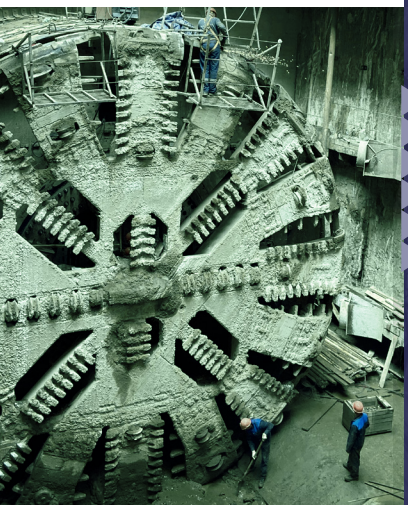
South African National
Committee on Tunnelling

SANCOT SYMPOSIUM 2026

13-14 APRIL 2026
SOUTHERN SUN ROSEBANK,
JOHANNESBURG



Unlocking Africa's Potential: Advances in Tunnelling in Civil Engineering and Mining

Abstract Book

SAIMM
THE SOUTHERN AFRICAN INSTITUTE
OF MINING AND METALLURGY

THE SOUTHERN AFRICAN INSTITUTE OF MINING AND METALLURGY JOHANNESBURG 2026

SANCOT SYMPOSIUM 2026

Unlocking Africa's Potential: Advances in Tunnelling in Civil Engineering and Mining

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FOREWORD

From the Chairperson of the Organising Committee of SANCOT Symposium 2026

It is with great pleasure that I present to you these proceedings of SANCOT Symposium 2026 held in Rosebank, Johannesburg, Gauteng, South Africa.

Rosebank, situated in the heart of Johannesburg's northern suburbs, is one of the city's most vibrant commercial and cultural hubs. Known for its modern office parks, bustling shopping centres, excellent restaurants, thriving arts scene at venues like the Everard Read Gallery, and the popular Rosebank Sunday Market, this cosmopolitan precinct embodies Johannesburg's transformation into a world-class African city. The area's central location provides easy access to Johannesburg's rich heritage sites, including the Apartheid Museum, Constitution Hill, and nearby Soweto, as well as the natural beauty of the Walter Sisulu Botanical Gardens. We sincerely hope that while here you will enjoy the city's renowned hospitality, diverse culinary offerings, vibrant cultural experiences, and dynamic urban energy.

We chose the theme **'Unlocking Africa's Potential: Advances in Tunnelling in Civil Engineering and Mining'** for SANCOT Symposium 2026 to showcase the continent's growing capacity in underground construction and to highlight the critical role that tunnelling plays in Africa's infrastructure development and mineral resource extraction. With several major civil engineering water transfer and transport projects underway alongside innovative mining developments incorporating cutting-edge technology across Southern Africa, the region presents a compelling narrative of technical advancement and economic growth through tunnelling, including:

- **Polihali Transfer Tunnel,** part of Phase II of the Lesotho Highlands Water Project (LHWP P2).
- Advanced mining decline and shaft development at various deep-level gold and platinum mines in South Africa, incorporating latest technology and safety innovations.
- **uMkhomazi Water Project Phase I (uMWP-1)**, a proposed water tunnel in KwaZulu Natal.
- **Oxbow Hydropower Project**, proposed hydropower tunnels and caverns in Lesotho.
- **Gautrain expansion projects,** including proposed extensions to Cosmo City, Soweto and Mamelodi, requiring extensive tunnel works in Johannesburg and Pretoria

We are also delighted to feature keynote presentations from several international experts covering topics such as geotechnical baseline reports, productivity challenges in tunnelling, and the synergies between mining and civil engineering practices. The technical programme encompasses geotechnical risk management (including new DMPR guidelines), mechanised boring technologies, pressure tunnel design, ground support systems, and digital data capture for tunnel construction. Several papers and presentations included in these proceedings provide comprehensive updates on major regional projects including the uMWP-1 and LHWP P2. The symposium also addresses the application of mechanised boring in mining, innovative shaft sinking technologies for deep mining operations, and logistical challenges in long-distance tunnelling, all critical to the region's infrastructure and resource development. Participation by the International Tunnelling and Underground Space Association further connects African practitioners with global tunnelling knowledge and best practices. The symposium proceedings thus reflect extensive local, regional, and international experience in tunnelling and underground construction, and we trust it will prove to be a valuable resource for tunnelling projects throughout Southern Africa and beyond.

Finally, we hope that all delegates attending the symposium here in Rosebank will leave with good memories of another successful SANCOT symposium where new acquaintances were made and old friendships renewed while sharing information on emerging tunnelling technologies, discussing progress on various projects, learning from both successes and challenges, and building collaborative networks that will advance the tunnelling profession across our continent.

Best wishes as always.

R. Freese,

Chairperson: Organising Committee

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The organisers of the conference thanks the following sponsors for their support

Conference Chairperson

Ryan Lloyd Freese

MSc: Engineering and Environmental Geology
Lead Engineering Geologist

Ryan Freese is a professionally registered engineering geologist with 15 years experience. He has a broad range of experience in various infrastructure developments in a wide range of geotechnical conditions. Ryan's experience in tunnel design and construction include being part of the design and supervision teams for the ongoing construction of the Polihali Transfer Tunnel and his involvement in the geotechnical investigation of the uMkhomazi Transfer Tunnel, apart from involvement in the investigation and design of a number of smaller hydro power and diversion tunnels as part of dam projects.

Keynote Presenters

David B Powell

Independent Consultant

Engineering of major hydroelectric (run of river and pumped storage) and transportation projects including the evaluation of management control systems, hazard and risk management assessments, technical assurance and quality control systems for major tunnelling projects.

Assessments of the ground conditions and design input parameters for hydroelectric projects, particularly in the faulted and thrust belts of the Himalayas, Karakorums, Andes and Zagros Mountains. Preparation of GBR's

Design of support systems for large span underground works including hydroelectric complexes, high speed rail and large span highway tunnels in soft ground, weak rock and hard rock employing a variety construction methods and support systems.

Construction supervision of hydro-electric and transportation projects, including the setting up of site teams and RE roles.

Experienced in the evaluation of tunnel failures and provision of recommendations for remedial measures and reinstatement of the works.

Expertise in the assessment of the potential impacts of systemic management failures on major hydro and tunnel related projects.

Specialist inputs as follows: participation in panel of experts; expert witness advice; reporting and presentations at arbitration hearings on major tunnelling projects.

Graham Russell Chamberlain

New Business Director
Cementation Africa

Director, Executive Manager, Operational Manager, Project Director, Mining Engineer, Graham has 40 years mining experience covering deep level, massive mining, opencast both alluvial and hard rock. Specialising in operational, project and contract management. Specialist knowledge of mine design, mechanised mine methods and shaft sinking operations.

Graham has a Master of Science degree in Mineral Economics from Wits University (1998).

Dr David James Lees

Director
David Lees and Associates

Beginning as a mining engineer in the South African mining industry in gold and platinum mines. He wrote his MSc thesis at Wits University and was involved in the introduction of trackless mining at HJ Joel Mine.

Returning to the UK in 1988 he commenced a new career in civil engineering with piling works at Canary Wharf, design for Jubilee Line Extension and CrossRail and cavern excavation in Jersey. Emigrating to Australia in 1995 he was supervising engineer at the Sydney LPG Cavern and Technical Advisor for the New Southern Railway as well as inspection of Snowy Hydro tunnels

David Lees and Associates was established in 1999 providing consultancy to civil and mining projects across Australia and Asia including Lane Cove Tunnel, Parramatta Rail Link, Delhi Metro, Singapore Deep Sewer System, Narrows Crossing LNG tunnel, inspection of Sydney sewer tunnels, grouting consultant for Blakefield South Colliery, plug designs for Russel Vale Colliery, and provided grouting and drainage proposals to Newcrest Mining for Havieron Decline.

Appointed as National Tunnel Manager for KBR in June 2002 and Manager of the NSW Civil Group, he was Banks Engineer for Lane Cove Tunnel and Brisbane By-pass, Technical Advisor for Metro West, and security advisor for Cross City Tunnel, carried out an inspection of the Otira Tunnel in New Zealand and a safety audit of a gold mine in Western Australia.

David established Grouting and Foundation Works Australia in June 2004 which provided specialist grouting and waterproofing for building, civil and mining projects across Australia including Shannon Creek Dam, Ranger Mine, Cross City Tunnel, and Pelican Point Power Station.

