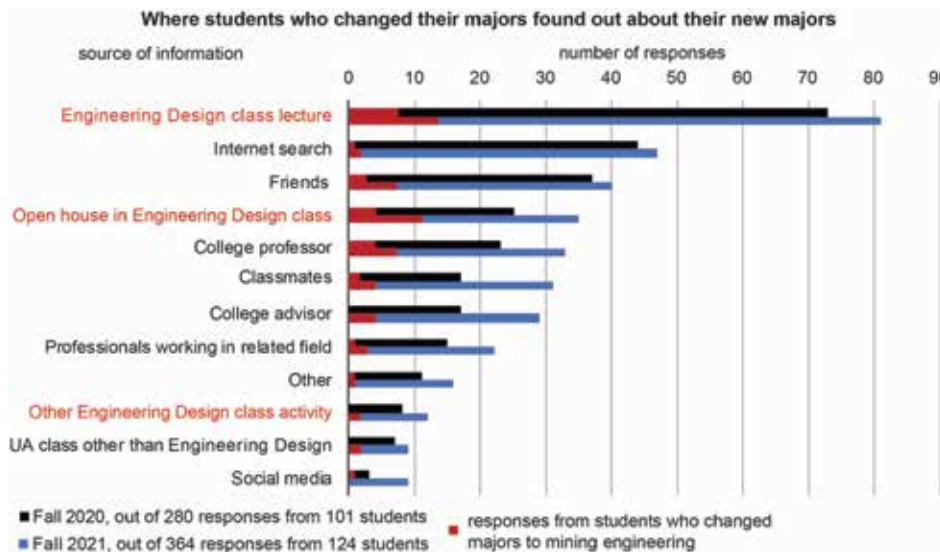
Where students look for (important) information about their majors

Two sources of information clearly stand out as most influential: family and internet searching. Particularly at the beginning of the semester, no other sources of information come close. Family ranks as slightly more influential than internet searching, but the two are close, and the gap decreases over the semester. Social media is the least influential in all surveys.

Clearly, information that reaches students in high school is important, especially early in the semester when their exposure to college material is limited. In the fall of 2020, the trends are obscure, since high school counselors and college advisors were grouped into the same

Figure 2

Responses as to why students change majors.



Friends, classmates and college professors were also influential. In contrast to most other students who changed their majors, new mining engineering majors were less likely to report being influenced by information from college advisors or the internet.

The results also underscore the importance to mining engineering recruitment of simply having a single first-year introductory class that exposes students to all engineering majors. Freshmen enter college already well-informed about mechanical, aerospace, electrical/computer and biomedical engineering.

Most of them will select one of those majors by default, particularly in the absence of exposure to other options.

By contrast, the lower-profile majors such as mining engineering and materials science see a disproportionate rise in levels of knowledge, interest and intended majors over the course of the engineering design class (Barton et al., 2021). As Fig. 2 demonstrates, most of that rise is due to exposure in the freshmen engineering design class and favorable experiences during associated open house activities.

By contrast, universities that admit students directly into individual majors without a common first-year class place smaller enrollment engineering majors, including mining, and are at a disadvantage relative to higher-profile alternatives.

response category as were high school teachers and college professors.

In the fall of 2021 these were broken out into four distinct groups, increasing the total number of options from seven to nine. Although this means that the results of the fall 2020 and fall 2021 surveys are not directly comparable, it did distinguish the influence of high school teachers and counselors (which starts out high and declines over the semester) from the influence of college advisors and professors (which starts out low but rises steeply over the semester). The influence of professionals in a related field is moderate and static. Friends begin as a significant source of influence, but this declines over the semester.

Why and when students change majors

At the end of the semester, we asked students if they had changed their planned major since the start of the fall semester. To students who said yes, a follow-up question asked them to select the principal reasons why. Overwhelmingly, the top answer was the information presented in the lecture series of the freshmen engineering design class. Internet and friends were a distant second and third, and the open house visits in the engineering design class and their engineering professors were close behind. Social media came in last.

The importance of information acquired in the freshmen engineering design class was particularly clear among students who changed to mining engineering majors. In both semesters, the lecture, video and question and answer sessions were by far the most common selections among new mining engineering majors, and the open house associated with the engineering design class came in second.

Does coming from a mining family matter?

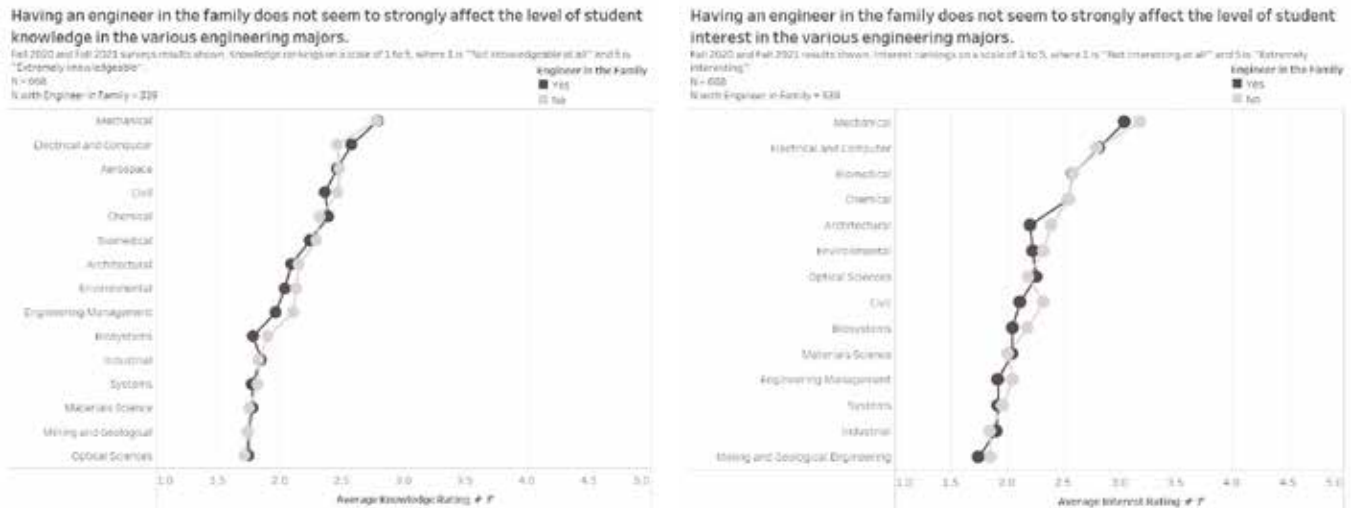
It is a common belief that most students who major in mining engineering are from families with mining engineers, miners or other mining industry professionals. Let's see whether that belief holds up against the data.

Starting with family influences: As both Figs 1 and 2 indicate, families outrank even the internet as important sources of influence. But judging from our in-depth results, family influence seems to consist more of a general encouragement toward an engineering career than as a push into any specific field.

The reported degree of family influence, or having engineers in the family, does not correspond to a higher-than-average level of knowledge or interest for any engineering major. When we compared the reported levels of knowledge and interest at the beginning of the semester between student groups with and

Figure 3

Results and possible influence of having an engineer in the family.



without engineers in the family, we found that there were no statistically significant differences. Figure 3 shows differences at the level of individual majors; the darker color represents students with engineers in the family.

But by drilling deeper into the survey data and looking at individual types of engineering, the picture changes. A total of 15 students in early fall 2020 and 2021 reported having a mining engineer in the family. Their average levels of knowledge about and interest in mining engineering were somewhat higher than the average for the survey populations as a whole: mining was the field they were most knowledgeable about and the third most interesting to them on average (behind mechanical and electrical/computer engineering). Three listed mining engineering as their planned major. Although the population is small, this is a significantly higher proportion (20 percent) than the less than 10 percent of students in the overall class who planned a mining engineering major in the early-semester survey.

The data show that students with mining engineers in the family are twice as likely to consider or plan a mining engineering major, but their numbers are so small that most mining engineering majors actually come from nonmining families. Thus, we conclude that while having a mining engineer in the family makes a student more likely than most to select mining engineering as a major, a larger number of students are attracted to the major by other sources, particularly exposure to mining engineering in the freshmen class.

Lessons learned: Channels for effective recruitment

Let's close with some takeaways from this phase of the survey. Where should university

mining engineering departments focus their recruitment efforts to maximize effectiveness? On the other hand, what is a waste of effort?

To recruit students already in college, one answer is clear: Put the most effort into ensuring that exposure in the freshmen engineering design course is high-quality and gives students a positive impression. Often in university departments, freshmen outreach and other recruitment-related tasks are allocated to faculty based on who has the most time and willingness to undertake them, not on who would do the best job.

As the results above demonstrate, exposure in the freshmen engineering course is the overwhelming reason why students change majors, particularly those who switch to mining engineering. Ensuring that mining engineering is well represented to incoming freshmen with high-quality and engaging materials and teaching is probably the most important part of a recruitment program for university mining engineering departments. It is also important that there be an accessible, friendly faculty or staff member available for students to follow up with. Many students want to consult with someone in the department before finalizing their decision, but they may not know whom to talk to or where to go.

It is harder for college professors to get into high schools for recruiting, but still important. By the time students get to college, most of them have already made up their minds about their majors, and most will not change them. High school teachers and counselors are an important source of information for students early on, at the time when most of them are selecting majors.

Feedback from our education and recruitment outreach coordinators suggests that very few high school teachers and counselors

Mining Education

know much about mining engineering careers. If the counselors are not aware of mining as a career option, students will not be either.

Lastly, online efforts are better spent optimizing internet search results than social media presence. Social media may be omnipresent in students' lives, but that does not seem to exercise much actual influence when they make important decisions like choosing a major. It is important to maintain a baseline social media presence, which is largely expected these days and can be helpful for giving students a taste of the social environment (what is it like to be a mining engineering student?), but we should not confuse presence with influence.

In contrast, students do seek out and use information from online searches. Making sure that they have abundant, reliable and accurate information about mining engineering at their digital fingertips is crucial to inducing them to think about it as a career.

Going forward

The UArizona's Lowell Institute for Mineral Resources and Mining and Geological Engineering department is continuing our research. In our next installment, we will examine how different demographic groups view mining engineering, drawing some lessons about how to reach a larger and more diverse range of students. We will look at the effectiveness of different approaches to recruitment and creating a larger and more diverse pool of future mining engineers. Stay tuned. ■

References

Barton, I.F., Banta, J.H., and Hutson, L.L., 2021: What can get students interested in mining engineering? Ongoing UA study finds some answers. *Mining Engineering* 73.10: 30-34.

Banta, J.H., Barton, I.F., and Hutson, L.L., 2021: Where have all the mining engineering students gone? *Mining Engineering* 73.2: 25-28.



Two Great Ways to Advertise Your Business

The official publication of the Society for Mining, Metallurgy & Exploration, Inc. (SME), Mining Engineering has delivered news, industry information, the latest technological developments, and more to the global mining community since 1949.

Mining Engineering offers a full array of affordable advertising with tremendous reach within the global professional mining industry. Mining Engineering's editorial products are respected and read often, giving advertisers the most engaged, most qualified mining industry target audience. Average circulation figures — which includes subscribers, SME members and bonus distribution at key industry events worldwide — are currently at 17,000 copies for each of twelve monthly issues.

- The ultimate advertising and marketing impact for your investment.
- Distributed to an average of 17,000 global readers every month.
- Actively involved in trade shows around the globe.
- Backed by the world's largest professional mining society, SME.

Classified Advertising

Classified advertisements are an efficient use of your budget, allowing you to purchase multiple ads for repeat exposure. Classifieds reach your audience inexpensively, targeting those looking for specific products or services, employment in the mining and engineering field, or general information about your company.

Professional Services

The Mining Engineering Professional Services Section is a wealth of information for subscribers and SME members. Market your company by state, or choose the US General category to efficiently and effectively publicize your company to prospective clients and associates.

Contact us today for special introductory advertising rates.

SME

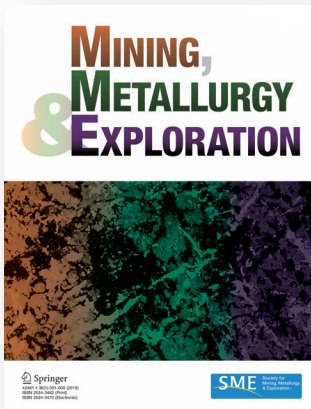
Society for
Mining, Metallurgy
& Exploration

Contact information:

Gary Garvey // Media Manager/Advertising
garvey@smenet.org // 1.800.763.3132

me.smenet.org

Extended abstracts from the SME journal Mining, Metallurgy & Exploration



Take full advantage of your SME membership. As a member, you can read and download for free all of the full-text papers in *Mining, Metallurgy & Exploration* (MME) and the archives of *Minerals & Metallurgical Processing* (MMP). Log in to the SME website as a member, and enter the MME Springer website through our dedicated SME link:

1. Log in at smenet.org with your email address and password.
2. Click on “Publications” in the top banner and choose “Mining, Metallurgy & Exploration journal” in the pull-down menu.
3. Scroll down and click on the “Read the MME Journal Online” link. This takes you to the MME Springer website as an SME member with free access.

To see a specific paper, use the search function or use the paper’s [https://doi](https://doi.org) link.

For assistance at any time, email Chee Theng at theng@smenet.org. ■

IMPACT FACTOR* 1.413

Submit your paper by clicking on the “Submit manuscript” box at springer.com/42461
Get Table of Contents (ToC) email alerts by clicking on “Sign up for alerts”

*MME is abstracted and indexed in Web of Science, Current Contents, Science Citation Index Expanded, Scopus, Google Scholar, EBSCO, ProQuest and many more.

A scale model experimental study for estimating the productivity of bulk push dozer operations in hard-rock mining

Royal Rea, Peter Knights* and Mehmet Kizil

School of Mechanical and Mining Engineering, The University of Queensland, Brisbane, Australia

*Corresponding author email: p.knights@uq.edu.au

Full-text paper:

Mining, Metallurgy & Exploration, <https://doi.org/10.1007/s42461-021-00505-9>

Keywords: Dozer productivity, Hardrock, Bulk push, Dozer trap, In-pit crushing and conveying

To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

A 1/20 scale experimental dozer push test rig was designed and constructed to quantify the expected production rates (loose cubic meters per hour) for dozers operating in hard-rock bulk push applications. The particle size distribution of the material employed in the test rig was modeled on a fragmented muckpile representative of that for a typical surface copper/gold mine overburden. Buckingham Pi theory was applied to mathematically develop factors for scaling up dozer productivity parameters, including blade loads and push times. Dozer production rates were investigated for various dozing distances and slope angles. A series of instantaneous productivity curves were produced which are applicable for use in hard-rock dozer push operations. The productivity curves produced demonstrate that dozer productivity declines rapidly over the range of 10 to 40 m.

Introduction

Bulk dozer push has been successfully applied to overburden and interburden removal in surface coal mines for many years, but there are few published examples of dozers being applied to remove muckpiles in hard-rock mines. This can be explained by material transport distances often exceeding the economic limits of dozer applications. However, two significant technological advances warrant a rethink of dozer application in hard-rock mines. The first of these relates to the development and deployment of semiautonomous dozers. Caterpillar’s latest semiautonomous tractor system (SATS) enables one operator to supervise multiple automated dozers. The second relates to the potential to significantly downsize truck fleets by replacing them with conveyor haulage through in-pit crushing and conveying

(IPCC) systems. IPCC operations have been widely applied in European lignite operations, often involving bucketwheel excavators and spreader systems. In the Latrobe Valley in Victoria, Australia, dozer push systems have been successfully implemented to feed lignite conveyor systems through dozer traps [1]. One possibility that has not been adequately explored in literature is to use dozers to feed IPCC systems in hard-rock surface mining operations. In order to assess the feasibility of this concept, it is essential to accurately forecast dozer production hours and dozer production rates when operating 24 × 7 hard-rock push operations.

Design of experimental rig

In order to quantify dozer production rates in fragmented hard-rock muckpiles, a scaled physical dozer testing rig was designed and constructed. A scale factor of 1/20 was chosen to enable dozer push experiments. Figure 1 shows the developed dozer push experimental rig in action.

The scale model dozer blade was fabricated in aluminum and modeled with the correct wings, curvature and dimensions from a carry blade for a Caterpillar dozer. The blade was attached to a carriage system fabricated from a welded angle iron section, which traversed on a rail guide manufactured from a modified steel ladder. The carriage was attached to a cable and pulley system powered by a 1/8-hp Baldor DC electric winch motor.

Scaling of the muckpile

Careful attention needs to be applied to maintain similitude between the properties of the scale dig medium and the actual muckpile. These include attention to the following parameters: particle size distribution (PSD), rock shape,

rock length, bulk density and cohesion factor. In the absence of specific site data, a representative PSD curve for a blasted muckpile at a copper/gold porphyry mine was used as a baseline reference [2].

Dimensional analysis

Dimensional analysis was first developed by Buckingham in 1915. The performance measured in the model system is related to that of the actual system by equating their respective nondimensional π values. This is known as the principle of similitude. The two nondimensional π values associated with the scaled dozer experiment were found to be:

$$\pi_1 = Vol^{-5/3} \rho^{-1} t^2 E \quad (1)$$

$$\pi_2 = \frac{Prod \times t}{Vol \times \rho} \quad (2)$$

where E is the work done by the dozer, equivalent to the dozer tractive power integrated with respect to the dozer push time. Table 1 lists the key influence parameters for the scale model test rig and actual muckpile and D11T system.

Using Eq. (1), the actual dozer push time is related to the model dozer push time by the following:

$$t_a = t_m \left(\frac{0.85}{0.9} \frac{0.65}{0.8} \frac{0.125}{850} \frac{1340}{1670} 20^5 \right)^{1/3} = 6.644 t_m \quad (3)$$

Return dozing times were calculated on the basis of the tables provided in Caterpillar's handbook [3]. It was assumed that the dozer reversed in first gear at a constant speed of 4.8 km/h over the dozing distance.

Experimental results

A series of experiments were conducted using the 1/20 scale dozer push rig for the following design-of-experiment parameters: (1) dozing distances of 0.5, 1.0, 1.5, 2.0 and 2.5 m, (2) horizontal, 5-degree and 10-degree downward pushes and (3) shallow versus deep depth of cut.

Ten repetitions were conducted for each combination of parameter values. The muckpile was re-established and graded between each repetition. Blade loads were dozed to a bucket trap beneath the table and subsequently weighed using an electronic scale. In total, this led to conducting some 300 tests with the experimental rig. The push times recorded for the experimental dozer trials were scaled up. This enabled a series of indicative dozer productivity curves to be established. Figure 2 illustrates one such curve for a 10-degree downhill push.

Table 1 – Scale model and actual system parameters.

Parameter	Scale model	Actual
Bulk density, ρ (kg/m ³)	1,670	1,340
Water content (cohesion)	dry	Assumed dry
Peak engine power, P (hp)	0.125	850
Drivetrain efficiency, μ (%)	85	80
Energy delivery in dig cycle, α (%)	65	85
Carry load factor	(1/20) ³	1



Fig. 1 Dozer test in action, showing winch, carriage, dozer blade and simulated muckpile.

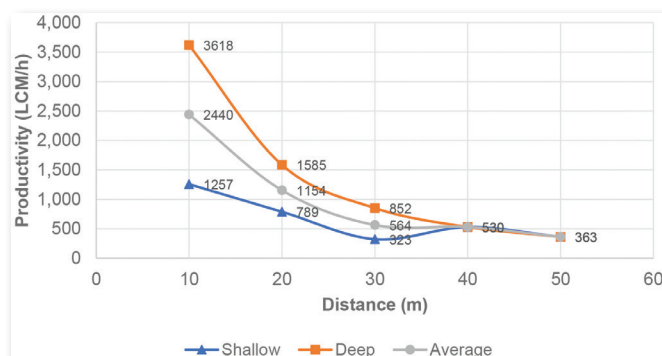


Fig. 2 Productivity curve for 10-degree downhill push.

Conclusions

1. Dozer productivity is an inverse function of dozer push cycle times. As dozing distance increases, both forward and reverse cycle times increase, thus accelerating the productivity decline between 10 m and 20 m dozing distances.
2. In practice, dozer push distances should not exceed 40 m. This is an important design criteria for fully mobile IPCC dozer push applications.
3. Dozing downhill greatly increases dozer productivity. For short dozing distances (less than 20 m), dozer push productivity is enhanced by approximately 30 percent. For 10-degree slopes, push dozer productivity

can be enhanced by more than 50 percent compared to flat horizontal push.

4. Depth of cut enhances dozer productivity. In practice, this will be limited by available dozer tractive power. The advantage of deeper cuts appears negligible when dozing distances increase beyond 40 m. ■

Selected references

1. Medland D, Methner R (2006) Radical Mining Process Change is Possible. 2006 Australian Mining Technology Conference 'Value through Cost Control'. Hunter Valley, NSW: The Australasian Institute of Mining and Metallurgy (AUSIMM). 397–410
2. Onederra I, Mardones F, Scherpenisse C (2010) Application of stochastic approach to blast fragmentation modelling. *Min Technol* 119(4):221–232
3. Caterpillar (2017) Caterpillar performance handbook 49th edition, 47:19–19–57 (Caterpillar: Peoria)

Usage of fly ash as binder in the micropelletization process as a partial replacement of bentonite

Sivalingaraju Barisetty*, Rameshwar Sah, Shyam Yadav, LR Singh and PK Ghori

¹JSW Steel Ltd., Vijayanagar Works, Toranagallu, Ballari, India

*Corresponding author email: sivalinga.raju@jsw.in

Full-text paper:

Mining, Metallurgy & Exploration (2021) 38:2249–2254, <https://doi.org/10.1007/s42461-021-00467-y>

Keywords: Bentonite, Binder, Fly ash, Micropelletization, Pozzolanic

To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

Fly ash is a by-product generated by the combustion of coal in thermal power plants. Its disposal is a major environmental concern for these power plants. Though a considerable part of fly ash is used in cement making and brick manufacturing, a substantial quantity remains unutilized. Bentonite is commonly used as binder in the micropelletization of process waste to attain the mechanical strength required for handling and transportation. The present paper deals with the partial replacement of bentonite with fly ash in the micropelletization process without affecting the quality of the micropellets. The mechanisms of both the binders are discussed. The bonding of particles by bentonite is a physical mechanism, while fly-ash bonding is a chemical mechanism. Silica and alumina are the major constituents present in fly ash along with lime. In the presence of water, the aluminosilicates and unhydrated lime present in fly ash undergo a pozzolanic reaction and form cementitious bonds, which hold the particles together. Use of fly ash as alternative binder for bentonite has cost benefits besides providing a better utilization option for fly ash.

Background

Significant quantities of iron and carbon-rich wastes in the form of sludge and dust — such as bag filter dust, cyclone dust, blast furnace sludge, sinter plant electrostatic precipitator (ESP) dust, direct reduced iron (DRI) sludge, basic oxygen furnace (BOF) sludge, coke dry quenching (CDQ) fines,

lime and dolomite fines, and BOF slag — are generated in the steel industry. They are currently being recycled in sinter making through micropelletizing and partly in pellet making after upgradation in an iron recovery plant.

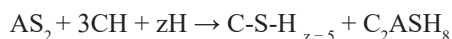
Fly ash, also known as flue ash, is one of the residues remaining after coal combustion. It is generally captured by electrostatic precipitators in thermal power plants. Fly ash's

Table 1 — Results of chemical analysis of binders.

Constituent	Bentonite (weight %)	Fly ash (weight %)
SiO ₂	42.88	41.60
Al ₂ O ₃	24.25	28.21
CaO	1.83	9.00
Fe ₂ O ₃	16.56	7.85
K ₂ O	0.30	0.83
Na ₂ O	2.26	0.70
P ₂ O ₅	0.45	0.67
SO ₃	0.24	0.34
MgO	0.90	0.33
ZnO	0.05	0.01
LOI (including C)	10.28	10.46

composition is typically SiO₂, 40 to 50 percent; Al₂O₃, 25 to 30 percent; CaO, 4 to 8 percent; Fe₂O₃, 3 to 7 percent; and loss on ignition (LOI), 6 to 22 percent, including unburnt carbon, 3 to 20 percent. Ripke and Kawatra [1] emphasized the importance of alternatives to bentonite as binders for the steel industry, owing to bentonite's limited availability and increasing cost.

While bentonite produces a physical bonding between iron ore concentrate grains in the pellet, fly ash undergoes a pozzolanic reaction to form cementitious bonds between the particles. The reaction between the aluminosilicates of fly ash in the presence of water and lime is [2]:



where C → CaO; A → Al₂O₃; S → SiO₂; H → H₂O, and z is a numerical variable.

Methodology

Characterization of binders. The binder samples — fly ash and bentonite — were characterized by physical, chemical and microscopic analysis, including X-ray diffraction (XRF), particle size analyzer, Blaine apparatus and scanning electron microscope (SEM).

The results of the chemical analysis (Table 1) indicate that the fly ash and bentonite are chemically similar, and their major constituents are silica, alumina and iron oxide. Fly ash has advantages over bentonite of having less alkali (Na₂O and K₂O) content and larger surface area. Table 2 shows the results of the size analysis. Figure 1 shows SEM micrographs of the binders at 200 μm magnification.

Laboratory- and plant-scale experiments. Micropellets in 10-kg batches were prepared using a disc pelletizer with fly ash and bentonite as binder (Fig. 2a). Figure 2b shows the green micropellets. The laboratory-scale experiments demonstrated that fly ash can be replaced with bentonite up to

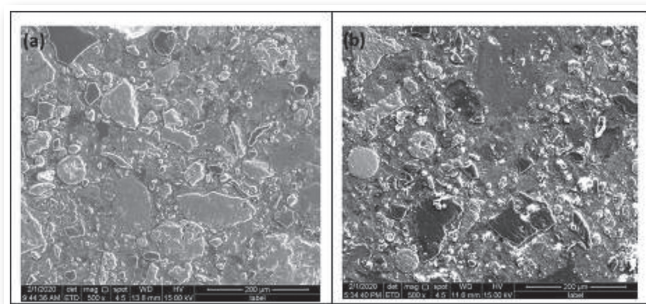


Fig. 1 SEM micrographs of binders at 200 μm magnification: (a) bentonite (b) fly ash.

30 percent without affecting the quality of the micropellets. Based on the laboratory-scale results, plant-scale experiments were conducted with the process flow sheet shown in Fig. 2c. Figure 2d shows micropellets produced on the plant scale.

Results and discussion

Based on the encouraging laboratory-scale results, plant-scale trials were conducted with optimized process parameters, and the use of fly ash was regularized in commercial application at a micropellet plant. The use of fly ash as a replacement for bentonite ranged between 25 and 30 percent without hampering the process and quality of the micropelletization, and a similar level of usage continued in regular operation.

Conclusions

A novel process of micropelletization is developed to use fly ash as binder by partially replacing bentonite, up to 30 percent, without affecting the quality of the micropellets.

The recycling of fly ash at a rate of 15 t/d as binder in the micropelletization of process wastes (dust, sludge and slag) promotes waste utilization and environmental protection. ■

Selected references

1. Ripke JS, Kawatra SK (2000) Can fly-ash extend bentonite binder for iron ore agglomeration? *Int J Miner Process* 60(3-4):181-198
2. Eisele TC, Kawatra SK (2003) A review of binders in iron ore pelletization. *Miner Process Extr Metall Rev* 24(1):1-90
3. Dutta SK (2017) Iron ore-coal composite pellets/briquettes as new feed material for iron and steel making. *Mater Sci Eng Int J* 1(1):10-13

Table 2 — Results of size analysis of binders.

Size (μm), cumulative passing	Bentonite (%)	Fly ash (%)
2	4.8	11.3
10	18.8	48.3
25	36.6	75.0
32	43.5	80.6
45	55.5	87.6
63	69.6	93.2
75	76.9	95.7
125	92.3	99.7
150	96.6	100.0
200	100.0	100.0

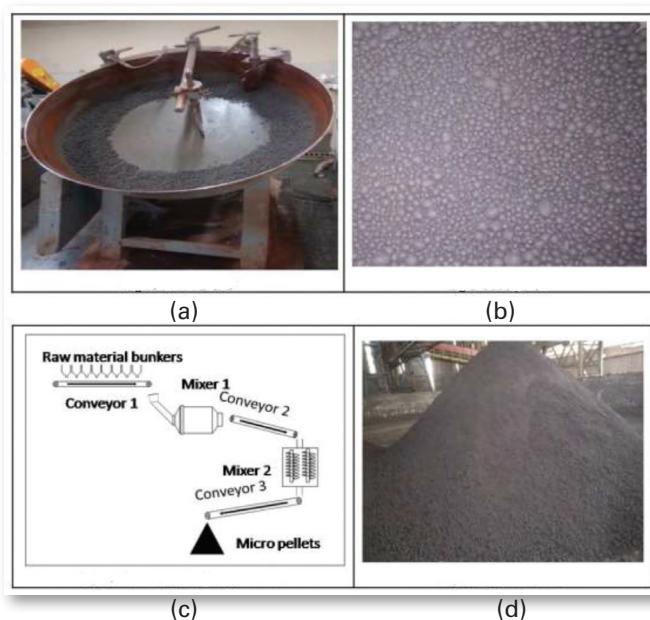


Fig. 2 (a) Disc pelletizer, (b) green micropellets, (c) schematic of micropelletization and (d) heap of micropellets.

Coupled finite-difference and discrete-element method for modeling direct shear tests on combined rock-cemented rockfill specimens

Chong Wei¹, Derek Apel^{1,*} and Tatyana Katsaga²

¹Department of Civil and Environmental Engineering, School of Mining and Petroleum Engineering, University of Alberta, Edmonton, Alberta, Canada

²Itasca Consulting Canada, Inc., Sudbury, Ontario, Canada

*Corresponding author email: dapel@ualberta.ca

Full-text paper:

Mining, Metallurgy & Exploration, <https://doi.org/10.1007/s42461-021-00500-0>

Keywords: Finite element method, Discrete element method, Numerical modeling, Direct shear test, Cemented rockfill, Shear behavior, Mechanical properties

To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

This study provides an effective determination process of the interface microstructural parameters in the numerical modeling of the mechanical interaction between two different geomaterials involved with frictional-bonded interfaces, such as the interaction between backfill columns and the surrounding rocks, or the soil-structure interaction, by using the coupled finite-difference and discrete-element (FD-DE) method.

The test results validated the feasibility and rationality of the coupled FD-DE method for modeling the combined specimens with frictional-bonded interfaces or joints. Furthermore, this study provides valuable numerical modeling experience for investigating the shear behavior at the interface between cemented backfill columns and surrounding walls by using the coupled FD-DE method.

Background

In mining engineering, to successfully simulate the mechanical interaction and the stress distribution law between backfill columns and the surrounding rocks with the coupled approach, the microstructural parameters at the frictional-bonded interface between them need to be determined. However, there are no previous studies dealing with the numerical simulation of direct shear tests on geomaterials with interfaces or joints by using the coupled FD-DE or FE-DE methods.

Thus, in this study, the coupled FD-DE models of the combined rock-cemented rockfill (R-CRF) specimens were designed for numerical direct shear tests to study the shear behavior of the frictional-bonded interfaces between the CRF columns and the surrounding rocks. These interfaces' microstructural parameters were determined for the future numerical modeling on the stability and stress distribution of underground stopes backfilled with the CRF columns.

This study can provide an effective determination process of the interface microstructural parameters in the numerical modeling of the mechanical interaction between two different geomaterials involved with frictional-bonded interfaces, such as the interaction between backfill columns and the surrounding rocks, or the soil-structure interaction, by using the coupled FD-DE method.

Methodology

In this study, finite zones were created to simulate the

FD model of the rock specimen, and the DE model of the CRF specimen was formed by randomly generated discrete spheres with a simplified particle size distribution. The interface of the combined specimen was modeled with the coupled FD-DE method.

Figure 1 shows the geometry, boundary conditions and creation procedures of the three-dimensional coupled FD-DE model of a combined R-CRF specimen. In the coupled model, $15 \times 15 \times 3.75$ m finite zones, representing the FD model of the rock specimen, were initially constructed with FLAC3D, a finite-difference program using an explicit Lagrangian calculation scheme and a mixed discretization zoning technique. A coupled wall with edge-connected triangular facets was then created to cover the top face of the finite zones. Each wall facet coincides with the corresponding finite zone, and the vertices of wall facets act consistently with the zone gridpoints.

Five more rigid walls connected to the coupled wall were

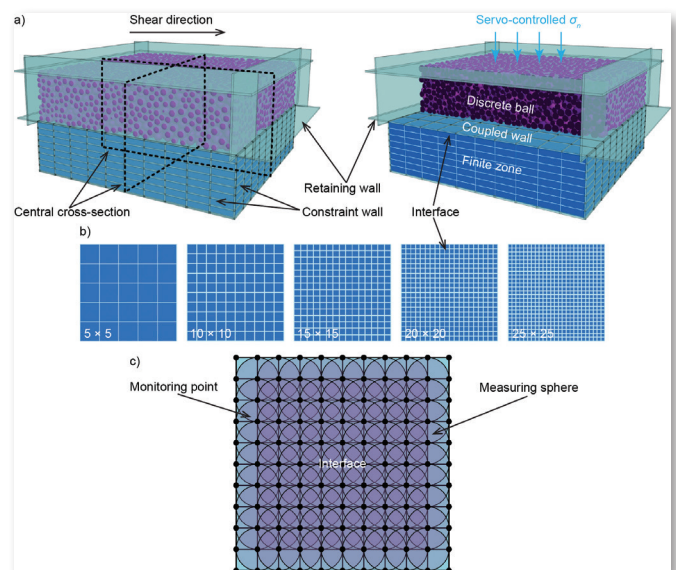


Fig. 1 Coupled FD-DE model of the combined R-CRF specimen: (a) full view, (b) cross-section and (c) different mesh sizes and measuring region.

generated to form a box with size of $15 \times 15 \times 3.75$ m to contain the discrete spheres of the DE model. The particle scaling method was adopted to simplify the generation of the discrete spheres in the DE model using PFC3D, a software that provides a discrete-element modeling framework.

Direct shear tests were performed on the coupled models under three different values of the normal stress: 0.25, 0.5 and 1.0 MPa. Initial servo-controlled normal stress was applied to the lateral and top walls that surround the discrete spheres, and the velocities at the lateral and bottom faces of the finite zones were fixed in the corresponding normal directions to provide constraints.

Conclusions

Under the direct shear condition, the coupled FD-DE model of the combined R-CRF specimen shows evident elastoplastic shear behavior of strain-softening, including the five main stages of initial bond breakage, elastic deformation, bond breakage propagation, shear strength collapse and frictional sliding (Fig. 2a). With the microstructural parameters of the DE model of the CRF specimen determined, the coupled model's strength parameters and deformation properties under the different servo-controlled normal stresses highly coincide with the expected results. The coupled model's failure envelope under the direct shear condition is also in good agreement with the Mohr-Coulomb strength criterion. The servo-controlled normal stress monitored in either the y - or z -direction maintains a stable value during the entire direct shear process (Figs. 2b and 2c). However, it can nonuniformly distribute at different locations on the corresponding central cross-section of the coupled model,

indicating that the numerical servo-controlling scheme based on the coupled FD-DE method can reflect the true nature of the laboratory operation more factually than the FD method alone.

Significant shear dilation phenomenon can be observed at the interface of the coupled model during the entire direct shear process, which leads to a rapid increase in the normal displacement during the elastic deformation stage, and then a stable plateau value during the frictional sliding stage (Fig. 2d). During the entire shear process, the magnitude displacement of the discrete spheres is higher at the top and lower at the bottom of the DE model, as the binding and frictional effects at the interface hinder the rightward motion of discrete spheres. For the FD model, during the elastic deformation stage, an evident convex thrust of the magnitude displacement can be observed in finite zones due to shear dilation. The convex thrust gradually diminishes after the collapse of the peak shear stress. A vortex zone of the magnitude displacement can be formed during the frictional sliding stage by the combined action of shear dilation and the constraint effect from boundary walls.

During the elastic deformation stage, a concentration band of the normal contact force in compression can be formed diagonally from the top left corner to the bottom right corner of the DE model. After the peak shear stress collapse, the concentration band gradually diminishes due to the weakened binding effect at the interface.

During the frictional sliding stage, a significant rightward trend can be observed in the chain of the normal contact force in compression, with the binding effect disappearing.

During the elastic deformation stage, a significant concentration zone of the stress in the x -direction can be formed and expanded on the left of the DE model. This concentration zone progressively diminishes and moves to the bottom right corner of the DE model after the peak shear stress collapse due to the weakened binding effect at the interface. However, for the FD model, the stress in the x -direction passively transforms from tension to compression along the shear direction from left to right during the entire shear process, during which the zx -component of the stress in the coupled model shows a nonuniform distribution at different locations on the interface due to the constraint effect and the random generation method of the discrete spheres.

For the peak shear stress at the interface, contours plotted from the DE and the FD models highly coincide, and both the contours have an excellent interpretation of the peak shear stress distribution of the coupled model.

For the residual shear stress, an evident increasing trend in the zx -component of the stress can be observed in the contour from left to right in the DE model. This trend results from the right-

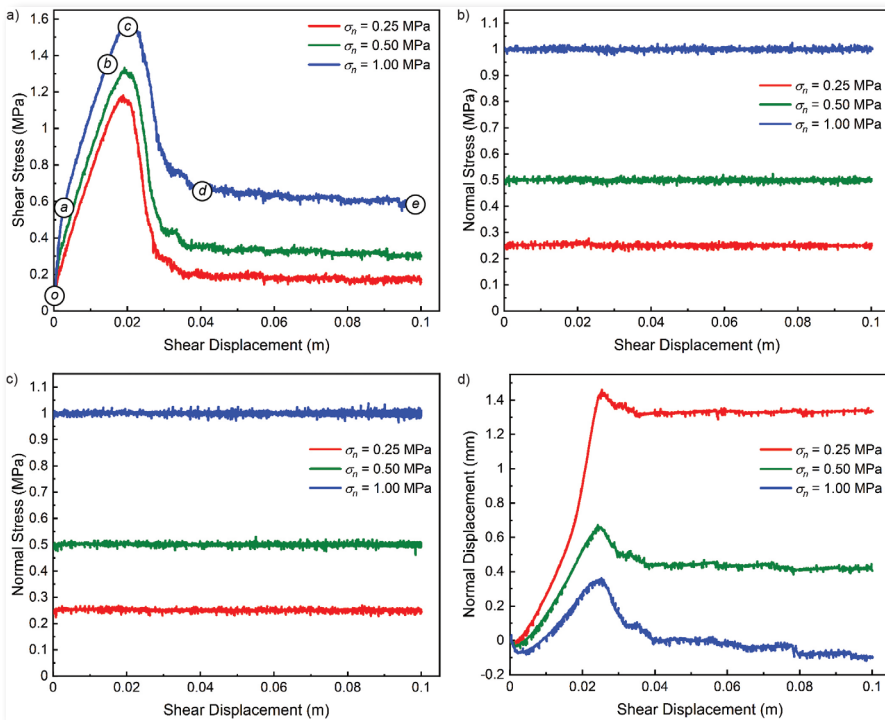


Fig. 2 Results of direct shear tests on the coupled model: (a) shear stress-displacement (τ_s - d_s) curves, (b) normal stress-displacement (σ_n - d_s) curves in the z -direction, (c) normal stress-displacement (σ_n - d_s) curves in the y -direction and (d) normal-shear displacement (d_s - d_s) curves.

ward motion of the concentration zone of the stress in the *x*-direction caused by the frictional sliding.

However, no corresponding trend can be observed in the contour plotted from the FD model due to the con-

straint effect at the boundary walls. ■

References

A list of all references is available in the full paper.

Effect of bucket geometry, machine variables and fragmentation size on the performance of rubber tire loaders

Atta Ur Rehman* and Kwame Awuah-Offei

¹Department of Mining and Nuclear Engineering, Missouri University of Science & Technology, Rolla, MO, USA

*Corresponding author email: atta@mst.edu

Full-text paper:

Mining, Metallurgy & Exploration, <https://doi.org/10.1007/s42461-021-00497-6>

Keywords: Bucket geometry, Draft force, Penetration, Rubber tire loaders, Motor power output, Speed

To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

This paper examines the effect of bucket geometry (cutting-blade profile, floor profile and blade thickness), speed, motor power output and muckpile particle sizes on bucket penetration and draft for rubber tire loaders. The work uses a 1:16 scale model of a load-haul-dump (LHD) in full-factorial experiments to examine the effect of the variables on penetration and maximum draft. The results show that speed and motor output are positively correlated with penetration and draft, and muckpile particle size is positively correlated with penetration and negatively correlated with draft ($p < 0.0014$). The results also show that buckets with a semispade cutting-nose profile yield the highest penetration (mean of 118.30 mm) followed by those with the spade profile (mean of 108.88 mm) and lastly, those with straight blades (mean of 95.19 mm). Bucket floor profile and blade thickness had no significant effect on penetration or draft. We determined that simultaneously increasing the speed and motor power output can reduce bucket penetration. Thus, operators should not waste energy for no additional gain or even loss in bucket penetration. In addition, this work finds speed and motor power output each combine with muckpile particle sizes to affect bucket penetration. This research

further our understanding of the effectiveness of different bucket geometries in improving penetration and reducing draft for rubber tire loaders.

Introduction

The overall performance of rubber tire loaders is affected by multiple factors, including machine characteristics such as drive mechanism, drive efficiency and bucket design; operating conditions such as formation characteristics, including fragmentation, bench design and bench conditions; and operator experience and skills, including cutting depth, tipping point and swing efficiency. The digging operation of these loaders can be divided into four distinct steps: penetration,

Table 1 – Summary of the experimental design.

Factor	Levels				
Maximum motor power output (A)	2	10	20		
Velocity (mm/s)	300	400	500		
Geometry*	B1	B2	B3	B4	B5
Pile	Waste or reject materialI	Processed material-I	Processed material-II	Blast rock-I	Blast rock-II

*B1, B2, B3, B4, and B5 refer to different buckets with different geometries. See full paper for descriptions.

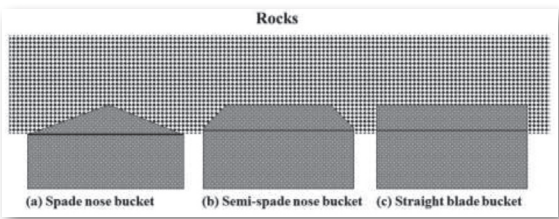


Fig. 1 Typical cutting blade profiles: (a) spade nose, (b) semispade and (c) straight (top views with the leading edge of each blade toward the top of the image).

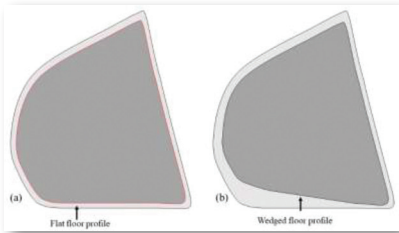


Fig. 2 Right side views showing typical bucket floor profiles: (a) flat floor and (b) wedged floor.

Table 2 – Analysis of variance for tested buckets.

Comparison	P-value	
	Penetration	Force
Flat-bottom versus wedged-floor bucket	0.5700	0.6938
Thick versus thin cutting edge	0.7473	0.6046
Semispade versus spade versus straight cutting edge	< 0.0001	0.9034

rotation, lift and pull out. An in-depth understanding of these four steps can improve the efficiency of the loading operation and facilitate the automation of these loaders. Typically, the buckets of rubber tire loaders differ in the geometry of the cutting-edge blade, floor profile, thickness of various parts of the bucket, and other geometric parameters. Generally, the mining and construction industry uses three types of cutting-edge blade geometries: straight, spade nose, and semispade (Fig. 1). The industry generally uses two different bucket floor profiles: flat floor and wedged floor (Fig. 2).

The objective of this work is to evaluate the effect of bucket geometry using buckets that differ in floor profile, blade thickness and cutting-blade profile, motor power output of the drive motor, and forward speed of the rubber-tire-loader bucket on penetration. The study uses a 1:16 scale model of a representative 18-t capacity Komatsu LHD (Fig. 3) as a simulator throughout the experiment.

Methodology

In this work, we tested five buckets of different geometries using five different muckpile particle size distributions at various speeds and limiting the maximum motor power output to assess their effect on longitudinal displacement or penetration and draft (Table 1).

Results and discussion

Figure 4 shows a summary of the experimental results for penetration and maximum draft for the experiments at speed of 300 mm/s. The results clearly show that the penetra-

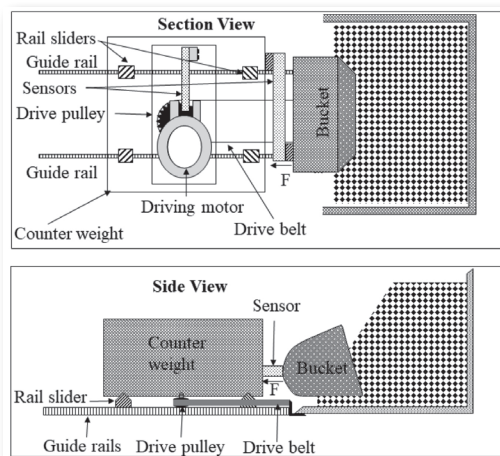


Fig. 3 The simulator: a 1/16 scale model of a Komatsu LHD.

Table 3 – Mean values for buckets with different cutting blades.

Type of bucket	Mean (mm)	Std dev (mm)
Semispade cutting blade	118.30	43.60
Spade cutting blade	108.88	45.26
Straight cutting blade	95.19	44.50

tion and draft differ for the different buckets, even at the same speed and in the same pile.

The results of the regression analysis for penetration and draft, respectively, can be found in the full paper.

Tables 2 and 3 show the analysis of variance for the tested buckets and the mean values for buckets with different cutting blades.

Conclusions

The results show statistically significant association between geometry, muckpile particle sizes, speed and motor power output on the one hand, and longitudinal penetration and draft on the other. The results also show that buckets with a semispade cutting-nose profile yield the highest penetration followed by those with a spade profile and lastly, those with straight blades. ■

References

A list of all references is available in the full paper.

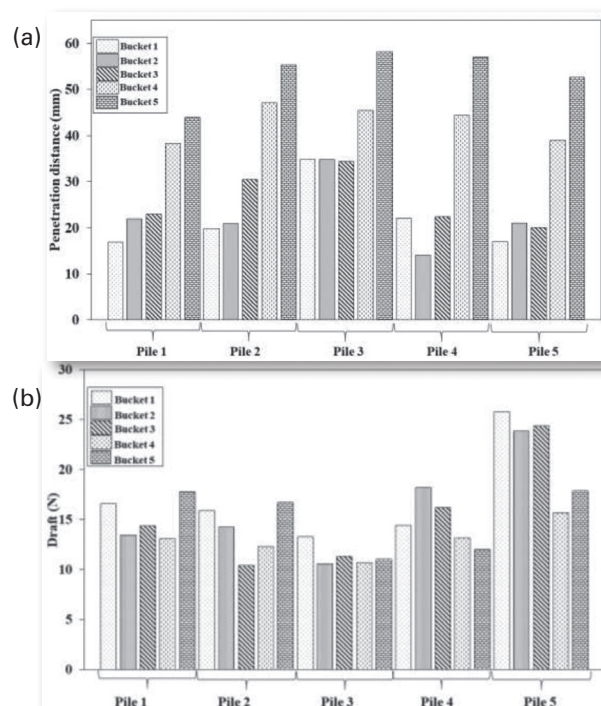


Fig. 4 Summary of (a) longitudinal penetration distances into muckpiles and (b) draft (2A minimum traction, 300 mm/s speed).

A discrete-event simulation and data-based framework for equipment performance evaluation in underground coal mining

Enver Yilmaz* and Mustafa Erkayaoglu

Department of Mining Engineering, Middle East Technical University, Ankara, Turkey

*Corresponding author email: enver@metu.edu.tr

Full-text paper:

Mining, Metallurgy & Exploration (2021) 38:1877–1891, <https://doi.org/10.1007/s42461-021-00455-2>

Keywords: Underground mining, Longwall top coal caving operation, Discrete-event simulation, Data-based framework, Shearer

To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

Coal mining is likely to sustain its critical role as energy requirements are increasing. While surface mining exploits coal seams near the surface, underground mining techniques are crucial for extracting deep coal reserves. Longwall mining is one of the most common methods used in underground coal mining operations. This paper introduces a data-based framework — including data collection, data analysis and the interpretation of operational data — for understanding the system efficiency of a longwall shearer. Operational performance is evaluated by the time between arrivals (TBA) and duration of the shearer stoppages, shearer drums' reversal time, cutting speed and flit speed on daily production in a longwall top coal caving (LTCC) mine. A discrete event simulation model is developed to represent the bidirectional cutting sequence of a longwall shearer.

Introduction

Energy requirements are rising with increasing demand for public and industrial consumption, and coal has a big share of energy production worldwide [1]. Coal is extracted from the Earth's crust by surface or underground mining. As the shallow coal deposits are consumed, underground mining activities are becoming more important [2].

Mining can be considered an interdisciplinary industry that is challenged by various operational difficulties, mostly stochastic processes that should be examined thoroughly to increase the system efficiency. To this end, discrete-event simulation (DES) has been implemented in mining activities for various applications [3]. This study investigated the daily shearer production of a LTCC mine by simulating operational conditions, including the TBAs of the shearer stoppages, duration of the shearer stoppages, shearer drums' reversal time, cutting speed and flit speed on daily shearer production. Operational data were collected on-site for a bidirectional cutting sequence. A data-based framework with an integrated data environment is proposed within the scope of the study.

Methodology

A field study based on operational data related to the bidirectional cutting process from an under-

ground mine in Turkey was completed to build the DES model. DES models can provide valuable information about the potential impact of changing operational parameters and therefore should be integrated with operational data. To do so, data collected from equipment in the longwall system should be used. According to this framework, the data can be collected from sensors, programmable logic controllers and other available on-board systems. The simulation model and the developed framework are shown in Fig. 1.

In this study, data were manually collected although the framework provides insight into business intelligence tools such as dashboards and reports. For better use of available data, the simulation could be executed automatically, and the output could also be stored in a data warehouse.

Results and discussion

Model outputs indicate that the shearer production is 726.73 t and the active cutting time of the shearer is 89.07 min in a day. During a field visit, it was determined that an

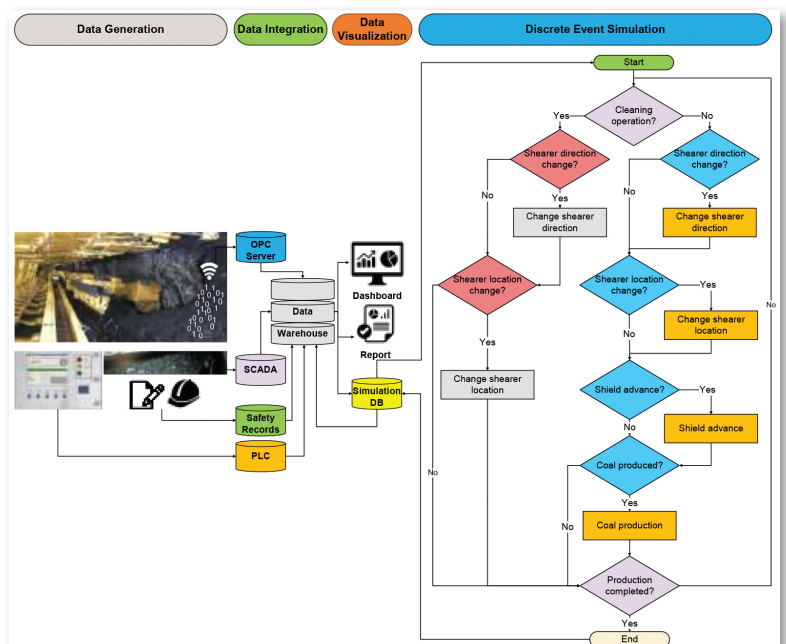


Fig. 1 Operational data-based framework for LTCC systems.

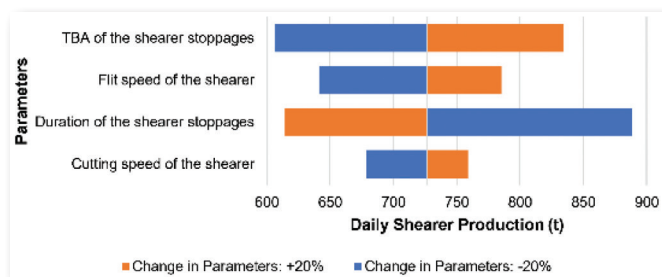


Fig. 2 Sensitivity analysis on the shearer daily production rate.

unexpected change in geotechnical conditions caused shearer stoppages. Therefore, the shearer spent the majority of time in nonproductive activities.

A series of sensitivity analyses on the shearer daily production rate were conducted with 20 different scenarios simulated. The results indicate that duration of the shearer stoppages was the most effective factor in the mine. TBA of the shearer stoppages can also be considered as a remarkable factor in mine production, followed by flit speed and cutting speed of the shearer. The effect of shearer drums' reversal time is not significant as drum reversal operations require only a short time, and there are only a limited number of drum reversal operations in the production cycle. The model outputs are represented in Fig. 2.

When the duration of the shearer stoppages varies in a range of 20 percent, shearer production can go up to 888.76 t/d and drop to 614.43 t/d.

Daily shearer usage in minutes was analyzed with another sensitivity analysis, which was in accordance with the sensitivity analysis on the daily shearer production rate. Total activity time of the shearer was inversely proportional to the duration of the shearer stoppages, as expected, and it

is concluded that if the duration of shearer stoppages is 80 percent of the current situation, shearer activity time could increase to 108.65 min/d. In the condition that the duration of the shearer stoppages is increased by 20 percent, shearer activity time is decreased to 73.93 min/d.

Conclusion

A bidirectional cutting system of the shearer was modeled by DES, with shearer activity and transportation of the extracted coal included in the model. Within the scope of the study, several operational conditions on shearer production rate, including the TBA of the shearer stoppages, duration of the shearer stoppages, shearer drums' reversal time, cutting speed and flit speed were investigated. The results showed that the shearer is mostly nonactive, and low shearer activity time indicates that the interruption of the shearer operations affects the production rate substantially in this mine. Thus, predictive maintenance strategies for the equipment should be developed to decrease the interruption of the shearer operations on-site. In this way, the production rate of the shearer and the general efficiency of the system can be increased. The information-technology infrastructure of the mine should be improved to enable accessing of the real-time equipment data and provision of a distinction between downtime events: that is, mechanical breakdown or operational delays. In this way, the data-based framework can be established, and the operations can be analyzed using integrated data. ■

Selected references

1. International Energy Agency (2021) World Energy Outlook. <https://iea.blob.core.windows.net/assets/888004cf-1a38-4716-9e0c-3b0e3fdbf609/WorldEnergyOutlook2021.pdf>. Accessed 05 November 2021.
2. Ghosh N, Agrawal H, Singh SK, Banerjee G (2020) Optimum chain pillar design at the deepest multi-seam longwall workings in India. *Min Metall Explora* 37:651–664
3. Dindarloo SR, Osanloo M, Frimpong S (2015) A stochastic simulation framework for truck and shovel selection and sizing in open pit mines. *J South Afr Inst Min Metall* 115:209–219

Effect of corn oil addition to TCMA-modified clay on ZEN removal

Kerri-Ann A. Hue¹, Ayman A. El-Midany^{2,*} and Hassan E. El-Shall¹

¹Institution Department of Materials Science and Engineering, University of Florida, Gainesville, FL, USA

²Mining, Petroleum, and Metallurgical Engineering Department, Faculty of Engineering, Cairo University, Cairo, Egypt

*Corresponding author emails: aelmidany@gmail.com; aelmidany@eng.cu.edu.eg

Full-text paper:

Mining, Metallurgy & Exploration (2021) 38:2493–2499, <https://doi.org/10.1007/s42461-021-00496-7>

Keywords: ZEN, Modified clay, Cationic exchange, TCMA, Corn oil

To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

Modifying the hydrophobicity of clay is necessary to accommodate large mycotoxin molecules such as zearalenone (ZEN). In this study, tricaprylmethylammonium (TCMA) chloride and common corn oil were used to modify clay. The results indicate that more than 90 percent of ZEN could be removed using clays modified by TCMA and corn oil at acidic and neutral pH due to the expansion of intergallery spacing

as a result of TCMA surfactant intercalation within the clay-forming layers. The removal percentage depends on the pH and amount of clay used. Complete removal can be achieved at acidic pH and small clay amount.

Introduction

Mycotoxins are toxic secondary metabolites that have

significant effects on human and animal health. The mycotoxins of most concern are aflatoxins, fumonisin, ochratoxin, T-2 toxin, deoxynivalenol and ZEN [1]. Mycotoxins can have a cumulative effect in humans causing cancer, acute symptoms and immune-deficiency diseases.

Raw clay has had a limited success in reducing the bio-availability of long-chain and hydrophobic mycotoxins. Clays modified with cetyl pyridinium, hexadecyltrimethylammonium and cetyltrimethylammonium bromide achieve greater ZEN removal than unmodified clays [2]. The modification of clay by TCMA at 30 percent of its cation exchange capacity (CEC) was tested to extract hydrocarbon molecules from aqueous solution [3]. Thus, the extraction of ZEN was investigated using hydrated sodium calcium aluminosilicate clays modified by TCMA at 40 percent of the clays' CEC in the absence and presence of corn oil, as a partial replacement of TCMA to reduce cost.

Materials and methods

Clays were modified by TCMA with 15.7 Å d-spacing at different CECs of the clay for ZEN extraction. To reduce the cost of modification, a mixture of generic corn oil and TCMA was used.

Results and discussion

The intergallery d-spacing increased from 15.7 to 22 Å by changing the CEC from 40 to 100 percent, which facilitates the accommodation of bigger molecules even if they are hydrophobic in nature. There was no significant change between the clay modified with TCMA alone at 40 percent of its CEC and those modified with corn oil.

The ZEN removal reached 90 percent using 40 percent CEC of the clay, but it needed greater amounts of clay. The extraction results at pH 3 shows higher ZEN removal. The amount of clay significantly affected the removal at pH 7 (Figs. 1a, b). The removal percentage increased by changing the CEC from 40 to 100 percent to reach almost 100 percent, regardless of the ZEN concentration (Figs. 1 c, d). Using 40 percent CEC modified clay and 10 ppm ZEN, the effect of corn oil at lower percentages (3 and 10 percent) by weight of clay, pH, and amount of clay was investigated using statistical design (Table 1).

At pH 7 and 125 mg of clay, the TCMA-corn oil clay completely removes ZEN molecules from the solution, compared with 90 percent removal using TCMA alone (Fig. 1). By lowering the clay quantity to 50 mg at pH 7, removal became more than 93 percent at 3 and 10 weight percent corn oil (Table 1). ZEN removal reached 100 percent at pH 3 even at lower corn oil percentage. Increasing the amount of clay enhances the ZEN removal with lower corn weight percentage. The lower extraction at pH 3 and higher corn oil concentrations is due to the presence of ZEN molecules in its phenolic anion form, which cannot attach to negative charges at -OH edge sites by ion-dipole interaction, and the oversaturation of the clay due to the presence of a high concentration of organic species.

Conclusions

Clay modification is necessary to expand the d-spacing to accommodate large mycotoxin molecules. Furthermore, the increase in clay hydrophobicity due to the intercalation of

Table 1 — IMTX-TCMA-corn oil extraction results at ZEN dosage of 10 ppm.

Std	Factors			Response
	A, Corn oil (weight %)	B, Clay amount (mg)	C, pH	ZEN removal (%)
1	3	50	3	94.3
2	10	50	3	82.94
3	3	125	3	100
4	10	125	3	92.8
5	3	50	7	93.5
6	10	50	7	93.93
7	3	125	7	99.9
8	10	125	7	99.93

TCMA enhances the sequestration of nonpolar toxins in the modified galleries. Beyond 100 percent CEC, the change in the d-spacing is insignificant. In addition, the TCMA adsorption and intercalation was proved using thermal gravimetric analysis and X-ray diffraction. Using TCMA alone at pH 3 and 7, extraction reached more than 90 percent. While using the corn oil, there is no intergallery spacing or overall mass loss changes; however, the manipulation with lower corn oil weight percentage leads to full removal of ZEN especially at acidic pH. The higher amounts of oil used have a negative effect on the extraction process due to either saturation of the galleries with oil molecules or covering the responsible site for interaction with ZEN molecules. ■

Selected references

1. Fokunang CN, Tembe-Fokunang EA, Tomkins P, Barkwan S (2006) Global impact of mycotoxins on human and animal health management. Outlook on Agriculture 35(4):247–253
2. Feng J, Shan M, Du H, Han X, Xu Z (2008) In vitro adsorption of zearalenone by cetyltrimethyl ammonium bromide-modified montmorillonite nanocomposites. Microporous and Mesoporous Mater 113(1–3):99
3. Lo IMC, Lee CH, Liljestrand HM (1996) Tricaprylmethylammonium bentonite complexes as adsorbents for benzene, toluene, ethylbenzene and xylene. Water Sci Technol 34(7–8):319–325

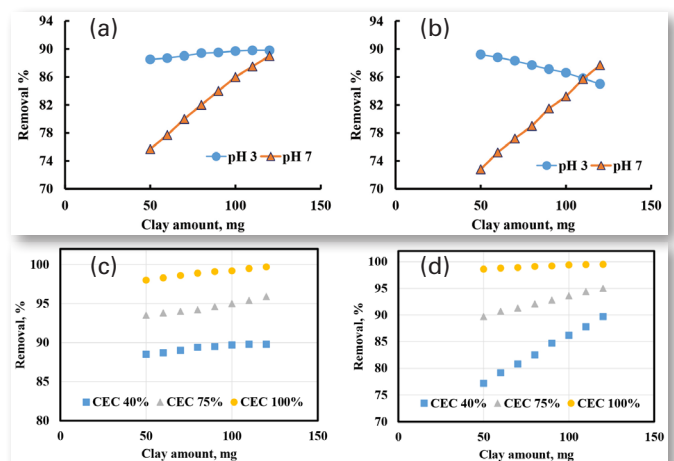


Fig. 1 ZEN removal as a function of clay amount with ZEN dosages of (a) 10 ppm and (b) 20 ppm (40 percent CEC, pH 3 and 7) and at (c) pH 3 and (d) pH 7 (different CECs, ZEN dosage of 10 ppm).

2021 Excellence in Prospecting Award presented to Epiroc's Jess Kindler

The 2021 SME Foundation Excellence in Prospecting award recipient is Jess Kindler, a member of Epiroc's Group Management team. This award proudly recognizes Jess' commitment and outstanding efforts to SME Foundation fundraising. His enthusiasm, diligence and dedication in securing significant contributions have strengthened the success and vision of the SME Foundation.

Jess Kindler serves as Epiroc's president of parts services and supply chain. He is responsible globally for marketing, sales and delivery of all parts and service products to Epiroc's customers, as well as the full Epiroc supply chain to also include drilling tools, consumables and hydraulic attachments. Kindler is further commercially responsible for all Epiroc operations in India, Korea, Mongolia, Russia, Central Asia and Southeast Asia. Additionally, he is responsible as the executive sponsor of Epiroc's People and Leadership Council, Live Works Elimination Council, and the Service Council. Previous to this role, Kindler was the director and general manager for PT Atlas Copco Nusantara, Atlas Copco's subsidiary in Indonesia.

Kindler graduated in 1998 from the Colorado School of Mines with a degree in mining engineering, and in 2012 from the Wharton School of Business (University of Pennsylvania) with a MBA. He received the Outstanding Mining Engineer Graduate Award and the Colorado

Engineering Council's Silver Medal from Colorado School of Mines, and the Dean Patrick Harker Leadership award from the Wharton School.

Upon graduation from Mines, Kindler served as an officer in the U.S. Army Corps of Engineers. He is a graduate of the U.S. Army Airborne School and the U.S. Army Ranger School. He received both the Army Achievement medal and Army Commendation medal during his service. He left the Army as a captain in 2002 and joined Ingersoll-Rand Drilling Solutions in Garland, TX.

He has held various engineering, management and executive positions with Ingersoll-Rand, Vulcan Materials, Unocal-Molycorp (now Chevron Mining), Epiroc (Formerly Atlas Copco). Kindler and his family (six children) have lived and worked in New Mexico, Arizona, Alaska, Nevada, Colorado, Texas, Illinois and internationally in Jakarta, Indonesia and Stockholm, Sweden. ■



Jess Kindler

SME Foundation thanks its donors and sponsors

The SME Foundation is grateful for the support we received in 2021 from Corporate and Individual Donors. During 2021, \$952,491 was donated from corporate donors, individual donors, SME Divisions, SME Sections, memorial donations and legacy gifts. Without this support, the Foundation would be unable to provide the programs and services critical for the future of mining. Therefore, we want to thank the following donors for their generous contributions.

SME News Contents

- 49**
Fine Grind
- 51**
Rock in the Box
- 52**
SME Awards
- 69**
Minerals Education Coalition

Corporate Donors

Pinnacle
\$200,000+
Freeport-McMoRan

Caterpillar Inc.
Cementation USA Inc.
CONSOL Energy Inc.

Influencers
\$15,000–\$24,999
Mining & Metallurgical Society of America

Champions
\$100,000–\$199,000
Newmont Corporation

Patrons - \$25,000–\$49,999

Epiroc
Eriez Manufacturing Co.
J H Fletcher and Co.

Developers
\$10,000–\$14,999
Boart Longyear
Brooks & Nelson LLC
Southwest Energy LLC

Benefactors
\$50,000–\$99,000
Rio Tinto

JENNMAR
Kinross Gold USA Inc.
Komatsu
Vulcan Materials Co.

Prospectors
\$5,000–\$9,999
Martin Marietta Materials, Inc.

(continued on page 48)

SME recognizes new Legion of Honor and 25-year members

SME members from the class of 1972 have achieved Legion of Honor (50-year) status. Of those who joined SME in 1972, 52 have maintained their memberships for the past 50 years. Each 50-year member receives a certificate and a gold lapel pin. Upon membership renewal for 2021, the following persons will have been members of SME for 50 years.

Richard Ackermann, Elko, NV
Lawrence Allen, Aurora, CO
Michael Barber, Tucson, AZ
Richard Bolen, Morgantown, WV
John Buffa, Reno, NV
Ken Byrne, Globe, AZ
Jeffrey Clevenger, Alpine, AZ
Allen Cooper, Tucson, AZ
Marion Davenport, Whitehall, MT
John DeYoung, Herndon, VA
Russell Dittrich, Spring Creek, NV
W Kent Eden, Bluffdale, UT
Rodney Elvish, Ingleside, NSW, Australia
Joseph Giraud, Layton, UT
Benjamin Guenther, Reno, NV
Karl Gurr, Englewood, CO
James Gusek, Golden, CO
Douglas Hambley, Lakewood, CO

James Hanley, Lacey, WA
Warren Harrison, Centennial, CO
Timothy Hawkes, Helena, AL
Heinz Hendriks, North Potomac, MD
John Hill, Green Valley, AZ
James Hitt, Sandy, UT
Nils Johansen, Evansville, IN
George Johnson, Bellingham, WA
Romeo Jurani, Las Vegas, NV
Kurt Keskimaki, Kamloops, BC, Canada
Cyril Kinane, Sandy, UT
Thomas Kovach, Cranberry Township, PA
Ronald Lewis, Canonsburg, PA
Richard LiConti, Washington, PA
Leonel Lopez, Broomfield, CO
Victor Miller, Whitehall, MT
Lloyd Mullikin, Bayville, NJ

David Nelson, Golden, CO
Timothy O Connor, Excello, MO
Dave Osborne, Wellington Point, Qld, Australia
Orus Patterson, Sanford, NC
Mark Pitt, Duncraig, WAS, Australia
Carl Schmuck, Eau Claire, WI
Martin Schwenk, Grants, NM
David Scriven, Casper, WY
Michael Skopos, Orangevale, CA
William Strickland, Columbus, MT
Donald Sutton, Hamilton, MT
Michael Toelle, Colorado Springs, CO
Tom Tveten, Florence, KY
David Tyson, Riddle, OR
James Vician, Daytona Beach Shores, FL
Mark Whitney, Blaine, TN
Victor Wicks, East Liverpool, OH

The SME members listed below joined SME in 1997 and have maintained their memberships for 25 years. Upon membership renewal for 2022, the 112 members listed below will receive their 25-year certificates.

John Abbitt, Petoskey, MI
Albert Adu Acheampong, Centennial, CO
Michael Alter, Round Hill, VA
Dayan Anderson, Phoenix, AZ
Michael Anderson, Morgantown, WV
Tony Auld, Lead, SD
Christina Bakavelou, Phoenix, AZ
John Baker, Yreka, CA
Fanuel Banda, Buckeye, AZ
Michael Barish, Sewickley, PA
Richard Beauchamp, Denver, CO
Timothy Beck, Pittsburgh, PA
Matt Bender, Lakewood, CO
Jeffrey Best, Woodstock, VT
Matt Blattman, Coeur D Alene, ID
Michael Blois, Highlands Ranch, CO
Mark Bowling, Vail, AZ
Daniel Brost, Cochranville, PA
Bruce Brown, Madison, WI
Timothy Bruner, Mount Morris, PA
Michael Callahan, Empire, CO
Robert Cannon, Newnan, GA
Lyndon Clark, Yellowknife, NT, Canada
Robert Collins, Tucson, AZ
Wendi Cooksey, Midvale, UT
John Craynon, Morgantown, WV
Robert D Aiello, Bartow, FL
Richard DeLong, Reno, NV
Clayton Deutsch, Edmonton, AB, Canada
Justin Douthat, Bluefield, VA
Robert Dunne, Kalamunda, WAS, Australia

Donald Dwyer, Elko, NV
Christopher Easton, Highlands Ranch, CO
Abdalla Elias, Tulsa, OK
George Ferrell, South Charleston, WV
Tony Freiman, Phoenix, AZ
Patrick Garretson, Tucson, AZ
Diane Garrett, Kerrville, TX
Paul Gates, Lafayette, CO
Herbert Gibson, Andrews, NC
Kenneth Gray, Gillette, WY
Danny Hall, Lexington, KY
Juliette Hill, Wheeling, WV
William Hill, Wheeling, WV
David Hopperstead, Elko, NV
Andrew Hustrulid, Bonita Springs, FL
Harold Hutson, Riverton, WY
Paul Joggerst, Elko, NV
Kent Johnjack, Tucson, AZ
Matthew Juth, Ridgway, CO
Alfred Kendall, Stevenson Ranch, CA
Darin Klewsaat, Fort Smith, AR
Gilbert Knappmiller, Pahrump, NV
Adam Knight, Lovelock, NV
Wendell Koontz, Hotchkiss, CO
Gregory Kruse, Casper, WY
Brent Kuhn, Woodland Park, CO
Amy Lamb, Research, Vic, Australia
Herbert Ley, Spring Creek, NV
Jim Lindsay, Portland, OR
James Llorca, Point Cook, Vic, Australia
Lavern Lund, Plano, TX
Michael Maxson, Corpus Christi, TX

Charles Maxwell, Queen Creek, AZ
Lee Miller, Denver, CO
Thomas Mills, Verdi, NV
Stephen Morrow, Sparks, NV
Timothy Mosey, Evergreen, CO
Michael Muhr, Littleton, CO
Michael Nees, Castle Rock, CO
Mackenzie Nichols, Mandurah, WAS, Australia
Dorian Nicol, Nevada City, CA
Kenneth Norris, Bormujos, Sevilla, Spain
Mike ODriscoll, Fetcham, United Kingdom
Steven Osterberg, Post Falls, ID
Penny Padgett, New Harmony, IN
Jon Peterson, Green River, WY
David Proudfoot, Victoria, BC, Canada
Mark Ramirez, Evergreen, CO
Pedro Repetto, Lone Tree, CO
Kyle Rhoderick, Montrose, CO
Nathan Riddle, Point Of Rocks, WY
Nino Ripepi, Blacksburg, VA
G Todd Ririe, Chino Hills, CA
Michael Rispin, Park City, UT
Alex Ruzycski, Sparks, NV
Stuart Saich, Helensvale Town Centre, QLD, Australia
Rodney Saulters, Vail, AZ
Roger Sawyer, Park City, UT
Ron Schuring, Pella, IA
Stefanie Self, Pittsburgh, PA

(continued on page 69)

Friends (Corporate) - Up to \$5,000

(Continued from page 46)

AIPG Foundation Inc.
Amazon Smile
Backswing Golf Events, Inc.
Civil and Environmental
Consultants Inc.
Digital Insurance LLC

ETH Zuerich
Genesis Alkali LLC
Hendco Services
Integra Golf
Lehigh Hanson
Montana Society of Engineers

Open Loop Energy Inc.
Pioneer EqPray & Company
SAK Construction LLC
SME Foundation
SME Environmental Division
SME Pittsburgh Section

Individual Donors

Benefactors

\$50,000–\$99,999

R. Gene Dewey

Influencers

\$10,000–\$24,999

C. Dale & Kathy Elifrits

Bo Yu

Developers

\$5,000–\$9,999

Richard Hodgson

Ronald & Connie Parratt

Steve & Peggy Richards

George Sturgis Jr.

William & Pamela Wilkinson

Prospectors

\$1,000–\$4,999

Barbara Arnold

Armine Banfield Jr.

Gregory Beckstrom

Robert Benbow

James Boyd

Kenneth Brunk

Dennis Bryan

Frank Calandra Jr.

Brad Cofield

Andrew Cole

Harry Conger

Stanley Dempsey Sr.

Thomas Drielick

William Edgerton

Ellen Emerson

John Fenn

Frank & Barbara Filas

Robert Filler

Robert Freas

Matthew Furniss

J. Steven Gardner

Dean & Maria Gehring

Gary Goldberg

Brian Groff

Peter & Jenessa Haarala

Timothy Haddon

Donald Hall

Bill & Lucy Hancock

Marc Herpfer

Steve & Cindy Holmes

John & Jeane Hull

G.F. Joklik

Dave & Trish Kanagy

Michael Karmis

Jess Kindler

Mary Korpi

Kurt Kost

Robert Kudlawiec

Ihor Kunasz

Scott A. Lawson

Marc & Meg LeVier

George & Dee Luxbacher

John Mansanti

John & Dana Marsden

George Mealey

Drew & Dixie Meyer

Hugh Miller

Brij Moudgil

John & Cathy Murphy

Ryan Murray

Michael & Sherri Myers

Jill Nelson

Thomas & Peggy O'Neil

Joshua Olmsted

Tim & Gail O'Neil

Joshua Patterson

Orus Patterson III

Michael Patton

Neil & Cami Prenn

Raja & Geetha Ramani

Thomas Rauch

William Reid

Rosa Rojas Espinoza

Emily Rose

Robert & Patti Schafer

J. Eric Shereda

Lowell Shonk

Gary Skaggs

Donald Taylor

Nikhil & Nishita Trivedi

Todd Tuntland

Herbert Welhener

Richard Whiting

Anne Williamson

Partners

\$500–\$999

Terrell Ackerman

Robert Berglund

Michael Blois

George Burke

Joseph Driscoll

Brianna Drury

Michael Garska

Jerry Gauntt

Louis Hill

Paul & Elena Joggerst

Catherine Joyner

Edward McCarthy

James & Virginia McLemore

Michael Moats

Jerry Oliver

Jordan Oxborrow

Robert Snow

Tim Swendseid

Larry Todd

Jack Waldron

George Webber

Friends

\$100–\$499

Sam Arentz III

Tim and Liz Arnold

Lynn Barr

Wolfgang Baum

Richard Bedell

William Berridge

Shawn Boltz

Jack Bradford

William Brice

Darrel Buffington

Stuart Burgess

Kenneth Castleton Jr.

James Clark

Christopher Cooney

Jaak Daemen

Thomas DeGrio

Kathryn Dehn

Alfredo Del Campo

Steve Denton

Haskell Dickinson II

John Dreier

William Durning

Perry Durning

Donald Dwyer

Mark Emerson

George Erdman

Christopher Erskine

Thomas Ewing

Shawn Frye

Douglas Fuerstenau

James Gebhardt

Elizabeth Gibbs

Paul Glavinovich

Gerald Grandey

Thomas Gray

Stanley Hamilton

Jack Hamm

James Harvey

Keith Heasley

Corolla Hoag

Gustavus Hobbs

Glenn Hoffmeyer

Kentland Holcomb

Katie Hutton

William Imrie

David Janecky

Donald Jennings

Gary Johnson

Keith Jones

Paul Jones

L. Michael Kaas

Daniel Kappes

Ken Karably

Peter Kern

Stephen Kesler

John Kortas

Fleetwood Koutz

Kurt Kroner

James Kvitkovich

Larry Lackey

Scott Langley

Don Le Heup

Reed Lewis

John Lucas

Megan Martin

David Mathewson

David May

Robert Mayville

Michael McCarter

Terence McNulty

Warren Merritt

Jan Miller

Joanne Moody

David Morris

Tracy Morris

Dennis Murr

Alan Noble

Christopher Nyikos

Dan O'Connor

Terry Owen

Thomas Patton

Jerry Pfarr

John Rajala

Donald Ranta

Jay Reynolds

Timothy Richmond

Richard Rickard

Harold Rolseth

Robert Russell

Richard Saccany

Ralph Sacrison

Fred Sanders Jr.

Robert Scharp

Jeanine Schmidt

George Schuler

John Schwarzgruber

Stephen Schwochow

Thom Seal

Eric Seedorff

Charles Seedorff

Cory Smith

William Smith

Kenneth Snyder

Robert Steele

Julius Stieger

Member survey results; Mineral & Metallurgical Processing Division presents its findings

by Jaeheon Lee, MPD Executive Committee

The SME Mineral & Metallurgical Processing Division (MPD) conducted a member survey in December 2021 to find out how to improve engagement with members and provide better service. There were 175 participants on the survey. This article summarizes the survey results with the intention to provide feedback and opportunities for SME and MPD.

More than 40 percent of the participating members have been an SME member for more than 30 years, while more than 22 percent have been an SME member for less than 5 years. This shows that the division members are more experienced, which is good, but apparently getting old. On the bright side, we have many young members whom we can focus on to develop them into lifetime members. The U.S. West dominated the geological region of the members at 46 percent, and more than 78 percent of the members are located in the United States and its territories. Central and South American members account for about 14 percent, making the total over 92 percent in the American continent. Members in Europe, Africa and Asia have been overlooked for many years. It is not easy to get involved with folks on those continents, but mining/mineral operations in Africa and Asia particularly are getting more important, so opportunities are there to expand. More than 83 percent of members are male from the survey and MPD needs to focus more on recruiting diverse groups to support diversity and inclusion.

When asked about attending the MINEXCHANGE

SME Annual Conference & Expo, more than 53 percent of members replied that they sometimes (50 percent or less) attend the meeting. We're not attracting more than half of the members to our annual conference, which is somewhat surprising. In addition to attending the annual conference, the involvement of members at the national level is only 25 percent of the activities, while over 27 percent said they aren't involved at all with SME. We need to attract more members to the annual conference, and regional/local chapters also need to focus on engaging with members. More than 64 percent of members said cost and time commitment were too high for them to attend the conference or be involved in activities.

The survey results showed that the best value of SME/MPD membership is networking and *Mining Engineering* magazine. We all know the networking opportunities during the technical sessions, in the exhibit halls, and many other nontechnical occasions. Members are also anticipating *Mining Engineering* magazine in their mailboxes, which is a great thing as the magazine is not going into the trash without being read. Members also want to have other activities during the annual conference and occasionally, such as plant/field tours, technical webinars and smaller events in local chapters.

There were also suggestions to MPD leadership to open the doors to members to be involved and support

(continued on page 50)

Individual Donors

Debra Struhsacker
Stanley Suboleski
Genevieve Sutton
Laurie Tahija
Alan Temple
Kathleen Tew
Stewart Thomas
Edward Tomany
Michael Trevits
W. David Tyler
John Uhrle
John Van De Beuken
Carl Vender
David Wahl Jr.
Robert Washnock
Robert Weyher
Robert Weyher Jr.
Mark Whitney
Stephen Whittington
James Wickens
Jeffrey Wilson
William Wilson
William Wilson
Lyall Workman
John Young

Event Sponsors

In 2021 the SME Foundation

hosted events that were supported by businesses in the community. These events included the Annual Conference Gala, the Golf Tournament and Move Mining.

Ames Construction
Apache Nitrogen Products
Brahma Group
Black and Veatch
Cashman Equipment
Civil & Environmental Consultants
Eagle Mines Management
Empire Southwest
Exyn Technologies
First Majestic Silver Corp.
Flottec, LLC
Golder Associates
Hexagon
KGHM
Komatsu
Maxam Tire North America
Metso Outotec
One Digital
Open Loop Energy
Pray & Company

Proudfoot
Skyline Assayers & Laboratories
Solensa
Southwest Energy
Stantec
Sumitomo Drive Technologies
Sunwest Supply
USC Consulting Group
Wagner Equipment Company
Weir Minerals
Memorial Donors
Each year, families of those we lost remember their loved ones with gifts in their honor to the SME Foundation. We appreciate the families thinking of us in their time of sorrow and helping to support the future of mining in honor of their loved ones. In 2021, the following people remembered their loved ones with gifts in their name.
Gifts made in memory of
Robert K. Russell
Mary K. Russell

Tribute Donors

Occasionally, people make gifts to the Foundation in honor of an SME member that is important in their lives. These are made to recognize an achievement, a birthday, an anniversary, their long-term membership or just to thank them for all they do. In 2021, the Foundation received the following tribute gifts:

Gifts made in honor of Gordon Carlson

Robert & Lucinda Berglund
Gifts made in honor of George & Dee Luxbacher

Carrie Buss
A full list of donors including Friends; from \$100-\$499; Supporters; up to \$99.00 and In-kind donors are recognized on the SME Foundation website www.sme.foundation.org. If your gift was omitted from this list, please accept our apologies and contact us at sme.foundation@sme.net.

Fine Grind

(continued from page 49)

universities to get young people into the industry and research programs. There were also quite a number of suggestions regarding diversity and inclusion to the leadership.

For the future, students are willing to upgrade their student memberships to professional ones upon graduation because they believe that there will be job opportunities, technical challenges and continuous education in MPD/SME.

The MPD Executive Committee thanks all participants who spent their time on the survey. We received great feedback from the survey, showing that we've done a

good job but need improvement. We also had a few great suggestions that need immediate attention for the division and SME. We will gather all inputs and make the Mineral & Metallurgical Processing Division the best in SME to serve all members. ■

Fine Grind serves as a forum for the presentation and discussion of facts, ideas and opinions pertaining to the interests and technology of the Mineral & Metallurgical Processing Division. Accordingly, all material published herein is signed and reflects the individual views of the authors. It is not an official position of SME or the division. Comments by readers will be referred to the division for response. The division chair in 2021 is Garland Davis.

SME welcomes new members

Nancy Acosta-Jauregui, Ciudad de Mexico, DF Mexico
Farnaz Aghabeyk, Tehran, Iran, Islamic Republic of
Nilufer Akbulut, Tucson, AZ
Zulqarnain Ali, Lexington, KY
Alkhalil Aljahdhami, Reno, NV
Mohammed Al-Masrouri, Reno, NV
Ali Alshami, Tempe, AZ
Adewale Omotosho Amao, Freiberg, Germany
Ramiz Aminov, Tucson, AZ
Albert Einstein Amponsem, Rolla, MO
Ginette Anderson, Mason, MI
Edward Anokye, Rapid City, SD
Fatih Aranoglu, Golden, CO
Kevin Arias Quiñones, Lima, Peru
Aderemi Bamiduro, Ibadan, Nigeria
Mikeala Basso, Elko, NV
Kartik Battulwar, Reno, NV
Jose Pedro Beltran Vazquez, Durango, Dgo Mexico
Steven Benson, Grand Forks, ND
Guillermo Bermudez, Oakville, ON Canada
Emma Bishop, Elizabeth, CO
Nathan Blumberg, Madison, WI
Dicken Bonsrah, Elko, NV
Harley Bradbury, West Valley City, UT
Kali Braning, Salt Lake City, UT
Mason Brevig, Highlands Ranch, CO
Everett Brill, Kellogg, ID
Fredericus Brooymans, Katy, TX
Chad Brown, Greenville, SC
Tom Brown, Greenwood Village, CO
Greyson Buckingham, Casper, WY
Alex Bullinger, Arvada, CO
Matt Bullock, Fort Collins, CO
Alexander Burchill, Fort Collins, CO
Dillon Cadwell, Spring Creek, NV
Anthony Calk, Jefferson City, TN
Brett Carlson, Rapid City, SD
Shaun Carr, Gillette, WY
Eric Cavazza, Indiana, PA
Dianne Ceniza, Elko, NV

Connor Chard, Bath, United Kingdom
Alexa Chavez, Rio Rico, AZ
Jay Chenier, Sudbury, ON Canada
Robert Cimarolli, Pittsburgh, PA
Curtis Clarke, Georgetown, ON Canada
Zachary Cochran, Huntsville, MO
Jesse Colangelo, Houston, TX
Michael Colburn, Las Vegas, NV
Grant Colligan, Minneapolis, MN
Kevin Cooke, Murray, UT
Tyler Corby, Greenville, SC
Aaron Cox, Layton, UT
Luis Aarón Cruzado Mezarina, Lima, Peru
Swathi Dasari, West Lafayette, IN
Jan De Ville, Boulder, CO
Clive Desouza, Alpharetta, GA
Andrew Dewhurst, Tampa, FL
Ben Diddle, Wilmore, KY
Joshua Dierking, Sullivan, MO
Keith Dolence, Groveport, OH
Travis Doughty, Spring Creek, NV
David Draper, Rydal, GA
Lorenzo Dripps, St Charles, IL
Diana Eck, Elko, NV
Ethan Eisenhart, Golden, CO
Emily Erickson, Greenwood Village, CO
Braden Error, Greenwood Village, CO
Maurice Fagan, Parker, CO
Ian Fairweather, Bozeman, MT
Amelia Faust, Farmington Hills, MI
Nursultan Fazylgaliyev, Golden, CO
Alma Feldpausch, Seattle, WA
Robert Brayam Fernandez Astupian, Lima, Peru
John Fletcher, Rolla, MO
Elmer Flores, Reno, NV
Ariana Floyd-Reading, North Las Vegas, NV
Ryan Foy, Nampa, ID
Rio Franzman, Bozeman, MT
Lauren Fritz, Sturgis, SD
Christopher Gates, Knoxville, TN
Darsen Gaughan, Pocatello, ID
Ron Geiger, Phoenix, AZ
Eddie Geisel, Oro Valley, AZ

Brennan George, Blacksburg, VA
Jesse Gill, Kennett Square, PA
Gordan Gjerapic, Highlands Ranch, CO
William Godwin, Pacific Grove, CA
Jeffrey Gordon, Socorro, NM
Kelsey Graves, Flagstaff, AZ
Ajanthia Gunaratnam, Elko, NV
Dylan Haddix, Gillette, WY
Emily Hagenah, Coeur D Alene, ID
Evon Harmon, Greenwood Village, CO
Mitchell Harvey, Butte, MT
Ian Haukdal, Springfield, VA
Scott Hawke, Aurora, CO
Jeff Hawman, New Marske, United Kingdom
Changdi He, Salt Lake City, UT
Gavin Heiser, Rapid City, SD
John Helmick, Carmichaels, PA
Eric Hinton, Niverville, MB Canada
Arturo Hirata Miyasaki, Golden, CO
Kenneth Holland, Columbus, OH
Nefertari Hooker, Atwater, CA
Ellen Hoppe, Sacramento, CA
Jay Horton, Denver, CO
Da Huo, Kingston, ON Canada
Mustafa Igdelioglu, Minneapolis, MN
Craig Iman, Beaver, PA
Santiago Iriarte Aguirre, Golden, CO
Olya Irzak, Oakland, CA
Aaron Isabel, Denver, CO
Tanner Jacobs, Rapid City, SD
Rosbel Jimenez, Morgantown, WV
Kelly Johnson, Salt Lake City, UT
Saeede Kadivar, Reno, NV
Tahmid Kawsar, Reno, NV
Carson Kellar, Centennial, CO
Nathan Kelley, Providence, KY
Danis Khafizov, Yekaterinburg, Belarus
Noah King, Brandon, FL
Curtis Kline, Oakland, CA
Todd Knauss, South Jordan, UT
Aleisha Knochenhauer, Tampa, FL
Eric Kolb, Grand Forks, ND

(continued on page 51)

Meet the new chair of the M&E Division;

Greg Sutton assumes chair position of the Division

Greg Sutton is the incoming Chair of the M&E Division for the 2022–2023 year. He has spent the past several years working his way through the various roles of the M&E Executive Committee and will finish his commitment to the committee in 2024 after holding the Past Chair role.

Sutton grew up in a mining family and his father was one of the miners who successfully opened the Fletcher Mine during the late 1960s. He joined SME as a student at the Missouri University of Science and Technology where he earned his bachelor's degree in mining engineering in 1988. Upon graduation he headed to South Dakota to work at the Homestake Mine as a planning engineer and later as a mine supervisor. Early on in his career Sutton found it difficult to stay involved in SME. He understands the struggle of new graduates to stay involved and appreciates the efforts of the Young Leaders Committee in keeping younger members involved.

After several years at Homestake, Sutton returned to Missouri to work for the Doe Run Co., where he has spent the majority of his career. Starting out as a mine engineer, he moved to a general foreman position and eventually worked his way up to be the general mine manager. He also became actively involved in the Southeast Missouri section of SME and was the section chair when they later merged with the St. Louis section. He began presenting at the annual SME meetings while working for Doe Run and was even featured as a Henry Krumb lecturer.

After more than 20 years with Doe Run, Sutton moved to Cementation USA as a project manager and oversaw many exciting projects in Louisiana, New York, Tennessee and Iowa. He even had the opportunity to participate in a shaft audit at the Grasberg Mine in Indonesia. He also became further involved with the M&E Division, serving as a program area manager twice, then joining the executive committee. During this time, he also earned his MBA from

Missouri S&T.

These days Sutton lives in Missouri with his wife Genevieve, an engineer who is also highly active in SME. The mining tradition has continued in his family; his son is a mining engineer and currently works in Louisiana as a mine supervisor. When work-related travel slowed down due to the pandemic, Sutton was able to enjoy more time at home and got reacquainted with his cows. He is now working at his dream job as the general manager of mining operations for Missouri Cobalt. Having the opportunity to build a new mine near his own backyard in an historic mining district is the most exciting project he has worked on to date.

Looking back over his career, Sutton said that the technology of mobile mining equipment is the most impressive advance he has seen in the industry. Things like more efficient engines, DPM reductions, operator cabs and improved ergonomics have dramatically improved safety and reduced long-term health effects on miners. He is very proud of the safety improvements he has been able to implement throughout his career. Sutton is also excited to get involved in other SME committees in the future and to continue supporting the annual technical programming. To interact with Sutton and the other members of the M&E Executive Committee, watch for announcements about the M&E virtual coffee break meetings throughout the year.

Rock In the Box serves as a forum for the presentation and discussion of facts, ideas and opinions pertaining to the interests and technology of the Mining & Exploration Division. Accordingly, all material published herein is signed and reflects the individual view of the authors. It is not an official position of SME or the division. Comments by readers will be referred to that division for response. The division chair in 2022 is Gary Sutton.