In July 2014 David was appointed as Senior Tunnelling Engineer for the Melamchi Water Supply Project in Nepal where he worked throughout the earthquakes of 2015. In August 2015 he was appointed as Chief Site Supervisor for the Uma Oya Project.

He returned to Australia in 20018 assisting in finalising the Snowy 2 contract documents, and as Principal Tunnelling Engineer with Jacobs he was CPS Manager at WestConnex, technical reviewer for Brisbane Metro, Baroota Pumped Hydro, More Trains More Services for Tansport NSW, Aukland Central Interceptor and Batang Toru Hydro Project in Sumatra.

Appointed Team Leader for Package 7A and 7B by AECOM of the Rishikesh-Karanprayag railway tunnels in Utarakhand in Northern India in September 2020, and Chief Resident Engineer for the Mahawelli Water Security Investment Program in Sri Lanka in 2021

David is currently Project Manager and Team Leader for the Tanahu Hydropower Project in Nepal.

David is a Fellow of the Institute of Engineers Australia, He was a Director of Engineers Media and has been Editor of the Australian Tunnelling Society Journal for 27 years. He has published two history books on tunnelling and three engineering novels.

Dr. Ulrich Rehm

Tunnelling Consultant
GmbH

1985 - 1991
Civil-engineering at the Technical University of Karlsruhe/Germany; Specialised in rock- and soil mechanics.

1992 – 1998
Ph.D. on silo- and soil mechanics at the Institute for Construction Management at technical University of Karlsruhe/Germany. Research and development as scientific assistant on cohesive soils. Programming of expert systems. Supervision and lecturing of graduands.

Career since 2008 -	Dr. Ulrich Rehm Tunnelling Consultant GmbH Chief Executive Officer
2005	Tunnelling expert adviser of Herrenknecht AG /Germany , worldwide consultancy
2004	Lecturer for mechanised tunnelling (TBM and conventional method) at University of applied science Stuttgart/Germany
2001	Director of research & development of TBM manufacturer Herrenknecht AG / Germany
1998	Director of the geotechnical department of TBM manufacturer Herrenknecht AG / Germany

The application of GBRs on projects with major underground works

D. Powell
Independent Consultant, Canada

First introduced in 1997, the "Suggested Guidelines for the preparation of Geotechnical Baseline Reports (GBRs)" have been around for almost 30 years. The intended purpose of the GBRs was to not just to prepare a document that was a geotechnical interpretive report but also a document that provided a means of both avoiding and resolving disputes. Essentially, it would play a significant role in minimising litigation by providing baselines and a content consistent with other contractual documents.

Updated and improved in 2007, this edition used the experience of 10 years of usage. After an additional 30 years, can there be further improvements?

There is also a broader issue of why on many international projects clients are not prepared to make use of GBRs. Recent experience of working on hydroelectric projects and major infrastructure tunnels internationally has shown that despite the benefits of GBRs, uptake has been poor. It is a concern that despite the need for a proper evaluation of the ground conditions and the increased use of risk management in underground works, some clients still want all risks transferred to contractors.
In 1984 the World Bank published a review document on long tunnel problems. The conclusion was that 85% of the delays and overruns were down to geological and geotechnical factors. They recommended ensuring clients make available appropriate funding for site investigations and not look to transfer all geological and geotechnical risks onto contractors. They also noted clients and consultants have much longer to study and investigate the ground conditions compared to contractors and it is fundamentally unfair to expect them to carry all risks with respect to the ground conditions.

In the August 2000 edition of Tunnels & Tunnelling there was an editorial note on the de-weaponising of GBRs. On many hydroelectric, water supply projects or infrastructure projects with long tunnels, carrying out site investigations where there is high cover, rough terrain and difficult access, can be a costly undertaking. Managing the risk of 'unforeseen ground conditions' is then about carrying out a hazard analysis and risk assessment. Guidelines for this process should follow those of the International Tunnelling Association (2012).

Having both reviewed and prepared a number of GBRs and recognising that we may not have all the information to characterise the ground conditions, it is apparent there is a wide variation in the quality of the product; which the T&T 2000 note as quite critical. There seems to be some confusion over what represents a baseline and this is a problem if the writers are more concerned about liability than the quality of the information. The overarching principle should be to follow the GBR guidelines and, using the data available, make the best possible assessment of the ground conditions and ground behaviour. Nevertheless, where the information is very limited there will be residual risks and this paper considers how to manage these so that there is a fair outcome for all parties. It will also look at case history where geological and geotechnical problems resulted in an arbitration. A GBR would have helped to provide better outcomes.

ASM Winzing applied in an East African gold mine

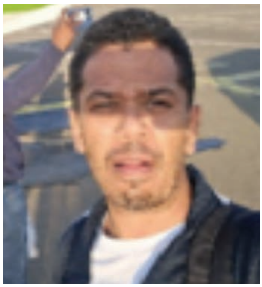
S.M. Rupprecht, L.A. Langton
University of Johannesburg, South Africa

This paper presents a case study of the winze development at a gold mining project in East Africa, offering practical insights into tunnelling methods tailored for artisanal and small-scale mining (ASM) operations. Drawing from firsthand experience, the study documents the complete mining cycle—including drilling, blasting, mucking, and ground support—implemented in a constrained underground environment.

Two distinct blast designs are analysed, with specifications on drill hole diameters, drill steel, explosive types, and achieved advance per round. The paper also outlines the modified rock removal method adopted to accommodate the mine's logistical limitations, as well as the support systems used to stabilize ground conditions. Cycle times for each activity are provided to illustrate operational efficiency and to benchmark performance in similar small-scale contexts.

The study highlights the practical challenges encountered during development—ranging from equipment limitations and ground control issues to logistical constraints—and critically examines the solutions applied. Emphasis is placed on the adaptability and ingenuity required in ASM environments, where resource constraints often demand unconventional yet effective approaches.

The paper concludes with a candid assessment of what worked, what didn't, and the lessons learned. These reflections are intended to support knowledge transfer within the African mining industry and to promote safer, more productive underground development practices in ASM operations. By documenting both the technical details and the decision-making processes behind the winze development, this work contributes to the growing body of knowledge aimed at professionalising and optimising ASM tunnelling practices across Africa.



Lance Alex Langton

Mining Engineer

Lance Alex Langton is a mining professional and emerging industry consultant with a strong focus on the development and optimisation of small- to medium-scale mining operations across Africa. With a practical foundation in mining operations, project evaluation, and resource development, he brings a solutions-driven approach to unlocking value in complex geological and operational environments.

Lance has built his experience across various facets of the mining value chain, including exploration support, project startup planning, operational improvement, and cost optimisation. He has demonstrated a particular interest in identifying underutilized or sterilised mineral resources and repositioning them into viable, revenue-generating assets. His work is informed by a deep understanding of African mining contexts, where regulatory, logistical, and socio-economic factors require adaptive and innovative strategies.

A key area of Lance's professional focus is the structuring and implementation of small-scale mining ventures. He is actively developing a niche capability in establishing modular, scalable mining operations that can be deployed efficiently with limited capital while maintaining compliance, safety, and environmental responsibility.

His approach integrates technical mining knowledge with entrepreneurial thinking, allowing him to bridge the gap between resource potential and commercial execution.

In addition to his technical capabilities, Lance is developing expertise in mining-related financial modelling, project feasibility analysis, and investment structuring. He is particularly interested in leveraging these skills to support funding readiness for junior mining projects and to facilitate partnerships between investors and operators. His goal is to contribute to a more inclusive and sustainable mining sector by enabling access to opportunities for emerging players in the industry.

Lance is also engaged in continuous professional development, with a focus on advancing his knowledge in areas such as mineral economics, underground and surface mining methods, and infrastructure planning. He is committed to aligning his work with broader industry trends, including sustainability, environmental stewardship, and the role of mining in supporting energy transition and urban development.

At the core of Lance's professional vision is the ambition to become a trusted advisor and operator capable of initiating and managing mining projects across diverse African jurisdictions. He aims to play a meaningful role in transforming mineral resources into long-term economic value, while contributing to job creation, skills development, and responsible resource management.

Lance's participation in the SAIMM conference reflects his commitment to engaging with industry leaders, sharing knowledge, and contributing to discussions on the future of mining in Africa. He brings a forward-looking perspective grounded in practical experience, with a clear focus on execution, innovation, and sustainable growth.