New Members

(continued from page 50)

Nolan Konen, Whitehall, MT
Paul Arvid Korpi, Provo, UT
Nikolett Kovacs, Whitehorse, YT Canada
Christopher Lam, Bothell, WA
Biraj Lama, Tucson, AZ
Pierre Landry, Victoria, BC Canada
Luis Larota Machacca, Rapid City, SD
Chris Lazear, Rapid City, SD
Patrice Lee, Baltimore, MD
Rachel Lindeman, Palestine, TX
Barret Loehden, Reno, NV
Simon Lotero Lopez, Socorro, NM
Peyton Low, Prescott Valley, AZ
Robert Luecke, Littleton, CO
Wade Lyles, Ashton, IL
Eurico Madureira, Socorro, NM
Brandi Maher, Grand Junction, CO

Daniel Manqueros Vargas, Durango, Dgo Mexico
William McKay Marshall, Pocatello, ID
Lauren Martin, Marietta, GA
Ever Martinez, Palm City, FL
Ana Santa Masie Masie, Tucson, AZ
Hunter Mattocks, Tucson, AZ
Michael McBride, Northbridge, MA
Evan McCorkle, Jefferson City, MO
Daniel McCormick, Winnemucca, NV
Muhammad Mehdi, Millcreek, UT
Hector Javier Mezquita Castillo, Hermosillo, Son Mexico
Lawrence Monson, Littleton, CO
Luis Sebastian Montesdeoca Portilla, Quito, Ecuador
Michael Morales, Mesa, AZ
Anne Morse, Denver, CO

Edmund Mushie Mould, Clausthal-Zellerfeld, Germany
Seyedkamal Mousavinezhad, Reno, NV
Chris Mueller, Concord, ON Canada
Alejandro Murgueitio, Nazareth, PA
Austin Murphy, Helena, MT
Ana Murrieta, Tucson, AZ
Chris Nelson, Spring Creek, NV
John Newcomb, Grand Forks, ND
Ashley Newman, Golden, CO
Frank Noland, Reno, NV
Andrey Obozhin, Sankt-Peterburg, Russian Federation
Jeremy Okolisan, Burlington, ON Canada
Meredith Olaya-Ramos, Newport News, VA
Douglas Oliver, Salt Lake City, UT
Haydee Olvera Prado, Snow Lake, MB

(continued on page 47)

SME, SME Foundation and AIME will present awards in 2022

SME, the SME Foundation and AIME will present the following awards during the MINEXCHANGE 2022 SME Annual Conference & Expo on Wednesday, March 2. The 2022 Class of SME Fellows, AIME Honorary Members and SME division award winners are recognized here.

SME Presidential Citations

JAMES R. WICKENS

SME recognizes Jim Wickens for his effort at spearheading the formation of the Nevada Mineral & Processing Division (MPD) Subsection and the creation of the Nevada MPD Annual Conference. We acknowledge Jim's unwavering enthusiasm and dedication to promote the art and science of mineral processing within the community of Nevada-based and other regional operators, leaving a legacy for future generations of mineral processors.



JAMES WICKENS

Wickens grew up in southeastern British Columbia where mining and forestry fueled the economy. Despite that, he never went to the University of British Columbia thinking he'd become a mining and mineral process engineer. He thought he was going to design cars. Well, the dream of designing cars lost out to the practical pull of mining...a guaranteed job, summer jobs, scholarship monies...and beer. The mining students had a beer machine in their common room. Yup, Wickens' kind of people.

After graduation, Wickens entered the consulting industry as a junior metallurgist. He went on to join Placer Development as an operating metallurgist a few years later and enjoyed several station-stops including mines in Canada and the United States. He jumped ship to Barrick to gain roaster and dry grind experience and then ended up in South Carolina on the Haile Gold Mine project. Since then, Wickens has had the great opportunity to work with Weir Minerals, McClelland Labs in Reno, Nevada, Titan Mining Corp., and is currently consulting as a partner with Woods Process Services.

ROBERT J.F. GOODFELLOW

SME recognizes Bob Goodfellow for his drive and vision to advance fifteen working groups under the banner of the Underground Construction Association, a division of SME (UCA). These groups have provided engagement opportunities for nearly 100 members and align with the International Tunneling Associations' efforts to move the tunneling industry forward.

Robert Goodfellow is the president of Aldea Services Inc. He is a licensed professional engineer in the United States and Canada. Goodfellow has more than 30 years of experience in the tunneling industry and he currently serves as past chair of the UCA Division of SME.

Goodfellow has project experience on five continents and is an industry expert in risk management for underground projects. He is co-author of the U.S. tunnel industry guidelines for risk management (GIRM) on tunnel projects. Goodfellow was the editor of a book on the use of concrete in underground construction and has authored multiple papers on a range of tunneling subjects. He writes a regular op-ed column as "The Insider" for North American Tunneling Journal.



ROBERT GOODFELLOW

PENNSYLVANIA ANTHRACITE SECTION

SME recognizes the Pennsylvania Anthracite Section of SME for its efforts to organize and execute the celebration of AIME's 150th Anniversary in Wilkes-Barre, PA on May 16, 2021. "We thank the Section for its commitment and recognition of this monumental achievement; its efforts to engage the general public, the political leaders of Pennsylvania and the AIME leadership in observance of this important day in the history of SME as well as its ongoing legacy to preserve the history of the mining, metallurgy and petroleum communities."

SME Awards

ROBERT M. DREYER AWARD TO JEFFREY A. PONTIUS

The Robert M. Dreyer Award is presented to Jeffrey A. Pontius, "In recognition of a career of successful mineral exploration and exceptional leadership, with special note for leading discoveries at Cripple Creek, Colorado; Livengood, Alaska and Bullfrog-Mother Lode, Nevada."

Jeff Pontius has worked in the mining industry

for more than 40 years and has led the discovery and development work on five North American gold deposits which include, the world class discoveries at Cripple



JEFFREY PONTIUS

Creek in Colorado, Livengood in Alaska and the new emerging Bullfrog gold district in Nevada. These discoveries now total more than 40 million ounces of gold. He has held senior management positions with a number of major mining companies over his career, although his true passion began in 2006 when he formed his first junior mining company, an area where he has excelled to this day. In 2011 he was awarded the Colin Spence award for

Excellence in Global Mineral Exploration. He holds a master of science degree from the University of Idaho, School of Mines, in economic geology, a B.Sc. from Huxley College in environmental science and a B.Sc. from Western Washington University in geology.

ROBERT E. MURRAY INNOVATION AWARD TO STRATALIS CONSULTING

The Robert E. Murray Innovation Award is presented to, “Stratalis Consulting’s Techno-Economic Modeling approach that allows mines to model the effects of



technology suites resulting in smarter, sustainable investments with broad environmental and

social impacts.” George Hemingway serves as managing partner and head of the Innovation Practice at Stratalis, a growth strategy and innovation consultancy, where he advises heads of companies, organizations and countries on the future and how to conquer uncertainty. Through his work, he has collaborated with the leading global mining companies to set their future visions and reimagine what is possible from industrial and mining companies.

Hemingway is considered one of the leading futurists in the mining industry, having delivered more than 100 keynotes on uncertainty, innovation and the future at venues ranging from the World Mining Congress to S&P Global, from NASA to the Pentagon, and at leading universities and organizations worldwide. His work in techno-economic and futures modeling for mining has won awards for innovation in 2019 and 2020, and he has been named a top-10 leader in mining technology. He is a published author and a monthly columnist on the future of industry and disruption.

Hemingway serves on several corporate and philanthropic boards, including Budapest Honvéd FC, a

top-flight European soccer club, Moon Mark Aerospace and the Chamber Orchestra of New York, and is on the advisory board to the Lassonde Institute at the University of Toronto. He holds an MBA from Columbia Business School and a B.S. from the Stern School of Business at NYU.

OUTSTANDING STUDENT CHAPTER AWARD TO THE NATIONAL AUTONOMOUS UNIVERSITY OF MEXICO

The SME National Autonomous University of Mexico is recognized for its outstanding efforts in planning and successfully implementing numerous activities throughout the year focused on industry engagement, fundraising, recruitment and community outreach. The SME Student Chapter at the National Autonomous University of Mexico aims to gather mining-related majors’ alumni with the fundamental purpose of promoting the industry’s best practices and values while pursuing the advancement of the technical capabilities of the academic community.

Through its active involvement in SME’s activities, UNAM’s student chapter seeks to form a new generation of engineers who, besides their technical competencies, are innovation-driven, accountable, and highly aware of the industry’s responsibility to the environment and the communities in which it operates.

The student chapter members find it imperative to contribute with fellow student chapters and universities worldwide. We think our global industry requires the collaboration of its future professionals to solve the problems that challenge the mining sector.

Thus, the SME student chapter aspires to become a seedbed of future mining leaders and innovators to serve humanity’s mineral needs for its wellbeing.



SME Foundation Awards

C. DALE AND KATHLEEN B. ELIFRITS MEC LEADERSHIP AWARD TO JULIE MARINUCCI

The MEC Leadership Award is presented to Julie Marinucci, “In recognition of a career dedicated to passionately advocating for responsible mining and mineral development through strong educational outreach.”



JULIE MARINUCCI

Julie Marinucci is a Michigan Tech mining engineering graduate who has dedicated her career to serving the iron mining industry and the people of northeastern Minnesota. Her family has called Minnesota's Iron Range home for many generations and it is where she resides with her husband and two daughters. In March of 2018, Marinucci made the move to St. Louis County and currently serves as the land commissioner

and director of Lands & Minerals with a focus on maximizing the potential in the 900,000+ tax forfeited parcels St. Louis County manages. Previously, she spent time with Caterpillar, Cleveland Cliffs and SEH with a focus in mine operations, engineering, project management and stakeholder engagement and can now include land and timber management to the list. Working with MN Section/Subsections, she has enjoyed the opportunity to engage with our communities and schools. She has a passion for the mining industry and the love to share it with anyone who will listen.

MEC PARTNERSHIP APPRECIATION AWARD TO THE PITTSBURGH COAL MINING INSTITUTE

The MEC Partnership Appreciation Award is presented to the the Pittsburgh Coal Mining Institute of America (PCMIA), "In recognition of PCMIA's efforts with teachers, students, and public outreach to increase the awareness of mining and minerals."

PCMIA was formed in 1976 as a result of the merger of the Pittsburgh Coal Mining Institute and the Coal Mining Institute of America. Its objective is to encourage education and the growth of knowledge relating to coal mining including providing scholarships, to advance study and research into mining methods and problems, to promote safety and efficiency in the coal mining industry, to encourage closer cooperation between the coal industry and state and federal government agencies, to disseminate information relating to the coal mining industry, and to otherwise advance the mutual interests of the members of this association.

MEC STUDENT CHAPTER AWARD TO THE NORWOOD STUDENT CHAPTER, UNIVERSITY OF KENTUCKY

The MEC Student Chapter Award is presented to the University of Kentucky, "For developing a digital brand that will enable expansion of educational outreach, as well as promoting community engagement through

a sustainable waste personal electronics recycling program."

SYD S. AND FELICIA F. PENG AWARD TO ROB THOMAS

The Syd S. and Felicia F. Peng Ground Control in Mining Award is presented to Rob Thomas, "For his practical, understandable solutions developed and implemented for complex ground control solutions."

A fourth-generation coal miner from South Wales, United Kingdom (UK), Thomas graduated with a degree in geology from Liverpool University in 1985 and a Ph.D. in coal mine geomechanics from Nottingham University in 1991. During and following his Ph.D., he worked in the Rock Mechanics group in British Coal



ROB THOMAS

and with the ongoing downsizing of the coal industry in the UK, decided to emigrate with his family to Australia in late 1993. After three years working for various consulting and research groups, he formed his own consulting company, Strata Engineering in 1996. Strata Engineering focused on the application of practical empirical engineering tools and mine site support and by 2012 had grown to 30 personnel with consulting activities located in Australia, the UK, South Africa, the United States, Canada, New Zealand, Norway, Turkey and the Czech Republic. In 2012, Strata Engineering was sold to Golder Associates and Thomas moved into the role of underground coal practice leader. In 2018 he and a previous business partner, David Hill, effectively put the "band back together" and formed Strata2. Again, specializing in the field of coal mine geomechanics, Strata2 continues on from where Strata Engineering left off.

MINERS GIVE BACK AWARD TO SME PITTSBURGH SECTION

The SME Foundation Miners Give Back Award is presented to the SME Pittsburgh Section, "In recognition of the Pittsburgh Section's leadership and contributions to Phase 1 of the Remediation of the Westmoreland Coal Co.'s Abandoned South No. 2 Mine Portal Area. The project will provide an outlet to communicate the historical importance of mining in the Export, PA region."

SME Fellows and AIME Honorary Members

The SME Fellow (previously Distinguished Member) class of membership was established by SME to honor those members who achieve distinction deemed worthy of special recognition. It acknowledges members who have attained eminence in industry or the academic world or who have made significant and sustained contributions to SME.

WILLIAM W. EDGERTON

William W. "Bill" Edgerton, P.E. is a principal with the firm of McMillen Jacobs Associates, headquartered in San Francisco, California. From 1999 through 2011 he served as President, directing strategic planning, business development and administration, while acting as the principal-in-charge and working in a technical capacity on various underground projects. From 2009 through 2016 he served as the manager of Tunneling for D.C. Water's \$2.6 billion Clean Rivers Project in Washington, D.C. and from 2017 through early 2019 he was the construction manager for



WILLIAM EDGERTON

Metro's construction management consultant on the \$1.4 billion Purple Line Extension, Segment 2, design-build subway tunnel in Los Angeles.

From 2013 through 2015 he served as the chair of the Executive Committee for the Underground Construction Association, a division of SME; and was on the SME board from 2015 to 2018. For the past 17 years he has served as an ASCE program evaluator for civil and construction engineering programs on behalf of the Accreditation Board for Engineering and Technology (ABET). He previously served on the board of directors of the Dispute Resolution Board Foundation. In 2002 he was recognized by the AUA as the Outstanding Individual in the Underground Industry at the North American Tunneling Conference.

In 2008, he edited *Recommended Contract Practices* for Underground Construction as published by SME, and has authored numerous technical articles on procurement practices. In 2010 he received the Outstanding Achievement Award from Tufts University, and in 2012 received the Golden Beaver Award for Engineering. He is a member of the Moles, and in 2015 he was inducted into the National Academy of Construction. He holds a B.S. in civil engineering from Tufts University, an MBA in procurement and contracting from George Washington University, and holds P.E. licenses in seven states.

VLADISLAV KECOJEVIC

Vlad Kecojevic is the Robert E. Murray Chair and Professor of Mining Engineering at West Virginia University (WVU). He was 2015 program chair of the Society for Mining, Metallurgy, & Exploration (SME) and 2013 chair of the SME Coal and Energy (C&E) Division. He also served as the chair of the SME

Distinguished Member Award Committee; the C&E Division Distinguished Service Award Committee; the SME Mineral Economics Award Committee; program chair for the C&E Division; the SME Stefanko Best Paper Award Committee; and the SME Robert E. Murray Innovation Scholarship Committee. He was also a member of several SME strategic committees. He served as the 2020-2021 president of West Virginia Coal Mining Institute and he is currently on the board of directors of the SME Pittsburgh Section. He serves as the secretary-general of the Society of Mining Professors/Societät der Bergbaukunde (SOMP), and he was 2015–2016 SOMP president.



**VLADISLAV
KECOJEVIC**

THOMAS PEYTON

Tom Peyton has been working in the underground construction industry for the past 50 years; the first 25 working for contractors and the last 25 working as a construction manager on a variety of projects.

Peyton has a BSCE from Columbia University, an MBA from Pace University, and is a registered professional engineer in five states.

He has been a member of the Moles for over 35 years and has served as a trustee of that organization. He is a past president of the American Underground Association (AUA), was the first chair of the Underground Construction Association of SME, and has served on the board of directors of SME.

While a contractor, he has worked on sewers in Staten Island, NY and Dedham, MA, the 3rd water tunnel in New York City as well as its subways, and also in Boston, MA and Washington, D.C. He also worked on a hydro-electric project in the Himalayan Mountains of India.

As a CM Tom has been involved in the MetroWest Water Supply Tunnel for MWRA, was the director of construction for Phase 1 of the Second Avenue Subway (2007 to 2017) and has participated in constructability reviews for major projects like East Side Access, Gateway, The Hudson River Tunnels, BSV II, The Great Lakes Tunnel and California Highspeed Rail.



THOMAS PEYTON

SA RAVISHANKAR

SA Ravishankar has 32 years of experience in minerals and connected industries as a global research and development leader. He earned a doctorate from Virginia Tech in material science and engineering and a master's degree in metallurgical engineering and chemistry. He has diverse experience in technologies for clays, phosphate, heavy minerals, gypsum, talc, carbonate, iron ore and rare earths. His expertise on energy efficiency, economic processing and the enhancement of physical separation received the Robert Richards and Frank Aplan awards for his seminal contribution. Ravishankar also received awards for innovation at Cytec industries including the highest circle of excellence award. Ravishankar has authored over 30 publications and has earned 15 patents. He has served SME as a chair of the Industrial Minerals and Aggregates Division in 2012 and as a member of the Structure and Governance Strategic Committee, 2013–2016. He currently serves the American Institute of Mining, Metallurgical, and Petroleum Engineers as a Hoover medal board member. He currently works at Saint-Gobain in the high performance solutions group.



SA RAVINSHANKAR

KENNETH J. REID

After earning his Ph.D. in chemical engineering from Cambridge England and a postdoc from the University of California, Berkeley, Reid joined the comminution group in the chemical engineering division of CSIRO, Australia and began his lifelong career in mineral engineering. He was an associate professor at McGill University, Canada before moving to Zambia as a senior project engineer on the world's largest copper SX plant and later, worked as head of IPAC Services, the first industry-wide technical services department in Zambia. In 1977 he was recruited by the University of Minnesota as professor of mineral engineering and director of MRRC. In 1984 he was named chair of the National Association of Mineral Institute Directors and was the opening plenary address speaker at the MINTEK, South Africa, 50th anniversary international conference. In retirement, as an SME TC director, he developed materials for SME outreach. He received the president's 2014 citation award and the Minerals Education Coalition leadership award in 2015.



KENNETH REID

AIME Honorary Members

MARY KORPI

A graduate of Michigan Technological University in Houghton, MI with a degree in chemical engineering, Mary Korpi began working for Newmont Mining Corp. in 1976 at Magma Copper Co. in San Manuel, AZ. She held various positions in the metallurgical services department including shift supervisor, quality control analyst, metallurgist and senior metallurgist of customer relations. She transferred to Newmont's Nevada operations in 1987 and served in a variety of capacities including director of metallurgical services, director of loss control, leach and mill superintendent, and in the final years of her career, as director of external relations and communications for North America. In this role she oversaw Newmont's North American regional activities in issues management, local



MARY KORPI

government, media management, community relations and development, external communications and minerals education. Korpi retired from Newmont in January 2016 after almost four decades in the mining industry.

Korpi has continued her involvement and support of the industry through volunteer boards and commissions. She served as the SME Foundation 2019–2021 president where she led the Foundation in its mission to be the source of funding for education and outreach to SME and the community it serves. Former Nevada Gov. Brian Sandoval appointed her to the State of Nevada's Commission on Mineral Resources in 2017 and in 2021, Nevada Gov. Steve Sisolak reappointed her to another four-year term. The commission reports to the Gov. of Nevada, the Mining Oversight and Accountability Commission, and the Nevada Legislature on all matters deemed pertinent to the Division of Mineral Resources and adopts regulations necessary for carrying out the duties of the commission. She represents the public at large and currently serves as vice chair.

Korpi was recognized in 2016 as the Distinguished Nevadan for her profound and lasting impact on the lives of all Nevadans. She has been inducted into Michigan

Technological University's Presidential Council of Alumnae and the Nevada Women's Fund Women of Achievement. Korpi has served in leadership roles on numerous nonprofit and community-based organizations in Northeastern Nevada such as the Northeastern Nevada Economic Development Authority, Elko Area Chamber

of Commerce, and Northeastern Nevada Regional Hospital. Besides SME, she is a member of several professional organizations including the Mining and Metallurgical Society of America, the Women's Mining Coalition, Geological Society of Nevada and the American Association of University Women.

AIME Awards

WILLIAM L. SAUNDERS GOLD MEDAL AWARD TO JOSEPH DICK

The William L. Saunders Gold Medal Award is presented to Joseph Dick, "For significant contributions to the mining industry including safe, productive operations and mentoring future industry leaders."



JOSEPH DICK

Joseph Dick joined Eldorado in December 2019 in the role of executive vice president and chief operating officer. Prior to joining Eldorado, Dick was senior vice president, Latin American Operations at Goldcorp, where he was responsible for four operating units producing more than 800,000 oz annually. Prior to Goldcorp, he held progressively senior roles for Barrick Gold Corp., including general manager for the Pueblo Viejo Mine in the

Dominican Republic during its transition from construction to operations and general manager of the Cortez District during the Cortez Hills expansion. He also held management roles with Rio Tinto in Utah and Alaska. He has more than 35 years of mining experience including executive, safe operations, projects, engineering and production support roles in gold, silver and base metals operations. He holds a B.S. in mining engineering from the Montana Technical University.

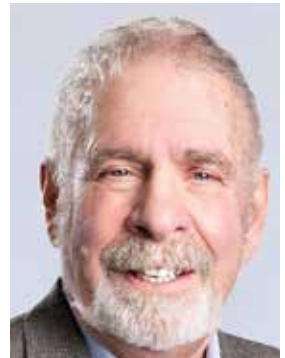
CHARLES F. RAND MEMORIAL GOLD MEDAL TO NEIL B. PRENN

The Charles F. Rand Memorial Gold Medal is presented to Neil B. Prenn, "A mining innovator that has advanced hundreds of mining properties throughout his career."

Prenn received an engineer of mines degree from the Colorado School of Mines in January 1967 and went to work for Cyprus Mines Corp. at its main office in Los Angeles, CA. During the summers of 1970, 1971 and 1972, he was sent to Challis, ID to work on the development of the Thompson Creek project.

After seven years in Los Angeles, Prenn was transferred to the Cyprus Pima Mine, where he held a number of different positions, going between the engineering department and the mine operating department. It was

a great time to be at the mine. In a period of three years, the mine went through two sizable expansions. In 1978 the mine shut down due to copper oversupply, which led to low copper prices. Prenn was then chief engineer and asked to complete a feasibility study for the Thompson Creek project. After completing the study, he was transferred to Cyprus Uranium and worked on an openpit uranium project near Canon City, CO.



NEIL PRENN

In 1981, Prenn was sent to help with the startup of the Northumberland gold project, near Kingston, NV. He was the acting mine superintendent and offered the position of manager of the project. It was a 220-mile round trip from their trailer to the closest grocery store in Fallon, Nevada. In 1984, he accepted the position of mine manager for the Zaca project for California Silver, located near Markleeville, CA. All permits to mine the property were received by 1986, but low gold prices shut down the project.

Prenn decided to give consulting a try and started Mine Development Associates in the offices of Kappes, Cassiday and Associates. The Prenn's moved to Reno, NV in 1989 and their business continued to grow. Most of the employees had been with the company for some time when it was sold to the principal employees in 2016. The employees resold the company in 2019 to a South Dakota consulting firm, RESPEC.

DANIEL C. JACKLING AWARD TO KEITH G. WALLACE JR.

The Daniel C. Jackling Award is presented to Keith G. Wallace, Jr., "For constant achievement in the advancement of practical mine ventilation and the elevation of health and safety in the mining community."

Wallace's career started in 1983 when he and Dr. Malcolm McPherson formed Mine Ventilation Services (MVS), Inc. He has been a consultant in mine ventilation engineering for coal, nonmetal and metal mines, as well as civil tunnel projects and nuclear waste facilities. In 2016 MVS merged with SRK Consulting (U.S.), Inc. He is presently a corporate consultant for SRK. He was awarded



KEITH WALLACE

the 2012 Howard Hartman Award for outstanding service in the field of mine ventilation engineering. He has been a member of SME since 1982 and a member of the underground ventilation committee of SME since 1988. He has authored more than 35 papers on mine ventilation and was the editor of the 12th U.S. Mine Ventilation Symposium held in Reno, Nevada. He has given keynote addresses at the 11th

International Mine Ventilation Congress in Xi'an, China, the 17th North American Mine Ventilation Symposium held in Montreal, Quebec, Canada and the 2019 annual joint meeting of SME/Pittsburgh Coal Mining Institute of America. He holds bachelor's and master's degrees from the University of California, Berkeley.

ENVIRONMENTAL DIVISION STEWARDSHIP DISTINGUISHED SERVICE AWARD TO KIMBERLY F. MORRISON

The Environmental Division Stewardship Distinguished Service Award is presented to Kimberly F. Morrison, "In recognition of the many contributions, knowledge and service to the ideals and purposes of the Society."

Kimberly Morrison is senior director, Global Tailings Management, at the corporate headquarters of Newmont Corp., where she is responsible for functional oversight of tailings and dams at Newmont's global operations. This includes review and development of standards and guidelines, overseeing governance programs, providing peer reviews and overseeing training and development programs.



KIMBERLY MORRISON

She serves as the founding chair of SME's Tailings & Mine Waste Committee, editor of SME's *Tailings Management Handbook: A Lifecycle Approach* (to be published in early 2022) and is a member of SME's Responsible Mining & Underground Construction Strategic Committee. She is also an active member of the International Council on Mining & Metals tailings working group, serves on the advisory board for the Tailings and Industrial Waste Engineering Center, and on the advisory board for EduMine.

Morrison was named to the 2020 edition of the 100 Global Inspirational Women in Mining (WIM100) and in 2021 received the SME president's citation for individual service.

ERSKINE RAMSAY MEDAL TO MADAN M. SINGH

The Erskine Ramsay Medal is presented to Madan M. Singh, "For the tremendous contributions to the health, safety and productivity performance of coal mines in the diverse areas of subsidence, ground control, ventilation and tunneling."

Dr. Singh was a pioneer in the fields of mine subsidence and high-pressure water-jet coal breakage and developed criteria for mining underwater. His ventilation research encompassed the use of foam for dust control in longwall shearers. At SME, Singh was presented with the Eavenson and Rock Mechanics Awards, and inducted as a distinguished member in the Legion of Honor.

He served as director of the Society and as chair of the Coal and Energy Division, on the Underground Ventilation Committee, the Chicago and Maricopa Sections, and was conferred the Herbert Hoover Award by the Washington, D.C. chapter. He chaired two American Institute of Mining, Metallurgical, and Petroleum Engineers committees and served on the Washington awards committee. For the National Academies he served on the rock mechanics and tunneling technology committees and participated in three reports. At Penn State he was bestowed the Robert Stefanko Distinguished Achievement Award and designated a centennial fellow. He is a distinguished alumnus of IIT (ISM), Dhanbad.



MADAN M. SINGH

FRANK F. APLAN AWARD TO HSIN-HSIUNG HUANG

The Frank F. Aplan Award is presented to Hsin-Hsiung Huang, "For his labor of love to StabCal and his tireless devotion to the mining industry as well as students and research."

Dr. Huang taught in the metallurgical and materials engineering department at Montana Tech for 40 years. He remains active as professor emeritus. His career in chemical metallurgy dates back to when he was a freshman in Taiwan. He and his advisor, Dr. Bob Bartlett, at Stanford University, received the Extractive Metallurgy Award from AIME. He is also a proud recipient of a Lifetime Distinguished Research Award from Montana Tech. Huang



HSIN-HSIUNG HUANG

spent most of his academic career at Montana Tech doing process analysis and modeling. He is the author of StabCal, a software package that is used to perform thermodynamic calculations and process simulations. The program can be used for applications in pyrometallurgy, hydrometallurgy, geochemistry, water chemistry, water treatment, environmental engineering and many other disciplines.

HAL WILLIAMS HARDINGE AWARD TO BOWEN LI

The Hal Williams Hardinge Award is presented to Bowen Li, "For outstanding contributions to the advancement of applied materials sciences in the field of industrial minerals and ceramics."

Bowen Li is a research professor in the Department of Materials Science and Engineering and Institute of Materials Processing at Michigan Technological University. His research interests include applied mineralogy, porous materials,

antimicrobial surface treatment, materials characterization and analysis, metals extraction and solid waste reuse. He has published more than 140 technical papers, authored/co-authored three books, edited/co-edited 14 books, and holds 16 patents.

Li received a Ph.D. in mineralogy and petrology from China University of Geosciences Beijing in 1998, and a Ph.D. in materials science and engineering from Michigan Technological University in 2008. He has been an active member of The Minerals, Metals & Materials

Society (TMS), the Society for Mining, Metallurgy & Exploration (SME), and the China Ceramic Society.

HOWARD N. EAVENSON AWARD TO MICHAEL A. TREVITS

The Howard N. Eavenson Award is presented to Michael A. Trevits, "For distinguished contributions to the advancement of the coal industry through mine health and safety research."

Michael A. Trevits, professional geologist, has been working in the mining industry for more than 48 years and is currently the president of Xtraction Science and Technology, Inc., MBBB Innovations LLC and is a founding member and president of the Rebuilding Their Future Foundation, Inc. Drawing upon his wide and varied career experience in the extractive energy industries, he provides national and international consulting services. His ongoing research work is dedicated to addressing difficult postevent mine rescue and response issues. Trevits left government research as a senior research scientist in early 2014 after more than 39 years of service (U.S. Bureau of Mines, Department of Energy and the National Institute for Occupational Safety & Health). Trevits

has been active in SME serving as a three-time chair of the Pittsburgh Section and on numerous SME national committees. He has served on the SME board of directors, as the chair of the Coal and Energy Division, as a founding member and president of OneMine.org, on the SME Foundation as secretary/treasurer and as a trustee. Trevits is a recognized distinguished fellow of SME and the Pittsburgh Section. He holds an undergraduate degree in geology and an MBA from the University of Pittsburgh. He is a registered professional geologist in North Carolina.



MICHAEL TREVITS

JAMES DOUGLAS GOLD MEDAL AWARD TO DEEPAK MALHOTRA

The James Douglas Gold Medal Award is presented to Deepak Malhotra "For a lifetime of dedication to the industry."

Deepak Malhotra, earned a B.S. in metallurgical engineering in 1970 from I.I.T, Kanpur, India, an M.S. in metallurgical engineering (1974), and a Ph.D. in mineral economics (1978) from Colorado School of Mines.

He worked for AMAX Inc. in various positions from 1973 to 1990. Malhotra started Resource Development Inc. (RDi), a testing and consulting company, in 1990. He has five decades of experience providing consulting services in process design, process development, plant auditing, project management and capital and opening cost estimates.

He has been active since 1973 and is currently a registered member of SME. He has authored more than 80 technical papers and written/edited several books. He is on the board of directors for several mining companies.



DEEPAK MALHOTRA

MINERAL ECONOMICS AWARD TO THOMAS W. CAMM

The Mineral Economics Award is presented to Thomas W. Camm, "In recognition of the outstanding contributions of Thomas Camm in the advancement of applied mining economics and his devotion to educating students in these disciplines."

Thomas W. Camm is the Freeport-McMoRan professor of mining engineering at Montana Technological University. He is a frequent session chair and presenter at national meetings; specializing in leadership and economic issues for engineers.

Recent scholarship while on sabbatical included



THOMAS CAMM

completion of two publications. The first, developing a new set of cost models (coauthor Scott Stebbins) resulted in the publication “Simplified cost models for underground mine evaluation: A handbook for quick prefeasibility cost estimates.” The second was the peer-reviewed article The dark side of servant-leadership, published in *The International Journal of Servant-Leadership*. Both are available on the Montana Tech Library Digital

Commons page.

Camm earned a B.S. and a Ph.D. in mining engineering from the University of Idaho, and a master of engineering management degree from Washington State University. He also studied leadership in the Gonzaga University doctoral program. He is a registered professional engineer in Washington.

MINERAL INDUSTRY EDUCATION AWARD TO JAMES L. HENDRIX

The Mineral Industry Education Award is presented to James L. Hendrix, “In recognition and appreciation of an illustrious and outstanding 50-year career as a dedicated educator and researcher to the minerals industry.”



JAMES HENDRIX

In 1969, Hendrix joined the University of Nevada Reno as an assistant professor in the department of chemical and metallurgical engineering. Employment within the Mackay School of Mines led to Hendrix’s involvement in the training of chemical and metallurgical engineering students with many choosing careers within the minerals industries.

Hendrix was at the Mackay School of Mines for 26 years.

He went to the University of Nebraska Lincoln in 1995 and remained there until 2014. He returned to the University of Nevada and retired in 2017. During his career he served as chair of four departments and dean of three colleges. During his career, with the help of many undergraduate and graduate students, Hendrix maintained an active research program in gold hydrometallurgy.

Throughout his career Hendrix has taught freshman and sophomore engineering classes with the goal of maintaining the students’ interests in the minerals industries.

ROBERT EARLL MCCONELL AWARD TO MARY M. POULTON

The Robert Earll McConnell Award is presented to Mary M. Poulton for, “Significant contributions in mineral and engineering education and innovations addressing real and challenging occupational training problems.”

Poulton is distinguished professor emerita in mining and geological engineering and co-director of the Lowell Institute for Mineral Resources at the University of Arizona. She was the first woman to lead an engineering department in the history of the University of Arizona, heading the Department of Mining and Geological Engineering for 14 years. She has conducted research on artificial intelligence (AI) applied to earth sciences for more than 30 years.

Poulton is a co-founder and officer of three technology companies working in the areas of AI-driven water-management software, safety data analytics and virtual-reality software for training. She is a Distinguished Member of SME, a past member of the SME board of directors, a recipient of the 2017 National Engineering Award and the 2019 Daniel Jackling Award.

She has received the AIME Minerals Industry Education Award, the Ivan B. Rahn Educator Award and the American Mining Hall of Fame Medal of Merit.



MARY POULTON

ROBERT PEELE MEMORIAL AWARD TO MINGLIANG TANG

The Robert Peele Memorial Award is presented to Mingliang Tang for the paper “Mapping Surface Moisture Distribution of Heap Leach Pad Using Unmanned Aerial Vehicle,” presented at the SME Annual Meeting, Feb. 2020, Phoenix, AZ.

Mingliang Tang is a recent graduate of the University of Toronto, Department of Civil and Mineral Engineering. He received his master’s of applied science degree in 2021 and is a member of the Mine Modeling and Analytics Lab at the University of Toronto. His research interests include applying machine learning techniques to resolve mining-related challenges and using unmanned aerial vehicles for mine operation monitoring.



MINGLIANG TANG

ROBERT H. RICHARDS AWARD TO KATHLEEN A. ALTMAN

The Robert H. Richards Award is presented to Kathleen



KATHLEEN ALTMAN

A. Altman, “For her dedication to mineral processing in operations, process design, academia, metallurgical sample selection and test programs.”

Dr. Altman began her career as a metallurgical engineer in 1967 when she enrolled at the Colorado School of Mines as one of only 19 female students out of a student body of about 1,500. Although Altman dropped out and returned to school five times before graduating in 1980, she later completed an M.S. and Ph.D. at the Mackay School of Mines. She initially worked at the CF&I Steel Corp. After helping to blow down the last blast furnace in 1984, Altman switched to the mining industry and worked at Climax, Barrick Goldstrike, FMC Gold Paradise Peak, designed mining projects with SNC-Lavalin and Samuel Engineering, taught in the mining engineering department of the University of Nevada, Reno worked as the Newmont processor and consulted with Roscoe, Postle Associates and headed up her own company. The hundreds of projects involved multiple metals and commodities and spanned approximately 30 countries across six continents.

PERCY NICHOLLS AWARD TO MICHAEL KARMIS

The Percy Nicholls Award is presented to Michael Karmis, “In recognition of his wide and varied contributions to the improvement of geomechanics and mine systems, health and safety, carbon management and the sustainable development of energy and mineral resources.”

Karmis retired in 2021, after 44 years at Virginia Tech, as the Stonie Barker Professor of Mining and Minerals Engineering and the Director of the Virginia Center for Coal and Energy Research. His expertise is in the areas of geomechanics, mine systems, health and safety, carbon management and the sustainable development of mineral resources. He has authored/co-authored 180 scientific papers and directed more than 62 major projects, funded by government, foundations and the private sector. Karmis served as the 2002 President of SME and the 2008 President AIME. He was elected as the 2002 President of the Society of Mining Professors and served from 2005 to 2012 as the Society’s Secretary General.



MICHAEL KARMIS

SME Division Awards Coal & Energy Division Awards

COAL & ENERGY DIVISION DISTINGUISHED SERVICE AWARD TO EDWARD F. ZEGLEN JR.

The Distinguished Service Award is presented to Edward F. Zeglen for, “Your impressive contributions to SME and SME Pittsburgh Section working with students in mine rescue techniques, the coal mining industry and opportunities available in the mining industry.”

Zeglen began his career with the U.S. Steel Corp. Frick District while attending the Pennsylvania State University (PSU). He has held the positions of production foreman, general mine foreman, engineering manager and corporate chief underground engineer. His expertise is in troubleshooting mine ventilation in Pennsylvania, West Virginia, Virginia, Kentucky, Illinois, Alabama, Colorado, Utah and New South Wales, Australia. He has 42+ years of experience in coal mining. He has a B.S. degree in mining engineering and is a registered project engineer and mine foreman in Pennsylvania and Utah.

He has participated in mine rescue for 33 years and in 2010, joined Dr. Larry Grayson – PSU mining professor and Susan



EDWARD ZEGLEN

Bealko – DeWitt – GMS safety director forming the PSU mine rescue team as their trainer. He is currently the GMS chief mine engineer. He is past chairman and is a board of director member of the Pittsburgh Coal Mining Institute of America and SME Pittsburgh chapter.

J.W. WOOMER YOUNG ENGINEER AWARD TO MATTHEW R. GRAY

The J.W. Woomer Young Engineer Award is presented to Matthew R. Gray, “In recognition of your engineering professionalism.”

Gray earned his B.S. in mining engineering and a minor in geosciences from The Pennsylvania State University in 2010. After graduation, Gray worked as an assistant mine foreman for Alpha Natural Resources at Cumberland Mine before joining the U.S. Mine, Safety and Health Administration (MSHA) in December of 2014. He is currently the mine ventilation and emergencies branch chief for the ventilation division at the Pittsburgh Safety and Health Technology Center. He participated in a variety of ventilation related studies at multiple coal and metal/nonmetal mines. He has also responded to mine emergencies and provided mine atmosphere monitoring and analysis of collected data to determine the explosibility of gas



MATTHEW GRAY

mixtures. Gray has conducted technical reviews to determine the appropriateness of proposed mine ventilation plans. Gray is active in SME and served as the 2019 chair of the Young Leaders Committee. He received the 2019 John T. Boyd Memorial Young Engineer Award from the SME-Pittsburgh section.

ROCK MECHANICS AWARD TO PETER K. KAISER

The Rock Mechanics Award is presented to Peter K. Kaiser for, "Outstanding innovation and impact in rock mechanics research and application and ongoing advancement of the state-of-art and state-of-practice." Dr. Kaiser is a graduate of the Federal Institute of Technology in Zurich and the University of Alberta, Canada. Since 1987 until his retirement in 2015, he was professor of mining engineering and chair for rock engineering and ground control at the Bharti School of Engineering of Laurentian University in Canada. Between 2007 and 2015, he was seconded to the Centre for



PETER KAISER

Excellence in Mining Innovation (CEMI) as founding director and then as director of the Rio Tinto Centre for Underground Mine Construction (RTC-UMC). He held an adjunct professorship at the University of Toronto and Waterloo as well as Queen's University in Canada. After his retirement from the university, he has shifted his educational efforts to training engineers at mine sites in many parts of the world; most recently in Australia, Canada, Chile, Indonesia, Peru and the

United States.

He is a specialist in applied research for underground mining and construction. His interests are in geomechanics, mine design, rock engineering and the application of innovative technologies to increase mine safety and productivity. He brings extensive experience from both the industrial and academic sectors having served as a consultant to numerous consulting companies, mines and public agencies. He has supported contractors, mining companies and public sector clients in claims and litigations on four continents. Among many geomechanics achievements, his contributions to deep mining in burstprone ground stand out. He has been a leader in ground support research and design, and his most recent developments in deformation-based support design may well become a most innovative step to move from common to best practices in ground control.

STEFANKO BEST PAPER AWARD TO WILLIAM RANDOLPH REED, SCOTT S. KLIMA, ANDREW MAZZELLA, GARRON ROSS, GARY ROBERTS AND JOE DELUZIO

The Stefanko Best Paper Award is presented to William Randolph Reed, Scott S. Klima, Andrew Mazzella, Garron Ross, Gary Roberts and Joe DeLuzio for their paper titled "A Second Case Study of Field Test Results for Comparison of Roof Bolter Dry Collection System with Wet Collection

System," published in SME's *Mining, Metallurgy & Exploration* journal, Vol. 38 (2020).

Reed received a B.S. in mining engineering from the University of Missouri-Rolla, an M.B.A. from Wingate University in North Carolina and a Ph.D. in mining engineering from Virginia Tech. He is a registered professional engineer in several states. His past industrial experience includes working for 10 years in mining operations. Reed worked 18 years at the National Institute for Occupational Safety & Health's (NIOSH) Pittsburgh mining research division's dust control, ventilation and toxic substances branch, conducting mine health and safety research on dust control for both underground and surface mining operations. His research includes developing respirable dust controls for surface mine blasthole drills, and for underground coal roof bolters, shuttle cars and longwall operations. He currently works in the NIOSH Office of Mine Safety and Health Research.

Scott Klima is a mining engineer with NIOSH's Pittsburgh mining research division in the health hazards prevention branch. He graduated from The Pennsylvania State University with a degree in mining engineering. Klima has been with NIOSH for more than seven years working on the respirable hazards team. His research at NIOSH focuses on reducing respirable dust exposures of mining personnel in underground coal mines to prevent coal workers' pneumoconiosis (black lung). This includes developing methods and technologies to improve dust control operating parameters of continuous miner and longwall mining sections to reduce these exposures.

Andrew Mazzella is an electronics technician with the NIOSH Pittsburgh mining research division in the health hazards prevention branch. He has been with NIOSH for more than 14 years working primarily with dust controls and ventilation. This includes projects with roof bolter collection systems, underside shield sprays and canopy air curtains.

After completing his bachelors of science degree in mechanical engineering at West Virginia University's Institute of Technology, Ross spent his early career at J.H. Fletcher & Co. working in research and development. His projects were primarily related to dust control and included multiple studies with NIOSH for the development of an approved wet dust collection system for roof bolters and air curtain canopies used on roof bolters, haulage and other equipment. Ross has been with J.H. Fletcher & Co. for seven years and is now involved in both mining and nonmining projects.



WILLIAM REED



SCOTT KLIMA



ANDREW MAZZELLA



GARRON ROSS

Deluzio started in mining in 1989 and has been at West Elk mine for 25 years. He has held numerous maintenance position from longwall maintenance foreman to CM maintenance coordinator. For the past three years he has worked as the maintenance superintendent.

Environmental Division Awards

ENVIRONMENTAL DIVISION DISTINGUISHED SERVICE AWARD TO PATRICK T. WILLIAMSON

The Distinguished Service Award is presented to Patrick T. Williamson for, “15 years of tremendous contributions to the Environmental Division through his project management experience in mine waste geochemistry, hydrogeology and international mining.”



PATRICK WILLIAMSON

Williamson has more than three decades of experience managing geochemical and hydrogeological investigations for mining projects including water balances, water resource evaluation and development, waste rock characterization and mine dewatering studies for due diligence, PFS, FS, operations and closure. Raised in Colombia and Venezuela, he found a niche developing and managing projects in Mexico, Colombia, Ecuador, Peru and Chile, which led to managing

two consulting practices in Mexico. A serial volunteer with the SME, Williamson was heavily involved with the SME ED, International Committee and ADTI, and was the 2014 SME conference chairman. Patrick has spoken extensively at conferences in the United States and Latin America on best practices for mine waste, water stewardship and the emerging concept of water footprinting and virtual water. In 1998 he began writing and presenting short courses in Spanish on mining hydrogeology and geochemistry, including the first Spanish language short course ever sponsored by the SME.

Health & Safety Division Awards

RESEARCH AND EDUCATIONAL EXCELLENCE AWARD TO GEORGE W. LUXBACHER

The Research and Educational Excellence Award is presented to George W. Luxbacher, “For his extraordinary contributions to advancements in the safety and health of miners during his 40 years of outstanding service to the mining industry.”

Dr. Luxbacher is the deputy associate director for mining at the National Institute for Occupational Safety & Health (NIOSH), where he is responsible for extramural research

funding under the MINER Act program, as well as assisting in the management of the overall mining program.

Luxbacher received his Ph.D. from Penn State where he conducted research in the areas of mine ventilation and electrical systems. He started his mining career as a union miner underground with Pittsburgh Coal Co., a then-subsubsidiary of Consolidation Coal Corp., and later worked for Island Creek Coal Co. in research, engineering and mergers and acquisitions roles through 1993 (when Island Creek was sold to Consol), then various subsidiaries of Occidental Petroleum dealing with legacy mining issues in coal, copper and oil shale, as well as chemical and O&G production, before taking early retirement from Occidental in 2014.

Luxbacher did several years of consulting before joining NIOSH in 2016. Luxbacher is a past-president of the Society for Mining, Metallurgy & Exploration (2008) and a past (2012) and current (2020–21) president of the American Institute of Mining, Metallurgical, and Petroleum Engineers. Luxbacher has served as an ABET program evaluator for many years, and is on the Industry Professional Advisory Committee for the Penn State mining engineering program.



GEORGE LUXBACHER

INDIVIDUAL EXCELLENCE AWARD TO KIRK HALEY MCDANIEL

The Individual Excellence Award is presented to Kirk Haley McDaniel, “For advocating and promoting advanced technology, research and development for the “Mine of the Future” to reduce risks and improve miner safety, and for his long tenure as an associate editor for SME’s technical publications.”

Dr. McDaniel is a licensed professional mining engineer with more than 35 years of experience in underground mining and tunneling environments. His areas of expertise include mine ventilation, operations, safety and health, design, technology and the mine of the future, training and qualitative and quantitative risk analysis.

McDaniel earned a Ph.D. in mining and Earth systems engineering from the Colorado School of Mines (CSM) with an emphasis on fire life safety and emergency preparedness in underground spaces. His credentials include a bachelor’s of science and master of engineering degree in mining engineering from CSM and a master of business administration from Regis University.

McDaniel is a certified mine safety professional (CMSP) of the Society for Mining, Metallurgy and Exploration (SME). In addition, McDaniel was instrumental in the creation of the CMSP exam materials and served as a member and chair of the CMSP certification panel. He holds U.S. Department



KIRK MCDANIEL

of Labor Mine Safety and Health Administration IU and IS certifications for mine safety training. He has worked in and around mining operations on multiple continents in roles with operations, technical support, consulting, safety and training.

McDaniel is currently working with the U.S. Department of Energy as a subject matter expert on underground ventilation for the Waste Isolation Pilot Plant in Carlsbad, New Mexico. He has been a member of SME since 1981.