Industry update: DMPR guideline for the compilation of a mandatory code of practice to mitigate geotechnical risk in civil tunnels and underground spaces

G.J. Keyter[1], T. Mateta[2]
[1]SRK Consulting, South Africa
[2]Department of Mineral and Petroleum Resources, South Africa

The Department of Minerals and Petroleum Resources (DMPR) is in the process of developing a new guideline for the compilation of a mandatory Code of Practice (COP) to mitigate geotechnical risk in civil tunnels and underground spaces. This involves thorough internal regulatory, legal review and approval processes. This new COP will be the fifth in a series of similar DMPR guidelines for the compilation of mandatory COPs to mitigate geotechnical risks within the mining sector, with the other four guidelines respectively focussed on hard rock tabular mining, underground coal mining, surface mining, and massive mining. The new COP will follow the same guideline layout and structure as the other guidelines in the series, but with a specific focus on the design and construction of civil tunnelling projects and other underground civil works, any subsequent maintenance and repairs during the operation of such schemes, and the requirement to maintain unused and abandoned civil tunnels and underground spaces in a safe and stable condition where such underground facilities are not permanently closed to prevent inadvertent access.

This paper provides an update on progress with the development of a new DMPR guideline for civil tunnels and underground spaces; reviews the implications of its implementation for engineering designers of civil tunnels and underground spaces, civil engineering contractors involved in its construction, and the owners and operators of such underground facilities, and provides guidance on DMPR processes to ensure compliance.

The paper furthermore focuses on risk mitigation strategies to be implemented during construction and commissioning of such underground schemes, as well as post construction during scheme operation, and reviews guidance included for regular inspection by competent geotechnical engineering practitioners of such facilities. Implications for civil tunnelling works and underground spaces constructed prior to promulgation of these new guidelines, as well as the need to maintain (or alternatively, permanently close) unused / abandoned tunnels are also discussed.

Finally, the paper reviews other requirements incorporated in this new guideline for civil tunnels and underground spaces including long term planning requirements, defined geotechnical roles and responsibilities, and requirements for geotechnical review and oversight.

Gerhardus Johannes Keyter

Principal Geotechnical Engineer, Pr. Eng.
SRK Consulting (South Africa) (Pty) Ltd

Gerhard Keyter is a civil engineer who specialised in geotechnical engineering in civil engineering and mining. Over the past 30 years, he has worked on, and led engineering teams involved in the design of open pit mines, railway cuttings, box cuts for adit portals and in pit crushers, other surface excavations, slimes dams and waste rock dumps, civil engineering tunnels, large hydropower caverns including large diameter surge shafts and chambers, mine tunnels, access and ventilation shafts, ore passes, and other underground mining excavations including crusher chambers, workshops, and main dewatering sumps. He has furthermore led an investigation into the root causes of a 2020 slope failure accident at a large open pit in South Africa and has also been involved in several mine closure studies.

Gerhard has been involved in projects in South Africa, Botswana, Burkina Faso, the Democratic Republic of Congo, Eritrea, Ghana, Guinea, Lesotho, Malawi, Mali, Mozambique, Namibia, Tanzania, Zambia, and Zimbabwe, as well as projects in Australia, Brazil, Chile, China, India, Panama, and Russia.
Since 2015, Gerhard has served on Mine Health & Safety Council (MHSC) Mining Regulations Advisory Committee (MRAC) and Mining Occupational Safety Advisory Committee (MOSAC) Task Groups tasked with:

- Reviewing South African Mine Health & Safety Act (MHSA) fall of ground regulations & associated incident/accident reporting requirements; and
- Reviewing and updating the DMPR's Guidelines for the Compilation of Mandatory Codes of Practice for the Mitigation of Geotechnical Risk on South African Mines.

uMkhomazi water project – Phase 1: Project update

M. Dhlamini
TCTA, South Africa

The uMkhomazi Water Project – Phase 1 (uMWP-1) is a strategic bulk water augmentation scheme aimed at securing a long-term water supply for the uMngeni Water Supply System, which supplies municipalities across KwaZulu-Natal. The system's yield is approximately 398 million m^3 annually, and uMWP-1 will supplement this system by transferring about 220 million m^3 per year (at the 2050 development level) of raw water from the upper uMkhomazi River to the proposed uMngeni-uThukela Water's (UUW's) water treatment plant.

Foundational scheme investigations and options were documented in a series of reports in 1999, followed by reconciliation planning in 2011 and 2024. A Technical Feasibility Study, conducted from 2011 and finalised in 2015, consolidated hydrology, environmental, socio-economic, and geotechnical inputs. This study confirmed the feasibility of a large storage dam and a mega water conveyance system. The implementation is led by the Trans-Caledon Tunnel Authority, as the implementing agent for the Department of Water and Sanitation. The design development is structured to support international construction tendering and secure funding.

The layout features a major transfer corridor from the proposed dam to the UUW infrastructure at Baynesfield Estate, comprising approximately 34 km-long, 3.5 m internal-diameter tunnel with associated portals, adits, and vertical shafts, a 5 km-long, 2.6 m nominal-diameter steel pipeline, and ancillary infrastructure. This conveyance infrastructure is undergoing detailed design, including constructability reviews, reliability analyses, and the development of operating rules and philosophy.

The progress to date includes completing inception-stage reviews and gap analyses, along with comprehensive subsurface investigations (drilling, geophysics, packer testing, hydrochemical analysis, and modelling) to guide and contribute to the ongoing designs and reduce uncertainty in the tender document ahead of the contractor's procurement. Simultaneously, environmental authorisation conditions and land access requirements continue to influence programme and sequencing, with tight implementation timelines driven by environmental processes and compliance obligations.

Mbonisi Dhlamini

Project Engineer
TCTA

Mbonisi Dhlamini is a registered Professional Engineer (Pr.Eng), Project Management Professional (PMP), and Professional Construction Project Manager (Pr.CPM), with over 14 years of experience in the planning, design, and delivery of large-scale infrastructure projects.

He currently serves as a Project Engineer at the Trans-Caledon Tunnel Authority(TCTA), where he leads multidisciplinary engineering teams on the uMkhomazi Water Project (uMWP-1). This flagship programme includes the development of a major dam and associated large-diameter tunnel infrastructure, contributing to long-term water security in South Africa.

His expertise encompasses the design optimisation, implementation, and management of complex infrastructure systems, with particular emphasis on tunnelling and integrated water sector projects. He has extensive experience operating within multi-stakeholder environments, where he supports technical delivery, programme alignment, and performance across large public sector initiatives.

Mbonisi holds a Master of Engineering degree from the University of the Witwatersrand and a Diploma in Tunnel Engineering from the City and Guilds(UK). He is also a member of the Golden Key International Honour Society, in recognition of his academic excellence, and remains committed to advancing best practice in infrastructure delivery and tunnelling engineering.

The uMkhomazi transfer tunnel: Background, geotechnical conditions and tunnel design considerations

R.L. Freese[1], G.J. Keyter[2]
[1]Knight Piésold (Pty) Ltd, South Africa
[2]SRK Consulting (Pty) Ltd, South Africa

The uMkhomazi Water Project Phase 1 is a major infrastructure initiative and the largest civil tunnelling project in South Africa in the last three decades. Its centrepiece is the uMkhomazi Transfer Tunnel, a 31.2 km long, 3.5 m finished diameter tunnel designed to transfer raw water from the proposed Smithfield dam to a new Water Treatment Works which will supply potable water to the eThekwini metropolitan area in the KwaZulu-Natal Province of South Africa. The tunnel will be excavated primarily through sedimentary and intrusive igneous formations using tunnel boring machines (TBMs) following some initial drill and blast excavation of tunnel portals and access adit declines.

Feasibility study investigations completed previously indicated a mixed geological setting comprising horizontally bedded sedimentary sequences of shales, mudstones, siltstones, and sandstones, which are variably indurated and with significant variation in strength. These sedimentary sequences have been extensively intruded by dolerite dykes and sills and contain several geological structures characterised by zones of fractured and weathered rock. While rock mass conditions are generally favourable to TBM tunnelling, site-specific concerns such as mixed (hard-soft) face conditions, high water pressures, gas bearing rock, chemical aggressivity, weak/sheared shale horizons, rock durability and potential squeezing conditions present significant design considerations.

The detailed design phase underway now includes a comprehensive geotechnical investigation programme comprising rotary core drilling, geophysical (seismic and resistivity) surveys, wireline logging, packer testing, hydrofracture and overcoring in situ stress testing. The objective of this work is to ensure optimal final tunnel alignment, ground support and final lining designs, excavation method selection, and waterproofing strategies – mitigating technical and contractual risks. These investigations were furthermore also designed to support the development of a Geotechnical Baseline Report in line with ASCE and FIDIC Emerald Book Guidelines.

This paper presents the background and layout of the project, the scope of the geotechnical investigations, and expected key tunnel design considerations.

Ryan Lloyd Freese

MSc: Engineering and Environmental Geology
Lead Engineering Geologist

Ryan Freese is a professionally registered engineering geologist with 15 years experience. He has a broad range of experience in various infrastructure developments in a wide range of geotechnical conditions. Ryan's experience in tunnel design and construction include being part of the design and supervision teams for the ongoing construction of the Polihali Transfer Tunnel and his involvement in the geotechnical investigation of the uMkhomazi Transfer Tunnel, apart from involvement in the investigation and design of a number of smaller hydro power and diversion tunnels as part of dam projects.

Design considerations and construction strategies for the uMkhomazi water project phase 1

M. Nasiri[1], G.J. Keyter[1], U. Rehm[2], T. Mac Kellar[2]
[1]SRK Consulting, South Africa
[2]Knight Piesold, South Africa

The uMkhomazi Water Project Phase 1 (uMWP-1) aims to augment water supply to the uMngeni Water Supply System (MWSS) in KwaZulu-Natal to address long-term regional water demand. A key component of the scheme is a 34 km waterway tunnel driven primarily by tunnel boring machines (TBMs), connecting the uMkhomazi intake to the Baynesfield outlet. The project presents several design and construction challenges, particularly due to the constraints of working within a relatively small 3.5 m internal diameter tunnel.

This paper outlines the main engineering strategies developed to manage these challenges, with preliminary design work completed to date, focused on practical solutions for tunnel logistics, including muck removal, segment transport, sequencing of construction activities, and the efficient use of equipment within the limited tunnel space. These aspects are essential in deriving workable construction methods for these long, small-diameter TBM tunnels. The paper also summarises options for TBM removal at the Baynesfield outlet, which represents a major project milestone with implications for programme, cost, and interfaces with downstream infrastructure.

Overall, the study highlights the importance of coordinated planning, effective logistics, and careful sequencing during the preliminary design phase to better manage construction risks and ensure long-term operability in complex tunnelling projects.

Keywords: TBM Tunnelling, Small-Diameter Tunnels, Long-Distance Tunnelling

Mehdi Nasiri

Geotechnical Tunnelling Engineer
Gibb-Knight Piésold Joint Venture

Mehdi Nasiri earned his Bachelor of Science (B.Sc.) in Mining Engineering in 1998 and his Master of Science (M.Sc.) in Rock Mechanics in 2001 from one of Iran's leading mining engineering universities. He began his career as a mining and geotechnical engineer with a consulting firm in Iran, where he worked for seven years. In 2005, his extensive experience as a senior rock mechanics engineer and project manager across mining and civil engineering projects led him to establish AZMA Rock and Tunnel Engineers, a consulting firm based in Tehran. As CEO, he managed a team of approximately twenty specialists for nine years. In 2014, Mehdi and his wife, also a mining engineer and rock mechanics specialist, relocated to South Africa to join a Johannesburg-based consulting company. He currently supports SRK Consulting on geotechnical and mining engineering projects worldwide and also serves as a Geotechnical Tunnelling Engineer for the Gibb–Knight Piésold Joint Venture. Mehdi is a registered Professional Engineer (Pr.Eng.) with the Engineering Council of South Africa (ECSA) and a member of the Southern African Institute of Mining and Metallurgy (SAIMM). He continues to apply his expertise in underground space design, slope stability, and geotechnical engineering across both mining and civil engineering sectors.

A practical approach to technology implementation in South Africa which unfortunately is lagging its international peers

G. Chamberlain
Cementation Africa, South Africa

Graham shares insights into evolving shaft-sinking techniques for deep-level mining and some of the off- the-shelf equipment available for civil and mining use. Furthermore, suggestions on a collaborative approach to implementing technology adoption in the industry.

Construction method evaluation for ventilation and surge shafts on the uMWP-1 water transfer tunnel project

B.C. Rodrigues[1], T. Mac Kellar[1], G.J. Keyter[2]
[1]Knight Piésold, South Africa
[2]SRK Consulting, South Africa

This paper presents an overview of the key considerations governing construction method selection for ventilation and surge shafts for the Phase 1 water transfer tunnel of the uMkhomazi Water Project (uMWP-1). The uMWP-1 project site is located between Impendle and Hopewell, south of Pietermaritzburg in KwaZulu-Natal, and includes two ventilation shafts (1.5 m finished diameter, with depths of 125 m and 190 m, respectively) and one surge shaft (5.0 m finished diameter and 110 m deep), to be constructed in Karoo mudrocks and dolerites.

Geotechnical characterisation of the shaft sites was undertaken using borehole logging, downhole wireline geophysical surveys, and laboratory testing. These investigations identified sequences of weathered and fresh shale, dolerite intrusions, structurally disturbed intervals, and variable groundwater conditions. Anticipated rock mass behaviour, together with structural data evaluated using Rocscience Dips and Unwedge, informed the evaluation of design risks and preliminary ground support requirements for shaft stability.

The paper compares shaft sinking methods, including reverse circulation (RC) drilling as the preferred method for the ventilation shafts, and alternative methods for the larger surge shaft. The discussion focuses on the suitability of these methods relative to anticipated ground conditions, groundwater, working footprint, cost and programme implications, and site-specific environmental constraints, particularly at the outlet end of the uMWP-1 transfer tunnel. Relevant precedent experience and comparable case studies are referenced where applicable.

The paper also considers the influence of logistical constraints, anticipated water inflows, and variable surface conditions on construction planning and risk management. Practical aspects of ground support, groundwater management, and spoil handling are discussed. The paper concludes with recommendations on method selection and risk mitigation, informed by the current investigations, precedent experience from similar shaft projects, and ongoing design of the uMWP-1 works.

Bridget Rodrigues

Senior Rock Engineer
Gibb Knight Piésold JV

Bridget Rodrigues is a Rock Mechanics Engineer with over nine years of experience in the mining industry. She holds a BSc (Hons) in Applied Science (Mining) from the University of Pretoria, South Africa, and has worked in both operational geotechnical roles (South Africa) and consulting environments (UK and South Africa).Bridget has extensive experience in both underground and open pit rock mechanics. She has contributed to a wide range of technical and multi-disciplinary mining projects, from early-stage scoping studies through to definitive feasibility studies. Her background includes due diligence assignments, geotechnical audits, and support to operating mines across several commodities and mining methods.

She has worked on projects across Southern Africa, Canada, the Middle East, South America, and Europe, gaining exposure to diverse geological environments and rock mass conditions. Her experience spans weak, highly weathered mudstones through to strong, competent norites of the Bushveld Complex. Bridget's technical strengths include site investigation planning and execution, geotechnical logging and interpretation, empirical and numerical analysis, ground support design, and the development of geotechnical models for both open pit and underground applications.

Over the past year, Bridget has been an integral member of the geotechnical design team for the uMkhomazi Water Project Phase 1 (uMWP-1), contributing to geotechnical investigation planning, logging oversight, analysis, and geotechnical characterisation for deep tunnel and shaft infrastructure.

She has substantial experience in geotechnical interpretation, limit equilibrium and stability assessments, and the design and of slopes, shafts, and underground excavations. Bridget is also experienced in preparing design reports, technical specifications, and tender documentation for mining projects.

Beyond the blast: How 3D data capture is reshaping tunnel construction

F. Phamotse
Knight Piesold, South Africa

Drill and blast tunnelling is being reshaped by modern ground data technologies that improve safety, accuracy and operational control. These tools create a detailed digital record of ground conditions and construction that can be revisited throughout the life of the project and beyond. The Polihali Transfer Tunnel demonstrates the potential of these advances in modern tunnelling construction in Africa. Geotechnical data capture technologies such as Measurement While Drilling (MWD), ShapeMetrix and Dibit are replacing traditional, largely manual methods with georeferenced 3D information for drilling, face mapping and support quality control, providing a stronger basis for geotechnical decision making. MWD combines guided drilling with automatic recording of the drill's response to the ground. Georeferenced drill patterns and hole depths are programmed onto the rig, reducing the need for manual hole positioning and depth control at the face. During drilling, key parameters are logged continuously, creating a detailed record along each hole that is interpreted to derive relative rock mass strength, degree of fracturing and water inflows – all visualised in 3D.