Industrial Minerals & Aggregates Division Awards

A. FRANK ALSOBROOK DISTINGUISHED SERVICE AWARD TO VISHAL GUPTA

The A. Frank Alsobrook Distinguished Service Award is presented to Vishal Gupta, "For his significant research contributions for improved development of technology for efficient processing of mineral resources, his support of SME activities and leadership of the Industrial Minerals & Aggregates Division."

Dr. Gupta specializes in surface chemistry of minerals and is working as senior chemical engineer with Tesla. His current research interests include lithium processing and the



VISHAL GUPTA

development of lithium batteries. His past 12 years of work experience include various roles such as project engineer/manager, research and development engineer and production supervisor with EP Minerals /U.S. Silica/ FLSmidth and NMDC. Gupta served SME in various capacities within the Industrial Minerals & Aggregate Division, recently served as division chair, and in the past as secretary/treasurer, program chair and

technical committee chair. He has also served on various awards and scholarship committees.

Gupta received his Ph.D. in metallurgical engineering from the University of Utah in 2010. Gupta also earned an M.S. from Southern Illinois University and a bachelor's of technology with honors degree from the Indian School of Mines. Gupta is recipient of the SME Henry Krumb Lecturer award for 2012–2013 and was the Industrial Minerals Young Scientist Award winner in 2012. Gupta has more than seven years of academic and 11 years of industry research experience working in surface chemistry of minerals, particularly clay minerals such as kaolinite, trona and other sulfide mineral flotation. Gupta has led creative and innovative efforts in mineral beneficiation such as coal washability, magnetic separation, flotation and tailings treatment.

INDUSTRIAL MINERALS & AGGREGATES DIVISION YOUNG SCIENTIST AWARD TO SWADHIN SAURABH

The Industrial Minerals & Aggregates Division Young Scientist Award is presented to Swadhin Saurabh, "For his outstanding accomplishments in industrial mineral processing plant and equipment design and engineering."

Saurabh received a bachelor's of science degree in chemical engineering from BIT Sindri, India and a master's degree in metallurgical engineering from the University of Utah. He is currently finishing his executive MBA from the David Eccles School of Business, University of Utah.

He specializes in minerals processing. Currently, he works as a process manager at FLSmidth Inc., based in Midvale, UT. Before FLSmidth, he worked for Millcreek Engineering Co. in Salt Lake City, UT as a project manager. Earlier, he worked for FLSmidth USA as a senior process engineer, for Taggart Global (now part of DRA Global) as a process/project engineer in the United States and Australia, and for Robinson Nevada Mining Co. as a summer intern. In India, he worked as a summer intern at SAIL Bokaro and the National Metallurgical Laboratory, Jamshedpur.

Saurabh has worked on more than 50 projects globally in base metals, precious metals, coal, industrial minerals and aggregates. He has experience in research and development, testing, plant design, process engineering, project management and operations. He is peer reviewer of several international mineral processing journals. He is a member of the Society for Mining, Metallurgy & Exploration (SME) and the Coal Preparation Society of America. He is also a qualified professional member of the Mining and Metallurgical Society of America. He served as the program committee chair (2020–2021) of the Industrial Minerals & Aggregates Division at SME. He has chaired technical sessions in SME conferences, the Physical Separation Conference, and the 19th International Coal Preparation Congress. He was recipient of the 2016 Minerals Engineering International (MEI) Young Persons Award, United Kingdom.



SWADHIN SAURABH

Mineral & Metallurgical Processing Division Awards

ANTOINE M. GAUDIN AWARD TO JAMES E. GEBHARDT

The Antoine M. Gaudin Award is presented to James E. Gebhardt, "For fundamental examination of flotation chemistry, electrochemical principles on sulfide flotation and optimization/control for various mineral processing/hydrometallurgical operations."

Dr. Gebhardt graduated with a B.S. in metallurgical



**JAMES
GEBHARDT**

engineering from South Dakota School of Mines and Technology and earned M.S. and Ph.D. degrees in minerals engineering from the University of California, Berkeley. He then joined the U.S. Bureau of Mines at Avondale, MD. He spent one year at the Mineral Processing Laboratory of the Italian National Research Council in Rome, Italy, and then moved to the bureau's Salt Lake City Research Center when the bureau closed the Avondale facility.

Gebhardt joined the private industry sector in 1991 with Control International, Inc. in Salt Lake City, UT as a senior engineer and group leader. In 1996, he co-founded Process Engineering Resources Inc. with four partners, where they developed the PERI PX-2100 X-ray fluorescence elemental analyzer, automatic ball charging equipment and software and simulation technology. In 2012, FLSmidth purchased PERI and Gebhardt joined the automation division as a technical specialist. Since 2019, he has been with the FLSmidth Mining research and development group providing technical support for the comminution and flotation research portfolios. Gebhardt is a registered professional engineer and has been an active member of SME since 1976. He is the current Section editor-in-chief for Mineral & Metallurgical Processing for SME's technical journal *Mining, Metallurgy & Exploration*.

MILTON E. WADSWORTH AWARD TO MATTHEW I. JEFFREY

The Milton E. Wadsworth Award is presented to Matthew I. Jeffrey, "For developing groundbreaking methods for studying electrochemical mechanisms in nonferrous metallurgy and elucidating the chemistry of gold in cyanide and thiosulfate media."

Jeffrey is currently a processing director with Newmont Corp., based in Denver, CO at the Malozemoff Technical Facility (MTF). Since 2014 he has been the process manager on the Yanacocha Sulfides project, a \$2.4 billion greenfields expansion that will add flotation, pressure oxidation and SX/EW to the existing site. His previous roles at Newmont



**MATTHEW
JEFFREY**

include director of metallurgical technology with management of the metallurgy lab at MTF and subject matter expert on hydrometallurgy. Prior to joining Newmont, 10 years ago, Jeffrey held various research roles with CSIRO Minerals in Perth, including gold research program manager, base and precious metals science leader, and Parker Center gold market leader. He also spent eight years as an academic, lecturing at the Monash University

Department of Chemical Engineering. Jeffrey obtained a BE (chemical) with metallurgy major from the University of NSW in 1993 and a Ph.D. from Curtin University in 1998.

In 1999 he joined Billiton, at first in Johannesburg and then transferred to London, where he worked with BHP Billiton Capital. In 2002, he returned to Johannesburg and established CM Solutions as an engineering consultancy. Under his leadership, the company expanded as it developed products and opened a metallurgical laboratory. He has since returned to London, where he runs Crundwell Metallurgy. He has an active interest in the mechanism of dissolution, a topic on which he continues to publish widely.

MPD OUTSTANDING YOUNG ENGINEER AWARD TO MICHAEL SPICHER

The MPD Outstanding Young Engineer Award is presented to Michael Spicer, "For applying his knowledge in mineral processing to design and optimize mineral processing facilities to improve mineral recovery and plant availability."

Growing up in a small agricultural community in Montana, Spicer never analyzed how many items in his daily life were extracted from deep below the earth's surface. The only thoughts of mining arose if an interesting exhibit on "the miners of old" popped up or during a customary school trip/stops at the Berkley pit overlook. The start of Spicer's path of a mining career was during a recruiting trip to Montana Tech, when he heard the word metallurgist for the first time. He thought, "Good scholarship money, who cares if that's a made-up word?" The hook wasn't completely set until Spicer was into the daily grind of his first internship in Elko, NV. Here he experienced a sample of life in a mill and the mining culture and the development of his affinity for working with operations, maintenance and technical teams began.



**MICHAEL
SPICHER**

After working at mines in Nevada, South Carolina, New Mexico, Arizona and now in Idaho, Spicer has fully embraced the tight-knit mining community. Spicer's spirit is fired up daily by getting to the root of problems, implementing sensible and sound solutions, working with multiple disciplines toward a common goal, getting home safely, and educating the public to ensure the longevity of the industry.

ARTHUR F. TAGGART AWARD TO VIVEK KASHYAP AND PATRICK R. TAYLOR

The Arthur F. Taggart Award is presented to Vivek Kashyap and Patrick R. Taylor for their paper titled, "Selective Extraction of Zinc from Zinc Ferrite," published in the *SME Mining, Metallurgy & Exploration* journal, Vol. 38 (2021), Issue 1, pp. 27–36.

Kashyap is currently working as a metallurgical research engineer at Brimstone Energy. He completed a Ph.D. in metallurgical engineering under the supervision of

Dr. Patrick Taylor at Colorado School of Mines in August 2021. His Ph.D. thesis titled “A comprehensive study on the extraction of zinc and indium from zinc residues rich in zinc ferrite” introduced a novel process of extraction and



VIVEK KASHYAP

recovery of indium by a combination of pyrometallurgy and hydrometallurgy methods. Prior to starting a Ph.D., he received a bachelor and masters in mineral engineering from Indian School of Mines, India.

Taylor is a registered professional engineer with more than 44 years of experience in mineral processing and extractive metallurgy engineering, research, teaching and consulting.

He is the George S. Ansell endowed chair and distinguished professor of chemical metallurgy and director, Kroll Institute for Extractive Metallurgy. Taylor has authored numerous papers and presentations.

He has served as a consultant to many companies and has been an expert witness several times. He has directed research for many graduate students and post-docs. He has taught extractive metallurgy and mineral processing in university courses for the past 44 years. He has developed and taught several short courses for industry. He is active in professional organizations: SME, The Minerals, Metals & Materials Society, ASM and MMSA. He has received many awards and honors: fellow of ASM, Milton E. Wadsworth award from SME, TMS EPD luncheon speaker, TMS EPD distinguished lecturer, distinguished member (fellow) of SME, TMS EPD distinguished service award, the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) James Douglas Gold Medal, and he was interviewed for the AIME oral histories program.



PATRICK TAYLOR

Mining & Exploration Division Awards

BEN F. DICKERSON III AWARD TO GEORGE STURGIS

The Ben F. Dickerson III Award is presented to George Sturgis, “For his dedication, professionalism and leadership in developing the mining industry and SME.”



GEORGE STURGIS

George Sturgis is a seasoned executive manager and project management leader with over forty years of experience in engineering, construction, construction management, evaluation, design and overall project management for surface and underground mining and civil operations.

Sturgis retired in 2019 as vice president for project development at Hecla Mining. Prior to joining Hecla Mining, Sturgis founded and operated Triple Constraint Solutions, a project management services company successfully serving the mining industry. Sturgis completed several critically important underground and surface mining operations in Finland, Australia, the Philippines, Taiwan, South Africa, Burkina Faso and Ghana.

Sturgis obtained his bachelors of science degree in geological engineering from the Colorado School of Mines, an MBA from Syracuse University, and a masters certificate in project management from George Washington University. Sturgis is a certified project management professional, a certified professional constructor and a registered member of the Society for Mining, Metallurgy and Exploration. He serves as an industry advisor to the WIPP facility, as an ABET

program evaluator in geological engineering, and is a member of the Colorado School of Mines mining department industry advisory committee. He is a member of the Association for the Advancement of Cost Engineering and the Mining and Metallurgical Society of America. Sturgis is a qualified professional for mining and minerals project costing, infrastructure and management by the Mining and Metallurgical Society of America.

MINING & EXPLORATION DIVISION DISTINGUISHED SERVICE AWARD TO CAMILLE PRENN

The Distinguished Service Award is presented to Camille Prenn, “For the advancement of geostatistics, creative and exceptional contributions and leadership in teaching geostatistics to the mining and petroleum industries.”

Cami Prenn’s introduction to mining came with a move to the Big Smoky Valley in rural Nevada in 1982, where she lived for two years. Nevada has been her home ever since, and mining has been the industry she’s chosen to work in. She worked at Mine Development Associates (MDA), Inc. since its inception in 1987 and served as its principal operations officer after founding the company with her husband, Neil. She retired from MDA in 2021 after the company was acquired by RESPEC. MDA has provided memberships for the mining engineering students at the University of Nevada, Reno since 2006. Prenn has also served with the Geological



CAMILLE PRENN

Society of Nevada (GSN) as its publications chair, treasurer and director. She continues with GSN as the chair of the GSN Foundation. She is the treasurer for the Women's Mining Coalition since 2002 and treasurer of the Nevada Mineral Exploration Coalition since 2010.

HARRY M. PARKER EXCELLENCE AWARD TO CLAYTON V. DEUTSCH

The Outstanding Young Professional Award is presented to Clayton V. Deutsch, "For the advancement of geostatistics, creative and exceptional contributions and leadership in teaching geostatistics to the mining and petroleum industries."



CLAYTON DEUTSCH

Dr. Deutsch is a professor and the director of mining engineering at the University of Alberta. He teaches and conducts research into better ways to model heterogeneity and uncertainty in mineral deposits. Deutsch has published seven books, more than 200 peer-reviewed technical papers, and about 200 papers in conference proceedings. He has taught more than 200 short courses for industry and

about 100 university classes. Deutsch holds the Canada Research Chair in Uncertainty Management and the Alberta Chamber of Resources Industry Chair in Mining Engineering. He is passionate about creating the best possible numerical models of geological sites.

OUTSTANDING YOUNG PROFESSIONAL AWARD TO ISABEL F. BARTON

The Outstanding Young Professional Award is presented to Isabel F. Barton, "For her technical expertise leading to significant contributions in the geometallurgy field specializing in interdisciplinary minerals research, leadership in technical and scientific organizations and recruitment efforts to the mining and geological engineering department at the University of Arizona."

Barton is currently an assistant professor at the University of Arizona Department of Mining & Geological Engineering. Her primary research area

is geometallurgy, which integrates concepts and techniques from mineralogy, geology, mineral processing and extractive metallurgy to make metal extraction more efficient and sustainable. Current research projects include mapping of deleterious minerals through hyperspectral imaging, coupled leaching and crystallographic studies on uranium, vanadium, cobalt, and copper ores, and using geological data to improve modeling. A 2021 recipient of career awards from SME and the National Science Foundation, Barton also enjoys studying the history of mining, metallurgy, and geology, and teaches courses on geometallurgy and on how the exploitation of mineral resources has affected the history of civilizations around the world.



ISABEL BARTON

MINER OF THE YEAR AWARD TO VERN GOGGIO

The Miner of the Year Award is presented to Vern Goglio, "For unwavering commitment to safety and personal and professional development of colleagues across all segments of the mining industry."

Vern Goglio started his journey in the mining industry in 1975 working underground in the Trona mines in southwestern Wyoming. He earned a mining engineering degree from Montana Tech and has worked in various roles. He now works with Cementation USA, Inc. focusing on leadership development.

Most of his mining career has been spent in new mine development at places such as the Carr Fork Mine in Utah and Cortez Hills Mine in Nevada with a focus on instilling a culture of "doing the right thing the first time and every time for all of the right reasons." He has had the opportunity to work alongside and with so many fantastic people who make this industry what it is.



VERN GOGGIO

WAAIME Division Award

THE WAAIME FOUNDERS AWARD TO DAPHNE D. LAPOINTE

The WAAIME Founders Award is presented to Daphne D. LaPointe, "In recognition of exemplary and continuous service to the Nevada-Reno section and for her years of service as Scholarship Chair including interviewing scholarship recipients and mentoring them, we the Executive Committee commend her for her faithful and continuous dedication to further the goals and

purposes of WAAIME."

LaPointe graduated from the University of Montana and worked for Exxon Minerals Exploration as a field geologist exploring precious metals in Idaho and western Montana.

She was a WAAIME member for about 40 years. During much of that time, D.D. was the scholarship chair of the Reno WAAIME section. She



DAPHNE LAPOINTE

encouraged students to apply, helped the students submit their applications, and arranged the interviews by getting an interview room, setting the times for the interviews, and encouraging other WAAIME section members to help with the interviews. Plus, she made cookies to

share with the interviewees. Then, she prepared the notes of the interviews and submitted the applications to the national WAAIMES. In all these years, she helped distribute perhaps as much as \$500,000 from WAAIME to students. ■

New Members

(continued from page 46)

Canada
Sandra Opoku, Accra, Ghana
Victor Ortiz, Elko, NV
Kayden Osborn, Elko, NV
Ryan Parker, Colorado Springs, CO
Todd Parkington, Greenwood Village, CO
Piyush Patil, West Lafayette, IN
Patrick Pelley, Charleston, WV
Antony Perez Lopez, Gilbertsville, PA
Eduardo Pérez Sangabriel, Ciudad de Mexico, DF Mexico
Ray Pinto, New York, NY
Kelsey Plummer, Winnemucca, NV
Andrew Procopio, Chapmanville, WV
Andrew Procopio, Chapmanville, WV
Jared Purdy, Santa Clara, UT
Cahyo Putro, Golden, CO
Jamal Qadri, Sahuarita, AZ
Jose Quintero, Rio Rico, AZ
Francesca Ramirez De Ferrari, Lima, Peru
Caleb Ratliff, York, SC
Therese Roa, Tucson, AZ
Alejandro Robles, Reno, NV
Jimmy Rose III, Lexington, KY
Rachel Rubin, Westminster, CO
Natalie Rubio, Yerington, NV
Lisa Rudstrom, Side Lake, MN
Alexis Rylaarsdam, Tucson, AZ
John Sackrider, Boerne, TX
Madison Sandoval, Reno, NV
Eitaro Sato, Tokyo, Japan
Derek Schluterman, Liberty Hill, TX
Brian Shapiro, Butte, MT
Grady Sherwood, Tucson, AZ
Lucas Z Silva, Sao Paulo-Sp, Brazil
Hart Singer, Oakland, CA
Spencer Snow, Golden, CO

Trevor Sparks, Duesseldorf, Germany
Russel Spaulding, Knoxville, TN
Valentin Spiess, Graz, Austria
Caleb Stetson, Idaho Falls, ID
Savannah Stewart, Yuma, AZ
Jim Stieben, Phoenix, AZ
Patrick Strike Jr., Spring Branch, TX
Kathiravan Subbaramani, Salem, India
Vishaal Sundar Raj, West Lafayette, IN
Ian Sutcliffe, Murray, UT
Chon Weng Tang, West Lafayette, IN
Aaron Tenesch, Philipsburg, MT
Michael Tetteh, Rapid City, SD
Derrick Thuringer, Elko, NV
Calvin Tohm, Whitewood, SD
Thi Truong, Tucson, AZ
Alhai Abdulai Turay, Freiberg, Germany
Muhammad Usama, Fort Collins, CO
Juan David Valencia Quiceno, Morgantown, WV
Kamala Vandervolk, Roxborough, CO
Johan Vanneste, Golden, CO
Hector Vazquez Marrufo, San Luis Potosi, Slp Mexico
Priyanka Selvi Venkatesa Palanichamy, West Lafayette, IN
Antonio Verdusco Mendez, Gilbert, AZ
Claudio Villamizar, Guanajuato, GTO Mexico
Paul Voigt, Reno, NV
Vrbas, Linch, WY
Amanda Wahrer, Davenport, FL
Hal Walls, Reno, NV
Kyle Walton, Fairbanks, AK
Wenkai Wan, Trondheim, Norway
Rachel Watts, Tucson, AZ
Grant Wick, Juneau, AK
Hans Wronka, Duluth, MN

Alejandra Yepes, Lehigh, PA
Zhen Yin, Stanford, CA
Nathan Youmans, Alexandria, VA
Jie Yuan, Corona, NY
Jason Zhang, Liaocheng City, China

Necrology

date elected name and city

1955	William D. Collins Conifer, CO **
1956	Richard E. Cribbs Tucson, AZ **
1949	Hugh W. Evans Boulder, CO **
1970	Dr. Simon D. Handelsman Vancouver, BC Canada **
1968	James S. Knowlson Edmonds, WA
1968	Orville A. Kiehn Ruckersville, VA
1972	Kenneth R. Paulsen Arvada, CO
2003	Hans de Ruiter Benthuisen, Netherlands
1972	James J. Viciano Daytona Beach Shores, FL
2011	Dr. Axel G. Nitschke Fairfax, VA

**** Legion of Honor**

Upcoming SME Events

2022 SME Minnesota Conference
April 11-13, 2022
Virginia, MN

RaSiM 10 (Rockbursts)
April 26-28, 2022
Tucson, AZ

North American Tunneling
Conference (NAT)
June 19-22, 2022
Philadelphia, PA

For additional information, contact: Meetings Dept., SME
Phone 800-763-3132 • 303-948-4200 • Fax 303-979-3461 • email sme@smenet.org • www.smenet.org

MEC announces Mining Next Gen award winners

The Society for Mining, Metallurgy & Exploration and the Minerals Education Coalition in partnership with our sponsor Newmont are proud to announce the 2021-2022 Move Mining Next Gen Award Winners. Please join us in congratulating the following teams.

- Best overall award selected by

judges: The Stop the Motion Siblings, Minnesota

- Best in grades 9-12 Award: Team Steele Chicken, Minnesota
- Best in grades 6-8 Award: Team Serendipity, Minnesota
- Peoples Choice Award and Best in grades K-5: Team Salty, Utah.

Move Mining Next Gen is a video

competition, similar to Move Mining that is only open to K-12 students.

The competition asks the students to consider their need for mining and to create a three-minute video answering the question "Why is mining important in our lives?"

The Minerals Education Coalition would like to thank sponsor Newmont Corporation. ■

James S. Knowlson V

An appreciation

The mining industry lost a great resource and friend with the passing of James Somerville Knowlson V on Jan. 2, 2022. Born on Nov. 27, 1940, in Hinsdale, IL, Knowlson was the oldest son of James Somerville Knowlson IV and Barbara Carr Baker. He was among the top underground mine engineers in the United States, a great supervisor and mentor, husband and father. His parents divorced when he was 9-years-old. His mother remarried William L. Jacoby and they moved to Cleveland, OH. After graduating from Shaker Heights High School, Knowlson attended The Ohio State University for one year. He then joined the Navy so he could see more of the world and decide what he wanted to do in life.

Knowlson became a Navy Corpsman aboard the aircraft carrier USS Essex and traveled throughout Europe. He was later stationed at the Navy Hospital in Key West, FL and served there during the Cuban Missile Crisis. It was in Key West where he met Mary Frase who was born and raised in Atlanta, GA, and worked as a ticket agent at the Key West Airport. They were married in 1964 at Saint John's Episcopal Church in Key West and honeymooned in Jamaica.

After being discharged from the Navy, Knowlson returned to Ohio State, where he decided to become a mining engineer. The best school in the country for mining was Montana Tech in Butte, MT. Jim and Mary moved to Butte, where he started to work for The Anaconda Co. as a sampler on the late shift so he could attend Montana Tech during the day. That job gave him a bedrock appreciation for practical engineering, mine geology, grade control, workplace safety and a treasure chest of underground experience and personal anecdotes which he enjoyed sharing conversationally, or to make a point. Knowlson graduated with honors from Montana Tech in 1973.

After graduation, Knowlson continued to work for

Anaconda as an engineer working his way up to become superintendent of all underground mines on the Butte Hill, "The Richest Hill on Earth." Because of his expertise in mining, he traveled for Anaconda to sites in Chile, Venezuela, Mexico, Alaska and the United States.

In 1985, after Anaconda, Jim, Mary, and their two boys moved to Edmonds, WA, where Knowlson started his own mining consulting business. He continued in mining until retirement in 1995 after several years as chief engineer at the Cannon Gold Mine. He then resumed part-time consulting activities, including procurement and installation of the shaft hoist for Getchell Gold's Turquoise Ridge operation. He was an active member of SME since 1968, and Registered Member until 2014. During his career, he held professional engineer licenses from Montana and Washington.

Knowlson had a love of fishing, hunting, competitive shooting and restoring his two wooden boats. His evenings were spent at home with his wife enjoying the sunsets from his deck, his koi fish pond, a glass of Irish whisky and a good book. He died at home in Mary's arms. He was buried at Edmonds Memorial Cemetery. Knowlson is survived by his wife Mary, their two sons James Somerville Knowlson VI and George Zachery Knowlson, his daughter-in-law Cathy E. Knowlson, and four grandsons, Gage S. Knowlson, Sawyer Z. Knowlson, Carter A. Knowlson, Parker S. Knowlson, and close family friend Laura Taylor. ■



James S. Knowlson V

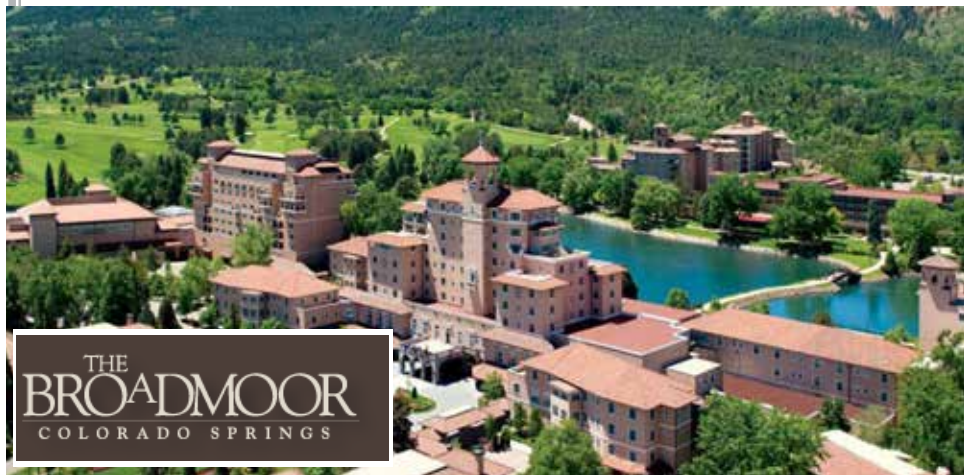
25-year members

(continued from page 47)

Jeff Sepp, Toronto, ON, Canada
Patrick Smith, Spokane, WA
Andrew Soderman, Vail, AZ
Trent Spendrup, Grand Junction, CO
Ross Stuart, Greenwood Village, CO
Donald Swartz, Arvada, CO
Peter Swistock, Port Matilda, PA

William Tanaka, Wheat Ridge, CO
George Teetes, Dallas, TX
Tiffany Thoma, Berlin, WI
Robert Thomas, Bishop, GA
Stephen Thompson, Montreal, QC, Canada
Matthew Twichell, Friedens, PA
Srinivas Veeramamuneni, Chicago, IL

Nathan Wanstrath, Batesville, IN
Harry Warries, Kewdale, WAS, Australia
Daniel Weber, Denver, CO
Terrence Williams, Sinking Spring, PA
Amber Withers, Salt Lake City, UT
Brett Zernich, Long Beach, CA
Songlin Zhang, Sammamish, WA ■



70th Annual Colorado MPD Meeting April 28-30, 2022

An Excess of Shortages

Registration is OPEN!

Advanced registration pricing through April 1, 2022

Technical Program:

Thursday, April 28 1:00 PM—4:00 PM
Friday, April 29 8:30 AM—4:00 PM
Saturday, April 30 8:30 AM—12:00 PM

Golf Tournament:

Saturday, April 30 1:30 PM

Spouse Activities:

Bubbles & Brunch
Friday, April 29 Time TBD

For Hotel Reservations call "The Broadmoor"

1-800-634-7711 Code "SME422" or

<https://book.passkey.com/go/SME422>

Note: the conference will be held in person following all local and state protocols in the response to COVID 19. Visit our website for more details.

For further details and registration , please visit our website at:

www.ColoradoMPD.com

You may also contact Jenny Pergola: 303-451-7677 jenny@pumpsplusinc.com
Alan Boylston: 719-332-9831 alan.boylston@mogroup.com
Brett Berg: 303-996-5936 brett.berg@intrepidpotash.com

DIAMOND SPONSORS



Metso:Outotec

Sponsorship Opportunities

are still available!

PLATINUM SPONSORS



SUNDT



Your chance to be part of *Mining Engineering's* upcoming coverage

Since 1949, *Mining Engineering* has delivered the best coverage of the global mining industry to its readers. In 2022, we will again bring you the information you need from the fields of mining, mineral processing and exploration.

Upcoming topics to be covered in 2022

APRIL

- Coal
- MINEXCHANGE 2022
- Mine rescue competition
- Business Profiles

MAY

- Annual Reviews USGS
- Education – Student recruitment
- Canada
- Products and Services Directory

JUNE

- Underground Mining
- Water management
- Space Mining
- **PLUS! Tunneling & Underground Construction Magazine**

Contact **Gary Garvey**, SME's media manager/advertising sales to advertise in *Mining Engineering*
garvey@smenet.org, 303.948.4243

Contact **Bill Gleason**, editor, for editorial consideration
gleason@smenet.org, 303.948.4234





Nevada Gold Mines strives to be among the very best 21st century companies, not just in our industry, but in any industry. If you thrive on challenge and collaboration, we offer opportunities on a global scale.

A career at NGM means:

- Competitive pay
- A leading benefit package (medical, dental, & vision)
- 401k retirement plan with generous employer contribution matched up to 11%
- Paid Time Off (PTO)
- Company-sponsored medical clinics
- Company match share purchase program



THE BEST IN MINING PRODUCTS AND SERVICES

Alta Mining & Technical Recruiting Services

We are a search & recruitment firm with a track record of success in both retained & contingency search. We operate exclusively within the mining industry placing qualified professionals at the executive, managerial and individual contributor levels.
Telephone: (480) 380-2700
www.altamining.com

BASF Corporation

Wide range of products including solvent extraction reagents, flocculants, coagulants, rheology modifiers for solid liquid separation and tailings management, flotation reagents, scale inhibitors, and solid or liquid organic binders for agglomeration.
3231 E. Valencia Rd., Tucson, AZ 85706
Telephone: (520) 622-8891
www.mining-solutions.basf.com

BETE Fog Nozzle, Inc.

Manufacturers of spray nozzles for fire protection, conveyor and truck washing and dust control.
Email: sales@bete.com
www.bete.com

FLSmidth (Dawson) Metallurgical Laboratories

Minerals processing testing & consulting
Telephone: (801) 871-7000
Email: lab.slc@FLSmidth.com
www.flsmidth.com

EarthRes

Industrial Minerals, Coal and Aggregate Exploration and Feasibility, Engineering Design, Operations and Technical Services, Hydrogeology, Mining Engineering, Process Plant Evaluation and Design, and Mineral Processing.
www.earthres.com

FLSmidth

Productivity provider #1 for the world's largest installed base of original equipment including: Crushing, Grinding, Classifying, Flotation, Thickening, Clarifying, Filtration, Pyroprocessing, Material Handling, Metallurgical Testing, Ore Characterization, Parts & Service.
Telephone: (801) 871-7000
www.flsmidth.com

J. H. Fletcher & Co.

Roof drills, long hole drills, mobile roof supports, prime movers, scalers, jumbos and other specialized underground mining equipment.
Telephone: (304) 525-7811
www.jhfletcher.com

Luff Industries Ltd. - Canada

Manufacturer of quality conveyor components. Idlers, Pulleys, Impact Beds, Accessories. The most dependable conveyor products available!
Toll-Free: (888) 349-LUFF (5833)
www.luffindustries.com

Mineral Technologies, Inc.

Working with customers in mining operations for over 80 years, Mineral Technologies delivers process solutions for the treatment of an extensive range of minerals worldwide, including mineral sands, gold, iron ore, tin, chromite, and others. Mineral Technologies is recognized as the go-to partner for process solutions across the project lifecycle – from prefeasibility to plant engineering and design to ongoing process support. With state-of-the-art process equipment including gravity, magnetic, and electrostatic separators, our product line maximizes grade and recovery whilst delivering low operational costs.
Regional Office: St. Augustine, FL
(904) 342-8354
jessica.stacy@mineraltechnologiesusa.com
<https://mineraltechnologies.com/>

Naylor Pipe Company

Manufacturers of Spiralweld Steel Pipe and Fittings 4" to 102", #14ga. to 1/2" wall.
Telephone: (773) 721-9400
Fax: (773) 721-9494
www.naylorpipe.com

Prep Tech, Inc.

Cyclones, spirals, flotation, filter press, magnetic separators, dewatering screens, engineering services.
4412 Rt. 66,
Apollo, PA 15613
Telephone: (724) 727-3439
www.preptech.com

Richwood

Belt Tracking, Conveyor Belt Cleaners, Load Zone Protection, Material Containment, Pulley Lagging, and Wear Liners. Rely on Richwood
Toll Free: (800) 237-6951
www.richwood.com

Seegmiller International

Established in 1974, SI provides mining geotechnical services on a world-wide basis. Our specialties include open pit slope stability, underground stability analysis, mining methods appraisal and expert witness services for earth failure problems.
Email: DrSeegmiller@SeegmillerInt.com
www.SeegmillerInt.com

Vertiflo Pump Company

Manufacturer of vertical process pumps, sump pumps, end suction pumps and self-priming pumps in cast iron, stainless steel and special alloys, delivered in about half the normal lead time.
Telephone: 513-530-0888
Email: sales@vertiflopump.com
www.vertiflopump.com



Professional Services

NORTH AMERICA

GeoTDR, Inc.

720 Greencrest Drive | Westerville, OH 43081 USA
614.895.1400 | www.geotdr.com | Kevin@geotdr.com

GeoTDR is the worldwide provider of Time Domain Reflectometry (TDR) for automated risk assessment and remote monitoring of subsidence and slope stability for mines, high walls, karst areas, and embankment and impoundment slopes.

**We thrive
on challenges**

WSP GOLDER



Weir International, Inc.

Mining, Geology and Energy Consultants

Providing Mining, Geology, Geotechnical, Operational, Environmental, Training and Engineering Services Worldwide

Serving the Mining, Mineral and Energy Industries for over 85 Years

630.968.5400 • info@weirintl.com
www.weirintl.com

ECRS

Engineering Affiliate of
METALOCK® CORPORATION

Engineered Casting Repair Service, Inc.
Analysis and Repair of Cracked and Eroded
Ball and SAG Mill trunnions
Phone 225-791-8900 • Fax 225-791-8965
email: metalock@eatel.net
You Know It's Cracked - How Do You Fix It?

SKELLY AND LOY ENGINEERS-CONSULTANTS

Harrisburg, Pittsburgh and State College, PA
Morgantown, WV • Hagerstown, MD • Hunt Valley, MD
Phone (800) 892-6532 or (717) 232-0593
www.skellyloy.com
"We Serve the Mining Industry Worldwide"

We re-manufacture Clarkson Knifegate valves

We have a large inventory of
Clarkson cores in stock to
meet our customers' needs.

K&M Industrial Valve Supply

www.kandmvalves.com Tel : 218-827-3455



ENGINEERING A BETTER WAY

When the job is important,
you wouldn't turn to a team
you can't trust. Lets get
started.



ST. LOUIS, MO | SHERIDAN, WY
CHARLOTTE, NC | TROY, IL
www.cdgenr.com

FLSMIDTH MINERALS TESTING AND RESEARCH CENTER

Dawson Metallurgical & Process Development Testing,
Ore Characterization & Process Mineralogy Labs

Precious Metals • Base Metals • Industrial Minerals

7158 S. FLSmidth Drive • Midvale, UT 84047 • USA
Tel: +1 801-871-7000 • Email: lab.slc@flsmidth.com

D'APPOLONIA

Engineering for the Mining Industry

Geotechnical
Water Resources
Regulatory Compliance
Construction Monitoring
Coal Refuse Disposal Permitting

Engineers • Consultants • Managers

800.856.9440
www.dappolonia.com



SGR
SUBHORIZON GEOLOGIC RESOURCES

Subhorizon Geologic Resources Geological Consulting Solutions

www.subhorizonresources.com

- Geologic Exploration & Mapping
- Economic Evaluation of Mineral Resources/Reserves
- Slope Stability Determinations
- Petrographic Services

Pennsylvania: 570.798.7824
North Carolina: 336.416.3656



Slurry Pumps made in USA
sales@splitvane.com
ph 360.988.6058

Slurry Pump Refurbishment & Testing to
Hydraulic Institute Standards

www.splitvane.com

Sacrison Engineering



Mining - Geological - Hydrological - Environmental - Maintenance

Construction Management - Project Management - Engineering

rsacrison@frontiernet.net
www.sacrisonengineering.com

c: 775-397-2683
t: 775-777-7455

ATLAS EQUIPMENT CO.

Slurry Pumps | 866.808.2950
www.atlaseqco.com

Providing products and solutions for severe-duty pump applications for over 10 years. AEC offers Lowest Total Cost Solutions, from small-horsepower dewatering pumps to large installations.

Warman AH Pumps and parts are interchangeable with the Battle Mountain Pump Horizontal fully lined and Vertical Cantilever for harsh abrasive service.



NORTH AMERICA

WORLDWIDE

BENETECH
SAFE MATERIAL HANDLING SOLUTIONS

Reduce Dust, Prevent Spillage, Improve Material Flow, Ensure Compliance



- DUST SUPPRESSION
- TRANSFER CHUTES
- WASHDOWN SYSTEMS
- WET DUST COLLECTION
- CONVEYOR COMPONENTS
- PLANT ASSESSMENTS

+ 1 (630) 844 - 1300
benetechglobal.com

JWRL Geomatics Inc.

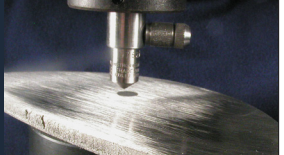
jwrl
GEOMATICS INC.

Providing acoustic and optical televiewer geotechnical interpretation services.

www.jwrl.ca
carol@jwrl.ca

Quality, Experience and Value

SilverLake
ANALYTICAL SERVICES

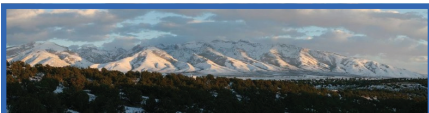


Grinding media... are you getting what you pay for?

It's one of a mine's largest expenses. Don't let poor product hit your budget and production goals. Silver Lake Analytical Services can help you:

1. **Ensure quality** with regular QA testing to catch product variability before it affects consumption
2. **Evaluate potential new suppliers** to avoid surprises and shorten trial time
3. **Analyze breakage** so you understand the why, can respond quickly and get your operation back on track fast

00 1 303 5220412 • @silverlakeAS
www.silverlakeanalytical.com



Independent Reviews | 3rd Party Reviews
Project Lead | Litigation Support

3+ Decades of Experience in
Geotechnical Tailings and Heap Leaching

Bryan Ulrich LLC

Bryan@BryanUlrich.Net
775-934-7581

DARCO ENERGY
MANAGEMENT CORPORATION
(Appraisal of All Mining Assets)

Roger Daugherty, President
Certified Senior Appraiser
Bluffton, SC
606-794-3234
darcoemc@gmail.com



James G. Baughman, PG, RM-SME
Consulting Economic Geologist

Field Work
Gold - Silver - Copper - Uranium
Management

307-392-7129
Denver, CO USA



REDPATH USA CORPORATION
Mining Contractors and Engineers



PROFESSIONAL
FULL-SERVICE
MINING SOLUTIONS.

Consider it done — safely.
redpathmining.com

[f](https://www.facebook.com/redpathmining) [i](https://www.instagram.com/redpathmining) [in](https://www.linkedin.com/company/redpathmining)

**RUGGED
AND
RELIABLE
VALVES**

Download DeZURIK's
Valve Solutions for
Mining Guide



DeZURIK

Find your next valves:
dezurik.com

24/7/365
me.smenet.org

srk consulting

Mine Ventilation Services:

- Mine ventilation surveys and audits
- Operational improvements
- Fire risk analysis and modeling
- Air heating and cooling studies
- Diesel particulate matter analysis
- Prefeasibility and feasibility studies
- Conceptual studies
- Ventilation monitoring system design

Ventilation, climatic, and fire modeling software:
VNet™ | Climsim™ | MineFire™ | DuctSim™

1625 Shaw Ave. Suite 103, Clovis, CA 93611
Tel: 559-452-0182 | Web: www.na.srk.com

Best on Planet
Vibration Stress Relief



- **Prevent Cracking**
(50% or more)
- **Prevent Weld Distortion**
(50% or more)

Sales, Rentals, Leasing, Service

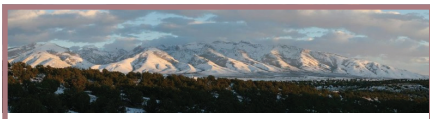
800-Meta-Lax

Bonal Technologies, Inc.
info@bonal.com • www.Bonal.com



Professional Services

WORLDWIDE



INTERNATIONAL
Independent Reviews | 3rd Party Reviews
Project Lead | Litigation Support

3+ Decades of Experience in
 Geotechnical Tailings and Heap Leaching

Bryan Ulrich LLC

Bryan@BryanUlrich.Net
 775-934-7581

**GROUND SUPPORT SYSTEMS
 YOU CAN BUILD ON**

**SUPPLYING MINING
 OPERATIONS
 WORLD WIDE FOR
 56 YEARS**

- GROUT SYSTEMS
- MIXERS
- SHOT-CRETERS
- CONCRETE PUMPS

CON MICO
 High Pressure Systems Technology

www.conmico.com TEL: 1(905) 660-7262



Rubber PLUS

CERTECH^{INC.} USA

ITALY - SPAIN - USA - MEXICO - CANADA

Patented Mill Lining Solutions,
 Parts & Installation



in

CERTECH^{INC.} USA
 www.certechusa.com



**We help clients
 succeed and
 communities thrive.**


synTerra

GREENVILLE, SC | BIRMINGHAM, AL
 CARY, NC | CHARLOTTE, NC
 LEXINGTON, KY | PIKEVILLE, KY

859.233.2103 | synterracorp.com

Science & Engineering Consultants

NEED EQUIPMENT FAST?
 NEW, SURPLUS, REFURBISHED, USED
 LARGE INVENTORY
 CRUSH | GRIND | PROCESS | ELECTRICAL

CALL US TODAY
+1-360-734-1046

INFO@DANGELOINTERNATIONAL.COM
 WWW.DANGELOINTERNATIONAL.COM

 **D'ANGELO
 INTERNATIONAL**

BIRD SEISMIC SERVICES

Serving your needs for seismic and
 geophysical exploration since 1991.
 We have the tools, knowledge
 and expertise for the best quality
 seismic data. Flexible and
 innovative, we are here for you.

Bird Seismic Services
 Globe, Arizona
 928.719.1848

birdseismic.com



EA&G
 1920

MINING CONSULTANTS

Eavenson, Auchmuty & Greenwald

724.942.5894
WWW.EAGMC1920.COM

CALL & NICHOLAS, INC.

Rock Slope Geological
 Mechanics Stability Engineering

2475 N. Coyote Drive (520) 670-9774
 Tucson, AZ 85745 Fax: (520) 670-9251
 email: cni@cinitucson.com
 Website: www.cinitucson.com


I2M
 Associates, LLC

Geoscience, Engineering & Environmental Services
 Mineral Exploration, Mine Permitting,
 Mining Operations, & Closure

www.I2MAssociates.com
 Seattle, Houston, and wherever we need to be in the world.

WORLDWIDE

RSV
USA Consulting Inc
Consulting Engineers and Project Managers
Mine Hoisting and Shaft Systems Design and Operations SPECIALISTS
CONTACT: JACKIE BOYD 604 763-4437
MATHEW WATT 520 391-0502
ALBERT WESSELS 351 924 216 976

John T. Boyd Company
mining and geological consultants
Pittsburgh Denver Brisbane Beijing Bogota
jtboyd.com

bc
birak consulting
www.birakconsulting.com
Email: djbirak1@outlook.com
Mobile: +1.208.699.4015
Donald J. Birak
Geologist
Regis. Mem. SME, Fellow AusIMM
Experience Integrity Reliability Innovation

TRUSTED
— SINCE 1979 —
GEOKON
TRUSTED MEASUREMENTS®
Producing
Quality Geotechnical
Instrumentation
Since 1979
www.geokon.biz/mining
GEOKON | Lebanon, NH, USA
+1.603.448.1562 | info@geokon.com

World-Class
SAFETY LEADERSHIP
Over the last two decades, Balmert Consulting has taught safety leadership practices - what to do, and how to do that - to more than 10,000 leaders the world over, in a multitude of industries, in 17 languages.
Now you can experience it for yourself. In-person or virtual options available. You may qualify to attend as a guest.
For more information:
www.balmert.com
281.359.7234 or 307.680.4359
BALMERT CONSULTING

QSP
Est. May 2005
Continuing to provide ...
Quality, Service & Price!
QSP Packers, LLC
Serving Your Complete Packer Needs
♦ INFLATABLE PACKERS
Pressure Grout, Wireline, Environmental, Water Well. Custom Sizes & Fabrication Available.
♦ MECHANICAL PACKERS
Freeze Plugs, Custom Applications
Call **QSP** with all your Packer questions!!
Phone: 253-770-0315
Email: info@QSPPackers.com
www.QSPPackers.com

MINE ISOLATION & VENTILATION DOORS
Luvan Group
ISOLATION GATE VENTILATION DOOR
UNDERGROUND MINE
sales@luvan-group.com
www.luvan-group.com

Agapito Associates, Inc.
Mining and Civil Engineers and Geologists
Serving the minerals and underground construction industries worldwide since 1978
Grand Junction, CO • Lakewood, CO
(970) 242-4220
www.agapito.com

KCA
Kappes, Cassiday & Associates
Specialists in the Testing and Field Application of Heap Leach and Cyanide Technology
Since 1972
7950 Security Circle, Reno, NV 89506
Phone: (775) 972-7575
Fax: (775) 972-4567
www.kcareno.com
e-mail: kca@kcareno.com



Professional Services

WORLDWIDE

SlideMinder Call & Nicholas
INSTRUMENTS

**Remote Wireline Extensometer
Slope Monitoring & Warning System**



- SLOPE MOVEMENT ANALYSIS
- REAL-TIME MEASUREMENTS
- RELIABLE
- AUTOMATED WARNINGS & ALARMS
- MINIMAL SITE PREP
- MODULAR & SCALABLE
- PRECIPITATION MEASUREMENT

www.slideminder.com 2475 N. Coyote Drive, Tucson, AZ 85745
Phone: (520) 670-9774 Fax: (520) 670-9251

INDEPENDENT
MINING CONSULTANTS, INC.