ShapeMetrix is a photogrammetric mapping system used to capture detailed face mapping records through a simple field workflow. From photographs taken at the face it produces high resolution, georeferenced 3D models that provide an accurate and auditable representation of ground conditions. Lithological and structural features can be measured directly on the model and revisited at any time, offering a safer, faster and more robust alternative to traditional face mapping.

Dibit is a laser scanning system for documenting as built lateral support and shotcrete application quality. Using high resolution 3D surface scans, the excavation profile before and after shotcrete can be captured, enabling accurate calculation of shotcrete thickness and precise recording of support locations. The resulting datasets underpin support quality control and form a detailed as built record for design verification and rearward support assessment.

While these technologies are already delivering clear benefits on the Polihali Transfer Tunnel, there is some untapped potential regionally. At present, MWD, ShapeMetrix and Dibit largely operate as separate, proprietary systems with limited interoperability and only modest scope for project specific customisation. Developing stronger local expertise, support services and integration solutions around such technologies could help address practical constraints and open further opportunities for innovation in the region.

Faith Phamotse

Engineering Geologist
Knight Piesold

Faith is an Engineering Geologist with 6 years of experience on large-scale infrastructure and mining projects across Southern and Central Africa. Project work includes water transfer tunnels and dams (Polihali Diversion and Transfer Tunnels, Lesotho–Botswana Water Transfer Feasibility Study) and tailings storage facilities (e.g. Glencore Copper and Sibanye-Stillwater TSF investigations). Experienced in core and test pit logging, surface mapping, and underground construction, including conventional drill-and-blast, NATM and TBM tunnelling.

She is currently part of the construction supervision team for the Polihali Transfer Tunnel, a key component of Phase II of the Lesotho Highlands Water Project. Faith is employed by Knight Piésold and forms part of the MSKC joint venture (SMEC, Knight Piésold, Zutari, Hatch and FM Associates), the consulting engineer for the project, which encompasses NATM (drill-and-blast) adits, raise-bored gate shafts and a TBM-bored waterway tunnel.

Introduction of the MC51 continuous hard rock miner / cutter

V. Hardy, C. Wade, M. Riley
Komatsu Joy Global, South Africa

Objectives
To present the design, operational principles, and performance outcomes of the Komatsu MC51 mechanical cutting system with Dynacut technology as a safer, more efficient alternative to drill-and-blast excavation in underground mining and civil tunnelling applications.

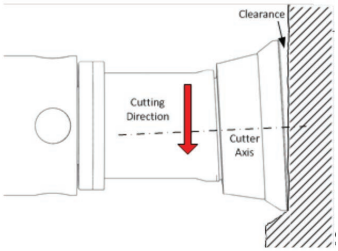
Methods
The MC51 employs a high-torque cutter head with either tungsten carbide or polycrystalline diamond buttons for dynamic rock-breaking technology to achieve continuous excavation. The MC51 utilizes an undercut/oscillating technique. Trials were conducted in mining (Hillgrove, Vale) and civil environments (Sydney M6 tunnels, Warringah Freeway underpass) to prove the concept and performance. Performance metrics included cutting accuracy, less dust generation, material fragmentation, and integration with ground support cycles. Comparative analysis was performed against conventional road headers and drill-and-blast methods.

Results
- Safety: Remote operation and electric drive eliminated personnel exposure to unsupported ground and reduced diesel emissions.
- Efficiency: Continuous cutting enabled near-24/7 production, reducing ventilation demand and ground support delays.
- Quality: Uniform chip sizing minimized downstream crushing; controlled excavation may reduce overbreak and rehabilitation costs as well as a cut accuracy of within 20 mm.
- Geotechnical Integrity: Non-blasting approach prevented stress redistribution and peripheral fracturing.
- Dust Control: Trials demonstrated significant reductions in airborne particulates compared to road headers.
- Adaptability: Achieved cut profiles from 4.2 m to 6.25 m width and 4.2 m to 5.35 m height, supporting niche applications such as caverns and underpasses.

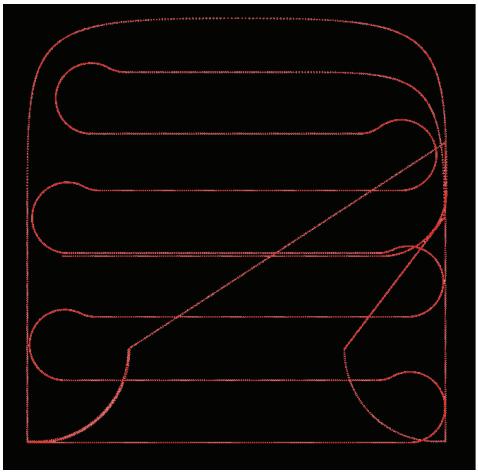
Conclusions
The Komatsu MC51 establishes a new benchmark for mechanized excavation, combining safety, productivity, and sustainability. Its ability to deliver precise profiles, reduce environmental impact, and integrate with existing infrastructure positions it as a transformative technology for both mining and civil tunneling sectors.

Technical Specifications

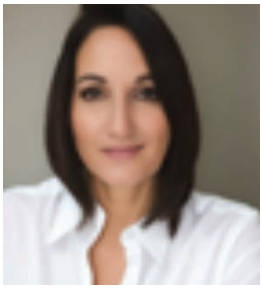
Cut Width	4.2 m (min) – 6.25 m (max)
Cut Height	4.2 m (min) – 5.35 m (max)
Drive	Electric (no diesel emissions)
Operation	Remote-controlled, automated
Applications	Mining headings, civil tunnels, caverns, underpasses
Key Features	Continuous cutting, uniform chip size, reduced dust, no blasting



Show the 7° undercutting technique



Explanation of the cutting cycle options (vertical or horizontal)



Vanessa Hardy

Business Development Manager – Southern Africa
Komatsu Joy Global

My name is Vanessa Hardy, an accomplished Business Development Manager at Komatsu Joy Global. Bringing over 19years of extensive experience in the mining industry. Throughout my career I have built a solid reputation for strong leadership skills and unwavering passion for the mining industry and assisting mining operations to achieve safe and sustainable productivity. My journey in mining has been defined by versatility and dedication. Over the last two decades I have held key roles including Contract Manager for Ground engaging tools at Sandvik Venetia Mine, Call Centre Manager for Southern Africa as well as Business Line Manager for Surface Drills Southern Africa. Each position has allowed me to develop a holistic understanding of both the operational and business sides of mining, from managing complex client relationships to driving product performance and operational safety in the field.

At Komatsu Joy Global I play a pivotal role in identifying business opportunities, cultivating long term partnerships and aligning customer needs with innovative mining solutions. I value the success of not only Komatsu products but the success of customer operations.

From an academic background I have earned by Diploma in Safety Management from Unisa, holds an opencast blasting ticket which assists me in the practical understanding of mining processes and on-site operations. I also completed numerous Managerial and product training certifications which have been enhanced by leadership, communication and technical proficiency.

I have a passion for the mining sector itself, the people, the products and the progress. I firmly believe that when mining is done responsibly and innovatively it plays a vital role in driving economic growth and improving lives. And firmly believe that the most important thing to come out of a mine, is the miner. My goal will remain consistent – to drive growth and proper capital fleet selection through meaningful partnerships, innovative solutions and a relentless dedication to success for both customers and the OEM's.

Investigating the effect of aggregate type on the strength and energy absorption of shotcrete in block cave mining

B.B. Makgate[1], V.C. Madanda[2], N.M. Chiloane[2], F.K. Mulenga[2], T. Mtshali[1], T. Chauke[2]
[1]Palabora Mining Company, South Africa
[2]University of South Africa, South Africa

In mining and tunnelling environments, large excavations are subjected to increasing rock stresses, making shotcrete performance critical for effective and sustainable ground support. Shotcrete stabilises excavations by controlling rock deformation and distributing loads, thereby reducing localised stress concentrations. Its performance, however, is strongly influenced by mix design, aggregate mineralogy, cement type, and additives such as fibres. This study investigates the decline in mechanical performance of fibre-reinforced shotcrete (FRS) at Palabora Mining Company following the introduction of mica-rich aggregates during the transition from a surface-based mixing plant to a newly commissioned underground batch plant. Laboratory testing was conducted to evaluate the uniaxial compressive strength (UCS) and energy absorption performance of shotcrete produced using mica-rich aggregates and dolerite aggregates. Specimens were cured and tested at 7 and 28 days to assess early-age and standard design strength development. The results indicate consistently poor performance of shotcrete incorporating mica-rich aggregates, with 28-day UCS values remaining below 40 MPa, failing to meet the mine's specified requirement of 45 MPa. The reduced performance was attributed to increased water demand and weakened cement–aggregate bonding, associated with the high phlogopite mica content. In contrast, shotcrete produced using dolerite aggregates consistently exceeded the required UCS at both curing ages and demonstrated superior energy absorption performance with the same fibre content. Although this investigation was conducted in a block cave mining environment, the findings are directly applicable to tunnelling operations, where reliable shotcrete performance is essential for long-term excavation stability.

Keywords: Shotcrete, Aggregate type, Energy absorption, UCS, Block Cave Mining

Thokozani Sidwell Mtshali

Chief Rock Engineer
Palabora Mining Company

Mr Mtshali Thokozani Sidwell is a highly passionate mining professional with experience in variety of mining methods from underground deep level gold mining, trackless operations, underground conventional gold mining, open pit and block caving (undercutting and draw bell development) at a copper mine. He is currently employed at Palabora Mining Company (PMC) as a Chief Rock Engineer tasked with the responsibility of the rock engineering duties for the whole mine starting from surface to underground mine.

Using the mobile tunnel borer for mining primary tunnel development

W. Roothman
Master Drilling, South Africa

Conventional excavation using drill and blast in hard rock mining has been the go-to method for underground access excavation in the mining industry for years. Utilising tunnel boring technology poses significant advantages in terms of efficiency, safety and quality. Recently Master Drilling has deployed this technology in a South African platinum mine to create access for underground mining operations. The equipment deployed has done two previous projects in a mining environment, where learnings have been tracked for continues improvement and have been applied to the current revision of this new technology in this mining system. To date a total of 112 m has been excavated at a diameter of Ø5.5 m including a turn radius of R50 m whilst mining at -9°. This paper will highlight some of the challenges faced during the project as well as key success elements that can shape the future of applying this technology in the mining industry.

Willem Roothman

Lead Project Engineer: Tunnelling
Master Drilling

Willem Roothman is a highly experienced mechanical and project engineer specializing in tunnelling and advanced mining technologies. He has built his career at Master Drilling, progressing from a junior mechanical engineer to his current role as Lead Project Engineer on mobile tunnel borer (MTB) projects.

With over a decade of hands-on experience, Willem has played a key role in the design, development, and implementation of innovative tunnelling solutions, including the advancement of "Cut & Break" technology and the redesign and full-scale rebuild of MTB systems. His expertise spans machine design, procurement, site layout planning, commissioning, and operational optimization, as well as budgeting, scheduling, and risk management.

Willem has been part of major underground excavation projects across South Africa, including work at Bokoni Platinum Mine and Mogalakwena, where he has overseen tunnel construction, managed multidisciplinary teams, and engaged closely with clients and senior leadership. His career also includes valuable international exposure through projects and technical engagements in Italy, Thailand, China, and Sweden.

Known for his strong technical insight and leadership ability, Willem combines practical site experience with strategic project management to deliver complex engineering projects safely, efficiently, and within budget.

Construction progress of the polihali transfer tunnel – Lesotho Highlands Water Project Phase II

B. Ranjan
Lesotho Highlands Water Project (Phase II), Lesotho

The Polihali Transfer Tunnel is a key component of Phase II of the Lesotho Highlands Water Project. The tunnel will convey water from the Polihali Reservoir to the Katse Reservoir through a 38.5 km long, 4.5 m diameter concrete-lined gravity tunnel. Once completed, it will be one of the longest water transfer tunnels in Southern Africa. The project is being delivered in a remote, high-altitude mountainous environment and passes through basalt formations with variable geological conditions.
The overall underground works associated with the project, including the transfer tunne
l and various access adits, amount to approximately 42.5 km of tunnelling. Construction of the transfer tunnel adopts a hybrid excavation approach, combining tunnel boring machine (TBM) excavation and conventional drill-and-blast methods. Of the total 38.5 km transfer tunnel, approximately 33.9 km is being excavated using two double-shield hard-rock TBMs launched from the Katse and Polihali ends, while the remaining sections are being constructed using drill-and-blast excavation with in situ concrete lining.

Several key construction milestones have already been achieved. Excavation of the intake tunnels has been completed, including concrete lining of the lower intake, and the Polihali gate shaft excavation has also been completed. The access adits and TBM assembly chambers at Polihali have been completed, enabling launch of the Polihali TBM. TBM excavation from the Katse side commenced in January 2025 from the access adit and, by mid-March 2026, had progressed approximately 614 m along the transfer tunnel alignment after completion of the adit, including sections excavated in open mode and sections lined with precast concrete tunnel lining segments. On the Polihali side, TBM excavation began in January 2026 and had advanced approximately 240 m by mid-March 2026. Other works, including the Katse outlet tunnel, connecting tunnel, intake structures, and gate shafts, are also progressing.

Investigations for the Katse lake tap have recently been completed, and work is currently underway to optimise the final location in competent ground beneath the live Katse reservoir.

The project presents several technical and logistical challenges, including tunnelling through basalt formations under significant overburden, managing groundwater inflows, and operating in a remote mountainous environment with limited access.

This paper provides an overview of construction progress to date, highlights key challenges encountered during TBM excavation, and discusses lessons emerging from the delivery of long hard-rock tunnel drives under complex geological and logistical conditions.

Balram Ranjan
Construction Project Manager
LHDA-PMU

Balram Ranjan is a tunnelling and underground works professional with more than 28 years of international experience in the delivery of major infrastructure projects across India, South Africa, Singapore, Malaysia, Saudi Arabia, and Lesotho. He holds a Bachelor of Engineering in Mining Engineering and an MBA in Project Management. Balram is a registered Professional Engineer with the Engineering Council of South Africa, a certified Project Management Professional (PMP®), and a member of the South African Institution of Civil Engineering (SAICE). He currently serves as Project Manager for the Transfer Tunnel under Phase II of the Lesotho Highlands Water Project, overseeing the delivery of the 38.5 km Polihali Transfer Tunnel. Today, he will present an update on the project's construction progress of the Transfer Tunnel.

What has the mining industry done for underground civil construction and what is the civil construction industry doing

D. Lees
David Lees and Associates, Australia

What has the mining industry done for underground civil construction and what is the civil construction industry doing in return? The first answer to this question is easy – the mining industry has trained and educated young mining engineers who have then found employment in civil tunnelling projects. What makes a mining engineer such a good prospect for civil tunnelling work? Firstly, they know the underground environment, but not only do they know and understand the underground environment but because their training and education is so well rounded in electrical and mechanical engineering, structural engineering, geology and geotechnical engineering, they can put their minds to all the everyday challenges that the fields of underground excavation present.

Pressure tunnel/shafts – risk of oversimplifications or overdesigning

M. Zoorabadi
SMEC, Australia

Hydropower and pumped storage projects are gaining popularity as alternative options for environmentally friendly energy generation and large-scale storage solutions. These projects rely heavily on pressure tunnels and shafts, which serve as essential elements in their infrastructure. Due to inadequate knowledge transfer and a lack of shared historical experience in the design of pressure tunnels and shafts, these structures are often either overlooked or overdesigned at the concept design stage. In both cases, the consequences can be catastrophic for the project. Oversimplification can lead to construction and operational challenges, while overdesign can unnecessarily increase project costs, potentially preventing the concept from advancing to approval. This paper discusses these issues by presenting some historical cases aimed at providing guidance for new projects.

Mahdi Zoorabadi

Chief Technical Principal – Underground Spaces and Rock
SMEC, ANZ, Melbourne, Australia

Visionary rock engineering and geotechnical leader with 25+ years of strategic technical direction, executive advisory, and multidisciplinary team leadership on high-value national and international infrastructure projects in tunnelling, dams, hydropower (including pumped storage), and underground structures.

Proven ability to lead feasibility-to-detailed-design phases, deliver innovative solutions (e.g., pressure tunnel lining alternatives, advanced stress measurement frameworks, hydraulic conductivity assessment methods), and provide independent peer review and risk management for multi-billion-dollar programs such as Snowy 2.0, Trojena Bow-Neom, and major Australian rail/water tunnel initiatives.