**Mine Design, Planning & Evaluation
Technical Reporting Documents
Feasibility Studies
Scheduling & Strategic Planning
Advisory of Expansions/Acquisitions**

www.imctucson.com
Tel: +1 (520) 294-9861

**World's Leader in Underground
Grouting Equipment**

Cable & Rock Bolts
Void Fillings
Waterproofing
Shaft Sealing



ChemGrout
THE INDUSTRY'S CHOICE SINCE 1963
708.354.7112
www.chemgrout.com

DSI SNAKE
www.dossantosintl.com

**DOS SANTOS
INTERNATIONAL**
Materials Handling & Engineering Specialists

- High Angle Conveyors • Overland Conveyors
- Expert Consulting • ExConTec Conveyor Analysis
- Rigging, Reeving & Hoisting

531 Roselane St NW, Ste 810
Marietta, GA 30060 USA
+1 770 423 9895 - office
info@dossantosintl.com • www.dossantosintl.com

US EPA permitting challenge
Great tailings design
\$6 million less in bond costs

Think of the savings. Visit: srk.com

srk consulting
resourceful | experienced | worldwide

POCOCK INDUSTRIAL, INC.
SPECIALISTS IN SOLIDS / LIQUID SEPARATION
CONSULTING • TESTING • EQUIPMENT DESIGN

INTERNATIONALLY RECOGNIZED EXPERTS IN:

- Gravity Sedimentation (Thickening & Clarification)
- Filtration (Pressure and Vacuum Applications)
- Rheological Properties Measurement
- Solids/Liquid Separation Systems Optimization
- Selection & Sizing for Solids/Liquid Separation Equipment
- On-site Troubleshooting and Process Consulting
- Water Treatment Applications/Flowsheet Development
- Precipitation Processes & High-Density Sludge Generation
- High-Density/Paste Design & Application
- Reagent Screening & Evaluation
- Piloting to Aid in Improvement of SLS Characteristics

6188 South 300 West
Salt Lake City, Utah 84107, USA
(801) 265-9000
Cell (801) 703-8055
www.pocockindustrial.com

AUTOMATIC STRUCTURE DESIGN SOFTWARE

OPTIMIZES buildings, structures and material handling systems at first client/investor meetings.

COMPUTE command adds UBC codes, unit costs, client's business or mine plan.

DISPLAY includes COST and RETURN ON INVESTMENT. Speed enables client to participate, modify and make optimized RISK based GO NO GO decisions in minutes.

Videos & free downloads at:

www.beltconveyor.com
www.winbuildit.com



me.smenet.org



Index of Display Advertisers

Index of Display **Advertisers**

MARCH 2022

Evonik Corporation	12
Sandvik Mining & Rock Technology	21
SME - Calender Ad	13
SME - Career Center	01
SME - Colorado MPD	70
SME - MME Call for Papers	09
SME - MN Conference	05
SME - PMM Book	07
SME - RaSiM Conference	03
SME - SME Foundation	11
SME - Tailings Book	Inside Front Cover
SRK Consulting	15
VEGA Americas, Inc.	Inside Back Cover
Weir Minerals	Outside Back Cover

Mining engineering®

OFFICIAL PUBLICATION OF SME

Business Office

12999 E. Adam Aircraft Circle
Englewood, CO 80112 USA
Main Tel: 1.303.948.4200
1.800.763.3132
Fax: 1.303.973.3845
www.miningengineeringmagazine.com

Advertising Manager

Gary Garvey
garvey@smenet.org

Sales Offices

Hooper Jones
Central, NW U.S.
1.847.486.1021
Cell: 1.847.903.1853
Fax: 1.847.486.1025
hooperhja@aol.com

Laura Lemos
East, South, West U.S.
Cell: 1.973.668.2449
Main: 1.973.822.9274
laura@boja.com

Darren Dunay
Canada
1.201.781.6133
Cell: 1.201.873.0891
sme@dunayassociates.com

Eberhard G. Heuser
Europe
+49 202 2838128
Fax: +49 202 2838126
egh@heusermedia.com

Patrick Connolly
United Kingdom
+44 1702.477341
Fax: +44 1702.477559
patco44uk@aol.com

Gary Garvey
International Sales
1.303.948.4243
Fax: 1.303.973.3845
garvey@smenet.org



Tailings management handbook published by SME



William Gleason
Editor

More than 100 authors contributed

It wasn't too many years ago that the issue of tailings management was rarely in the spotlight within the mining industry or beyond. A few well-publicized disasters at tailing facilities in Brazil and Canada, including the 2019 failure at the Córrego do Feijão Dam near Brumadinho Brazil that killed at least 270 people changed that. Suddenly the entire world was taking note of tailings. The high-profile incidents like that in Brumadinho, the Samarco Fundão failure in Brazil in 2015 and at the Mount Polley Mine in Canada in 2014 eroded the public's trust in the mining industry and served as a catalyst toward making change.

Kimberly Finke Morrison, senior director, global tailings management, Newmont Corp. and chair of SME's Tailings and Mine Waste Committee had been in Brazil for business not related to the Córrego do Feijão Dam and had visited the area near the mine just days before the tragedy happened. In fact, the dam failed while she was flying home to Colorado where she was greeted with a number of messages about the incident.

Morrison is a global leader in tailings management and the news of the failure at Córrego do Feijão hit close to home.

"The human, social and environmental elements of tailings management did not get the attention they deserve until then," Morrison told me. "That failure that killed 270 people really started to highlight the importance of recognizing the communities near these operations and the downstream impacts. It has pushed operators to really think about what does the ALARP (as low as reasonably practicable) principal mean and how do I apply that?"

For Morrison, one of the answers to that question was to develop a comprehensive handbook to help educate others on the best practices in order to avoid such incidents.

Morrison is the editor of the "Tailings Management Handbook; A life-cycle approach." This handbook was developed by SME in partnership with Newmont and includes contributions from more than 100 experts in the field and an additional 40 reviewers.

When I asked her what motivated her to take

on such a large effort she explained that she, and others, saw a need for the book and that the timing was right to create it.

"Technology has advanced and things have changed. Our understanding of tailings has changed," she said. "With the Global Industry Standard on Tailings Management that was published in 2020 there has been a significant shift in the industry from a governance perspective as well as a continued push in the other areas such as improved technology. It became clear that no one had taken the time to really put together a comprehensive resource on tailings management. The handbooks that had been developed in the past were very focused on the geotechnical element of tailings management. But tailings management is truly a cross-functional and multidisciplinary field and because of that it was important to pull together numerous functions and experts for this resource. This handbook includes the geotechnical aspects, and so much more. There are chapters on environmental permitting, site selection, how to run a project, risk assessment, how to operate a facility, emergency response ... it covers all aspects of tailings and waste management."

The book weighs in at about four pounds and is more than 1,000 pages. Morrison pulled this all together in less than two years. To call it a Herculean task underestimates the strength of Hercules.

Like many who have focused their careers on tailings and waste management, Morrison operated for much of her career away from the spotlight, and at the back end of the mining process. But now, she is one of the global leaders working to make improvements in the field.

"Tailings had always been in the background, even within SME," said Morrison. "The home for tailings professionals was in the Environmental Division but even there it was somewhat hidden, which is how the Tailings and Mine Waste Committee came about. SME recognized that this very important component of the mining life cycle was missing and created a committee to address it."

The new handbook, along with work to create a web portal dedicated to tailings management are huge steps in the right direction to make information available to anyone who desires to learn more.

"Tailings Management Handbook; A life-cycle approach" (2022) 1,024 pages, is now available from SME at smenet.org/store. ■



Tunneling & Underground Construction

The Official Publication of UCA of SME

www.TUCmagazine.com

Volume 16 NO. 1 March 2022



Tunnel rehabilitation
Technical advances
Cutting Edge recap

All New

Business Profiles

Inside!

Special Editorial Supplement from the publisher of

Mining
engineering

METRO LOS ANGELES, USA

SUCCESS STORY IN CALIFORNIA WITH 10 TBMS

120 million passengers are travelling through Los Angeles every year. In the past 15 years a total of 10 EPB Shields have been built for more than 35 km of new metro lines. Herrenknecht guarantees the local support with their office in Sumner, WA.

› herrenknecht.com/MetroLA

Client:

› Los Angeles Metropolitan Transportation Authority

Customer:

- › Purple Line Section 3 – Frontier-Kemper Constructors, Inc. / Tutor Perini JV
- › Purple Line Section 2 – Frontier-Kemper Constructors, Inc.
- › Purple Line Section 1 – Skanska / Traylor / J.F. Shea JV
- › Regional Connector Transit Corridor - Regional Connector Constructors (Skanska / Traylor JV)
- › Crenshaw/LAX Transit Corridor – Walsh / Shea Corridor Constructors
- › Gold Line Eastside Extension – Traylor Bros., Inc.

**PIONEERING
UNDERGROUND
TOGETHER**

HERRENKNECHT



Tunnelling Systems

Departments

4
Chair's column

6
Underground
construction news

25
UCA News

27
Business Profiles

70
Tunnel demand
forecast

72
Classifieds

Cover Story



In This Issue

In this issue the rehabilitation of the Tuscarora Tunnel is examined in detail. The current \$110 million repair effort seeks to modernize the tunnels, improve safety and extend the structure's design life, see page 12. In Dallas, TX, the tunnel boring machine named Big Tex is boring the Dallas Mill Creek Drainage Relief Tunnel, an 8.4 km (5 mile) tunnel that will provide 100-year flood protection, page 16.

Feature Articles



12 Rehabilitation of the Tuscarora Tunnel

*Thomas Martin, Thomas Leckrone
and James Stump*



16 Utilizing the TBM, Big Tex for the Dallas Mill Creek drainage relief tunnel

*Paul J. Smith, J. Milton Brooks,
Quan D. Tran and Eudomar A.
Silva*



23 Advances in tunneling technology discussed at Cutting Edge Conference in Dallas, TX

Nancy Profera

tucmagazine.com

AN OFFICIAL PUBLICATION OF UCA OF SME | WWW.SMENET.ORG | VOLUME 15 NO. 4 | DECEMBER 2021

Copyright 2021 by the Society for Mining, Metallurgy and Exploration, Inc. All rights reserved. TUNNELING & UNDERGROUND CONSTRUCTION (ISSN 0026-5187) is published quarterly by the Society for Mining, Metallurgy, and Exploration, Inc., at 12999 E. Adam Aircraft Circle, Englewood, CO 80112-4167. Phone 1-800-763-3132 or 303-973-9550. Fax: 303-973-3845 or e-mail: sme@smenet.org. Website: www.smenet.org. **POSTMASTER:** Send changes of address to TUNNELING & UNDERGROUND CONSTRUCTION, 12999 E. Adam Aircraft Circle, Englewood, CO 80112-4167. Article copies and back issues available on microfilm or microfiche from Linda Hall Library in Kansas City, Mo. Printed by Publication Printers.

Reproduction: More than one photocopy of an item from SME may be made for internal use, provided fees are paid directly to the Copyright Clearance Center, 27 Congress St., Salem, MA 01970, USA. Phone 978-750-8400, fax 978-750-4470. Any other form of reproduction requires special permission from, and may be subject to fees by SME. SME is not responsible for any statements made or opinions expressed in its publications. Member subscription rate included in dues.

Special editorial section
from the publisher of
Mining Engineering

Mining
engineering



East Link Extension
Bellevue, Washington
Role: Design Services

Beyond Tunnel

Delivering innovative and inclusive solutions for our cities and communities.

HNTB experts have the insight and knowledge to provide innovative solutions on a wide range of tunnels, including cut-and-cover, tunnel boring machine tunnels, conventional tunneling, NATM, immersed tube tunnels, shaft construction and micro-tunneling. Our long history in planning, program management, design, construction management and technical services for tunnel structures includes award-winning projects on some of the country's most complex tunneling projects to help communities connect.



Vision

Sanja Zlatanic

Chair, National Tunnel Practice
szlatanic@hntb.com
(646) 652-9440

Mark Stephani

National Tunnel Practice Lead – Central
mstephani@hntb.com
(917) 334-2731

Raymond Sandiford

National Tunnel Practice Lead – East
rsandiford@hntb.com
(917) 710-3395

Mike Wongkaew

National Tunnel Practice Lead – West
mwongkaew@hntb.com
(425) 389-2281



The HNTB Companies
Infrastructure Solutions

hntb.com



Who needs to know about tunnels and underground infrastructure?

The short answer is: Everyone. The benefits that tunnels and underground infrastructure bring to people the world over are indisputable. Those of us in the industry know that our solutions in terms of performance, environmental standards and economics are the right ones in a long-term context and that they deliver huge value, whether transportation, water, sewer or other applications. The industry is growing globally at a compound annual growth rate of around 10 percent for a reason ... the world needs tunnels and tunnels are a good investment.

This is what the UCA calls stakeholder awareness, one of our three key strategic objectives. And, while the public-at-large is a stakeholder, as referenced in the first paragraph, is it realistic to target our UCA efforts to that group? Probably not. We need instead to focus on the decision-makers who make infrastructural investments – owner organizations, legislators – and get the message to them to help ensure that they have all the facts at their disposal when they make their decisions for or against underground investment. This is a strategic “must do” for our association, and we are focusing a variety of efforts in this regard.

Moussa Wone, of DC Water, one of our executive committee members, has recently taken up the leadership of the Owners’ Forum. The intent here is to give focus to the folks who commission the building of, and own and operate tunnels. This focus now extends beyond one meeting a year at a conference and, despite challenging time schedules, moves forward on a variety of fronts. We look to grow participation on this team. Owners: Moussa wants you.

I hope that you took notice in the Dec. 2021 issue of *T&UC* that we have now published a “Tunnel Project Watch List,” which highlights

20 active projects and 20 projects needing to be built, to draw attention to what our industry is doing and what, in the near future, our society needs us to do. This UCA program now slots under the auspices of the Owners’ Forum, with the intent that the list will be reviewed and published annually. It is a tool to reference and be used with stakeholders.

We have begun discussions around an “educate the owner/legislator” initiative. This is envisaged to be something akin to the “teach the professors” program I referenced in my last column. It is a way to get the right tools and information onto the hands of those who can make a difference. It’s understood that it is sometimes difficult for owners to get to our conferences and access content and contacts. So, if we can’t get the owners to the conference perhaps we can still get the information from the conference to them. We’re looking to build a package of information that can be sent to owners, to give them facts and figures about tunnels, so that they can have a fully formed picture when it comes time to decide. Down the road, we also hope to identify a “task force” of individuals who could travel to owners and be a resource during that period when options are being weighed.

On the subject of legislators, I’d like to share with you a recent anecdote. Dave Klug, of Klug & Associates, a former UCA Chair himself, had a serendipitous meeting at a charity event he sponsors. At dinner, he sat beside a senior staffer of Sen. Joe Manchin (D-WV). She showed great interest in his involvement in underground infrastructure work in the United States. This led to a request for a follow-up visit which he and Jon Klug, a current UCA Executive

(continued on page 9)

EDITORIAL STAFF

Editor

William Gleason
gleason@smenet.org

Associate Editor

Nancy Profera
profera@smenet.org

Production Graphic Artist

Ted Robertson
robertson@smenet.org

BUSINESS STAFF

Media Manager

Advertising
Gary Garvey
garvey@smenet.org

Phone +1-800-763-3132 or +1-303-973-4200

Fax +1-303-973-3845

Internet www.smenet.org

SOCIETY FOR MINING, METALLURGY, AND EXPLORATION, INC. OFFICERS

President

Ronald Parratt

President-Elect

K, Marc LeVier

Past President

William Edgerton

Executive Director

David L. Kanagy

Underground Construction

Association of SME

Executive Committee

Mike Rispin (Chair), Erika Moonin (Vice Chair) Robert Goodfellow (Past Chair), Shane Yanagisawa, Robert Robinson, Michael Vitale, Tony O'Donnell, Paul Schmall, Michael Bruen, Mark Johnson, Leon Jacobs, Jonathan Klug, Sarah Wilson, Matthew Preedy, Mike Mooney, Douglas Gabriel, Moussa Wone, John Huh and Grover Vargas.

Make an Exciting Career Move with the **UCA Career Center**

Search a dedicated career resource specific to the underground construction industry.



The UCA Career Center connects you with employers actively looking for professionals in the tunneling and underground construction industry.

Interested in posting a job or internship opportunity and connecting with the talented UCA membership?

Learn more at uca.careerwebsite.com or contact Laura Nelson at nelson@smenet.org.

Visit tunnelingjobs.org to:

- ▶ Create a job seeker profile
- ▶ Post a resume
- ▶ Apply for jobs
- ▶ Get job flash emails



Underground
Construction
Association

New rating clears way for Hudson Tunnel

The U.S. Federal Transit Administration (FTA) upgraded the long-awaited, planned \$10 billion Hudson Tunnels project's rating to medium-high, thus making it eligible to receive federal funding.

The project was given lower ratings during the Trump administration which clashed with the states of New York and New Jersey over the financial commitment of each entity.

Under an understanding reached during the administration of former President Barack Obama, the states had agreed to split half the cost of the tunnel, using federal loans to be paid back over decades, with federal grants accounting for the other half.

Under former President Donald Trump, the FTA said states weren't allowed to use federal loans as part of their funding match to get the federal grants. That policy was rescinded by the administration of current President Joe Biden, the *Associated Press* reported.

Funding for the tunnel will come out of money earmarked for rail projects in the recently passed \$1 trillion infrastructure bill.

In a statement, the Gateway

Development Commission, which is overseeing the project, said, "Along with the more than \$6 billion commitment from New York and New Jersey, and the \$1.4 billion that Amtrak has pledged, today's action moves us a big step closer to a true Federal-local partnership that finally brings 21st-century rail infrastructure to the heart of the nation's economy."

The existing tunnel beneath the Hudson River is more than 110 years old and prone to problems and delays due to crumbling walls and aging signals and wiring. Saltwater intrusion from Superstorm Sandy in 2012 accelerated the tunnel's deterioration and forced Amtrak, which owns the tunnel, to embark on costly repairs to keep it functioning reliably.

Hundreds of trains and hundreds of thousands of passengers per day pass through the tunnel during normal times, and delays can ripple up and down the East Coast between Boston and Washington. Once primary construction begins, the new tunnel could take as long as seven years to complete.

Under the Gateway project, the new tunnel would be built parallel to

the existing tunnel. Once completed, the existing tunnel would be taken out of service for a complete overhaul, estimated to take as long as two years.

Among other large-scale rail improvements in the region are the replacement of a century-old rail bridge in New Jersey that has been a regular source of delays; tunnels connecting the Long Island Rail Road to Grand Central Terminal, scheduled to open this year; and the transformation and eventual expansion of the aging and unsightly Penn Station in midtown Manhattan.

"As a major component of the Gateway Program, the Hudson Tunnel Project will improve commuter safety, help address the myriad of delays that impact the entire Northeast Corridor, and increase our nation's economic competitiveness," said Sen. Corey Booker. "For years, I have worked with colleagues on both sides of the aisle to ensure this vital infrastructure project gets the federal investment it deserves and am glad to see this announcement from the FTA which will allow construction to commence and create jobs for our state's residents." ■

Los Angeles rail line receives approval

Transportation officials in Los Angeles, CA approved an \$8.5 billion, 31-km (19.3-mile) light rail line project that will include 3.7 km (2.3 miles) of underground tunneling. The line will serve largely working-class Latino communities in southeast Los Angeles County, and the officials agreed to look for ways to speed up the project slated for completion in 2043.

The *Los Angeles Times* reported that the line runs from Artesia northwest to Union Station, cutting through the cities of Cerritos, Bellflower, Paramount, Downey, South Gate, Cudahy, Bell, Huntington Park and Vernon. It would provide key connections to other lines, helping build out a rail system

decades in the making.

The costs of the project is \$8.5 billion and is more than double the original estimate. The Metropolitan Transportation Authority decided to construct the project in two segments.

Local leaders have complained about the long wait for rail service.

The rail line was part of Los Angeles Mayor Eric Garcetti's plan to build 28 transit projects by the 2028 Olympics.

The first 23.8-km (14.8-mile) phase runs from Artesia along a former Pacific Electric right of way to Slauson Avenue and Long Beach Boulevard, where it would connect with the A (formerly Blue) line. Groundbreaking for the \$4.9-billion phase is slated for next year and

completion about 10 years later.

The second phase heads north 7.2 km (4.5 miles) from the Slauson depot to Union Station and is set to be completed by 2043. About half of the line is planned to run underground through Little Tokyo, where Metro construction disrupted businesses for years and tunneling is driving up costs.

The Metro board unanimously approved a plan that will look at cheaper alternatives to tunneling that could accelerate construction for the second phase. In an hours-long public comment period, dozens of elected officials representing the communities along the rail line pleaded with the board to speed up

(continued on page 7)

Aecon awarded contract for Annacis project

Aecon Group Inc. announced that Traylor-Aecon General Partnership, a consortium comprised of Aecon (40 percent) and Traylor Bros Inc. (60 percent) has been awarded a \$288 million contract by Metro Vancouver (Greater Vancouver Water District) for the Annacis Water Supply Tunnel, Fraser River Crossing project in British Columbia. Aecon's share of the contract will be added to its construction segment backlog in the first quarter of 2022.

The scope of work includes the construction of two deep vertical shafts, one on each side of the Fraser River, connected by a 2,350-m (7,710-ft) tunnel between New Westminster and Surrey, as well as the installation of a watermain, valve chambers and surface piping. Construction is expected to commence in the first quarter of 2022, with anticipated completion in the second quarter of 2027.

"This complex, multi-year project further strengthens our diverse backlog in Western Canada and demonstrates our position as the partner-of-choice in the civil construction market for tunnelling and water infrastructure projects," said Jean-Louis Servranckx, president and chief executive officer, Aecon Group Inc. "This project will ensure the sustainable, reliable supply of

clean drinking water for growing communities. As we continue to execute the Second Narrows Water Supply Tunnel project with Traylor, we are pleased to strengthen our partnership and further our relationship with Metro Vancouver."

The tunnel will be one of five

new water supply tunnel crossings in the region built to withstand a major earthquake. Once complete, the new tunnel will be connected to the region's drinking water system and will help ensure the continued, reliable delivery of clean, safe drinking water in a growing region. ■

LA rail line

(continued from page 6)
the timeline.

The rail line was a cornerstone of Measure M, a \$120-billion half-cent sales tax approved by voters in 2016, which gained widespread support among elected officials in the region. Along with Measure R, approved in 2008, the tax fueled a rail construction boom.

Metro plans to tap \$3.1 billion in federal funds and an additional \$850 million in state funds for the first leg of the rail line. ■



DEPARTMENT OF PUBLIC UTILITIES

LEGAL NOTICE

Capital Improvements Project No. 650033-100002 BIG WALNUT SANITARY TRUNK EXTENSION, PHASE 2

SCOPE: The project consists of the construction of approximately 12,350 linear feet of 72-inch diameter sanitary sewer (fiberglass reinforced polymer mortar) via an open face tunnel boring machine through shale rock, full face conditions. Construction also includes two (2) shafts to be constructed using secant piles; two (2) intermediate shafts and two (2) hydraulic drop structures to be constructed by drilling. The project will include ancillary work at the shaft sites as shown on the detailed drawings, as specified in the contract specifications, and the City of Columbus Construction and Material Specifications as set forth in this Invitation For Bid (IFB).

BID OPENING: Bids will only be received electronically by the Department of Public Utilities of the City of Columbus, Ohio, via Bid Express (www.bidexpress.com). No public bid openings will be held pursuant to Columbus City Code Chapter 3219.18.

PROCUREMENT OF DOCUMENTS: Bidding Documents, including the Invitation for Bid, Drawings, and Technical Specifications will be available as separate documents at Bid Express (www.bidexpress.com) in March 2022.

CLASSIFICATION: This project has been selected for financial assistance from the Ohio EPA's Water Pollution Control Loan Fund (WPCLF) Program. For this reason, Federal Davis-Bacon Wage Rates and Requirements will apply. A ten percent (10%) proposal guarantee is required for this bid, and a one hundred percent (100%) performance and payment bond will be required for the making of a contract.

PREQUALIFICATION REQUIREMENTS: Pursuant to Columbus City Code Section 329.20(c), the bidder must demonstrate that it has satisfied the City's construction pre-qualification requirements. Contact the Pre-Qualification Office at (614) 645-0359 or <http://www.columbus.gov/prequalification.aspx> if you are unsure about your construction pre-qualification status.

For additional information concerning this bid, including procedures for obtaining a copy of the bidding documents and how to submit a proposal, you must go to the City of Columbus Vendor Services web page (<http://vendors.columbus.gov/sites/public>), and view this bid number in the "Open Requests for Quotations" listing.



Two TBMs arrive at London's HS2 project

The first two Earth pressure balance tunnel boring machines (TBM) arrived on site for the HS2 London Tunnel program. The Herrenknecht TBMs were delivered to HS2's Main Work's Civils Contractor, Skanska Costain STRABAG joint venture (SCS JV).

The start of tunneling works is expected to begin in 2022.

The two machines will be the first of six TBMs that will bore 21 km (13 miles) of twin bored tunnels underneath London where HS2 services will run. They will join eight other machines that will operate on Phase One of the HS2 project between London and the West Midlands, which will dig 103 km (64 miles) of tunnels in total.

Getting the huge pieces of the TBM to site required a huge amount of logistical coordination, with support from the police and National Highways. The largest components of the machines were transported by road from Essex ports on vehicles

that could support the extra wide loads," HS2 reported.

"The HS2 team at West Ruislip have been preparing the site for over two years to ensure it is ready to launch the first two London TBMs in 2022. This will be an exciting step as we begin our four-year program of tunneling under London, showcasing the best of British engineering, and building Britain's newest low carbon transport network."

The two machines have been designed specifically to bore predominantly through Lambeth group (a set of geological rock strata), chalk and London clay, and are automated to install 4,220 tunnel segment rings each, to create each 8 km (5 mile) tunnel.

Around 15 people at a time will operate on each TBM working in shifts, keeping the machines working around the clock for two years, only stopping at Christmas and Easter. A team of approximately 40 people are working to assemble the TBMs,

preparing for the launch in 2022.

"Delivering these huge TBMs to West Ruislip was an enormous logistical challenge involving 260 deliveries, including 110 abnormal loads," said James Richardson, Managing Director of Skanska Costain STRABAG joint venture. "Our team worked tirelessly to deliver these items efficiently, whilst minimizing disruption to our neighbors. All eyes will be on West Ruislip in 2022 as we start to build the London tunnels, reaching depths of 30 m (90 ft) below ground."

As the date for tunneling to begin draws closer, HS2 will be seeking to name each TBM and has already begun that process, working with local schools in Hillingdon where the TBMs will be launched. In early 2022, a shortlisted set of names will be put to a public vote, to help choose the names for HS2's fourth and fifth TBM, after Florence, Cecilia and Dorothy who have already started their journeys underground. ■

Crossover TBM holes through in Chile

A Robbins 4.6 m (15.1 ft) diameter crossover tunnel boring machine (TBM) holed through in the Andes Mountains of Chile in the last quarter of 2021. The XRE TBM bored a 3.3 km (2.1 mi) long tunnel for Chile's Los Condores Hydroelectric Power Project (HEPP) and project owner Enel.

A dedicated team guided the machine to breakthrough in conditions including tuff, sandstone, breccia and conglomerate with sections of high-pressure water inflows. Ground cover reached up to nearly 450 m (1,500 ft) above the tunnel with rock strengths maxing out at 60 MPa UCS.

"Robbins Field Service was an important part of the success of the excavation, evaluating continuous improvements in the machine and correcting faults," said Ricardo Riveros Puratic, project engineer for Enel.

For Riveros Puratic, crossover machines make sense despite the challenging conditions: "Toward the end, [the TBM] exceeded expectations. Crossover TBMs are suitable for Andean geology of sedimentary and volcanic type, where there is a great range of rock strengths and hydrogeological conditions." Maximum advance rates topped out at 605.8 m (1,988 ft) in one month and 212.8 m (698.2 ft) in one week.

The crossover machine featured a heavy duty, centrally mounted screw conveyor for the duration of the drive. The TBM remained in a hard rock configuration with muck chute installed, along with paddles, bucket lips, scrapers and disc cutters on the cutterhead. However, "75 percent of the excavation was performed using the main drive gearboxes in high torque configuration (EPB or low

speed mode). We never physically changed the cutterhead or screw conveyor to EPB mode," said Omar Alvarez, Robbins field service site manager at Los Condores.

High-pressure groundwater inflows were the key challenge of the project. "When we started the excavation, we used dewatering hoses to reduce the water into the cutterhead during the excavation," said Alvarez. Water pressures rose whenever the TBM stopped, however. "During the segment ring installation, we stopped the water from draining through the rear shield drilling ports and we closed the screw conveyor rear gate. We reached 7+ bar in the cutterhead earth sensors."

"We bored in places with 5,500+ l (1,500 gal) /min, making back-fill grout injection behind the concrete

(continued on page 11)

Chair's Column: Growing the workforce

(continued from page 4)

Committee member, undertook, during which they presented, two copies of the History of Tunneling in the U.S. (provided by the UCA) one for the home office and one for the federal office in DC. Now, this was a personal effort which resulted in an industry connection being created with a legislator. Wouldn't it be wonderful if this could be replicated with every legislator? Granted, that is an ambitious vision. However, if we are systematic about it, perhaps it is something that we can build toward.

So, the owners' forum is now discussing an initiative that, at least for the time being, we are calling "50 State Reps." The idea is to

identify at least one individual in a jurisdiction who can become a go-to underground construction resource in-state. At the start, states with vigorous tunneling activity will be a priority ... and we can build from there. From a starting point, we can progress from passive to assertive. The more we can get the right information and expertise about underground construction into the hands and minds of the decision-makers, the better off the future state (no pun intended ... well, maybe a little) can be.

This spring, we will resume our Legislative Fly-In program in conjunction with ASCE. Ten UCA members will attend either in person or virtually for this opportunity which has been conducted very

successfully in the past. Hopefully you saw the call for volunteers and, if you were interested and motivated, you got on the slate.

Other discussions are gestating with respect to how the UCA may make an impact in the arena of government and public affairs. Our country's decision-makers deserve to know as much as they can about tunnels and underground construction and their beneficial impacts to society, so they can make the right long-term decisions which impact a legacy upon their jurisdictions, whether federal, state or municipal. Please stay tuned, and ...

Tunnel on!

Michael Rispin,
UCA Chair



SHARE YOUR PASSION FOR THE INDUSTRY

Get the most out of your Underground Construction Association (UCA) membership by volunteering. While volunteering helps UCA, it also benefits you as a volunteer:

- Get to know other UCA members as you build your professional network.
- Showcase your skills and work style, as you plan and implement activities and projects for UCA members.
- Give back to the underground construction community through UCA's programs and services.

Learn about UCA committees, volunteer opportunities and submit a volunteer interest form at: smenet.org/uca/volunteer-portal

George A. Fox Conference moves to Spring date

The George A Fox Conference, has been rescheduled for May 10, 2022.

The conference with a 21-year tradition in the tunneling and underground construction industry, was scheduled to return to New York City on Jan. 19, however the rapid spread of COVID-19 due to the Omicron variant forced the change in plans. For those who have already registered, your registration will be transferred to May 10. If you have scheduling conflicts with the new date, simply contact SME customer service at 303-948-4200, or by email at cs@smenet.org.

For those who attend the conference in May, they can expect the same high-quality programming. The one-day conference will include project updates, strategies for overcoming challenges and discussions about critical industry issues including workforce challenges and diversity and inclusion. It is also an opportunity for attendees to reconnect with colleagues.

Robert Palermo from GZA is the chair of the 2022 conference. He and the Fox Conference committee has established a fantastic technical agenda that includes a keynote presentation from Nuria Fernandez, Administrator from the U.S. Federal Transit Administration (FTA). Fernandez was confirmed by the U.S.

Senate as the 15th Administrator of FTA. She was previously Deputy Administrator and senior FTA official. With more than 35 years of experience, Fernandez made a name for herself as an inspiring leader in the transportation industry. She came to FTA after serving as general manager and CEO of the Santa Clara Valley Transportation Authority (VTA).

Among the highlights of her tenure at VTA was the completion of the first Bay Area Rapid Transit (BART) heavy rail service into Silicon Valley, a 10-mile, \$3 billion line that opened to passenger service in June 2020. She also received federal approval in 2018 to extend the heavy rail service for another 10 km (6 miles).

Fernandez is also responsible for the creation of VTA's Innovation Center, an incubator to encourage collaboration, test the latest technology, and imagine new ways to keep the valley moving forward by leveraging the expertise of Silicon Valley's high-tech corporations and universities.

"We are very excited for her to speak at the conference," said Palermo. "We feel this is a good way to develop a stronger relationship with the FTA and our members so that both sides and better understand each other. I think both sides, government and industry, will

be able to learn a lot from each other."

The conference will also include the always popular industry update in which projects around the world are discussed as well as two very interesting historical presentations. Angus Gillespie, professor at Rutgers University will speak about the Holland and Lincoln Tunnels and how they were built to cross under the Hudson River and Ed Plotkin will give a history of the conference and a tribute to George Fox. George A. Fox, a leading figure in the construction of Third Water Tunnel in New York. Fox was a civil-engineer who devoted his career to the design and management of major construction projects, including roads, bridges and tunnels. His largest, undertaken by his company in the mid-1970's, was the construction of a 60-mile water tunnel hundreds of feet beneath the city. A brief history about Fox can be found here (<https://www.georgefoxconference.org/index.cfm/why-attend/overview/>)

And a full schedule of events can be found here (<https://www.georgefoxconference.org/index.cfm/conference/agenda/schedule/>)

The in-person conference will be held at the Hilton New York and will adhere to all local and state COVID protocols including proof of vaccination and wearing a mask when in a public setting. ■

Coming Events



**George A. Fox
Conference**

May 10
New York Hilton Midtown,
New York, NY

NAT2022
NORTH AMERICAN
TUNNELING CONFERENCE

June 19-22, 2022
Philadelphia, PA

More information:

Meetings Department, SME, phone 800-763-3132, 303-948-4200, fax 303-979-4361, email sme@smenet.org

Sydney Airport Metro tunneling contract awarded

Sydney Metro has awarded a \$A1.8 billion contract to CPB Contractors and Ghella Joint Venture to excavate 9.8 km (6.1 miles) of dual-bore tunnel as part of the Western Sydney Airport project.

The driverless 23-km (14.2 mile) metro line will link St Marys to the center of the new Aerotropolis via the new Western Sydney International (Nancy-Bird Walton) Airport, with six stations to be built along the alignment.

The contract is split in two sections: the 4.3-km (2.6-mile) northern tunnels run from St Marys to Orchard Hills; and the 5.5-km (3.4-mile) southern section of tunnels runs between the Airport Business Park and the Aerotropolis Station.

The Station Boxes and Tunnelling contract includes: 9.8 km (6.1 miles) of twin rail tunnels in two sections. The 4.3-km (2.6-miles) northern

tunnels run from St Marys to Orchard Hills and the 5.5-km (3.4-mile) southern section of tunnels runs between the Airport Business Park and the Aerotropolis Station as well as excavation and civil works for new stations at St Marys, Orchard Hills, Western Sydney International (Nancy-Bird Walton) Airport, and Aerotropolis. Four hard rock tunnel boring machines (TBM) will build one of the two temporary precast concrete factories for the project on the Western Sydney International site. The project will include more than 67,000 concrete segments to line the twin tunnels and two TBM launch sites at Orchard Hills and Western Sydney International and two TBM retrieval sites at St Marys and Aerotropolis Station.

The first of four TBMs will be in the ground by early 2023 under the terms of the contract. Tunneling is

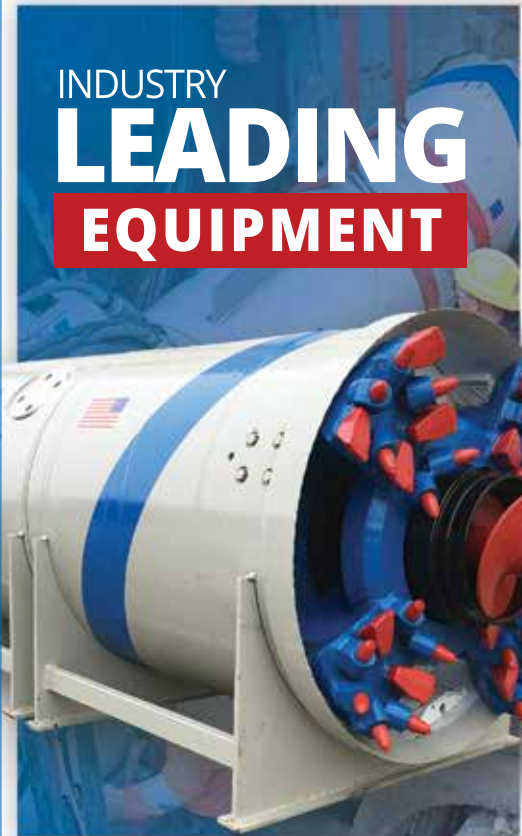
scheduled for completion by late 2024 when fit out will commence. ■

Robbins: Los Condores project

(continued from page 8)

segments a challenge. We decided not to use the grout injection through the tail shield ports, but instead injected grout directly through the concrete segment with hoses. This approach was more flexible and reduced the need for reinjections," said Alvarez.

Once brought online, the Los Condores HEPP, located in the mountainous southern Maule region, will have an annual generating capacity of 150 MW. ■



**INDUSTRY
LEADING
EQUIPMENT**

**AMERICAN MADE PILOT TUBE
MICROTUNNELING
EQUIPMENT SYSTEMS**

- Install Pipe Directly Online And Grade
- Ideal For Manhole-to-Manhole Installations
- Minimizes Shaft Size Requirements
- Install Up To 48-in OD Flush Wall Jacking Pipe
- Ideal For Soft, Displaceable Soils

AMERICAN MADE SINCE 1973





+1 (800) 533.0386



58256 266th Street
Brownsdale, MN USA

AKKERMAN.COM

Rehabilitation of the Tuscarora Tunnel

Repairs are underway at Pennsylvania Turnpike's Tuscarora Mountain Tunnels between the Fort Littleton interchange (Exit 180) and the Willow Hill interchange (Exit 189).

The construction of the eastbound tunnel began in the 1800s for railroad use, but it was never finished. The area was converted to roadway use as part of the original Pennsylvania turnpike construction started in 1940. The westbound tunnel, completed in 1968, increased the flow of traffic along the Pennsylvania Turnpike.

Typical deterioration has resulted in both tunnels experiencing water intrusion. Due to its advanced age and the construction technology available at the time, the eastbound tunnel has more significant systemic leakage throughout the structure than the westbound. The westbound tunnel has less systemic leakage, but locations of significant water leakage are still present, particularly at construction joints.

The current \$110 million repair effort seeks to modernize the tunnels, improve safety and extend the structure's design life. Once nicknamed "Lake Tuscarora" because of the degree of water infiltration, the tunnels will be repaired by multiple methods addressing the different leak regimes.

The westbound tunnel will have drainage installed at each construction joint and all water-bearing cracks will be repaired. An umbrella system to convey water into the tunnels' existing drainage systems will be used in the eastbound tunnel.

This article focuses on the eastbound tunnel repairs as they represent the majority of the repair effort.

Design summary

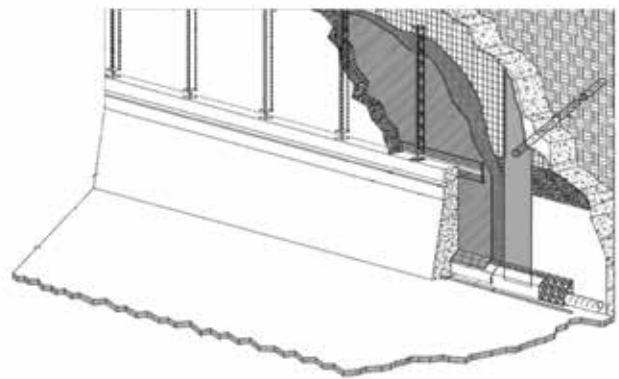
Installation of the umbrella system in the eastbound tunnel will extend the lifetime of the tunnel by 100 years while also significantly reducing the amount of maintenance required. Given the systemic nature of the water infiltration in the tunnel, the repair of each leak individually would lead to chasing leaks throughout the structure. Therefore, a more systemwide solution was chosen.

In this method, water is captured by a waterproofing

membrane and conveyed to the structure's existing drainage system. This eliminates maintenance costs that would occur if more work would be needed to plug new leaks. With this design, only occasional standard maintenance is needed to ensure the drainpipes are flowing properly.

FIG. 1

Typical drainage system isometric view.



The Pennsylvania Turnpike Commission (PTC) tasked Gannett Fleming and subcontractor Gall Zeidler Consultants with developing a design for long-term remediation, with the goal of relieving PTC from excess maintenance costs and extending the life of the tunnel structures.

Therefore, the Tuscarora Tunnel rehabilitation design was developed with the idea that a tunnel with systemic, structure-wide leakage could not be successfully rehabilitated by treating individual leaks. Rather, the structure should be treated wholly by understanding the leakage regime, geology, hydrogeology and maintenance history.

After reviewing these factors, an umbrella system was chosen as the best option to accomplish the goals for the eastbound tunnel. The umbrella system consists of installing a polyvinyl chloride (PVC) waterproofing system on the walls and ceiling of the tunnel. The waterproofing system includes a PVC waterproofing membrane with remediation hoses and PVC water barriers. This system is more resilient than a PVC membrane alone, as it isolates any potential leaks, increasing the ease and effectiveness of a repair. In the event of leakage, the water barriers prevent the PTC from having to chase leaks.

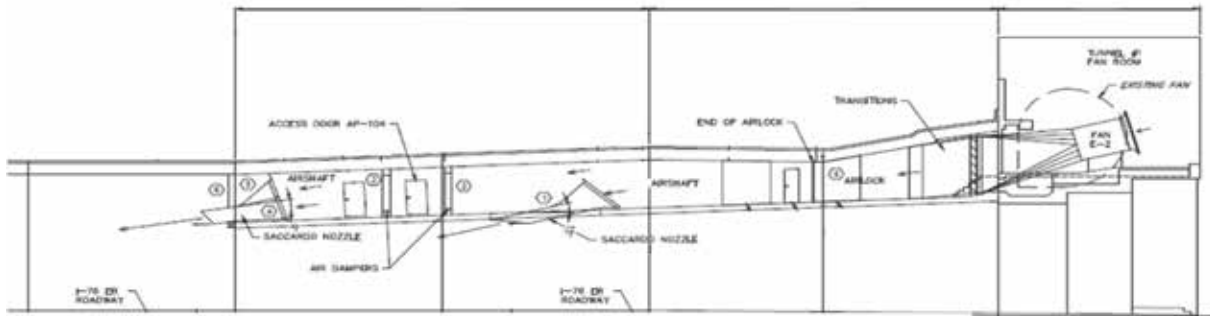
The membrane is welded to a drainage angle installed at the roadway surface, allowing the water to flow through a newly installed porous concrete block

**Thomas Martin, Thomas Leckrone
and James Stump**

Thomas Martin, member UCA, is tunnel engineer, GZ Consultants, Thomas Leckrone is bridge department manager, Gannett Fleming, and James Stump is assistant chief engineer, design, Pennsylvania Turnpike, email office@gzconsultants.com.

FIG. 2

Tunnel 1 East portal section B-B.



into a slotted drainage pipe. This pipe then follows the existing slope of the roadway and is eventually routed to the existing tunnel drainage. New concrete barriers and a self-supporting reinforced shotcrete liner will protect the membrane.

The installation of the umbrella system requires the removal of the tunnel plenum ceiling. Since the existing ventilation design, which requires a plenum the length of the tunnel, would no longer be possible, an alternate design was developed using a Saccardo nozzle, which is a system that introduces a strong jet of air flow into a tunnel from an existing fan room.

To implement this system, the ceiling remained in place for a short portion at each end of the tunnel. Fans and ductwork were designed that would direct the air as needed to create the desired effect. This design decision allowed for the work to progress on the umbrella system.

Given the intricate nature of parts of the design, significant detail was put into the design documents. An embedded channel was designed to support tunnel lighting directly from the lattice girders prior to the shotcrete gaining full strength, and to eliminate the need for hundreds of anchors.

Mounting eyelets were precisely shown on the lattice girder geometry details for easy mounting of the embedded channels. The construction sequencing challenges were also addressed, with membrane protection details developed for lapping lengths that had to be exposed for months given the construction schedule.

Tunnel specific details were also developed for the sectioning, terminations and transitions in the portal sections.

Construction sequencing

Unlike metropolitan tunnels, the Turnpike's tunnels have traffic peaks

on the weekends, and thus construction is limited to weekdays only. Due to the nature of the repairs in the eastbound tunnel, the entire tunnel needed to be closed to ensure safe and efficient working conditions. As a result, traffic in both directions was reduced to one-lane in the westbound tunnel during weekdays. Based on the challenges posed by the eastbound tunnel needing to be open every weekend, it was critical that construction sequencing be well thought out to avoid delays and lessen any impacts to scheduling.

The preliminary step was to demolish the existing tunnel ceiling and sidewall barriers. After the barriers had been demolished, the new drainage system was installed at the base of the walls. Waterproofing was installed over the new drainage system and up to a height of approximately 2.4 m (8 ft). New barriers were then constructed over the waterproofing, measuring

FIG. 3

Eastbound tunnel rehabilitation: Membrane and lattice girder installation.



FIG. 4

New barrier and shotcrete liner over drainage system.



1.5 m (5 ft) high. Metal flashing was installed over the final 1 m (3 ft) to protect the waterproofing, which was not covered by the new barriers. The new barriers were installed on each side of the tunnel prior to moving on to the next phase of construction.

Once the new barriers were in place, the waterproofing membrane was installed radially from barrier to barrier in 9 m (30 ft) panel sections. Following the membrane installation, lattice girders were installed along with the welded wire mesh. Embedded lighting channels were also installed on the lattice girders to allow for easy light installation without installing anchors. A 20 cm (8 in.) shotcrete liner was then installed in 10 cm (4 in.) lifts. This process is currently being completed panel by panel for all 180 panels in the eastbound Tuscarora tunnel.

While it was originally assumed that this phase of work would occur with panels being completed consecutively, that was not ultimately the case. To lessen the impact of waterproofing reinforcement installation and shotcrete operations on each other, the contractor had its crews working at spaced out locations along the tunnel.

Innovations and challenges

Innovations in sequencing: Originally, only limited sections (lapping length of under 0.6 m (2ft) of the waterproofing membrane were to be exposed leading into the weekend of the tunnel opening. However, it was determined that this requirement would make construction difficult, especially on the proposed schedule. The PTC permitted the contractor to leave exposed waterproofing in the eastbound tunnel to ease schedule concerns.

Before shotcrete and the lattice girders are installed, the membrane is carefully inspected for damage. If there is damage that has occurred to the membrane, the area is repaired prior to the work continuing.

In addition to opening every weekend, there had to be contingencies for the tunnel to open as soon as possible for weather or traffic emergencies. If an accident or blockage occurs in the primary transit tunnel, the contractor must be ready to quickly move out of the worksite to allow traffic to flow through the tunnel.

This means that all equipment and supplies must be mobile and ready to clear out of the tunnel within defined time periods set in the contract. Additionally, a minimum shotcrete liner strength is specified prior to opening the tunnel to traffic. It is a cardinal project

FIG. 5

Shotcrete liner installation over welded-wire mesh in tunnel.



goal from the PTC that there is as little inconvenience to drivers as possible.

Optimizing shotcrete means and methods: When construction began, the contractor proposed several alternates to the shotcrete liner installation shown in the design drawings. The design drawing prescribed two 10 cm (4 in.) lifts in both the vertical and overhead applications. The contractor requested that instead of spraying shotcrete through one layer of mesh in 10 cm (4 in.) lifts on the walls, they spray through two layers of mesh in 20-cm (8-in.) lifts on the walls.

After a proof of concept during the construction mock-up phase of the work, it was determined that the contractor could safely spray through two layers of mesh in a 20-cm (8-in.) lift on the walls of the tunnel. With this improvement, additional float was allowed during the weekly construction schedule. This in turn allowed for work to proceed more efficiently without compromising worker safety.

Embedded channels: One major challenge faced during the design phase was how to install lights without having anchors in the new shotcrete liner. A solution was devised to use lattice girders with eyelets to which embedded channels could be affixed. These channels were installed after the first shotcrete lift was sprayed.

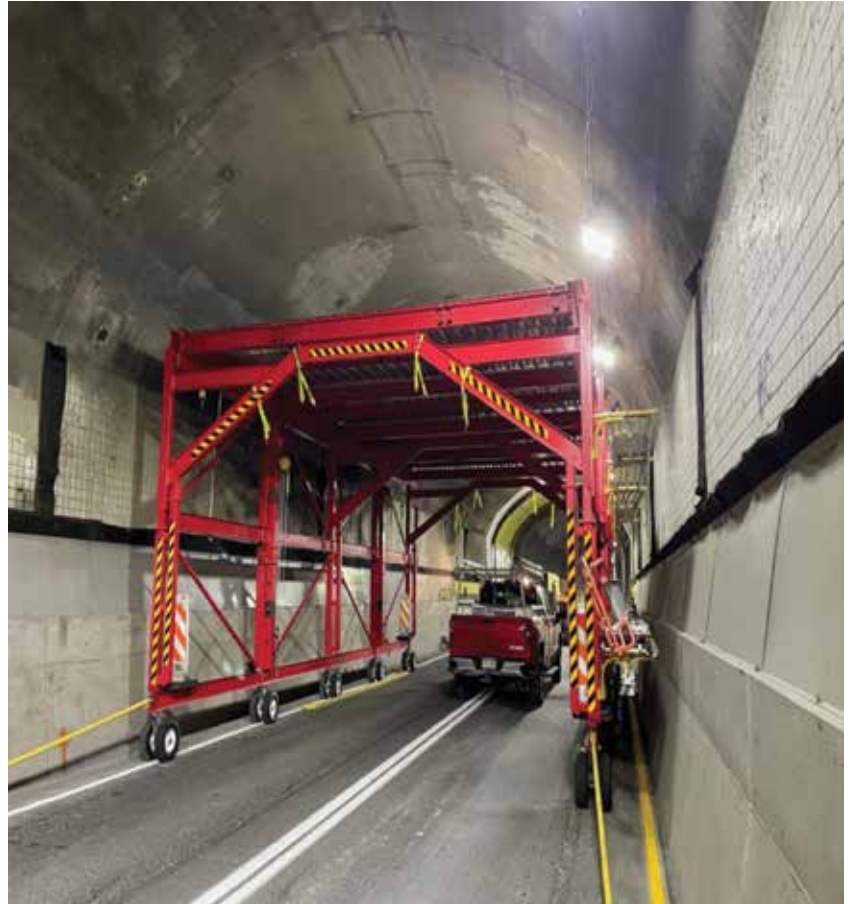
Since the tunnel lights have two points of attachment, two embedded channels had to be installed in parallel wherever lights were planned for installation. The contractor developed an innovative solution whereby the embedded channels were preconnected in parallel with curved steel supports. This allowed for two embedded channels to be connected to the lattice girders as one unit, resulting in easier installation of the embedded channels.

Waterproofing installation means and methods: When the project first began, the waterproofing membrane installation was set by manlifts that raised the membrane into place. This process was tedious as only two manlifts could be operating in one panel at the same time. Additional coordination was required for vehicles or personnel to safely pass under the manlifts while they were in operation.

Custom scaffolding was ordered to allow an entire panel to be scaffolded while vehicles and personnel could pass underneath. This helped to alleviate worksite congestion and make construction more efficient. The

FIG. 6

Mobile custom scaffolding used to install waterproofing membrane.



scaffolding was determined to be much safer to use than the manlifts in the tunnel, as the scaffoldings' fixed structure reduces potential hazards inherent with high variable lifts.

Conclusion

The PTC set out to bring the Tuscarora Tunnels to current design standards and address the leak infiltration problems that had plagued the structures for years. The design team reviewed the existing conditions, evaluated possible remediation options and after consultation with PTC, chose the remediation option that most completely remedied the tunnels going forward.

Collaboration with the contractor before and during construction has allowed this design to come to life more efficiently, meeting an ambitious design schedule and goals while maintaining quality workmanship. With the state-of-the-art umbrella system, the lifespan of the Turnpike tunnels will be extended, and anyone transiting the tunnels will take notice of the effort that has been put into improving these structures. ■

Utilizing the TBM, Big Tex for the Dallas Mill Creek drainage relief tunnel

The Dallas Mill Creek Drainage Relief Tunnel is an 8.4 km (5 mile) tunnel that will provide 100-year flood protection for impacted neighborhoods in the east Dallas area. “Big Tex” is a main beam gripper tunnel boring machine (TBM) capable of changing diameters in mid-tunnel to excavate 2.83 km (9,290 ft) of 11.45 m (37.58 ft) diameter tunnel and 5.21 km (17,095 LF) of 9.93 m (32.58 ft) diameter tunnel. Construction began in April 2018 and is anticipated to be completed in 2024. This article will discuss the challenges and lessons learned during assembly, reassembly, start-up and mining with Big Tex.

FIG. 1

Dallas Mill Creek drainage tunnel alignment.



History and background

The city of Dallas has a long history of severe flooding over the years that has resulted in property damage, injuries and even deaths. Efforts to mitigate the flooding included a series of levees built by the U.S. Army Corps of Engineers in the early 1900s along the Trinity River that evolved into what is today the Dallas floodway.

A 1995 flooding event, caused by a series of heavy rainstorms throughout the Dallas metro area, overwhelmed the storm drains and box culverts installed in the 1930s and 1940s and flooded streets in some areas with up to 3 m (10 feet) of water. This devastating event resulted in the deaths of 15 people, injuries to more than 100 people, and severe damage to hundreds of homes and businesses, including flooding the emergency room of a major hospital in Dallas, Baylor University Medical Center.

Subsequent severe storm events in 2006 and 2007 accelerated the level of planning and design for flood relief using stormwater diversion and conveyance to the Trinity River. The city looked at the drainage areas most impacted by severe flooding and selected the Mill Creek, Peaks Branch, East Peaks Branch, and State Thomas drainage areas for stormwater flood mitigation.

The city and design engineer assigned to the project collaborated to develop and evaluate separate conceptual designs for three of the four drainage areas, but construction costs, environmental impacts, the inconvenience of expected large cut and cover trench construction, various detours and multiple road closures resulted in combining the three separate drainage designs and the State Thomas drainage area into a deep drainage tunnel discharging into White Rock Creek.

After completion of a detailed boring program, the final design resulted in the 8.4 km (5 miles) long Dallas Mill Creek Drainage Relief Tunnel as shown (Fig. 1).

The project

After more than 10 years of planning and design, the Dallas Mill Creek Drainage Relief Tunnel project was finally let out for bid in September 2015 followed by bid openings in December 2015. However, the decision was made to reject all bids due to bid irregularities, revise the plans, revise the bidding process and rebid the project. The city also replaced the construction management firm. The city, design engineer and new construction management firm revised the bid

Paul J. Smith, J. Milton Brooks, Quan D. Tran and Eudomar A. Silva

Paul J. Smith, member UCA, and **Eudomar A. Silva** are construction operations manager and project manager, Black & Veatch, **J. Milton Brooks**, member UCA, is senior engineer, City of Dallas, DWU Stormwater Project Management and **Quan D. Tran** is senior project manager, Southland Holdings, email milton.brooks@dallascityhall.com.

documents and advertised the project in July 2017. The city successfully awarded the Dallas Mill Creek Drainage Relief Tunnel Project to Southland Mole JV (SMJV) in February 2018 and awarded notice to proceed in March 2018.

Outfall shaft site

The outfall shaft is the design discharge point of the Dallas Mill Creek Drainage Tunnel and will be the main working shaft during construction of the tunnel. The outfall shaft site is located at the end of Barber Avenue on property purchased by the City of Dallas (Fig. 2).

Large diameter tunnel and shaft projects typically require large work sites because of the lay down areas required for specialty equipment and to enable room for operations facilities as well as tunnel muck stockpiles and muck handling areas.

To secure the land required for the project, the city purchased as many properties located along Barber Avenue as possible, but not all residents accepted purchase offers. In anticipation of multiple truck loads 12-hours a day on Barber Avenue, the city and design engineer added Barber Avenue street improvements, including utilities and new pavement to the contract.

Challenging muck limitations and handling

SMJV realized the limited size and location of the outfall shaft site would impact TBM production because of muck storage limitations and muck handling and hauling restrictions from 7 a.m. to 7 p.m. due to noise ordinances on city streets.

SMJV proposed changing the location of the muck shaft operation from Site O to a location across Scyene Road (state route 352) approximately 594 m (1,950 ft) up station from the outfall shaft. SMJV negotiated a land use agreement with the property owner of the muck shaft site that resulted in a win-win situation for the city's residential neighborhood along Barber Avenue and Dixon Avenue, and for SMJV, as it would allow SMJV to mine and haul tunnel muck

FIG. 2

Outfall shaft site.



FIGS. 3

Robbins 11.5 m TBM "Big Tex" assembled on the surface.



TABLE 1

Tunnel muck handling, 24 hour and 12 hour.

Item	TBM tunnel reach (metric)		TBM tunnel reach (U.S)	
	Reach	Reach 2	Reach 1	Reach 2
Station	010+71	100+90	010+71	100+90
Station	100+90	271+85	100+90	271+85
Length (L)	2,750	5,212	9,019	17,095
Diameter (L)	11.46	9.93	37.58	32.58
Area (L ²)	103	78	41	31
Volume (L ³ /L)	103	78	41	31
Avg. Prod (L/day)	24	24	80	80
Volume (L ³ /day) 60% swell	4,024	3,025	5,259	3,953
Truck loads (L ³) 24 hr	268	202	263	198
Volume (L ³ /12 hr) 60% swell	2,012	1,512	2,630	1,977
Truck loads (L ³) 12 hr	134	101	131	99

FIG. 4

TBM trailing gantry assembly on rail and slab.



The upper reach is a 9.1 m (30 ft) finished diameter circular tunnel 5,212 m (17,095 ft) long and the lower reach is a 9.1 m × 10.8 m (30 ft × 35.5 ft) finished horseshoe tunnel 2,750 m (9,019 ft) long.

It was thought that the contractor would excavate the complete tunnel with a TBM from the outfall shaft to the Woodall Rodgers intake shaft and then complete the horseshoe tunnel bottom excavation by roadheader or excavator. The horseshoe tunnel liner would require additional concrete forms and multiple diameter placements that would result in increased costs and increased schedule.

TBM assembly and TBM launch

The Robbins Co. (TRC) and SMJV elected to assemble the TBM onsite using TRC's patented onsite first-time assembly delivery method.

24-hours per day.

The proposed change would eliminate heavy truck traffic on residential streets and allowed for hauling muck 24-hours a day, six days a week on a state highway (Table 1).

The Dallas Mill Creek Drainage Relief Tunnel was designed with two different cross-sections to handle peak flows of 424.7 m³/sec (15,000 cu ft/sec) through the upper reach and 566.3 m³/sec (20,000 cu ft/sec) through the lower reach.

FIG. 5

Lowering rear main beam section with grippers and gripper carrier.



- Deliver TBM components and assemble the TBM onsite (Fig. 3).
- Commission, startup and test various systems. Provide "factory" test reports.
- Reassemble the TBM in the starter tunnel, complete final testing and provide final factory test reports.

SMJV installed a reinforced concrete slab system to assist TRC with the TBM onsite assembly and trailing gear on. The 1,133 t (1,115 st)

TBM (cutterhead, cutterhead support, main bearing, mainframe, finger shields, grippers, gripper carrier, gripper feet, etc.) was assembled on a 0.61 m (2 ft) thick 31 MPa (4,500 psi) concrete slab with a double mat of reinforcement.

The four trailing gantries were fully assembled on a 0.3 m (1 ft) thick concrete slab with a single mat of reinforcement and rolled onto an 85 lb. rail that simulated the 2.9 m (9.5 ft) gauge leapfrog rail system for the gantries to roll on during excavation. (Fig. 4).

The various components and pieces of the TBM, including all of the parts for the four gantries, the vertical conveyor system and the continuous horizontal conveyor system began arriving onsite in February 2019.

Delayed delivery of major TBM parts, including the mainframe, grippers, main bearing and cutterhead support, drive motors and cutterhead resulted in significant slippage of the project

FIG. 6
Starter tunnel with curved pocket and gripper walls.

schedule and resequencing of the TBM assembly by TRC and SMJV.

To accelerate the disassembly and reassembly in the starter tunnel, TRC and SMJV used a 653-t (720-st) Manitowoc MLC650 super-lift crane to make eight heavy-lift picks of the TBM and gantries (Fig. 5).

The four TBM heavy picks included the cutterhead at 190.5 t (187.5 st), the cutterhead support with main bearing at 389 t (375 st), the front main beam section at 127 t (125 st) and the rear main beam section with grippers and gripper carrier at 228.6 t (225 st).

The four gantry heavy lifts included each gantry assembled and fully dressed weighing in at an average of 91 t (90 st). Prior to lifting the gantries, all utilities including electric, hydraulics, communications, ventilation ducts, etc. were disconnected. All eight heavy lifts were sequentially lowered down the excavated 14 m (46 ft) diameter outfall shaft and assembled in the 76.2 m (250 ft) long × 12.2 m (40 ft) horseshoe starter tunnel.

The reassembled TBM was moved to the face of the starter tunnel on a curved invert cast in the working slab (Fig. 6) followed by rolling the four gantries on the leapfrog rail system (Fig. 7). The TBM was launched from STA 10+71± after final testing was complete, and the TBM was certified as ready to go and the muck conveyance system was installed.

The muck conveyance system is comprised of seven belt conveyors, an advancing tail piece, and a double-stacked horizontal belt storage unit on its surface.

1. TBM conveyor.
2. Transfer crossover conveyor.
3. Gantry transfer conveyor.
4. Horizontal continuous conveyor.
5. Vertical conveyor.
6. Surface transfer conveyor.
7. Radial stacker conveyor.

SMJV, with TRC on board, advanced the TBM for the first 305 m (1,000 ft) to confirm and verify the capabilities of the TBM per the contract. SMJV continued advancing the TBM and was scheduled to relocate the mucking operation (vertical conveyor and radial stacker conveyor) from the outfall shaft to the muck shaft after reaching STA 30+50±.

In an effort to mitigate project schedule slippage, SMJV and TRC elected



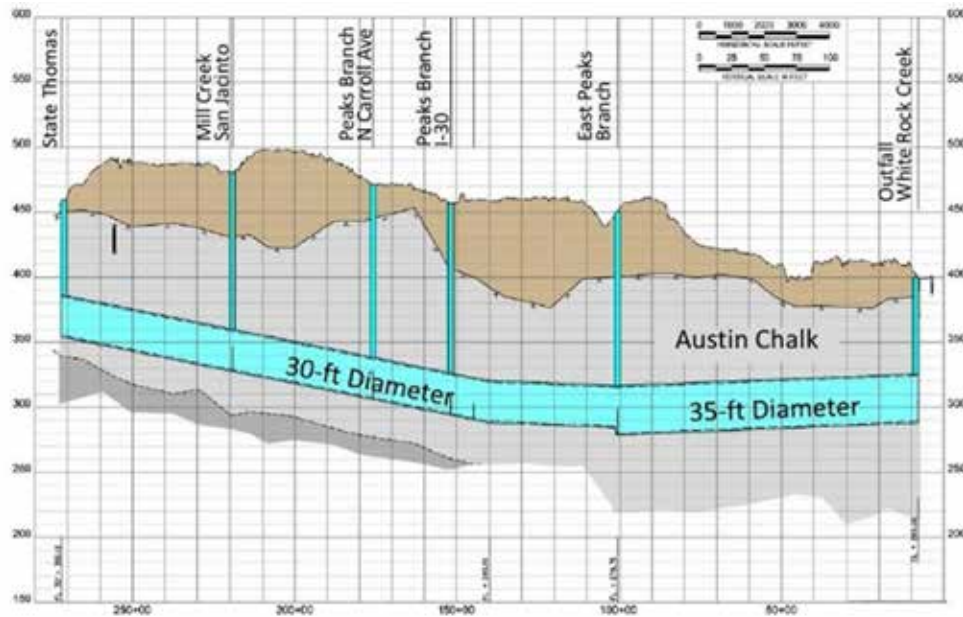
to relocate the mucking operation concurrently during the scheduled TBM cutterhead diameter conversion in late December 2020, however SMJV and TRC reversed their decision and kept the mucking operation at the outfall shaft.

The tunnel is being excavated through Austin Chalk, a geological formation in the Gulf Coast region of the United States made up of weak limestone with an average unconfined compressive strength of 24.8 MPa

FIG. 7
Last gantry in starter tunnel on leapfrog rail.


FIG. 8

Dallas Mill Creek drainage tunnel geotechnical profile.



(3,597 psi) at depths of 33.5 m to 51.7 m (110 ft to 170 ft) below the surface (Fig. 8).

SMJV is using an average TBM production rate of 24.4 m/day (80 ft/day) for the project schedule that is based on previous tunnel projects in the Dallas area that occurred within the same geology. However SMJV has not been able to achieve that production rate. The

excavation will generate 1.15 million m³ (1.5 million cy) of tunnel muck. In an effort to maintain the scheduled advance rate of 24.4 m/day (80 ft/day) and not get muck bound, an average of 230 trailer dump loads per day of muck must be removed from the outfall shaft site.

SMJV has experienced up to 400 trailer dump loads

FIG. 9

Plan and section of cutterhead diameter conversion at lateral A.

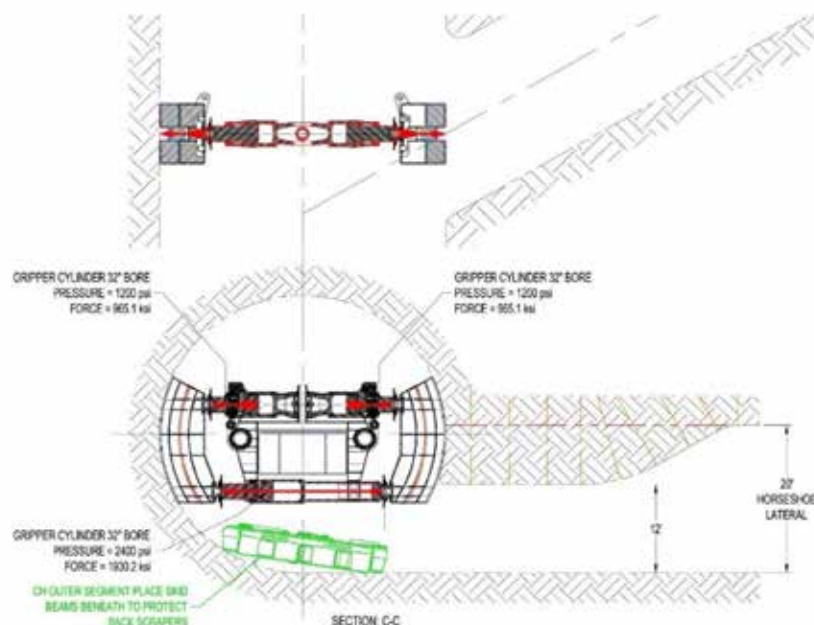
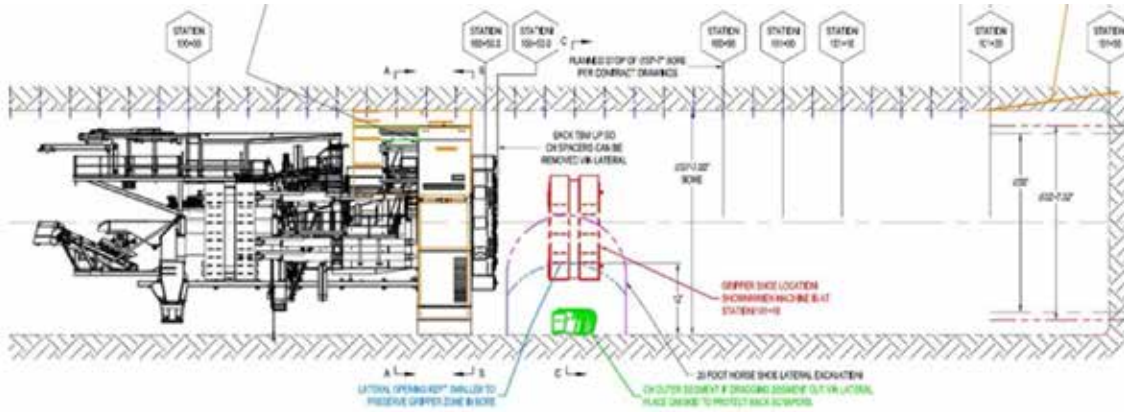


FIG. 10

Section profile of cutterhead diameter conversion at lateral A.



per day. The relocated muck shaft site would have enough surface area available to stockpile up to three days of excavated tunnel muck.

TBM cutterhead diameter conversion in mid-tunnel

To mitigate the extra work, time and cost of the lower reach $9.1 \text{ m} \times 10.8 \text{ m}$ (30 ft $\times$ 35.5 ft) finished horseshoe tunnel, SMJV proposed to change the 2,749 m (9,017 ft) lower reach from the horseshoe tunnel to a 10.7 m (35 ft) finished diameter circular tunnel by using a Robbins hard-rock gripper TBM designed to reduce cutterhead diameters from 11.5 m to 9.9 m (37.6 ft to 32.6 ft) in the tunnel underground at STA 101+55±, the beginning of the lower reach.

The larger diameter cutterhead uses 67 432 mm (17

in.) disk cutters and the reduced diameter cutterhead will use 59 432 mm (17 in.) disk cutters. The end of the lower reach location includes the East Peaks branch intake structure, shaft A, lateral A, lateral P and shaft P.

SMJV and TRC set out to complete the TBM diameter conversion from the larger diameter to the smaller diameter through a sequence developed by SMJV and TRC that included mining to a specific station and sequentially removing (unbolting) the 0.76 m (2.5 ft) cutterhead extensions and the outer cutterhead quadrants while backing the TBM up approximately $31.4 \text{ m} \pm$ (103 ft) to the lateral A transition area at STA 100+52±.

SMJV continued the diameter conversion by cutting (plasma torching) the 0.76 m (2.5 ft) extension outer wraps off the grippers, cutterhead support side

FIG. 11

Cutterhead diameter conversion area.

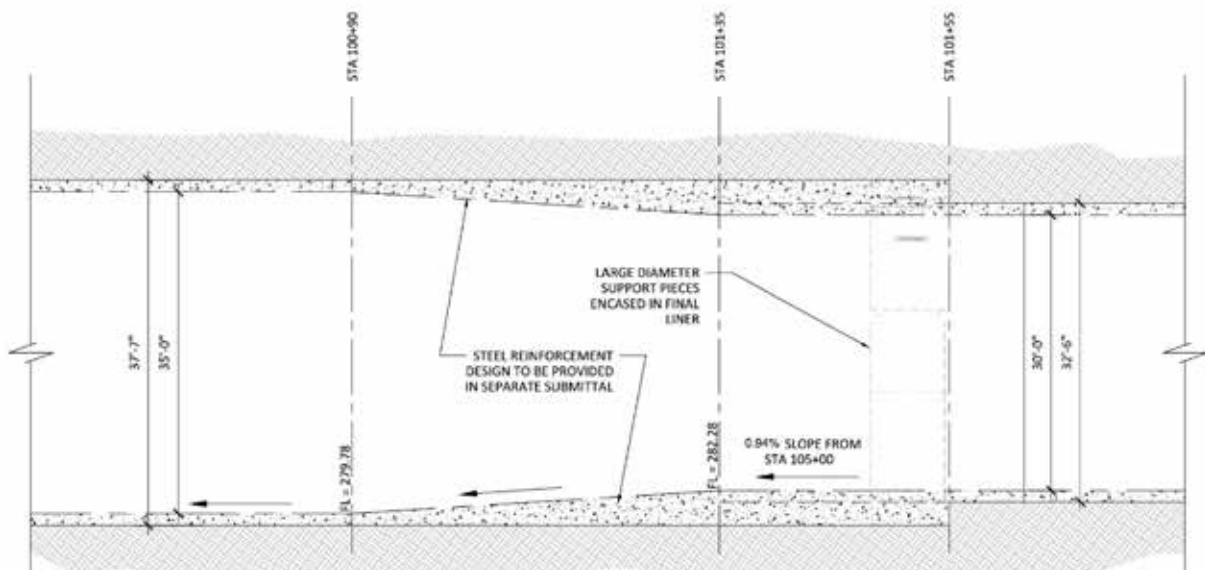


FIG. 12

Dallas Mill Creek Drainage Tunnel mega hard rock TBM "Big Tex"



stabilizers, the three roof finger shields and the rear support (gripper feet).

The 0.76 m (2.5 ft) cutterhead extensions, outer cutterhead quadrants and cut pieces were removed through the 3.7 m (12 ft) horseshoe tunnel extension of lateral A and excavated after the right gripper passed lateral A (Figs. 9 and 10).

The cutterhead extensions, outer cutterhead quadrants and cut pieces were removed through the 91 m (300 ft) long 6.1 m (20 ft) diameter lateral A and out the 6.1 m (20 ft) diameter shaft A. The cutterhead quadrant buckets required additional machine work to meet the smaller diameter.

The TBM was moved forward as the outer cutterhead quadrants were rebolted sequentially to the center section and the leapfrog rail and trailing gantries blocked up to line up with the new diameter. The gripper outer wraps and cutterhead support side stabilizer outer wraps were cut and pinned to the tunnel wall in the 11.5 m (37.6 ft) tunnel prior to the main beam with grippers sliding by.

SMJV resumed mining with the 9.9 m (32.6 ft) diameter TBM on a 1 percent grade to STA 105+00± where the TBM was back on contract grade (Fig. 11).

Shafts, intake structures and dewatering pump station

The drainage tunnel, with a capacity of 605,666 m³ (160 million gal), has six shafts that vary from 3.8 m to 12.2 m (12.5 ft to 40 ft) in diameter and are 33.5 m to 57 m (110 ft to 187 ft) in depth. There are five intake structures that intersect five existing storm

box culverts and will convey stormwater to the tunnel via vortex drop shafts and laterals.

The horseshoe laterals vary from 15.8 m to 149.4 m (52 ft to 490 ft) in length and 3.66 m to 6.1 m (12 ft to 20 ft) in height. There is a dewatering pump station in shaft P at the East Peaks branch intake designed to dewater the tunnel for maintenance and inspection.

The pump station has three submersible pumps with a design capacity of 113.6 m³/min (30,000 gal/min) located in shaft P, the deepest part of the drainage tunnel at 57 m (187 ft) deep.

The pump station is designed to dewater the inverted siphon conveyance tunnel within three to five days during dry periods.

Conclusion

The Dallas Mill Creek Drainage Tunnel will be the largest hard rock gripper TBM tunnel under construction in the Western hemisphere, and possibly the world. There were valuable lessons learned on this project by everyone involved during site mobilization, shaft construction, large diameter TBM assembly, launching the TBM, excavating the Dallas Mill Creek Drainage Tunnel with "Big Tex" (Fig. 12), and preparing for the unique cutterhead diameter conversion in mid-tunnel.

The expected and unexpected challenges encountered during the start-up and production mining of the Dallas Mill Creek Drainage Tunnel were solved by collaboration and communication between the experienced individuals involved with the Dallas Mill Creek Drainage Tunnel team.

The proposed relocation of the muck shaft to accommodate hauling 24-hours per day on a state highway, eliminating the large horseshoe tunnel construction with a round tunnel construction, and the innovative changing TBM cutterhead diameters in mid-tunnel should result in a more efficient excavation operation and should save time on the construction schedule.

The city, construction management team and SMJV were able to work through issues while maintaining an open line of communication that helped keep the project moving forward during difficult times. Many thanks to everyone directly and indirectly involved in this challenging world class project. ■

Advances in tunneling technology discussed at Cutting Edge Conference in Dallas, TX

by Nancy Profera, Associate Editor

The SME and UCA (Underground Construction Association) “Cutting Edge” conference hosted its largest attendance yet with 285 in-person participants meeting in Dallas, TX Nov. 15–17. Attendees came from the United States, Europe, Israel and Canada and included engineers, contractors, project managers and college students. Elisa Comis from McMillen Jacobs Associates chaired the three-day event.

Priscilla Nelson, professor and head of mining engineering at the Colorado School of Mines in Golden, CO was the opening speaker and delivered a keynote address discussing crumbling infrastructure in tunnels, waterways, sewage and drainage systems in the United States and world and ideas on how to address resilience and the underground. Nelson has worked as a program director and senior advisor at the National Science Foundation, as a professor at the University of Texas at Austin, and was formerly provost at the New Jersey Institute of Technology. She is internationally known for her expertise in geological and rock engineering.

Her talk focused on the fact that cities throughout the world are growing in population and that growth is anticipated to continue in the coming years. “Our future is one of population and urban growth worldwide,” said Nelson. “It’ll be interesting to see how people want to live, considering the long-term effects of the pandemic.”

Nelson encouraged the audience to think about the often vast, public and private infrastructure systems that are frequently created independently from one another and in silos in many cities. She explained that many have been created in an uncoordinated manner and need to be considered by engineers in more of a “systems of systems” approach. The complexities and interdependence of waterways, sewage, drainage, electricity and transportation modes need to be looked at more holistically, she said.

“We have to inform the public, professionals and politicians, and provide truths, examples and answers,” said Nelson. She cited natural disasters and the recovery time it took for each including Hurricane Sandy in 2012, Hurricane Katrina in New Orleans in 2005, and the earthquake in Kobe, Japan, in 1995, lessons learned and the necessity of studying what went wrong and how to anticipate for these types of events in the future.

Crumbling infrastructure

There is growing demand for equity in any proposed

A tour of the Mill Creek Tunnel project followed the Cutting Edge Conference. Photo courtesy of Southland Holdings.



infrastructure rebuild efforts of cities. Repairing and replacing water mains, gas pipelines and sewers in places like New York City, where much of the systems are 60 to 100 years old, requires consideration of what neighborhoods are most affected and where the work should be prioritized. According to Nelson, the Federal Emergency Management Agency (FEMA) does not have these potential breakdowns on its list of possible emergencies, though they should be added.

Scott Elmer from the Harris County Flood Control District presented “Going Deep to Reduce Harris County’s Future Flood Risks,” as he represented the city of Dallas’ flood control project, equating the length of it to the driving distance between New York and Los Angeles. Elmer said that historically, people did not think tunnels could be built in this area because of weak soil, yet there are lots of water and waste tunnels in downtown Dallas.

Hurricane Harvey, a devastating Category 4 hurricane that made landfall in Texas and Louisiana in August, 2017, impacted all of Harris County. Tens of thousands of homes were flooded and this generated political support for a bond package that was approved by voters. “Tunnels are one of the ways we’re looking at this differently. We were told to be innovative, and so now we are asking, ‘Can tunnels be built in Harris County?’” said Elmer, adding, “If so, can they move enough water to make a difference?”

The team has created 2D models of the entire county, establishing critical mass areas with consideration of social

equity. They believe the answer is “yes” to the feasibility of the work and have moved on to phase two of the study. “We’re not quite sure where we’re going to build these tunnels—we’ll need all of you engineers and contractors in the future. We’ve got some good projects coming up,” Elmer said to the crowd.

The team considered water quality and sedimentation issues and collected data to look at the watershed and history of flooding in the area over the last 100 years. They also considered how the land was being used.

John Kinnear from Jacobs in Toronto, Canada presented on the London Thames Tideway Tunnel Project. The project involves sewage upgrades necessary because “every time it rains in London, the system goes over and into the river,” said Kinnear. He explained that in London, the river generally drains to the east, and that the Thames water management project is run by a private utility, which is a common practice in England, and in this case, amounts to managing systems worth £4.2 billion pounds (equivalent to \$6 billion U.S.).

Jacobs has developed a reference design for the project and the work is being done as design/build contracts. The Thames is made up of clay to the west and above the river is mixed sand and gravel.

Milton Brooks with the City of Dallas and Paul Smith, Black & Veatch, discussed “Changing TBM Excavation Diameter Mid-Tunnel in Dallas.” When Dallas was founded in the 1920s it was a much smaller city, and as it began to develop, it spread east and north. Brooks shared that deep, underground tunnels have never been built in this city, but the need has become apparent as there is “\$4 billion worth of property to protect in Dallas.”

The city is trying to build an alternative outfall for the current drainage system to reduce possible flooding, moving from a 9.1 to 10.7 m (30 to 35 ft) section. The soil in the build area is made up of soft limestone, is 8 km (5 miles) long, and currently has seven shafts. Completely paid for by the city of Dallas (no federal or state funds), the project is estimated to cost \$210 to \$285 million.

On Wednesday of the conference attendees who had preregistered visited the Mill Creek drainage relief tunnel project site and learned about its design change from a horseshoe to round tunnel design.

Brad Grothen from Robbins presented “The Future is Noncircular: TBM Solutions for Flat Inverts,” and discussed recent advancements in nonround tunnel designs. These include noncircular tunneling and mechanized excavation for soft ground and soft rock. He shared lessons learned from the company’s work at the Fresno Mines in Mexico, where the geology is hard rock.

“Grouting and Greasing in Frozen Ground” was presented by Sean Grant of Traylor Bros. He is a registered civil engineer working in Los Angeles and shared about the company’s recent work experience on a tunnel in Vancouver, Canada. The project was challenging and involved highly variable geology with abrasive ground and rock.

Werner Burger from Herrenknecht discussed TBM

technologies of the future. Burger, a mechanical engineer, said the company is focused on optimizing existing technologies, including those in operator assist systems for slurry and hard rock machines.

Also in attendance and presenting were Mark Stephani of HNTB on the topic of resilience through design, Angel Del Amo of Aldea Services on building tunnels that cross fault lines in Los Angeles, and Mark Funkhauser of McMillen Jacobs Associates on geotechnical considerations and the alignment selection for the lower Olentangy Tunnel in Columbus, OH.

Mike Rispin of Strata Worldwide led a panel discussion on research and development “from idea to implementation.” There was discussion of the typical length of time it takes to complete projects; whether owner, contractor and designer all need to be in alignment for innovation to take place (the consensus was not necessarily); and how to work cheaper and faster. Alternative design and build delivery methods, how to measure innovation and its effects, the increasing cost of projects, inflation, supply chain and labor shortages were all reviewed.

Around the discussion of innovation, Bill Edgerton, SME president, said “we innovate to do things we haven’t done before.”

During the UCA Young Members session, Sean McDonald from Jay Dee discussed next generation technology and climate change. Katherine Westerlund from Mott MacDonald led a carbon portal and building information and modeling (BIM) integration talk, and Rachelle McDowell from Atkinson discussed working through the pandemic on the courthouse commons tunnel in downtown San Diego, California.

Federico Bonaiuti from Lane Construction in Italy presented “3D modeling for Tunnels: A Tool for Inspecting and Foreseeing Construction Activities from Planning to Execution.” McDonald discussed the “Down for That” website and young member development initiatives.

In the afternoon, Sanja Zlatanic and Brandi Crawford of HNTB gave an update on the DART D2 subway project in Dallas using 3D animation to show the progress. The project has brought 150,000 jobs to the area.

Nick Chen from Jacobs discussed the Amtrak East River tunnel reconstruction project. During Superstorm Sandy, four of these train tunnels were flooded. Chen said the reconstruction project involves a “total organ transplant, to use an analogy of the body,” because the tunnel is over 100 years old. One of the tunnels in the project is underwater, and issues like egress from the train to inside parts of the tunnel in case of fire or emergency must be considered. Fire, life safety, ventilation, drainage and building redundancy into the construction methodology are all aspects to be addressed. Chen said that the project schedule is a fast, 16 months and there’s been “lots of knowledge gained and lessons learned.” ■

UCA scholarships open March 1

The UCA is committed to the future of the tunneling and underground construction industries by supporting the next generation of professionals to enter the field. One of the ways in which this goal is accomplished is through the scholarships that are awarded during the summer events. This year, the UCA will host the North American Tunneling Conference June 19–22 in Philadelphia, PA, where three scholarship opportunities are available.

The application process opens on March 1, 2022 and will close on May 1, 2022.

UCA Young Members Scholarship

UCA Young Members Scholarship for the North American Tunneling Conference (NAT) provides selected students with an opportunity to attend conferences where they can experience the challenges, opportunities and rewards of a career in the field of tunneling and underground construction. Each recipient will receive:

- NAT conference registration.
- One-year student membership to UCA.
- An invitation to the UCAYM networking event.
- Round-trip airfare to the conference.
- Hotel accommodations at the

conference hotel.

- Orientation at the conference.
- Conference proceedings.
- Valuable opportunities to network with industry experts and potential employers
- A \$1,000 stipend for miscellaneous cash needs.

UCA and RETC Attendance Scholarship

The UCA and Rapid Excavation and Tunneling Conference (RETC) Attendance Scholarship provides students with an opportunity to attend this conference. Applicants must be full-time freshman, sophomore, junior, senior or graduate students with a designated major in an applicable field of engineering (civil, mechanical, mining, electrical, geological) or construction management. Applicants must have a demonstrated interest in the underground industry. Up to 12 recipients can be selected. Each recipient will receive:

- NAT conference registration.
- Round-trip airfare to the conference.
- Hotel accommodations at the conference hotel.
- Conference proceedings.
- Social function tickets.
- A \$200 stipend for miscellaneous cash needs.

Recipients are responsible for their own ground transportation and for other expenses including meals, other than at social functions.

RETC Executive Committee Scholarship

RETC annually awards one or more scholarships to college students who want to develop their skills in the tunneling industry. The total amount of the award, approximately \$5,000, is apportioned to one or more students at the discretion of the RETC Executive Committee. Each recipient will receive:

- NAT conference registration.
- Round-trip airfare to the conference.
- Hotel accommodations at the conference hotel.
- Conference proceedings.
- Social function tickets.
- A \$200 stipend for miscellaneous cash needs.

The goals of the award are to increase exposure to career opportunities and to provide educational and networking opportunities to future underground industry professionals.

Visit <https://www.smenet.org/uca-of-sme/membership/scholarships> for more information on these awards, including criteria and deadlines for application and instructions on how to apply. ■

WTC moved to September in Copenhagen

The World Tunnel Congress (WTC) that was to be held in Copenhagen from April 22–28 has been moved to Sept. 2–8, 2022 because of ongoing complications associated with the COVID-19 pandemic.

The WTC2022 Organizing Committee and the International Tunneling Association (ITA) announced the conference will remain at Bella Center in Copenhagen.

In a statement, WTC and ITA said the decision was made in a

context of a global health crisis and awareness of the difficulty for many industry professionals at this time to commit to participate in the WTC2022 in April.

“The expectation is, as it was also the case in 2021, that by September the COVID-19 virus will be less virulent and therefore will allow the entire tunnel and underground profession to finally meet and see each other again in good conditions.

“The organizing committee and the 150 exhibitors will look forward

to meeting you all, and we will ensure that the conference will follow any health regulations that may be in force by next September in Denmark, if any,” the statement read.

All ITA activities will also take place between Sept. 2 and 8 such as the general assembly and meetings of the working groups and committees.

The WTC2022 will take place in a hybrid mode (physical and digital). More information is available at <https://wtc2022.dk/> ■

Axel Nitschke

Tunnelling professionals globally are mourning the premature passing of U.S.-based Dr. Axel Nitschke, who died on Dec. 26, 2021. Nitschke was a much-valued contributor to *Tunnels and Tunneling International (T&T)*.

Born in Germany in 1968, Nitschke relocated with his family in 2008 to the United States where he continued his distinguished tunnelling career in earnest. By the time his career tragically ended, he had worked with some of the biggest names in consultancy, leading tunnelling projects in the United States, Canada, South America and Europe.

Throughout his career, Nitschke wrote numerous technical papers, some of which have become standards in the tunnel industry. In the last technical paper he wrote for *Tunnels & Tunneling* (November 2020) he proposed a labelling and classification system designed to provide an effective and easy way to specify FRC for tunnel linings.

Nitschke graduated in 1993 with a master's degree in civil engineer-

ing from Ruhr University, Bochum, Germany and immediately embarked on a Ph.D. there, his thesis focusing on the loadbearing capacity of steel fiber-reinforced concrete in tunnelling. This he successfully completed in 1998. During his time at the university, he was also employed as an assistant professor and chair of construction technology, tunnelling and construction management.

There followed a highly successful career in tunnel design and consultancy in both Germany and subsequently the United States, spanning well-known firms such as IMM, BeMo Tunnelling, Wayss & Freytag, Gall Zeidler, Shannon & Wilson and WSP.

While at Gall Zeidler in Washington, Nitschke was senior tunnel engineer and then vice-president; later at Shannon & Wilson, also in Washington, he was vice president, director of operations for underground services. From October 2015 to January 2021, at the American Shotcrete Association (ASA), he was chair of the underground committee, rising to vice



Axel Nitschke

president of the executive committee. His time at ASA overlapped with some of his other employments.

Nitschke's final role was as vice president and tunnel practice leader (NATM) at global engineering consultancy WSP in Washington, where he had started working in June 2017.

He is survived by his wife, Anke and their four children. ■

Grouting short course returns in August

The 2022 Grouting and Ground Improvement short course at the Colorado School of Mines will take place Aug. 1-4, 2022 at the campus in Golden, CO.

The four-day course covers engineering, equipment, materials and methods for grouting and ground modification used in civil and geotechnical engineering, underground construction, tunneling and mining.

The course combines classroom instruction with hands-on labs and demonstrations, providing par-

ticipants with the opportunity to see grouting and ground improvement field equipment in action including compaction, cellular, chemical and permeation grouting equipment.

The course is intended for industry professionals including owners, planners, designers, contractors, consultants and suppliers involved in the design, planning and construction of civil and geotechnical engineering, underground, tunneling and mining projects.

The Colorado School of Mines

will award 2.4 continuing education credits up successful completion of the course.

The course instructors are Dr. Reza Hedayat of the Colorado School of Mines and Ray Henn of RW Henn, LLC. Bill Warfield is the coordinator for field day demonstrations.

Registration will open March 1. Space is limited and early-bird and group discounts are available through June 20.

For more information visit www.learn.mines.edu/ggi/. ■



Renew your UCA membership today!
<https://www.smenet.org/ucahome>





Underground construction and tunneling history is made by the investment of companies worldwide that dedicate their efforts and vision to the advancement of the industry.

SME and T&UC acknowledge these companies that demonstrate a continued focus on providing the world with the best in underground technology, products and services.

Tunneling & Underground Construction makers of **Underground** history



Rock Splitting Mortar

Dā-mite Fractures Rock and Concrete in No Blast Conditions

Dā-mite aids and accelerates mechanical rock excavation

No fly rock, no vibration, no noise,

Applications: Boulders, mass rock, tunneling, concrete removal

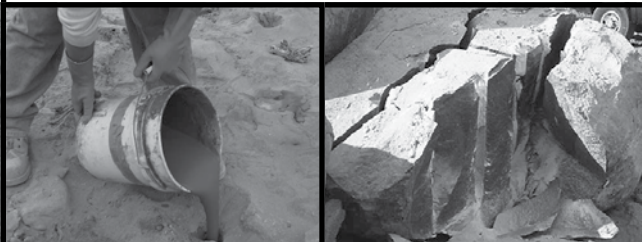
DAIGH COMPANY, INC.

2393 Canton Hwy, Ste 400, Cumming, GA 30040

Office: 770-886-4711, Fax: 770-887-3783

www.daighcompany.com

sales@daighcompany.com



Dā-mite Rock Splitting Mortar from the Daigh Company, Inc.

Daigh Co. is the supplier of Dā-mite Rock Splitting Mortar. Dā-mite is used to fracture rock and concrete in “no-blast” conditions. Dā-mite is an ideal and effective tool for fracturing mass rock, boulders, trench rock, dimensional

stone, concrete and reinforced concrete. “Dā-mite is mixed with water and placed in the appropriately placed predrilled holes, where it sets and expands, fracturing the rock/concrete”. No license required. There are four grades of Dā-mite, providing enough versatility to be utilized in drilled hole diameters from 1 in. to 2 ¾ in.



Daigh Company, Inc.
111 Industrial Park Drive
Cumming, GA 30040
Telephone: +1-770-886-4711
Fax: +1-770-887-3783
Email: sales@daighcompany.com
www.daighcompany.com



HNTB'S TUNNEL VENTILATION AND FIRE LIFE SAFETY TEAM DEMONSTRATES GROWTH

Practice boasts one of the industry's largest and most experienced team of experts, focusing on technical excellence, innovation and quality delivery.