Published textbook author (Rock Engineering for Concrete Dam Foundations), award recipient (David Sugden Award, Australasian Tunnelling Society), Adjunct Associate Professor at UNSW Sydney, and active contributor to industry bodies (Deputy Chair, ATS Victoria; ANCOLD course delivery).

Lining design for pressure tunnels and shafts focusing on more reliable crack spacing and crack-width calculations

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SMEC, Australia

Hydropower and pumped hydro projects are highly relevant sources of renewable energy and play a crucial role in the provision of sustainable energy supply and storage. The design of pressure tunnels is one of the most critical technical challenges of this type of project. If the intrados of a pressure tunnel has higher water pressure compared to the extrados, the support of the differential water pressure will be split between the lining and the surrounding rock mass. The distribution of the load between the lining and the rock mass depends on the stiffness and hydraulic conductivity of both. Structural cracking of the lining occurs when the stresses in the concrete exceed its tensile strength. In general, stiffer rock masses will absorb a larger portion of the differential water pressure, reducing the likelihood of lining cracks. When designing a reinforced lining, the primary objective is to determine the most economic thickness of the lining and the density of reinforcement, while also ensuring that the width of cracks caused by differential water pressure remains within a specified limit. Commonly used design methods, such as those proposed by Schleiss (1986, 1997), determine the cracking pressure based on the tensile strength of concrete, which can exhibit significant variability depending on the characteristic strength. These approaches also rely on purely empirical and rather approximate techniques to estimate crack spacing. This paper presents an extension of the Fernandez (1994) method, which adopts the cracking strain of concrete—a parameter with considerably lower variability—as the basis for cracking pressure assessment. It further integrates the more logically grounded crack spacing/crack width calculation procedure from Eurocode 2, offering improved reliability and consistency.

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Logistical challenges with long, relatively small tunnels

U. Rehm
Tunnelling Consultant GmbH, Germany

As the length of a tunnel increases, so do the possibilities for automating tunnelling operations, but so too does the amount of maintenance required due to wear and tear. Both processes – high-performance tunnelling and the increasing maintenance necessary to sustain it – demand highly professional logistics. These logistics depend significantly on factors such as tunnel diameter, tunnel length, the tunnelling system and its mucking technology, the staff's shift system, and, of course, the contractor's experience. The latter is crucial with regard to what is arguably the greatest uncertainty factor in tunnelling: geology. An experienced contractor should be able to identify the specific daily challenges for tunnelling and maintenance, depending on the geological conditions, early on and thus quickly fine-tune the logistics for high-performance tunnelling accordingly. While theoretical models for assessing tunnelling performance are helpful tools, they can only be implemented through adequate practical experience and a high degree of flexibility on the part of the contractor in the face of daily changing geological conditions. The logistical challenges associated with long and relatively small tunnel diameters can therefore only be overcome to the satisfaction of all involved parties through professional coordination between the three key influencing factors: geology, tunnelling system, and human factors.

Mechanised solutions for hydropower tunnelling and shaft construction

K. Bäppler
Herrenknecht AG, Germany

As countries plan for their net zero targets, substantially more long-duration energy storage will be needed to support the integration of variable renewable energy. Various storage technologies exist or are being developed. Of particular importance is pumped storage hydropower (PSH), a mature and proven technology that already provides around 90% of installed electricity storage globally. PSH schemes are characterised by a widespread network of tunnels including pressure tunnels and pressure shafts. This paper highlights the latest state of mechanised tunnelling technology used to drive the construction of PHS projects, thereby supporting clean energy transition.

Dr. Karin Bäppler

Head of Business Development and Presales
Herrenknecht AG

Karin graduated as a civil engineer from Technical University of Karlsruhe, Germany (today KIT, Karlsruhe Institute of Technology) and completed post graduate studies with her PhD at the Colorado School of Mines, USA. She joined Herrenknecht in 1997 and since then has specialized in geotechnology, research and development.

From 2008 till 2024 Karin has managed parallel to her current role the Geotechnical and Consulting department for the Traffic Tunnelling Division at Herrenknecht's head office in Schwanau, Germany. In her current role she is responsible as Head of Business Development and Presales.

Since June 2013, Karin has also been a member of the Supervisory Board of Herrenknecht AG.
She is an invited lecturer for postgraduate degrees at Universities in France, Germany, Switzerland, Italy and the USA on the topic of Tunnelling and Tunnel Boring Machines and she lectures at international tunnel conferences on mechanized tunnelling technology.

Karin was Vice Animateur in Working Group 14, Mechanized Tunnelling, within the ITA between 2016-2024.

About the International Tunnelling Association, its vision and how this could be applied in Africa

D. McGirr[1], E. Chiriotti[2]
[1,2]ITA
[1]COWI, United Kingdom
[2]INCAS Partners, France

The International Tunnelling Association (ITA-AITES) is a non-profit and non-governmental organisation founded more than 50 years ago. It presently comprises 81 Member Nations, plus corporations and individuals who can participate in the association's activities.

ITA-AITES advocates the innovative, safe and equitable use of underground space and underground solutions for a better, sustainable and liveable world.

ITA-AITES has a special consultative status with the United Nations Economic and Social Council since 1987, and its vision and mission is aligned with the United Nations Sustainable Development Goals; including to advocate and raise awareness on the use of tunnelling and underground space; facilitate interaction and joint activities between Member Nations and industry for development and sharing of knowledge; empower decision makers and professionals to make informed choices about efficient, reliable and resilient underground infrastructure for current and future generations; share technical knowledge, experience and best practices; create a platform for Education and Training through the contribution of ITA Working Groups and Committees.

The activity of the association is articulated through committees ITA-COSUF - Operational Safety in Underground facilities; ITA-CET - Education and Training; ITACUS - Underground Space; ITAtech - New Technologies; ITA Sustainability Committee, Working Groups, Activity Groups and Owners Forum.

Over the years, ITA-AITES has produced a number of publications on different topics related to the underground space and its use, which intend to share technical knowledge and experiences, deliver best international practices, and provide guidelines for owners, practitioners and young engineers. Publications are freely available on the ITA-AITES website.

The use of underground space has shown its potential and benefits as a strategic opportunity to unlock smarter mobility, resilient infrastructures, efficient utilities, climate adaptation, and more sustainable city growth, while practices exist to manage the associated risks.

ITA-AITES is now mobilised for contributing to grow stakeholders' awareness on the benefits of using underground space through a specific Engage Africa objective.

ITA-AITES's vision, objectives and membership opportunities are presented.

Elena Chiriotti

Co-founder and Managing Director
INCAS Partners

With a degree in civil engineering and a PhD in rock mechanics, Elena has almost 30 years' experience developed on different, large-scale, international projects for transport infrastructures and water transfers. During her career, Elena has actively contributed to a multitude of ambitious projects, covering design and engineering roles for the first 20 years of her professional experience, and advisory roles in the last decade, when she co-founded INCAS Partners, an independent company specialised in providing technical and contractual consulting services to decision-makers and key stakeholders involved in underground infrastructure projects in France and abroad. Elena developed skills covering the technical, contractual and strategic fields related to projects including roads, railways and metros, spanning from early conception and detailed design to construction follow-up, and from project & risk management to procurement and contractual aspects. Elena has a strong specialization in the problems associated with tunnels in complex conditions and in urban environment, in the management of risks and in the evaluation of the impacts induced on existing structures, domain in which she contributes developing an approach which became a reference internationally and is still in use today (Mechanised Tunneling in Urban Areas, ed. Taylor and Francis, 2007). As INCAS Partners, Elena regularly intervenes for Owners and Contractors. She is often charged of challenging strategic projects seeking contractual robustness, improved technical performance, integration of disciplines, anticipation and management of risks and opportunities, optimise project solutions, schedule and costs, or analyse technical and contractual problems occurred during construction. Her experience results in technical insight, strategic vision and operational capacity. The PhD gives her the attitude to manage technical complexity, prioritizing objectives, structuring and analyzing information from different sources with a pragmatic and operational approach adapted to complex and/or large-scale projects. Elena is often invited as lecturer at international conferences, training courses (ITACET, Master Tunnel Course in Turin, CNAM Paris). Within ITA, Elena participated to WG2 since 2006, and coanimated / animated the same working group in the last 9 years, leading a group of motivated international experts publishing ITA recommendations on different aspect of design & engineering of underground projects. She has been elected by the other WGs to participate to the Task Force for the WGs reorganization. Finally, together with the project owner SNCF Réseau, she was part of the project team who won the ITA Awards 2023 Major Project of the Year category over 500 M€ with the project EOLE – Paris East-West Rail Express Link, France.