HNTB continues to expand its tunnel ventilation and fire life safety (FLS) practice and team, completing numerous high-profile projects in recent years and becoming a preferred provider of fire and life safety engineering services in North America through sustained growth and a focus on technical excellence, innovation and quality delivery. The team has also spearheaded recent industry efforts to improve infrastructure safety for transit clients across the U.S., promoting the increased resiliency of systems in response to the pandemic, as well as readiness to face possible similar events in the future.

"HNTB is committed to ensuring the infrastructure we design and support is safe, reliable, sustainable and efficient for our clients," said Bernd Hagenah, Ph.D., principal engineer for tunnel ventilation and fire life safety at HNTB. "By growing our technical expert resources on the ventilation and fire life safety team, we demonstrate our commitment to improving safety of road, rail and facility systems and rolling stock including protecting lives in the event of an emergency (for both 'cold incidents'/accidents during operation, or a fire event). National and international experiences of our enhanced team draw the lessons learned from major global projects; the team implements state-of-the-art approach to efficiently resolve most complex issues."

Over the past five years, the company has added professionals from around the world to its ventilation and fire life safety team, including leading experts in engineering, ventilation, fire protection, and rail aerodynamics. The company offers a full and wide range of services, from concept designs, cost benefit analysis for different options, and risk analysis to state-of-the-art modeling processes and simulations; fire protection strategy and evaluation; air quality analysis and environmental impact studies; climate and pressure control; specification of mechanical and fire protection equipment for tender processes; evacuation concepts and modelling; inspection, rehabilitation and restoration; preparation, execution and evaluation of tenders, site supervision, testing and commissioning, and optimization under operation. We provide valuable support to our clients during the whole lifecycle of transportation infrastructure with a holistic approach.

"Ultimately, HNTB's ventilation and fire life safety team ensures that future generations will have safer infrastructure, designed to have a robust and reliable service with minimal operating and maintenance cost and long life span," said Sean Cassidy, HNTB Fellow

and principal engineer, who was engineer of record for design of ventilation and fire life safety systems on SR-99 Alaskan Way Tunnel – the world's second-largest double deck highway tunnel, nearly two miles long, beneath downtown Seattle, which replaced the earthquake-damaged Alaskan Way Viaduct in 2019. "There are a number of examples where team collaboration is key," noted Cassidy, "to overcoming challenges in conceptualizing efficient ventilation, fire detection and suppression systems that would effectively mitigate carbon emissions. Teamwork had brought a major value toward application of cutting-edge technology to control possible fire scenarios and evacuate smoke while allowing people to exit safely."

The ventilation and fire life safety team also has provided infrastructure planning and design for transit agencies such as Sound Transit (Seattle), Bay Area Rapid Transit (San Francisco), St. Louis Metro, Dallas Area Rapid Transit, Massachusetts Bay Transportation Authority (Boston), Los Angeles County Metropolitan Transportation Authority, and New York City Transit Authority, and enabled HNTB's continued expansion into other markets.

"Our national tunnel practice is known nationally and internationally to include the world's leading experts and thought leaders in tunnel ventilation, fire life safety and aerodynamics," said Sanja Zlatanic, PE, HNTB chair national tunnel practice, senior vice president and HNTB Fellow. "Our expertise brings value to every mobility solution including both highway and rail tunnels and stations, as well as to wide range of multi-modal transportation hubs including airports. As tunnel methodology continues to evolve and grow in importance in the U.S. due to increased population migration to cities and a need to minimize surface disturbance and construction impacts on communities, tunnel solutions are becoming broader to include larger tunnel diameters and house transit stations within. Our team had proven that the engineering solutions to resulting complex ventilation and safety solutions need to evolve as well to include RAMS (reliability, availability, maintenance and safety), as a sustainable approach more and more agencies require, as well as consideration of tunnel climate issues for ensuring long-term service life of majority of system components. The team's knowledge and experience in this realm is unique and would bring value to the projects and clients across the nation."

HNTB's Tunnel Ventilation and FLS Technical Leaders



Bernd Hagenah, National Tunnel Practice Consultant

Bernd Hagenah has more than 23 years of experience in tunnel ventilation, climate, aerodynamics and safety and has worked on numerous major international infrastructure projects, including iconic rail tunnel projects such as the Gotthard Base Tunnel, Brenner Base Tunnel, Vienna Metro, Melbourne Metro, Brisbane Metro, highway tunnels in Europe and the French Nuclear Waste Depository (CIGEO). He is a recognized leader in the design of tunnel safety, electromechanical equipment including ventilation systems for underground transit systems, and high-speed rail aerodynamics.



Sean Cassady, Principal Engineer

Sean Cassady has more than 24 years of experience developing creative solutions for tunnel ventilation and FLS systems for enclosed facilities including road/rail tunnels and stations. His specific skill set developing ventilation, fire hazard and energy analysis with numerical modeling and other engineering analysis methods, integrated with practical experience, has been employed in facilities such as the 1.7-mile, 57.5-foot diameter, SR99 stacked highway tunnel in Seattle. Many projects that Sean has worked on such as San Francisco's Muni 3rd Ave Extension and BART San Jose Extension have maximized safety and efficiency based on design approach that emphasizes robust simplicity.



Petr Pospisil, Principal Engineer

Petr Pospisil has worked in the field of tunnel safety and ventilation since 1997, contributing to more than 150 major infrastructure projects worldwide, including the Gotthard Road Tunnel, the Seelisberg Highway Tunnel, Klosters Bypass Tunnel (adjacent to the Sunniberg Bridge), high-speed rail tunnels between Tel Aviv and Jerusalem in Israel, as well as some of the world's longest rail tunnels, the 55km long Brenner Base Tunnel and the 57.5km long Mt. Cenis tunnel on the Lyon-Turin rail line. He has led standards development teams and research projects, and published various books on tunnel ventilation, and risk and safety, focusing on a holistic approach.



Jesse Harder, Senior Supervising Engineer

Jesse Harder has 21 years of experience in the planning, design and commissioning of tunnel ventilation and fixed fire-fighting systems. He has served in key roles supporting both new tunnel construction and tunnel retrofit projects including the Marmaray Tunnel, BART San Francisco International Airport Extension, BART Transbay Tube, Caltrans Caldecott Tunnel, Sound Transit North Link and East Link Extensions, and the Midtown Tunnel. He has a proven record of design leadership and technical expertise in the areas of fire hazard analysis, emergency egress, tunnel safety, maintenance and operations.



The HNTB Companies
Infrastructure Solutions

hntb.com



© 2022 HNTB Companies. All rights reserved.
Reproduction in whole or in part without
written permission is prohibited.

ANTRAQUIP CORPORATION – your reliable, innovative partner

Antraquip Corporation continues to solidify its position as a leading designer, manufacturer and supplier of roadheaders, hydraulic rock cutting attachments, shaft sinkers, specialty tracked machines with a variety of boom options as well as ground support solutions for NATM tunnels.

Within Antraquip's rock cutting attachment product line, Antraquip has introduced diamond and carbide saw attachments for excavators ranging from 1 to 60 tons. Additionally, Antraquip has designed and manufactures the world's most powerful rock cutting attachment with 400 kW+ cutting power for excavators in the 80+ ton weight class. By continuing to invest heavily into research and development Antraquip strives to be able to cut hard rock which has previously not been possible with mechanized excavation methods.

As to roadheaders, Antraquip offers not only standard roadheaders in the 12 – 85 t on class but is proud to offer project oriented engineering solutions whenever requested and necessary. Some of the recent projects have included AQM roadheaders equipped with customized drilling attachments, fully automated remote control systems and automated guidance systems.

Within its ground control program, Antraquip specializes in any support product needed for NATM as well as drill and blast tunnels like lattice girders, steel ribs, specialized rock bolts, spiles, wire mesh and arch canopy systems (barrel vault system or arch pipe system).

In addition to offering project consultations, innovative cutting and support solutions, Antraquip recognizes the importance of after sales service. This commitment to offering the best service and technical support is carried out by highly proficient and experienced service engineers and technicians, all reinforced with large spare part inventories at hand. Innovation, reliability and experience offered by Antraquip makes them a reliable partner for any tunneling project.

Antraquip's main goal is: SAFETY, SAFETY and again SAFETY! Antraquip continues to strive to offer innovative products to make any job safer, faster and increase the bottom line for any contractor and owner.

Antraquip is well represented all over the world, but takes pride in paying detailed attention to any local tunneling challenge small or large.

IN THE FUTURE, THE WORLD WILL NEED MORE AND MORE TUNNELS – AND ANTRAQUIP INTENDS TO BE AN IMPORTANT, RELIABLE PARTNER FOR ANY UNDERGROUND PROJECT!



AQ6 Hydraulic Cutting Attachment



AQC180 on CAT336



Photo credit-Catherine Bassetti Photography



ANTRAQUIP[®] CORP

Experienced, Innovative & Reliable

YOUR PARTNER FOR PERFORMANCE

DRUM CUTTER
ATTACHMENTS

ROADHEADERS
13 - 85 TONS

THE ULTIMATE CHOICE FOR TUNNELING APPLICATIONS!

ROADHEADERS • ROCK AND CONCRETE CUTTERS • SCALING ATTACHMENTS • TUNNEL / GROUND SUPPORT SYSTEMS



Proudly Made in the USA from Domestic Steel

GROUND SUPPORT PRODUCTS

LATTICE GIRDERS • ARCH CANOPY SYSTEM • PIPE ROOF SYSTEM
SPILES & ROCK BOLTS • STEEL RIBS & MORE

antraquip.net | info@antraquip.net | 301.665.1165

ANTRAQUIP[®] CORP

PROVIDING INNOVATIVE SOLUTIONS FOR TUNNELING, SCALING, TRENCHING, & SOIL REMEDIATION PROJECTS

Demanding Conditions, Demand JENNMAR

We are a diversified manufacturer and services provider for above and below ground infrastructure that sets standards in terms of quality and safety for our stakeholders. Our mission is total customer support and satisfaction.

Our portfolio of brands are rebuilding America's infrastructure. Because we understand the ever changing and demanding conditions above and below ground we have built the richest portfolio of diverse and complementary brands. From engineering to resin manufacturing, rolled-steel and drill-steel manufacturing, custom steel fabrication, precision wear parts, tools and bits, chemical roof support and sealing products, staffing solutions, transportation and more – we ensure the customer has the support at every stage of their projects. Visit our brands at www.jennmar.com, www.xcaltools.com, or www.xcalindustries.com

JENNMAR continues to grow, but our focus will always be on the customer. We feel it is essential to develop a close working relationship with every customer so we can understand their unique challenges and ensure superior customer service. Our commitment to the customer is guided by three words: SAFETY, SERVICE, and INNOVATION. It's these words that form the foundation of our business. It's who we are.

JENNMAR Civil, a brand of JENNMAR has been working on some exciting projects over the past year. See photos and description below:

JENNMAR
258 Kappa Drive
Pittsburgh, PA 15238 USA
Phone: +1-412-963-9071
Web: www.jennmar.com



JENNMAR Civil and Specialty are excited to be a part of such an impressive job. Twelve miles of tunnel ribs and shaft rings. Great job everyone! #civilengineering #infrastructure #tunneling



JENNMAR Civil & Specialty Products are in GA with Garney/Bradshaw Construction for re-alignment of a gravity sewer line. This elliptical design is supported with JENNMAR shaft rings and ConTech liner plate. Great work! #civilengineering #infrastructure #manufacturing

SAFETY, SERVICE, AND INNOVATION



DEMANDING CONDITIONS
**DEMAND
JENNMAR.**

JENNMAR Civil offers a wide range of products used in supporting, building and rebuilding our infrastructure from above and below ground. Our strength lies in our ability to offer our customers solutions in every phase of their projects. We manufacture arch systems, girders, liner plates and Impact Resistant Laggings® and much more for your projects. Whether mining, rehabbing or re-supporting transportation, water, wastewater or infrastructure tunnels, Jennmar Civil is backed by experienced engineers and technicians who are with you every step of the way, from initial consultation to qualified instruction and on-going technical support to make your project a success!

GLOBAL HEADQUARTERS • (412)-963-9071 • PITTSBURGH, PA USA • WWW.JENNMAR.COM

For more information on our portfolio of diverse and complementary brands visit us at www.jennmar.com.

MAPEI Corporation

MAPEI's Underground Technology Team (UTT) provides the construction market with a range of products dedicated to underground construction work. MAPEI's UTT group and the products it represents were created to meet the expectations of these challenging environments. From the project specification to the admixtures for shotcrete and concrete to the final protective coatings, MAPEI's UTT group and technology are there "for the whole job," said Cristina Onate, PhD, UTT Business Development Manager — Tunneling.

The UTT group is a successful division of MAPEI Group, which has provided proven construction system solutions for more than 80 years. Established in 1937, MAPEI Group is a global corporation, based in Milan, Italy, and with 90 subsidiaries that include 83 plants in 36 countries. MAPEI is the

world-leading manufacturer of mortars, grouts and adhesives, as well as complementary products for installing floor and wall coverings. MAPEI manufactures chemical products for building, including waterproofing products, admixtures for concrete and repair products, and decorative and protective exterior coatings — as well as the UTT product line.

"The UTT group started in earnest in the U.S. in 2015," stated James Pinkley, Country Manager UTT — North America. "But the business has grown substantially since then." In the underground industry, speed is essential — not only of the products themselves, but also of the evolution of technology. MAPEI reinvests a considerable percentage of its annual profits back into research and development to maintain a leading technological advantage. MAPEI's commitment to R&D ensures that the UTT line comprises the most innovative and technologically advanced products available. In addition to the latest in cutting-edge products, the UTT team is trained in their use, with decades of experience in the underground marketplace.

The UTT product line is divided into six categories: Mechanized Tunneling; Injections for Heavy Civil and Mining Applications; Waterproofing & Water Membranes; Shotcrete Products; Renovation, maintenance and repair; and Coatings for underground construction. No matter the division or the product line, MAPEI is known for quality products and for providing system solutions. As Pinkley stated, "The distinguishing point for UTT is our field support, and our applied technology in the field. Simply put, we don't just sell a product, but rather we go into the field and help our customers use our products — on their jobsite, with their conditions, personnel and equipment. MAPEI UTT services a project from the very beginning to the very end like no one else in the industry does," he said. "UTT also has the agility to adjust to the customers' needs when necessary per the demands of changing geological settings"

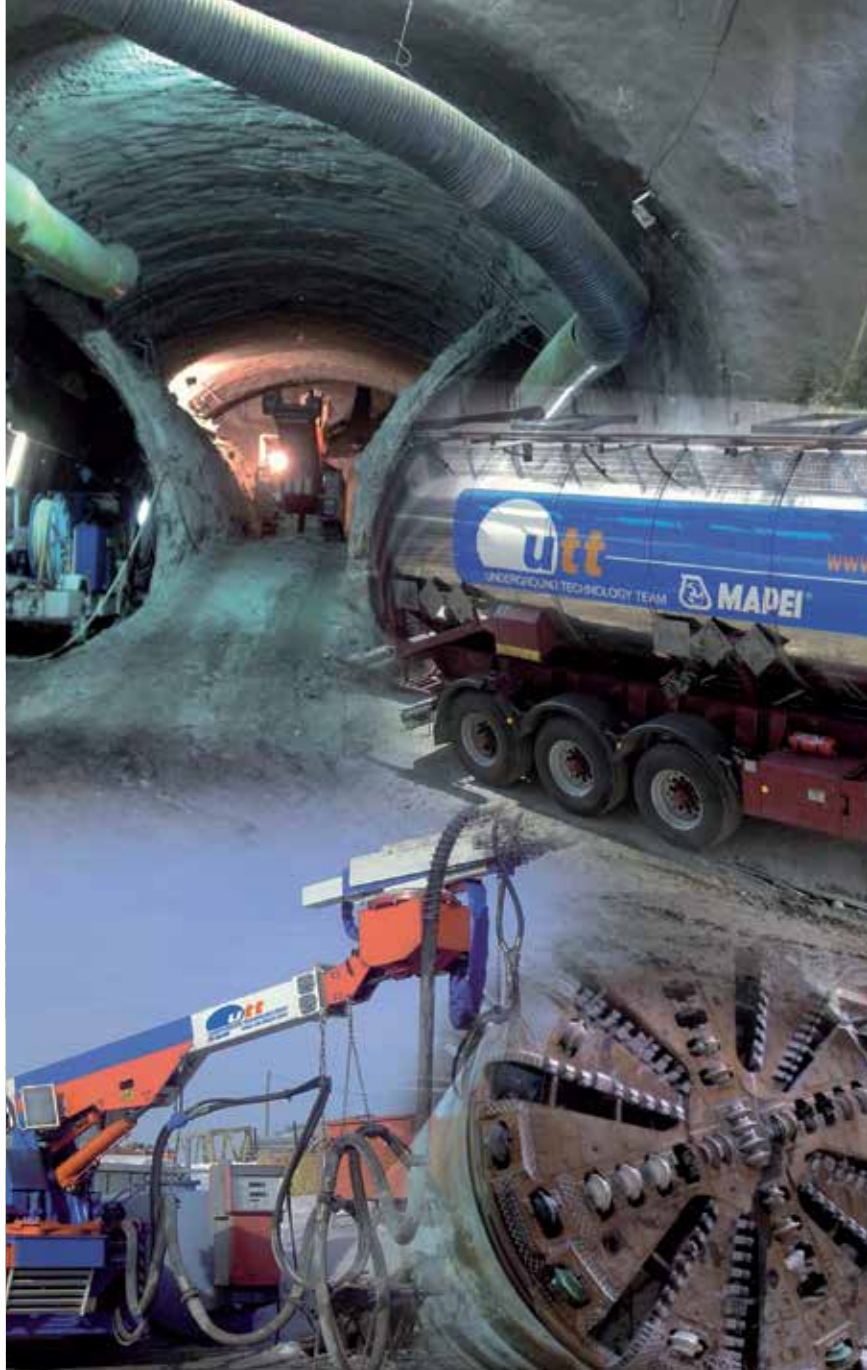
For more information, contact MAPEI's UTT group at www.utt.mapei.com.



MAPEI's UTT products were used to help a tunnel boring machine dig the Anacostia River Tunnel, which extends for 2.37 miles from Robert F. Kennedy Stadium in northeast Washington, D.C., to Poplar Point in southeast D.C.



Proven Technology for **Underground Construction**



Our commitment is the detail that makes the difference.

Reliable technology and expertise for underground construction

- Alkali-free set accelerators and admixtures for shotcrete
- Products for mechanized tunneling: foaming agents for soil conditioning, polymers, sealants and lubricants
- Products for grouting and consolidation
- Products for concrete repairing, protection and coating
- Products for waterproofing: synthetic waterproofing membranes and waterproofing accessories

Discover the world of MAPEI: Visit www.utt-mapei.com or email us at hq.utt@utt.mapei.com



Reliable Automatic Sprinkler Co., Inc.

Protecting the 'New M4' East Tunnel

About the Tunnel

The 'New M4' East (M4E) tunnel project is located in the inner west of Sydney, Australia. The M4E tunnel is a twin tube design of 3 lanes in both directions. Each tube is 5.5 km (3.4 miles) in length. Therefore, the project has approximately 11 km (6.8 miles) of tunnels in total. The tunnels are divided into 517 fire deluge zones along the entire length, including the covered entry & exit ramps. Each fire deluge zone is approximately 30 meters (98 ft) long. The tunnel is equipped with fibre optic detection that signals a central monitoring station. Each deluge zone is monitored by operators and manually activated.

When the specifications for the project were being developed, the design brief called for "an extended coverage nozzle that could effectively deliver 10 mm/min (0.25 gpm) density". At the time, no such product was commercially available. In response to this requirement, the Reliable® model TNL280 nozzle was developed.

About Deluge Systems

Deluge systems consist of water supply, a valve, a system of piping and nozzles that are open to atmosphere, and a means of detection and actuation. When the deluge valve is activated, water flows through all nozzles controlled by the valve. Unlike automatic sprinkler systems, where water flows only through individual sprinklers that have activated close to the heat source, deluge systems are designed to "surround and drown" an entire zone to prevent the spread of fire in hazardous environments.

About the TNL280 Nozzle

The Reliable TNL280 pendent nozzle has been specifically designed to provide an extended coverage nozzle suitable for use in vehicle tunnels. Key to the design of the nozzle is a very large K-factor (orifice size). The large nozzle coverage area typically results in lower installed costs by reducing the amount of material (pipe and hangers) and facilitates faster installation. By comparison, traditional tunnel nozzles — usually spaced at around 9 m² (97 ft²) — are much more material and labour intensive.

Project Quick Facts:

- Consulting Engineer: Norman Disney Young (NDY)
- Site Engineer: Jessica Keogh
- Number of Deluge Systems: 417
- Tunnel height: 5.3m (17.4 ft)

Learn More:

Reliable Automatic Sprinkler Co., Inc. is a manufacturer and distributor of fire protection equipment. Reliable manufactures the highest quality and most innovative fire sprinklers, valves, and special systems on the market. Reliable also distributes a full line of best-in-class system components. All Reliable products are backed with premier customer service. Reliable's corporate headquarters is located in Elmsford, NY with manufacturing headquarters in Liberty, SC. Regional sales and distribution centers are located throughout the US and around the world.

For more information on Reliable® products, systems, and innovation, visit our website at
www.reliablesprinkler.com/tunnels



Disruption is not an option



Reliable® Tunnel Deluge Systems protect your most critical infrastructure assets

Reliable deluge systems are the perfect solution for the challenges of tunnel environments:

- The Model DDV Diaphragm Deluge Valve is simple to maintain and rated for pressures up to 400 psi (27.6 bar). Available with a remote resetting pressure regulating option, the Model DDV features a compact footprint and can be installed in any orientation.
- The industry-leading low-pressure/high density TNL280 nozzle features a corrosion-resistant Electroless Nickel PTFE (ENT) finish and anti-reflective black paint topcoat.



TNL280

Over 100 Years of Reliable Experience

Reliable Automatic Sprinkler Co., Inc. has been a trusted source for high-risk fire protection solutions since 1920. Our manufacturing headquarters are in Liberty, South Carolina, USA, while our Sales and Technical Services teams span the globe.

Reliable®

Manufacturer and Distributor
of Fire Protection Equipment

Contact our Technical Services team to identify
the ideal solution to your specific need—
no matter what the challenge.

reliablesprinkler.com/tunnels

Colorado School of Mines' Earth Mechanics Institute

EXPERIENCE MINES

Colorado School of Mines is a public university focused on science and engineering, dedicated to pioneering research that addresses and offers innovative solutions to the great challenges society faces today—particularly as they relate to the Earth, energy and the environment—and committed to educating students who will do the same. The following is a selected list of tests performed by EMI.

STANDARD TESTS:

- Uniaxial Compressive Strength (UCS)
- Indirect (Brazilian) Tensile Strength
- Cerchar Abrasivity Index (CAI)
- Punch Penetration Test
- Acoustic Velocities and Dynamic Elastic Constants
- Point Load Test
- Thin-Section Petrographic Analysis
- Schmidt Hammer Hardness
- Shore Scleroscope Hardness
- Taber Abrasion
- Abrasive Mineral Content and Mohs Hardness
- Static Elastic Constant
- Triaxial Compressive Strength

- Direct Shear Test
- Moisture Content
- Permeability
- Porosity
- Rock Quality Designation (RQD)
- Slake Durability Index

SPECIALIZED TESTING

- Linear Cutting Testing
- Cutterhead and Bit Performance Evaluation
- Full-Scale Cutterhead Performance Testing with Laboratory TBM
- Bearing Life Evaluations
- SINTEF Rock Boreability/ Drillability Testing
- Soil Abrasion Testing for EPB Tunneling
- Miniature Linear Cutting Testing
- Bit Analysis using Full-Scale Top Hammer Percussive Drill
- Sieve Analysis

Additional information about technical papers, upcoming short courses, details on current and past projects and descriptions of research and work capabilities is available online at emi.mines.edu.

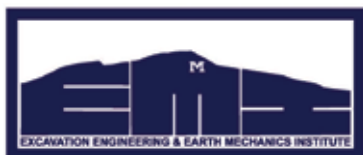


COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT



EARTH MECHANICS INSTITUTE

The Earth Mechanics Institute was established at the Colorado School of Mines in 1974 to enhance education and research in the field of excavation technology. Over the past 40 years, EMI has developed suites of tests and modeling procedures for performance prediction, project costing analysis, mechanical excavation tool design and machine concepts.



Contact us to discuss your unique needs:

1312 Maple St. Golden, CO 80401

+1 303 273 3123

emi@mines.edu





PIONEERING UNDERGROUND TOGETHER

With the experience of more than 5,300 projects, Herrenknecht is a technology and market leader in the area of mechanized tunnelling technology. Herrenknecht is the only company worldwide to deliver cutting-edge tunnel boring machines for all ground conditions and in all diameters – ranging from 0.10 to 19 meters. The product range includes tailor-made machines for traffic, supply and disposal tunnels, technologies for pipeline installation as well as drilling equipment for vertical and inclined shafts and deep drilling rigs.

The Herrenknecht Group achieved a total output of 1,069 million euros in 2020. The independent family-run business employs around 5,000 people worldwide, including around 200 trainees. With around 70 subsidiaries and associated companies working in related fields in Germany and abroad, Herrenknecht is able to provide a comprehensive range of services close to the project site and the customer, quickly and in a targeted way. Under the umbrella of the Herrenknecht Group, a team of innovative specialists offers integrated tunnelling solutions with project-specific equipment and service packages upon request: separation plants, belt conveyor systems, navigation systems, rolling stock systems as well as segment moulds and even turnkey segment production plants.

As a reliable project partner, Herrenknecht supports its customers with an extensive range of services from the beginning of the project to breakthrough. From the initial project idea through manufacturing, transport, assembly, tunnelling support and spare parts service to disassembly, Herrenknecht accompanies the process at the customer's side. Even personnel solutions for the temporary supplementing of jobsite crews are provided if required. With competent service specialists and more than 40 years of experience in the tunnelling industry, the company regularly supports around 300 jobsites worldwide and offers customized service packages tailored to individual project requirements.

Road, metro, and railway tunnels for efficient traffic network. By the middle of this century, the world's population is expected to reach nine billion, and two thirds of these people will live in large conurbations. To keep people and goods on the move, the way ahead for new efficient infrastructures is leading underground. With state-of-the-art technologies, efficient infrastructures are created exactly where they are needed, even in cramped and complex jobsite conditions. Herrenknecht technology pushes the boundaries of feasibility and creates new tunnelling standards worldwide. Herrenknecht technology extends existing transport networks and creates new connections in urban and rural areas – under mountains or deep beneath water.

Innovative solutions for underground supply and disposal systems. As the world's population grows the need for underground supply tunnels is also increasing; in emerging and developing countries as well as in modern metropolises. That is why more than 850 Herrenknecht Utility Tunnelling Machines are in operation around the world constructing or laying water and wastewater systems, gas and oil pipelines, as well as conduits for electricity and telecommunications. Here, trenchless tunnelling technology offers a range of advantages compared to conventional construction procedures: transport, business and the environment remain mostly undisturbed when Micromachines, HDD rigs or shaft sinking equipment are being used. Innovations such as Direct Pipe® set new standards in the semi-trenchless installation. The new technology E-Power Pipe® allows the secure and quick installation of underground cable protection pipes with smaller diameters and long advance lengths. Innovative HDD tools simplify pipeline construction operations at key sections. The Herrenknecht product portfolio is completed by a broad range of equipment for the areas of mining (construction of underground infrastructures around raw material deposits) and exploration (oil, gas and geothermal energy).

**Herrenknecht Tunnelling
Systems USA Inc.**
1613 132nd Avenue East, Suite 200
98390 Sumner, WA
USA
Phone +1 (253) 447-2300
pr@herrenknecht.com
www.herrenknecht.com



DSI Underground

Reinforcing Progress - DSI Tunneling LLC.

Our future begins underground. From providing the commodities on which everyday life depends, to creating the spaces, transport conduits and communications networks that connect our world, mining and tunneling are vital to human progress. As ground support specialists, and a proactive partner to underground operations everywhere, we're the people that make it all possible.

We have been a leader in the underground support business in North America since 1920 for over 100 years of excellence. Our core product line ranges from steel ribs and liner plates to injection chemicals, anchors, bolts

and pre-support systems. We design and develop technically sophisticated Tunneling Systems; offer technical planning with integrated customer support and produce in house to ensure the availability of our systems and our special equipment - anytime and anywhere.

Each support system is customized and professionally engineered to your specific application. Our ground support systems are designed to make tunneling safer. Thanks to our local presence around the globe, we can satisfy your needs for ground control quickly and efficiently - no matter where you are. Our customized products and systems are just in time delivered to service our customers.

Wherever you are in the world, whenever you need us, we'll be on the ground - and beneath it - to reinforce your operation and drive you deeper, further, faster.

You want to advance your operations efficiently. To improve safety. To minimize downtime and maximize productivity and performance. We have the people and the products for every challenge, and a supply chain you can rely on to deliver. Working along side you, we help you progress towards your objectives - quickly, reliably, cost-effectively.

When you're tackling a seemingly insurmountable objective, facing tons of rock and earth, and need the skills and knowledge to achieve it, we're with you. We understand the complexities and considerations, the depths and dangers far below the ground - and we work with you to navigate them, taking you downward and forward, efficiently and intelligently, safely and sustainably. By helping you progress, we're helping our society progress. Which is why it all begins underground. Together, we can help you advance into the earth - and into the future.

DSI Tunneling LLC. Reinforcing progress.



www.dsiunderground.com
502.473.1010





Reinforcing Progress

You want to advance your operations efficiently. To improve safety. To minimize downtime and maximize productivity and performance. We have the people and the products for every challenge, and a supply chain you can rely on to deliver. Working alongside you, we help you progress towards your objectives – quickly, reliably, cost-effectively.

DSI Tunneling LLC
Phone 502 473 1010

dsitunneling.com

Derrick Corporation

Founded by H. William Derrick Jr. in 1951, Derrick® Corporation was created to solve some of the most challenging mechanical separation needs of the Mining Industry. At the heart of our present-day offering resides the Integrated Vibratory motor. Our pioneering spirit pulses through the organization and inspires development of our leading-edge solutions.

Over the years, we have experienced exponential growth, expanding from our Mining roots to Oil & Gas Drilling, Civil Construction, Industrial and other challenging markets worldwide. We have an extensive network of thousands of cohesive individuals located across the globe.

SERVING THE CIVIL INDUSTRIES

Derrick has offered premium slurry separation and desanding equipment to the worldwide Microtunneling, Diameter Tunneling, Slurry Wall/Foundation Drilling, Horizontal Directional Drilling, Hydrovac Mud Processing, Water Well Drilling, Dredging and other Civil Construction Industries for over 30 years.

Throughout this time, Derrick has remained dedicated to complete in-house manufacturing of every piece of solids/liquid separation equipment. Each unit is created and assembled at Derrick's Buffalo, New York headquarters facility.

EQUIPMENT THAT MAKES THE DIFFERENCE

Drilling or tunneling performance is directly related to the overall cleaning ability of the separation equipment. Drilled solids remaining in the slurry have numerous adverse effects on the overall operation, significantly reducing its profitability. Consequently, selecting the proper separation equipment for your fleet is just as critical as the drill or tunnel boring machine. Derrick answers this critical need with innovative, high performance solids control equipment proven time and time again to increase the rate of advance while reducing:

- Non-production time
- Hauling and disposal of solids-laden drilling fluid
- Cost of drilling fluid and chemicals
- Water usage and hauling
- Wear on downstream pumps, plumbing, and other equipment
- Environmental impact

Visit us at www.Derrick.com to discover more.



Derrick Corporation
15630 Export Plaza Drive
Houston, Texas 77032 U.S.A.
Office: (281) 590-3003
Email: Info@derrick.com
www.Derrick.com

DERRICK SLURRY SEPARATION TECHNOLOGY

PATENTED SCREEN SURFACES | COMPLETE SYSTEMS | SOLIDS REMOVAL EQUIPMENT

Civil Construction Applications:

- Microtunneling
- Large Diameter Tunneling
- Hydrovac Mud Processing
- Slurry Wall/Foundation Drilling
- Water Well Drilling
- Horizontal Directional Drilling



Leading-Edge Slurry Separation Solutions

Backed by over 70 years of cost-effective solutions, Derrick has manufactured innovative technologies for numerous civil construction applications for over three decades. Derrick's separation technology offers unmatched solids removal performance. Our civil construction solutions are currently used worldwide by companies that require high-efficiency separation and slurry dewatering in environmentally sensitive and urban environments.



Site Video

In camera mode, hover phone over QR code to watch full video.
(No app required)



Derrick Corporation
15630 Export Plaza Drive
Houston, Texas 77032
Toll Free: (866) DERRICK
www.Derrick.com



Exclusive Distributor
Clean Slurry Technology, Inc.
4101 Union Ave
Bakersfield, California 93305
Toll Free: (877) 365-8396
www.CleanSlurry.com

Northwest Laborers-Employers Training Trust – Safety and Hazard Awareness for Tunnels (SHAFT) program

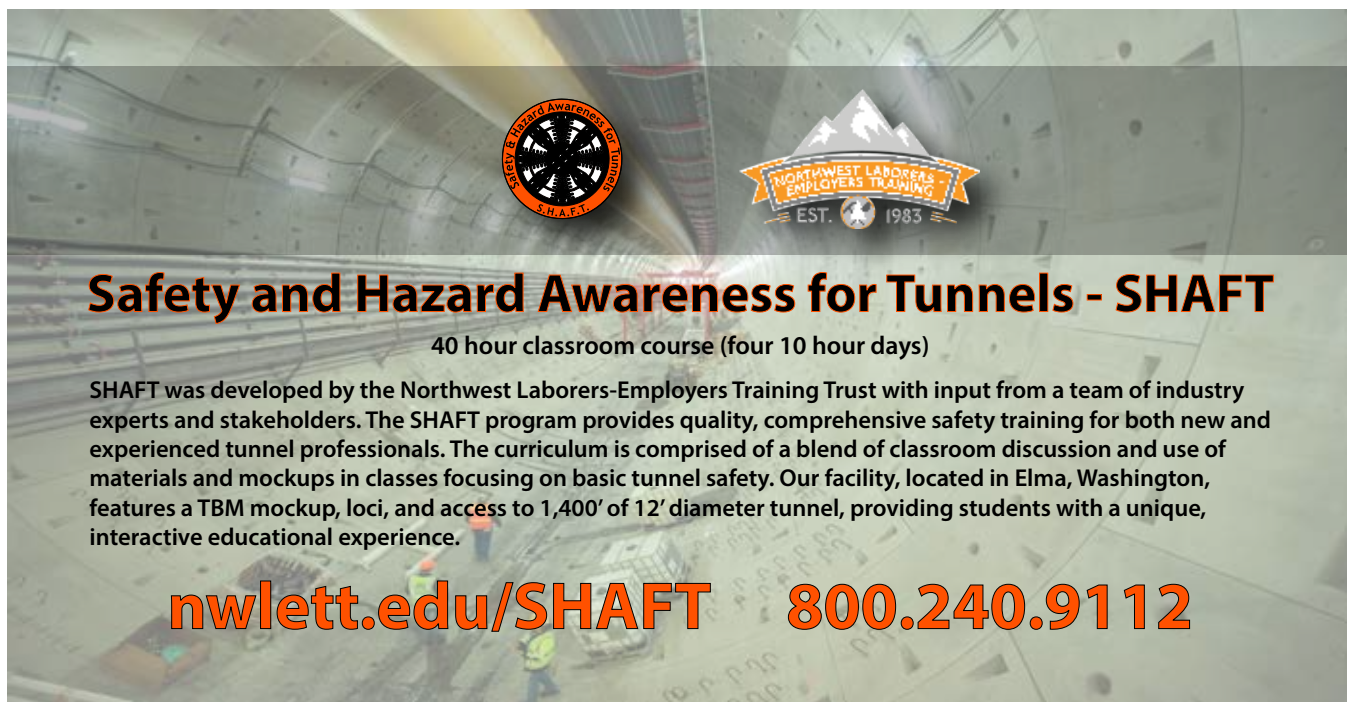
The Safety and Hazard Awareness for Tunnels (SHAFT) program, developed by the Northwest Laborers-Employers Training Trust with input from a team of industry experts and stakeholders, is comprised of a blend of classroom discussion and interactive use of materials and mockups.

The curriculum offers comprehensive safety training for both new and experienced tunnel professionals; classes focus on tunnel safety, rail, and utilities.

The training facility, located in Elma, Washington, features a TBM mockup, rail, and access to 1,400' of 12' diameter tunnel – providing students with a unique educational experience.



Northwest Laborers-Employers Training Trust
+1 (800) 240-9112 www.nwlett.org






Safety and Hazard Awareness for Tunnels - SHAFT

40 hour classroom course (four 10 hour days)

SHAFT was developed by the Northwest Laborers-Employers Training Trust with input from a team of industry experts and stakeholders. The SHAFT program provides quality, comprehensive safety training for both new and experienced tunnel professionals. The curriculum is comprised of a blend of classroom discussion and use of materials and mockups in classes focusing on basic tunnel safety. Our facility, located in Elma, Washington, features a TBM mockup, loci, and access to 1,400' of 12' diameter tunnel, providing students with a unique, interactive educational experience.

nwlett.edu/SHAFT 800.240.9112



Bradshaw Offers Innovative Tunnel Engineering and Construction Technology

Bradshaw Construction Corporation strives to apply the most appropriate tunneling technology to each project based on its purpose, subsurface conditions and surface restrictions. The company's management team is proud of its ability to construct any type of tunnel in any soil condition both above and below the water table. From small hand mined, wood-box and liner plate tunnels to large NATM shotcrete-lined tunnels; from small pilot tube guided auger bores to large rib-and-board shield and tunnel boring machine (TBM) tunnels; from conventional pipe jacking to slurry microtunneling (MTBM) to earth pressure balance (EPB) TBM tunnels; and from hand mined drill and blast to rock tunnel boring machines (TBMs), Bradshaw Construction has a solution.

For your next project, let our knowledgeable staff of tunnel engineers and construction professionals create the most cost effective, safest, and highest quality solution for your unique tunneling needs.

Bradshaw Construction Corporation
175 West Liberty Road
Eldersburg, MD 21784 USA
Telephone: +1-410-970-8300
Fax: +1-410-970-8340
www.bradshawcc.com



TUNNELING SPECIALISTS | bradshawcc.com 410.970.8300

By combining superior craftsmanship with innovative tunnel engineering and construction technology, Bradshaw Construction Corporation successfully provides cost effective tunneling solutions to the utility and transportation industries.

PROVIDING INNOVATIVE SOLUTIONS FOR TUNNELING PROJECTS



MICROTUNNELING | TBM TUNNELING | HAND TUNNELING | SHAFT WORK

BRADSHAW
CONSTRUCTION CORPORATION



Kiewit

As a construction, mining, and engineering leader, Kiewit is a FORTUNE 500 company consistently ranking in the ENR's Top 10 Contractors. Kiewit is owned by active employees, creating a level of motivation that keeps the company on top. Kiewit, through its operating companies, brings a wealth of diverse resources and track record for delivering the highest quality results – on budget and on schedule. Our size and experience provides the stability, predictability, and knowhow our clients and partners expect – and the flexibility and overall best value they deserve.

Kiewit has built some of the most complex tunneling and underground projects for more than 60 years. We self-perform soft ground and hard rock TBM tunneling, along with conventional tunneling techniques such as SEM and Drill and Blast, and trenchless technologies such as MTBM and HDD. As one of North America's largest and most respected construction and engineering organizations, Kiewit's underground capabilities offer clients unique advantages to navigating complex, challenging projects from engineering and design, through construction.

We're hiring. Go to kiewitjobs.com to learn more.



Kiewit Infrastructure Co.
1550 Mike Fahey St.
Omaha, NE 68102
(402) 346-8535



DRIVEN.

For those who get the job done.

Kiewit is currently hiring:
Interns, Field Engineers, Project Engineers,
Superintendents, Safety Managers and more

Apply for our
job openings:



Want a career that can take you places? Look no further.

kiewitjobs.com

CDM Smith – A Leader in Tunnel Engineering

CDM Smith is a leader in underground space and tunnel engineering. Working collaboratively with our clients, we employ our extensive global tunnel design and construction experience to develop holistic and optimal solutions for a wide range of projects.

Tunneling Expertise

With our experience encompassing soft ground, mixed face, and rock tunnels and excavations, CDM Smith offers a unique perspective and skillset that addresses the specific needs of each project. Our capabilities are comprehensive and include:

- Tunnel engineering
- Geotechnical engineering
- Geotechnical data & baseline reports
- Lining & structural engineering
- Numerical analysis
- Ground improvement & ground freezing design
- Deep excavations & ground support design
- Groundwater modelling & control
- Soil and rock testing

To support our clients, we offer comprehensive consulting, engineering, and construction support services.

Market Sector Experience

Tunneling and ground engineering is unique—it crosses market sector boundaries. CDM Smith's global tunneling assignments are executed within all market sectors, including:

- Transportation
- Environment
- Water/wastewater
- Mining

Award-Winning Projects

MEED Project Award (2020), International Project of the Year, Ismailia Tunnels under Suez Canal

ENR Global Best Projects (2017), Best Water/Wastewater, Abu Hamour Surface and Groundwater Drainage Tunnel

ACEC Engineering Excellence Award (2018), New York Harbor Water Siphon

Contacts:

Michael Schultz, PE | SchultzMS@cdmsmith.com | 617-452-6399

Mahmood Khwaja, PE | KhwajaM@cdmsmith.com | 617-452-6391



Leading the tunneling industry

- Engineering design
- Program/construction management
- Inspection/rehabilitation of underground structures
- Resident engineering
- Geotechnical engineering
- Risk management
- Cost estimating & life cycle cost analysis
- Value engineering & peer review

**CDM
Smith**
cdmsmith.com

Master Builders Solutions

Master Builders Solutions continues to break new ground in addressing the needs of tunneling professionals. Our Underground Construction team brings a total solutions approach to your projects, providing an added resource to help meet your challenges underground. Our solution-based systems enhance the efficiency and performance of the TBM operations and offer performance-based ground support solutions, from novel soil conditioning technologies to innovative anchoring systems; no matter the tunneling method. Throughout the life of your project, our team of specialists work with all relevant stakeholders to help maximize your production rates and to ensure the most successful product and system selection.

The MasterRoc® product line offers a wide range of solutions for TBM excavation in soft ground and hard rock, with high-performance products including soil conditioners, polymers and anti-clay agents. Our full line of greases and sealants help to maximize efficiency for every excavation method and soil type. Sprayed concrete, Rock Bolt Anchoring systems, Injection and water management systems are also widely considered selected and used for ground support and enhancement in Tunneling and Mining applications. Master Builders Solutions offers customers innovative

product solutions and experienced technical resources to tailor cost-effective solutions to specific project needs. These solutions dramatically improve working environments, production, and safety.

The Master Builders Solutions product line is designed to be a single source for all your underground construction needs. In addition to the wide range of products and systems, our globally connected team assists our customers in selecting the right systems and combinations, allowing for successful operations, coupled with the highest safety standards. Master Builder Solutions, a world leader in reliable products specifically designed to address the requirements of tunneling projects worldwide... where production meets performance and safety. Utilizing our global expertise, we are steadfastly focused on the needs of tunneling professionals.





SOLVING YOUR UNDERGROUND CHALLENGES

Our customers shape the future. By listening to their needs and challenges, we have developed a complete and comprehensive offering for the tunneling industry.

We continue to focus our R&D efforts on safe, sustainable, innovative solutions for tomorrow's challenges.

**[www.master-builders-solutions.com/
en-us/products/mining-and-tunneling](http://www.master-builders-solutions.com/en-us/products/mining-and-tunneling)**

Photo credit: Catherine Bassetti Photography

® registered trademark of a MBCC Group member in many countries of the world

A brand of
MBCC GROUP

Miller Contracting

MILLER has the ability to sink shafts conventionally from 16' diameter and larger to depths of 1,600' or greater. We utilize nontraditional mucking methods that give us an edge on both safety and productivity. We own two raise bore machines with the capacity to do shafts as small as 48" diameter with our Atlas Copco 73R and as large as 26' diameter with our Herrenknecht RBR400 and up to 2,400' deep. We offer steel lining or cast in place concrete lining. We also offer pilot hole guidance to ensure tight tolerances are attained on hole deviations for elevators, man and material hoist, or emergency escape hoist applications. A MILLER shaft is not just another hole in the ground, it is a finely crafted structure that the owner can use and be proud of! Please give us the opportunity to do one/another one for you!

At MILLER, we strive to bring the best value to our customer's projects. With fair prices, superb service, and outstanding quality, all delivered by an honest hard-working team of professionals. We are committed to seeing that our values are a part of every project we do. We strive to practice the highest levels of integrity with all persons involved and praise God in every interaction.

Please contact us with all your shaft needs! email- Jake Welch jwelch@millercontracting.us or Matthew Miller matthew@millercontracting.us or call them at the office- 618.994.4616 -Jake ext. 115 or Matthew ext. 103



MILLER

SHAFT DIVISION

We at MILLER have a great team of highly trained men in our shaft division. We have the ability to sink shafts conventionally from 16' diameter and larger to depths of 1,600' or greater. We utilize nontraditional mucking methods that give us an edge on both safety and productivity. We own three raise bore machines with the capacity to do shafts as small as 48" diameter with our Atlas Copco 73R and as large as 26' diameter with both of our Herrenknecht RBR400s and up to 2,400' deep. We offer steel lining or cast in place concrete lining. We also offer pilot hole guidance to ensure tight tolerances are attained on hole deviations for elevators, man and material hoist, or emergency escape hoist applications. A MILLER shaft is not just another hole in the ground, it is a finely crafted structure that the owner can use and be proud of! Please give us the opportunity to do one/another one for you!

At MILLER, we strive to bring the best value to our customer's projects with fair prices, superb service, and outstanding quality, all delivered by an honest hard-working team of professionals. We are committed to seeing that our values are a part of every project we do. We strive to practice the highest levels of integrity with all persons involved and praise God in every interaction.

Please contact us with your shaft needs!

Check us out on our website: millercontracting.us



David R. Klug & Associates, Inc.

Since 1996, David R. Klug & Associates, Inc. has provided international and national manufacturer's representative services to the underground heavy civil and mine construction industries. The company specializes in the sale and coordination of specialty products, equipment and services for soft ground, conventional and NATM/SEM tunneling practices. Expertise is offered in the supply of various componentry used in the manufacture of one pass precast segmental tunnel linings inclusive of EPDM gaskets, plastic and steel connectors, grout lifting assemblies and precision steel segment casting moulds plus final lining forming systems for C-I-P final lining applications. Through their distribution company, Klug Construction Systems, LLC offers Nittetsu ultrafine cement, GFRP rock bolts and soft-eyes, steel and synthetic fiber reinforcement, prefabricated welded wire fabric and rebar reinforcing panels, and specialty grout systems for various tunnel backfill grout requirements for highway, rail, subway, water and CSO tunnel construction applications.

David R. Klug & Associates, Inc.
1994 Lumber Ave.
Wheeling, WV 26003
Tel: 304-905-8932
Fax: 304-905-0154
Cell: 304-281-4239
E-mail: jklug@drklug.com
Website: www.drklug.com



DAVID R. KLUG & ASSOCIATES, INC.

Specialty Products and Services for the
North American Tunneling and Mining Industries

Jonathan D. Klug - Vice President

www.drklug.com

1994 Lumber Ave.
Wheeling, WV 26003
Email: jklug@drklug.com

Tel (304) 905-8932
Fax (304) 905-0154
Cell (304) 281-4239



www.tucmagazine.com



Drill Tech Drilling & Shoring, Inc.

Drill Tech Drilling & Shoring, Inc. is a recognized leader in the foundation and excavation industry in the United States. The same guiding principles that helped Drill Tech become a top 10 Foundation Contractor, according to ENR's Top Specialty Contractors, can be seen in Drill Tech's Mining & Tunneling Division (DTM&T).

On the Barrick Range Front Declines, DTM&T has almost completed over 18,000 feet of twin declines almost six months ahead of schedule. Rock conditions varied in strength along the decline and while the contract was initiated using Roadheader excavation methods, DTM&T has utilized both drill & blast and roadheader techniques to overcome these varied rock strengths. Throughout the execution of the work, DTM&T focused on building a safe project ahead of schedule that met the quality expectations of Barrick. Drill Tech's efforts were recognized by Barrick and additional work was issued to Drill Tech's contract.

In addition to the twin declines, DTM&T performed contract work for other contractors on the project site that included Mass Excavation of 129,314 CY of rock and the application of 15,995 CY of shotcrete. During the course of these projects, DTM&T has performed safely for 814 days.

For more information, please visit www.drilltechdrilling.com, email us at dtlds@drilltechdrilling.com or call at 925.978.2060
Drill Tech Drilling & Shoring, Inc.
2200 Wymore Way
Antioch, CA 94509



DRILL TECH
DRILLING & SHORING, INC.

EARTH RETENTION
DEEP FOUNDATIONS
ARCHITECTURAL SHOTCRETE
GROUND TREATMENT
DEWATERING

SHAFTS
TUNNELING
TUNNEL REHABILITATION
MINE DEVELOPMENT
CONTRACT MINING

DRILL TECH
MINING & TUNNELING

DRILLTECHDRILLING.COM

CALIFORNIA - TEXAS - COLORADO - KANSAS - MARYLAND

Mining Equipment Ltd.



Mining Equipment Rolling Stock for Columbus, Ohio

"Rolling for more than 35 years"

Mining Equipment continues to supply the tunneling and mining industries with top-quality rolling stock, Jetair fans and steel ventilation ducting, as well as a large inventory of rebuilt equipment such as scooptrams, trucks, drill jumbos and other underground gear.

Mining Equipment is based in Durango, Colorado, with a main shop facility in Farmington, New Mexico. They also have steel fabrication capabilities near Shanghai.

Mine Hoists International, a sister company of Mining Equipment, is based in North Bay, Ontario. They boast the world's largest inventory of used mine hoist and large capacity stage winches for mining and shaft sinking projects. Their new 20,000 square foot shop in North Bay, Ontario can handle the largest of hoist and winch rebuilds.



Mining Equipment 10 Ton Locomotives for Columbus, Ohio

IF IT
ROLLS ON RAILS,
WE'VE GOT YOU COVERED.

Completely rebuilt and repowered Plymouth 25 ton locomotive, flat cars and muck cars work on SAK's Deer Creek project in St. Louis, Missouri.



HEAD OFFICE
+1 (970) 259-0412

EUROPEAN OFFICE
+49 (6061) 97969-30

MININGEQUIPMENTLTD.COM

- > LOCOMOTIVES
- > ROLLING STOCK
- > JETAIR VENTILATION SYSTEMS
- > MINE HOISTS & STAGE WINCHES
- > METALLIANCE MSVs
(NORTH AMERICAN, GERMAN DEALER)

Normet - Defining the Future Underground.

The underground future built on three pillars, which highlight our expertise and focus:

1. Securing a safe and sustainable future – means building the safest places underground while minimising the impact to the environment and is committed to exceeding industry standards.
2. Innovating for Performance – means delivering productivity with leading-edge solutions and technology.
3. Partnering for the Future – means that our whole team is committed to our customers' goals, and we build capacity for agile cooperation.

We work in close collaboration with our customers. The process expertise amassed over thousands of mine and tunnel projects all over (and under) the globe translates into experience and expertise about what should and should not be done to achieve the optimum results. We utilise our process expertise into concrete actions and financial results for our customers.

Normet has a broad underground offering:

- › Equipment for concrete spraying and transport, explosives charging, scaling, lifting, installation works, and logistics.
- › Construction chemicals for sprayed concrete, admixtures for

all types concrete, injection systems for rock improvement and water control, reinforcement systems for high deformation conditions, spray applied waterproofing systems and needed chemicals for Tunnel Boring Machine (TBM) technology covering hard rock, Earth Pressure Balance (EPB), open face and slurry type machines,

- › High quality and innovative rock reinforcement products that reduce the risk and consequences of accidents and facilitate high productivity in challenging rock conditions.
- › Services for underground mining and tunnelling, including for example spare parts, rental equipment, remanufacturing and upgrades, performance and field services.

Normet has delivered over 14,000 built-for-purpose underground machines which are serviced and supported with a broad service portfolio.

Normet currently employs over 1600 business professionals with a passion for doing "big" things for its customers and for the industries which the company serves.

Normet is a Finnish company operating globally with over 50 locations in 33 countries worldwide. This breadth allows rapid response and reliability to all customers whenever and wherever in the world they may be. Company revenue in 2020 was over 300 M€.

DESIGNED FOR THE FUTURE UNDERGROUND

normet
SmartDrive®
NORMET.COM



Higher performance



Zero local emissions



Increased efficiency



Improved health and safety



Reduced total cost of ownership

Normet SmartDrive® is a modular battery electric vehicle (BEV) architecture designed to optimize energy consumption and performance in underground mining and tunnelling applications. The Normet SmartDrive® product family provides high productivity with decreased operating costs. For more information please visit www.normet.com/smartdrive

Start your electrification journey with Normet SmartDrive® today!

Innovative Onsite Concrete Production Equipment for Rent

OUR SERVICES, EQUIPMENT & PARTNERSHIP

GALLOVICH CONSULTING LLC, with over 20 years of professional experience in American Concrete Industry and the support of a concrete machinery manufacturer, Fiori Group SpA, a worldwide leader known for its history and industry leadership of over 70 years, brings to the market the most innovative onsite concrete production and transportation solutions with our Simple Rent or Rent-to-Purchase program.

Our fleet is exclusively made by FIORI GROUP SpA, always keeping equipment new or with few hours, providing maximum performance experience to customers.

Fiori Group SpA has its headquarters in Finale Emilia (MO) Italy, that designs, develops and manufactures off-road Concrete Batching Vehicles and Dumpers for the construction industry. The company's product portfolio is rounded off by the Group's capabilities in finding the most effective solution for any customer in making and transporting concrete on-site with great flexibility, minimizing energy costs and reducing environmental impact.

Let us help you to set up your concrete production and transportation equipment for your next tunneling project.

info@gallovichconsultingllc.com

P: +1 (786) 762-4068

M: +1 (240) 893-6580

8333 NW 53rd Street

Suite 450

Doral, FL 33166



HIGH QUALITY FACTORY PRE-BATCHED CONCRETE



REVERSIBLE SITE DUMPER



INCREASE ON SITE PRODUCTIVITY

CONCRETE BATCHING VEHICLE



CERTIFIED CONCRETE PRODUCTION AND TRANSPORTATION. ANYTIME, ANYWHERE.

FIORI Concrete Batching Vehicle series (CBV) produces Certified Concrete anywhere, anytime, for all job sites and for all kinds of applications. These four-wheel drive vehicles are true batching plants equipped with highly-advanced yet simple to operate controls and mixing systems which facilitate production of Certified Concrete of any mix design. FIORI Site Dumpers are the perfect solution of material transportation in all job sites and particularly in Underground projects using the drive seat swiveling feature, four wheel drive and four wheel steering.

BRAND NEW EQUIPMENT AND RENTALS AVAILABLE FOR YOUR PROJECT.

GALLOVICH CONSULTING LLC

8333 NW 53rd Street, Suite 450, Doral, FL 33166

info@gallovichconsultingllc.com

www.gallovichconsultingllc.com



Premier Pipe Systems Manufacturer for Over 95 Years

Since 1925, Naylor Pipe Company has been the premier manufacturer of Spiralweld pipe systems.

Naylor Spiralweld is available in diameters from 4" through 96" and wall thickness from 14 Ga. through 1/2" wall. The Spiralweld pipe is complemented with all types of fittings, fabrications to specification, and joint connections, including the exclusive Naylor Wedgelock Coupling, to complete your pipe system.

Naylor Spiral Buttweld pipe features two welds along the spiral seam. This creates a pipe structure in which the weld is as strong or stronger than the parent metal.

The Naylor manufacturing process creates a pipe that maintains an accurate diameter throughout its length. The uniformity of the pipe ends speed connection, whether mechanically coupled or welded.

Uniform wall thickness is assured because tolerances of steel strip are governed by the standards established by the American Iron and Steel Institute. In addition, the pipe is furnished in any required length with a cutting tolerance of plus or minus 1/8". In addition to carbon steel, spiralweld pipe can be formed from many steel grades, including abrasion resistant, weathering (A-588/A-606) and stainless.

Every length of Naylor Pipe is inspected and where required hydrostatically tested to applicable ASTM specifications. The pipe is available in lighter weights than other pipe making it possible



to save money, not only on initial cost, but also in transportation, handling and installation. By sizing the diameter of the pipe to the exact requirements, with exact lengths and factory-sized ends, the greatest economies can be realized.

Quotations are immediately available on inquiry.



Naylor Pipe Company
1230 East 92nd Street
Chicago, IL 60619 USA
Tel: 1-773-721-9400 Fax: 1-773-721-9494
Email: sales@naylorpipe.com
www.naylorpipe.com

NAYLOR PIPE

Vent • Compressed Air • Water Discharge • Shaft Pipe

- Diameters from 4" to 96"
- Thicknesses from .074" to .500"
- ASTM A-139, ASTM A-211
- Lightweight, Accurate Diameter
- High Salvage and Re-Use Value
- Exclusive Naylor Heavy Duty Wedgelock Coupling Reduces Connection Time
- Fittings, Connections, Coatings and Linings to Complete Your Pipe System



NAYLOR
Spiralweld PIPE SYSTEMS
CHICAGO

For more info on our complete line of Pipe Systems, check our new website
www.naylorpipe.com

1230 East 92nd St • Chicago, IL 60619
773/721-9400 • Fax: 773/721-9494
E-Mail: sales@naylorpipe.com

Brokk 200 Packs the Power of a 3-ton Machine Into a 2-ton Package

Brokk Inc. has been the world's leading manufacturer of remote-controlled demolition machines and attachments for 45 years. Through continuous innovation in engineering and design, Brokk is able to offer unique solutions to multiple industries worldwide, including construction, demolition, mining and tunneling, cement and metal processing, nuclear and other specialty applications.

Brokk offers the Brokk 200, a new weight class of machine, ideal for heavy duty, difficult-to-access projects and applications. The model packs the power of a 3-ton Brokk machine into a 2-ton package. It is equipped with Brokk's signature SmartConcept™ technology for increased efficiency. SmartConcept includes the extra power of SmartPower™, the added reliability of SmartDesign™ and enhanced ergonomics and productivity of SmartRemote™. The 27.5-kilowatt machine operates tools with requirements typical of one weight class above. When paired with the new Brokk BHB 305 breaker, the unit's hitting power is increased by 40%. The new class of machine delivers 450 foot-pounds (610 joules) with each blow of the 650-pound (295-kilogram) hydraulic breaker. Additionally, the Brokk 200 offers 15% longer vertical and horizontal reach in a compact footprint similar to the Brokk 170. The extra chassis length and machine weight ensures proper balance, even when wielding heavy attachments.

BROKK®



The Brokk 200 packs the power of a 3-ton Brokk machine into a 2-ton package

For more information: Brokk Inc., 17321 TYE Street SE, Suite B, Monroe, WA 98272; 800-621-7856; info@brokkinc.com; www.brokk.com; Facebook: @BrokkUSA; YouTube: @BrokkIncUSA; LinkedIn: Brokk Inc.; Twitter @BrokkUSA; and Instagram: @BrokkUSA.



MEET BROKK 900

THE WORLD'S MOST ROBUST DEMOLITION ROBOT

With the perfect combination of great power and compact size the Brokk 900 completes demanding jobs in confined spaces with ease. Maximized durability and reliable SmartPower™ makes it optimized for tunneling applications.



Brokk Inc. | 1-360-794-1277 | www.brokk.com | info@brokkinc.com

BROKK®

Trinity Products

Trinity Products' weldless interlocking system, Tri-Loc, offers contractors the ability to install casing much faster by eliminating field welding. The machined Male and Female teeth of each pipe joint means that once engaged, do not separate, making it ideal for trenchless Pipe-Jacking installations. Trinity Products manufactures two variations of Tri-Loc steel casing; a 3-Tooth Design used in Auger Boring, and a 4-tooth Design for Micro-tunneling. For Auger boring, the 3-Tooth design allows for a reduction in the required jacking forces to fully set or engage the interlocking joints.

Using a press-fit connection steel pipe eliminates the timely and costly process of welding each joint of steel casing before advancing more pipe down hole. A joint that may usually takes hours to weld, is connected in minutes.



WELDLESS INTERLOCK SYSTEM



TRINITYPRODUCTS.COM



800-456-7473

Dr. Sauer & Partners

Dr. Sauer & Partners is an independent consultancy specialized in providing the full range of design and construction management services for underground tunnelling and infrastructure projects. The company has nearly 40 years' experience delivering innovative, cost-effective designs, providing solutions for some of the world's most challenging tunnelling projects for metro, highway, water, rail and mining, and in any type of geology.

Services delivered include initial consultation and feasibility studies, final design, temporary works, supervision and construction management, tunnel inspection and condition surveys, rehabilitation, waterproofing and water control, geotechnical engineering, and mining support services. Dr. Sauer & Partners' approach is to work collaboratively and integrate fully with all disciplines (design and construction) on a project to achieve a robust and innovative solution.

Current and recent projects include: Hampton Roads Bridge Tunnel Expansion (USA), Chesapeake Bay Bridge Tunnel (USA), Effluent Outfall Tunnel Los Angeles (USA), Westside Purple Line Extension Los Angeles (USA), Eglinton West Extension Toronto (Canada), Bank Station Capacity Upgrade (UK), Metro M2 Tel Aviv (Israel).

www.dr-sauer.com



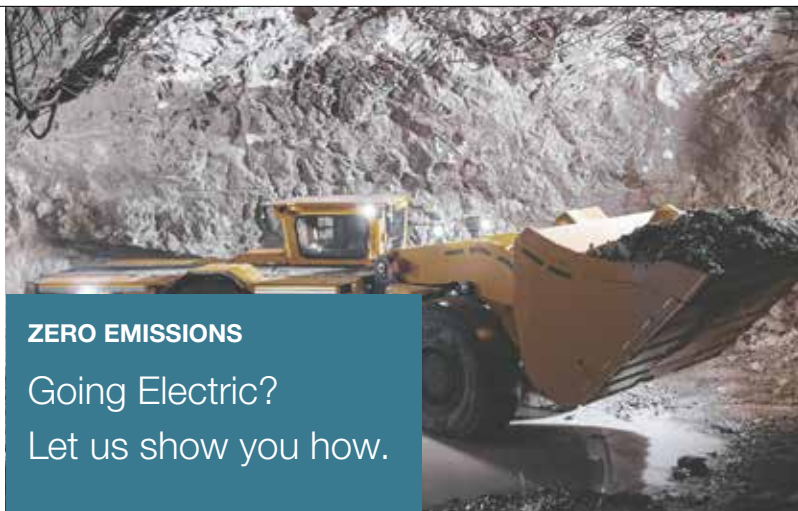
INNOVATIVE TUNNEL ENGINEERING



www.dr-sauer.com

Salzburg | London | Washington | Toronto | Tel Aviv

**TEMPORARY WORKS
TUNNEL DESIGN
GEOTECHNICAL ENGINEERING
CONSTRUCTION MANAGEMENT
INSTRUMENTATION & MONITORING
WATERPROOFING & WATER CONTROL
TUNNEL REHABILITATION
MINING SUPPORT SERVICES**



ZERO EMISSIONS

Going Electric?
Let us show you how.

Reliable hands free charging

Stäubli provides a universal solution for automatic charging of electric mining equipment with its innovative **QCC (Quick Charging Connection)**. For high power charging systems designed to stand up to the harshest environments, the Automated Connection Device (ACD) makes it possible to **transfer high levels of power (1MW+)** which ensures fast recharging of energy storage devices such as Li-Ion batteries and super capacitors.



The **high efficiency** and **reliability** of the QCC means less maintenance with decreased down time. The ability to quickly charge with the QCC allows manufactures to offer smaller onboard battery packs so that machinery can better serve its intended purpose – to transport the weight of ore, not the weight of extra batteries.



To find out more about the QCC solution,
scan the QR code or call us at
+1 707 838 0530
www.staubli.com/en-us/

STÄUBLI

Stäubli is a trademark of Stäubli International AG, registered in Switzerland and other countries. © Stäubli 2022

Connection solutions designed for safety and reliability

Stäubli Electrical Connectors meet the highest standards in even the most demanding and competitive industries, where absolute performance, safety, durability, reliability and efficiency are crucial.

High performance, long-term reliability and highest mating cycles for the connection of all types of industrial applications. We calculate our solutions for maximum reliability in the harshest environments.

With its innovative connector for high power charging systems the QCC by Stäubli provides a universal solution for automatic charging of various kinds of electric vehicles (Mining equipment, AGVs, buses, trucks, etc.). The automated connection device (a so-called ACD) makes it possible to transfer high levels of power, which ensures fast recharging of energy storage devices such as Li-Ion batteries and super capacitors. The QCC offers high efficiency and low maintenance requirements. The amount of stored energy required is reduced due to quick recharging stops, which enables the vehicle to better serve its purpose – transport of the weight of goods, not the weight of batteries.

Working closely with our customers, both conceptually and geographically, we assist with the most uniquely demanding tasks of our longstanding partnerships. Our customers' requests or project requirements are processed quickly, creatively and competently. These collaborations motivate us to move forward and constantly improve our products and services. Innovation is the driving force, which supports us to start trends and set standards.

Contact Info:

PH: +1 707 838 0530

Email: ec.us@staubli.com

Web site: <https://www.staubli.com/en-us/electrical-connectors/multi-pole-connectors/e-mobility-connection-solutions/qcc/>

Video: <https://youtu.be/WEQHFk8Zt2w>



Brookville

BROOKVILLE 27-Ton MSHA Permissible Locomotives Boosting Safe Work Environment at Major Los Angeles Tunneling Project

Brookville Equipment Corporation (BROOKVILLE) recently shipped three 27-ton MSHA-permissible tunneling locomotives to the Walsh-Shea Corridor Constructors for use on the Crenshaw/LAX Transit Corridor Tunnel Project in Los Angeles. By design, the locomotives reduce the risk of explosion due to geological conditions that may host the presence of methane and other combustible gases. Cal-OSHA has classified the tunnel drives on this project “gassy”, mandating the use of MSHA permissible locomotives.

The 27-ton locomotives’ special safety features include air start, an enclosed engine block, an exhaust filtration system, wiring and piping guards, and an intake flame arrestor, among other upgrades, to fully comply with MSHA’s permissibility requirements. Featuring an 8.3L Cummins six-cylinder diesel engine and four-speed transmission, the 185-horsepower locomotives operate on 36-inch rail gauge underground for Walsh-Shea Corridor Constructors.

“BROOKVILLE was selected based on past performance, simplicity of operation and diagnostics, their ability to communicate locally with MSHA, and knowing we would be dealing with the good people of Brookville, PA, U.S.A.,” said Walsh-Shea Corridor Constructors Tunnel Construction Manager David Girard, P.E.



**Durable.
Dependable.**

**Designed
to Meet
Your
Demands.**

BROOKVILLE

+1 814.849.2000 • brookvillecorp.com

**Read
& TUC
Always Boring
Never Boredom**



BORAID® GROUND CONDITIONERS FOR TBM EXCAVATIONS

Traylor Bros., Inc is a heavy civil construction company with decades of extensive experience throughout North America. They specialize in TBM tunneling, the sequential excavation method (SEM), and drill and shoot excavation.

Originally established in 1946 in Evansville, Indiana, Traylor Bros. experts employ state-of-the-art technology to deliver projects in every type of ground. TBM tunneling methods include mixed shield/slurry, earth pressure balance and hard rock tunnel boring. In earth pressure balance (EPB) applications, special soil additives are typically used to assist with and optimize the TBM mining. These ground conditioners create more stable, cohesive conditions, which in turn improve the speed and efficiency of production and help to protect the TBM and its components from excessive wear and tear. The team of skilled engineers at Traylor Bros. crafted these conditioning agents and polymers to meet specific customer needs and solve specific problems. Over the years, they have successfully formulated a collection of Boraïd® ground conditioning agents.

Soilax®-S – A concentrate for sands and silts.

Soilax®-AC – An “anti-clay” concentrate that converts clay into perfect EPB muck.

Soilax®-P – A water-absorbent polymer that is used in sandy, high-water content ground to help to improve muck consistency.

Bert's Drillin' Juice – Specially formulated concentrate for sands and silts that was developed in response to difficulties experienced in specific conditions.

“We use a combination of technological knowledge and applied experience in developing the soil additives, and continually adapt and modify them to work in differing conditions. They are not solutions formulated in labs, but rather tested, used and proven in the field on real projects,” stated Chris Hebert, Vice President and Underground Division Manager for Traylor Bros.

Realizing the effectiveness and evident advantages offered by Boraïd® products, other contractors began requesting the solutions as stand-alone products for their own projects. Market demand eventually drove Traylor Bros. to explore their options in marketing and selling their products directly to end users.

In 2021, Traylor Bros. selected Strata Worldwide to exclusively represent the Boraïd® line and the companies jointly announced their new partnership agreement in November. Consultation and

proposals are immediately available for existing and upcoming projects.

“We are very excited to be working with Traylor Bros. to bring the Boraïd® line directly to market,” states Mike Rispin, VP of Tunneling for Strata Worldwide. “For Strata, it is not only about offering the products and technologies, but also about bringing expertise to help solve problems.”

For more information please contact Mike Rispin at:
385-234-1474 or email us at:
info@strataworldwide.com.

www.strataworldwide.com/tunneling


/ strata geotech



Boraïd® technologies comprise special conditioning agents and polymers for sands, silts and clays in mechanized tunnel boring applications, as well as a tail shield sealant for EPB & Slurry TBMs.



STRATA
WORLDWIDE

TUNNELING

USA

T: 385-234-1474

CANADA

T: 705-978-2304

www.strataworldwide.com/tunneling

BORAID

STRATA
WORLDWIDE

Michels Construction, Inc.



Michels Construction, Inc.'s foundations capabilities serve the deep foundation, ground improvement and earth retention requirements of the energy, heavy highway and building trade industries.

As one of North America's largest infrastructure contractors, Michels Construction's design-build capabilities ensure cost effective, engineered solutions for even the most complex deep foundations projects. Look to us for a variety of foundations work including Secant Drop Shafts, Temporary ERS, Augercast Piles, Micropiles, and more. Our in-house professional engineers can design temporary and permanent solutions that are cost effective in any soil condition.

We are conditioned to operating on challenging sites, including urban, high-traffic, low-headroom and off of barges. Our specialized equipment can meet any subsurface and site access conditions.

Safe access is a critical aspect of many underground construction projects. Michels Construction builds and designs shafts to the specific size and depth you need to supply crews, material and equipment to your work area.

Contact us today at 920.583.3132 or visit www.Michels.us.



EOE/AA/M/F/D/V

Infrastructure. Delivered.

Whether building new or maintaining existing, we enhance North America's infrastructure. It takes strength, adaptability, and the alignment of your goals and ours.
Challenging projects require the dedication and skill of true pioneers.
That's what we deliver.

MICHELS®
CONSTRUCTION, INC.

An Energy & Infrastructure Contractor

www.Michels.us



EQUIPMENT SOLUTIONS



Kelley Engineered Equipment LLC provides engineering support and custom equipment design for your most challenging underground projects.

PROFESSIONAL
ENGINEERING SERVICES

CONCEPTUAL DESIGN TO
FIELD SERVICE

SPECIALIZED FABRICATION,
ASSEMBLY & SHOP TESTING

SITE SPECIFIC ENGINEERING
SUPPORT

www.keellc.com

tyler.sandell@keellc.com
+1 206 412 4234

PROUD PARTNERS OF



Kelley Engineered Equipment

Kelley Engineered Equipment (KEE) celebrates their 15th anniversary of supplying custom equipment and professional engineering services to the tunneling and underground construction industry. KEE provides innovative, efficient designs optimized for safety and productivity. A growing team of 40+ professionals and a Seattle office staffed by TBM experts, the Kelley team has professionals with decades of underground experience, PE Licenses in 10 states and more on the way. KEE accepts your challenges and provides solutions with unmatched quality and customer support.

Contact KEE for: Tunneling Equipment, below-the-hook lifting systems, gantries, pipe carriers, mucking systems, trailing gear, custom tunneling shields, custom hydraulic attachments, conveyors, lift cars, equipment modifications, heavy load handling, custom cranes, personnel access systems and bespoke engineered solutions.

KEE is proud to represent Terratec TBMs in the USA and Canada along with Roxard Industries' TBM Cutters and Soft Ground Tools in North and South America.



Unearth Challenges?

T&UC - Tunneling & Underground Construction - covers all things underground. From extreme excavating challenges to large civil projects worldwide, T&UC has the solutions 15,000 industry readers rely on.

Unearth Solutions.



Help Promote Careers in Underground

Visit
undergroundcareers.org
to see how you can participate

Down for that.



OneTunnel.org is the definitive, global, online digital research library for the entire tunnelling, minerals and mining industries. The web-based document library contains more than 140,500 articles, technical papers, books and other documents from industry societies worldwide.

***Dig In
Today!***

Gall Zeidler Consultants

Gall Zeidler Consultants is an international engineering consultancy firm specialized in innovative solutions for tunnel and underground projects. For over 20 years, we use our broad expertise in transportation, infrastructure, water conveyance, energy and mining projects to help our clients overcome challenging conditions and providing innovative solutions from conceptual and planning phases through construction and operation.

Our tunnel and geotechnical engineering services cover all stages of a project:

- Conceptual to Final Design
- Program & Construction Management
- Construction Site Support
- Tunnel Inspection & Rehabilitation
- Mine Access Tunnels & Shafts
- Independent Design Verification Services
- Building Information Modeling (BIM)

With our diverse team of experts and young professionals, we are represented in all major global markets with offices in North America, Latin America, Europe and Asia.



ELEVATED THINKING, UNDERGROUND.

We provide award-winning tunnel consultancy and design services for underground schemes around the globe. By taking challenges as a motivation, we are a leader in our field and have successfully completed 300 miles of tunnels worldwide.



Gall Zeidler Consultants
Geotechnics | Tunnel Design | Engineering

Washington DC · London · New York · San Francisco · Toronto
Salzburg · Santiago de Chile · New Delhi · Singapore

www.gzconsultants.com

Dr. Mole, Incorporated

Doctor Mole, Incorporated is a sole-proprietor consulting practice that was started in January, 2013 when Dr. Brierley stepped down as President of Brierley Associates Corporation. DMI specializes in providing advice to project owners, contractors, and designers about all aspects of the design and construction of underground openings. Dr. Brierley has also been involved with the implementation of scores of subsurface investigations and with the preparation of the Geotechnical Data and Baseline Reports associated with those investigations. As has been noted many times in the project literature, the single-most important aspect of project success for a tunneling project is the provision of accurate and reliable discussions of the ground conditions inside of which the underground openings will be constructed.

DMI is also retained on a regular basis to provide forensic evaluations relating primarily to claims for Differing Site Conditions. Doing "Battle with Mother Earth" is never easy, and when things go wrong during construction it becomes necessary to evaluate what is happening in order to minimize potentially detrimental impacts both to the construction process itself and to existing third party structures and utilities.

Dr. Mole, Incorporated
2000 S. Colorado Blvd.
Annex Bldg. Suite 420
Denver, CO 80222 USA
303-704-6955
<http://drmoleinc.com/>

Dr. Gary S. Brierley, P.E.

50 years of experience providing consulting services to Owners, Contractors, Attorneys and Engineering firms.

- Subsurface Planning, Design and Construction
- TBM Selection and Evaluation
- Prebids
- Design/Build
- Dispute Resolution
- Claims

DOCTOR MOLE
INCORPORATED

gbrierley@drmoleinc.com • 303-704-6955

www.tucmagazine.com



tuc
&

UCA Young Members Presents

TUNNEL VISION SERIES

MONTHLY: EVERY 4TH WEDNESDAY
FROM 4:00 PM TO 4:45 PM EST

Learn more at smenet.org/UCA/YMTunnelVision

**Down
for that.**

*Conversation encouraged.
Walls brought **down**.
Bars **raised**.*



**Down
for that.**

A New Website for a New Generation of Underground Engineers

Down for That encourages engineering students to pursue a career in underground construction and tunneling by providing students and professors with introductory industry information including:

- Resource Library
- Tunnel Tours
- Industry Profiles
- Presentations
- Case Studies



Share the excitement and reward of a career underground.
undergroundcareers.org

Together we'll grow the underground workforce.



Exhibit and Sponsorship

A comprehensive plan for advertising, exhibiting and sponsoring tie your marketing program together. Learn more about exhibiting and sponsorship opportunities at these upcoming events.

FIND
DETAILS
ONLINE AT
ucaofsme.org



NAT2022
NORTH AMERICAN
TUNNELING CONFERENCE

North American Tunneling Conference

June 19-22, 2022 | Philadelphia, PA



**Cutting Edge
Conference**
Advances in Tunneling Technology

Cutting Edge Conference
Fall 2022



**George A. Fox
Conference**

George Fox Conference
January 2023 | New York, NY



© Herrenknecht

SPONSORSHIPS

Emma Li Salditt
+1.303.948.4200 | sponsorships@smenet.org

EXHIBITS

Justin Courtney and Corey Carlson
+1.303.948.4200 | exhibits@smenet.org

ALWAYS ADVANCING

www.terratec.co



MUMBAI'S WATER TUNNEL PROJECT

TERRATEC has recently delivered the second 3.2m diameter Open TBM for the Amar Mahal water transfer tunnel contracts in Mumbai, India.

In recent years, TERRATEC's order book has demonstrated significant growth & diversity globally including projects in Argentina, Turkey, Thailand and India which have been the result of robust custom-made TBM designs, a readily available stock of TBM spares and consumables, and a highly-skilled team offering specialised TBM support and prompt onsite assistance throughout tunnelling operations.

COMPILED BY JONATHAN KLUG, DAVID R. KLUG & ASSOCIATES

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Gateway Tunnel	Amtrak	Newark	NJ	Subway	14,600	24.5	2023	Under design
2nd Ave. Phase 2	NYC-MTA	New York	NY	Subway	16,000	20	2023	Under design
2nd Ave. Phase 3-4	NYC-MTA	New York	NY	Subway	89,600	20	2024-29	Under study
Kensico-Eastview Connection Tunnel	NYC-DEP	New York	NY	Water	10,500	27	2024	Under study
Flushing Bay CSO	NYC-DEP	New York	NY	CSO	13,200	20	2026	Under study
Cross Harbor Freight Tunnel	NYC Reg. Develop. Authority	New York	NY	Rail	25,000	30	2025	Under study
Metro Tunnel Program - Northern	Boston MRWA	Boston	MA	Water	23,760	10	2027	Under study
Metro Tunnel Program - Southern	Boston MRWA	Boston	MA	CSO	50,160	10	2028	Under study
Silver Line Extension	Boston Transit Authority	Boston	MA	Subway	8,400	22	2024	Under design
Narragansett Bay CSO Phase III - Conveyance Tunnel	Narragansett Bay Commission	Providence	RI	CSO	8,800	10	2024	Under design
Amtrak B&P Tunnel	Amtrak	Baltimore	MD	Rail	40,000	32	2023	Awaiting funding
Ellicott City North Tunnel	Howard County	Ellicott City	MD	CSO	5,800	15	2022	Under design
Potomac River CSO Tunnel	DC Water and Sewer Authority	Washington	DC	CSO	24,000	18	2022	RFQ 1Q 2022
Superconducting Maglev Project - Northeast Corridor	TNEM/BWRR	Washington	DC	Rail	146,520	43	2023	Under design
Alum Creek Relief Tunnel Phase 1 Phase 2	City of Columbus	Columbus	OH	Sewer	30,000 21,000	18 14	2022 2023	Under design Under design
Southerly Storage Tunnel	NEORS	Cleveland	OH	CSO	18,000	23	2024	Under design
Big Creek Storage	NEORS	Cleveland	OH	CSO	22,450	18	2026	Under design
Northside Interceptor Tunnel	City of Akron	Akron	OH	CSO	6,850	24	2024	Under design
Enbridge Line 5 Tunnel	Enbridge	Traverse City	MI	Oil	23,760	12	2020	delayed
Minneapolis Central City Parallel Tunnel	City of Minneapolis	Minneapolis	MN	CSO	4,200	10-19	2022	Final planning
ALCOSAN CSO Ohio River Allegheny River Monongahela River	Allegheny Co. Sanitary Authority	Pittsburgh	PA	CSO	10,000 41,700 53,900	14 14 14	2023 2027 2030	Under design Under design Under design

To have your major tunnel project added to the Tunnel Demand Forecast, or to update information on a listed project, please contact Jonathan Klug at jklug@drklug.com.

TUNNEL NAME	OWNER	LOCATION	STATE	TUNNEL USE	LENGTH (FEET)	WIDTH (FEET)	BID YEAR	STATUS
Stormwater Control Program	Harris Co. Flood Control District	Houston	TX	CSO	52,800	25-40	2021	Under design
Project Connect Subway Program	City of Austin	Austin	TX	Subway	8,500	20	2023	Under design
Section 19 Long Tunnel Crossing	City of Dallas	Dallas	TX	CSO	12,310	10	2021	Taylor-Sundit JV awarded
D2 Subway - 2nd Light Rail Alignment	Dallas Area Rapid Transit	Dallas	TX	Highway	3,000	22	2020	Under design
Mill Creek Trunk Improvements	City of Nashville	Nashville	TN	CSO	13,800	10	2023	Under design
I-70 Floyd Hill Highway Tunnel	Colorado Dept. of Transportation	Denver	CO	Highway	15,840	60x25	2022	Under design
West Seattle to Ballard Extension	Sound Transit	Seattle	WA	Transit	10,500	18	2024	Under design
LA Metro Speulvada Pass Corridor	Los Angeles MTA	Los Angeles	CA	High/Trans.	55,500	60	2024	LOI received
Folsom Area Storm Water Improvement	SFPUC	San Francisco	CA	CSO	4,000	12	2022	Under design
BART Silicon Valley Phase 2 Tunnel	Santa Clara Valley Transit Authority	San Jose	CA	Subway	26,400	56	2021	Under design
California Waterfix 1 California Waterfix 2	Delta Conveyance Design and Const.	Sacramento	CA	Water	39,905 403,400	28 40	2020 2020	Delayed Delayed
Yonge St. Extension	Toronto Transit	Toronto	ON	Subway	15,000	18	2022	Under design
Massey Tunnel	City of Toronto	Toronto	ON	CSO	20,000	18	2022	Under design
Inner Harbour West	City of Toronto	Toronto	ON	CSO	18,400	19	2022	Under design
Scarborough Rapid Transit Extension	Toronto Transit Commission	Toronto	ON	Subway	25,000	18	2018	Strabag low bidder
Elington Crosstown West Extension	Toronto Transit Commission	Toronto	ON	Subway	40,000	18	2020	West End Contractors JV awarded
Ontario Line North Extension	Toronto Transit Commission	Toronto	ON	Subway	29,500	20	2022	Under design
Ontario Line South Extension	Toronto Transit Commission	Toronto	ON	Subway	29,500	20	2021	Shortlist announced
Blue Line Extension	Societe de transport de Montreal	Montreal	QC	Subway	19,000	20	2021	Under design
Green Line LRT	City of Calgary	Calgary	AB	Transit	26,250	20	2021	RFQ submitted
Nose Hill Project	City of Calgary	Calgary	AB	CSO	10,800	10	2020	Under design
Annacis Water Supply	City of Vancouver	Vancouver	BC	Water	7,500	15	2021	RFQ requested
Millennium Line Broadway Extension	Metro Vancouver	Vancouver	BC	Subway	18,700	18	2020	Acciona/Ghella JV awarded
Eagle Mt. Pipeline	Fortic BC Woodfibre	Vancouver	BC	Oil	29,500	13	2021	Awaiting final award
Stanley Park Water Supply Tunnel	City of Vancouver	Vancouver	BC	Water	5,000	15	2021	Under design

tuc[®] CLASSIFIEDS

World's Leader in Underground Grouting Equipment

- Tunneling & Mining
- Heavy Construction
- Building Construction
- Restoration Repair
- Highway & Bridges
- Environmental Remediation
- Well Drilling
- Geothermal



www.chemgrout.com 708.354.7112



Contact QSP with all your Packer questions!!

253-770-0315 or 888-572-2537

Fax #: 253-770-0327

Email: info@QSPPackers.com

Web: www.QSPPackers.com

QSP Packers, LLC

Quality - Service - Price

Serving Your Complete Packer Needs

- ◆ **INFLATABLE PACKERS** - Wireline, Pressure Grout, Environmental, Water Well. Custom Sizes and Fabrication available.
- ◆ **MECHANICAL PACKERS** - Freeze Plugs, Custom Applications.

Prompt Shipping in US & International
Usually in just One or Two Days!

GROUND SUPPORT SYSTEMS YOU CAN BUILD ON

**SUPPLYING MINING
OPERATIONS
WORLD WIDE FOR
55 YEARS**

- GROUT SYSTEMS
- MIXERS
- SHOT-CRETERS
- CONCRETE PUMPS

CON MICO INC.
High Pressure Systems Technology

www.conmico.com

TEL: 1(905) 660-7262



Ad Index

Akkerman	11
Antraquip Corporation.....	31
Bradshaw Construction Corp.....	45
Brokk	58
Brookville.....	61
CDM Smith	47
Colorado School of Mines.....	38
Daigh Co. Inc.....	27
David R. Klug.....	52
Derrick Equipment.....	43
Dr. Mole	66
Dr. Sauer.....	59
Drill Tech.....	53
DSI Underground.....	41
Gall Zeidler	65
Galloovich Consulting	56
Herrenknecht.....	Inside front cover, 39
HNTB.....	2-3, 28-29
Jennmar.....	33
Kelley Engineered Equipment.....	64
Kiewit Infrastructure	46
MAPEI.....	35
Master Builders Solutions	49
Michels Corporation.....	63
Miller Contracting	51
Mining Equipment Ltd.	54
Naylor Pipe	57
Normet Americas, Inc.	55
NW Laborers-Employers.....	44
Reliable Automatic Sprinkler.....	37
Stantec / City of Columbus	07
Staubli	60
Strata Worldwide	62
Trinity Products.....	59
UCA - George Fox Conference	Outside Back Cover
UCA - Volunteers.....	09
UCA - Career Center	05
UCA - NAT Conference	Inside Back Cover

Advertising Information



Hooper Jones
CENTRAL, NW U.S.
+1.847.486.1021
Cell: +1.847.903.1853
hooperhja@aol.com

Laura Lemos
EAST, SOUTH, WEST U.S.
Cell: +1.973.668.2449
Main: +1.973.822.9274
laura@boja.com

Darren Dunay
CANADA
+1.201.781.6133
Cell: +1.201.873.0891
sme@dunayassociates.com

Eberhard G. Heuser
EUROPE
+49 1520.9269629
Fax: +49 202 2838126
egh@heusermedia.com

Patrick Connolly
UNITED KINGDOM
+44 1702.477341
Fax: +44 1702.177559
patco44uk@aol.com

Gary Garvey
INTERNATIONAL SALES
+1.303.948.4243
Fax: +1.303.973.3845
garvey@smenet.org

MAKE PLANS TO ATTEND



NAT2022
NORTH AMERICAN
TUNNELING CONFERENCE

JUNE 19-22, 2022

PHILADELPHIA, PA



1,000+

Underground Professionals

Connect with contractors, engineers, vendors and owners from the tunneling industry at NAT. It's a fully comprehensive event.



150+

Exhibiting Companies

Get a firsthand look at new products, comprehensive services and integrated solutions – all from industry vendors who understand your needs.



20+

Technical Sessions

Increase your knowledge and learn how you and your company can advance in the tunneling and underground construction industry.

Registration **OPENS** Spring 2022

FIND A 360° PERSPECTIVE AT NAT

Visit natconference.com for program details and registration.



George A. Fox Conference

New York, NY • May 10, 2022

TUNNELING: RESPONDING TO THE NEEDS OF A MODERN SOCIETY

Tuesday, May 10, 2022

**NEW
DATE!**

New York Hilton Midtown

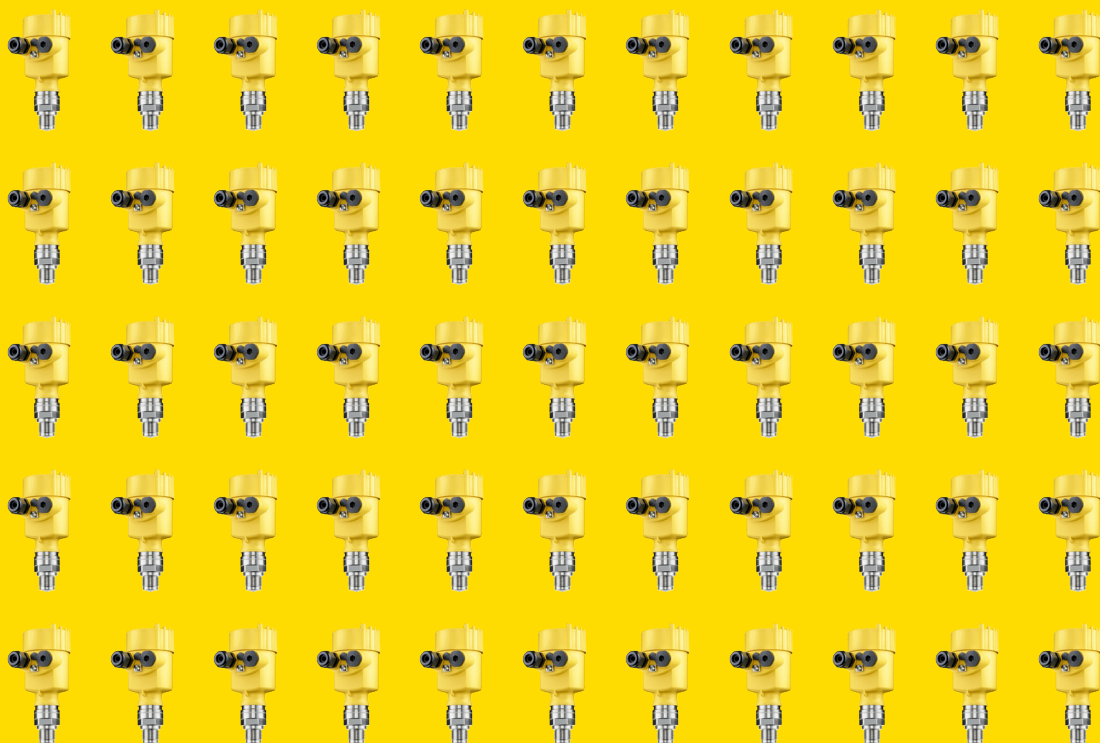
1335 6th Ave
New York, NY 10019

Don't miss this intensive, one-day tunneling conference tailored to busy industry professionals.

The George A. Fox Conference brings it all together in one convenient place, on one day.

- **Learn** from industry experts as they share project updates, strategies for overcoming challenges, and discussions surrounding critical industry issues.
- **Connect** with like-minded professionals and experts, and expand your professional network.
- **Earn** PDHs for attending this industry event focused only on the issues that matter most.

Register at georgefoxconference.com



WHAT'S MORE IMPORTANT THAN A MILLION RADAR SENSORS? **ONE MILLION SATISFIED CUSTOMERS.**

After 30 very successful years in radar measurement technology and 1 million sensors sold, an exciting new chapter is about to begin. Watch this space, so you don't miss out as we write the next pages in this best-selling story.

www.vega.com/radar

VEGA

THE LINER THAT LASTS LONGER

**The best mill liner has a green strip
and lasts longer than ever.**

With more abrasion resistance and a better wear life, Vulco® R67 liner keeps your mill running at capacity longer. That means a measurable reduction in mill downtime, as well as a reduction in installation, maintenance costs and total cost of ownership. It's all thanks to the unique patented material that forms our innovative premium rubber compound. The R67 mill liner is the most wear-resistant we've ever made. Which for Vulco is pretty impressive. So, if you don't see that green strip, you know you're not working with the best.

Get more from your mine with Vulco® mill lining systems. Visit info.global.weir/vulcor67

WEIR

Minerals