Application and prospects of tunnel boring machines in the mining industry

J. Xiong
CRCHI, China

The application of tunnel boring machine (TBM) technology in the mining industry has undergone significant evolution over several decades. Initially developed for civil tunnelling projects such as transportation infrastructure, TBM technology was gradually adapted for mining operations – beginning in the late 20th century. Early applications focused primarily on relatively homogeneous geological conditions, but advances in cutterhead design, ground support systems, and real-time monitoring capabilities have expanded TBM applicability to increasingly complex mining environments. In recent years, the growing demand for safe, efficient, and environmentally sustainable underground mining methods has accelerated TBM adoption, particularly for decline development, ore access tunnels, and mine infrastructure projects. Looking forward, ongoing innovations in artificial intelligence, remote operation, and hybrid mechanical excavation technologies are expected to further transform TBM deployment in the mining sector.

Qiang Xiong

Regional Sales Manager for Southern Africa
China Railway Construction Heavy Industry Co., Limited

A seasoned international business executive with over 15 years of expertise in construction and mining machinery sales across emerging markets, I began my career in 2010 with Zoomlion Heavy Industry Science & Technology Co., Ltd., entering the international construction equipment sector focusing on truck crane sales in the Indian market where I developed comprehensive understanding of South Asian market dynamics, established localized distribution networks, and delivered consistent revenue growth in a competitive landscape, and was subsequently promoted to Product Sales Director for South Africa, overseeing regional product strategy, channel development, and key account management while leading cross-functional teams to expand market presence and strengthen brand positioning across Southern African markets. In 2016, I relocated to the Democratic Republic of Congo as General Manager of the local subsidiary, assuming full P&L responsibility for mining machinery sales in one of Africa's most challenging yet lucrative markets, building operations from ground zero by assembling local sales, service, parts, and logistics teams to support the copper-cobalt mining belt, navigating complex regulatory environments, cultivating strategic relationships with government stakeholders and international mining majors, and successfully integrating large-scale mining equipment into flagship projects to transform the subsidiary into a significant regional supplier. Appointed Regional Sales Manager for Southern Africa in 2023, I pivoted focus to tunneling equipment including drill-and-blast machinery and Tunnel Boring Machines, capitalizing on Africa's infrastructure acceleration to spearhead market development across transportation tunnels, hydropower projects, and mining shafts in Zambia, Zimbabwe, and South Africa, leveraging technical marketing and project-based sales approaches to address complex geological conditions and deliver tailored construction solutions while driving adoption of Chinese advanced tunneling technology in high-growth markets. My core competencies span end-to-end management with full lifecycle expertise from market entry and team building to profitable subsidiary operations, technical-commercial acumen combining deep product knowledge with sophisticated deal structuring for large-scale projects, regional expertise gained through 15-year immersion in African and South Asian markets with nuanced understanding of resource-driven economies, and proven leadership in repeatedly recruiting, developing, and managing multicultural teams in challenging environments, all committed to advancing industrial cooperation through reliable equipment supply and localized service excellence while contributing to regional infrastructure development and mining productivity enhancement.

Developing a narrow-reef rock boring system for near-horizontal slots based on tunnelling experience

I. Crous
Master Drilling, South Africa

Traditional underground mining, particularly for narrow-reef deposits, has long relied on drill-and-blast methods. These techniques, while effective, introduce substantial safety hazards –including explosive handling, ground instability, dust generation, and vibrations –alongside elevated operational costs, frequent downtime, and energy-intensive processes. This paper presents the development of an innovative mechanical rock cutting technology specifically engineered for thin-reef ore extraction; designed to potentially replace conventional drill-and-blast operations with a safer, continuous excavation system. The development followed a structured, phased methodology: (1) a comprehensive desktop study evaluating existing rock cutting technologies, thin-reef orebody characteristics, and prevailing mining practices to define baseline parameters; (2) underground testing and verification of disc cutters on ore-bearing rocks to establish empirical relationships between applied forces and penetration/production rates; (3) conceptualisation and detailed design of critical high-risk subsystems, including the cutterhead and an integrated vacuum-based cuttings conveyance system for simultaneous cutting and material removal; and (4) full-system design, integration, and underground prototype testing to assess real-world performance, safety, and economic viability under operational constraints and ancillary mining requirements. The primary goal was to deliver performance metrics that render the technology competitive with – or superior to – established underground methods in resource efficiency, grade control, productivity, and personnel safety.

Key outcomes include:
Ore dilution reduction: up to 60% lower than conventional techniques, enabled by precise excavation geometry and controlled material handling. Ore recovery: approaching 100% through integrated mining and backfilling strategies, maximising resource utilisation, maintaining stability, and minimising waste dilution. Geological range: effective excavation of orebodies with dip angles of 0°–25° and minimum seam thicknesses of 600 mm, thereby accessing previously marginal or uneconomic deposits. Production and grade performance: monthly output rates comparable to traditional methods, coupled with an approximate 60% increase in run-of-mine head grade, primarily attributable to reduced dilution. Safety enhancements: incorporation of remote-operated control systems from the outset, with a defined progression toward full autonomy, reducing human exposure in active stopes and mining panels. Collectively, these results establish a proof-of-concept for thin-reef and gently dipping seam mining, delivering improved selectivity, enhanced resource recovery, elevated head grades, competitive productivity, and superior safety performance. Future extensions to other mineral commodities and geological settings will necessitate targeted adaptations or redesigns to accommodate variations in orebody geometry, dip angle, seam thickness, operating constraints, and deposit scale.

Izak Abram Crous

Project Engineer
Master Drilling

Izak Crous is a seasoned mechanical engineer with over 14 years of specialized experience in the drilling industry. Since joining Master Drilling in 2012, he has progressed through increasingly senior roles, beginning as a Junior Engineer, advancing to Project Engineer and Drawing Office Manager, and currently serving as Lead Project Engineer for Reef Boring.

Throughout his tenure, Izak has honed core competencies in complex problem solving, technical documentation, CAD software proficiency (including advanced 3D modeling), engineering design, leadership and mentoring, and effective stakeholder communication. He played a pivotal role in transforming the company's engineering drafting and modeling standards, leading the transition from a 2D CAD environment to a fully integrated 3D-based Product Data Management (PDM) system. This initiative significantly enhanced design accuracy, collaboration, and operational efficiency.

A key highlight of his career is his leadership in the collaborative development, research, testing, and implementation of an innovative Reef Boring drilling solution—the first of its kind worldwide—in close partnership with the client. Leveraging his deep expertise in drilling technology, Izak has consistently positioned himself at the forefront of niche, high-value projects. He excels in delivering comprehensive technical solutions while effectively managing project costs, schedules, and risks through a structured, phased approach that systematically validates critical components and systems prior to full deployment.

Izak holds a Bachelor's degree in Mechanical Engineering and brings a proven track record of driving innovation and excellence in challenging drilling applications. Outside of his professional commitments, he maintains an active lifestyle through mountain biking and values quality time spent with family and friends.

Progress in developing a shaft boring system as an alternative to conventional shift sinking for deep and hard rock applications

N. Goodwin
Master Drilling, South Africa

Traditional shaft sinking in deep, hard rock environments has long been constrained by safety risks and slow advance rates. As an alternative, the shaft boring system (SBS) represents a step change in shaft development. Testing began in 2019, focusing on the validation of a novel W-shaped cutterhead, specialised gearbox, and an integrated pneumatic cleaning system. By 2024, the full-scale system underwent rigorous field trials, successfully boring a 50 m test shaft in hard rock conditions exceeding 300 MPa. This milestone proved the viability of the SBS. Building on these results, the Mark II generation is currently in production, featuring enhanced design iterations based on initial performance data. These next-generation machines are scheduled for deployment and testing in Q1 2027. This paper explores the technological evolution of the SBS, the results of the tests, and its potential to redefine efficiency and safety standards for the global mining and civil sectors.

Nicolaas Goodwin

Lead Project Engineer: Shaft Boring
Master Drilling

Nicol Goodwin is a dedicated mechanical engineer with over a decade of specialized experience in the design and implementation of advanced blind shaft boring technologies. He holds a Bachelor of Mechanical Engineering from North-West University and began his professional journey in 2015, joining the New Technology division of Master Drilling as a Junior Engineer.

Throughout his career, Nicol has established himself as a key innovator in the mining and infrastructure sectors. A significant milestone in his professional history includes serving as the Project Engineer for an operation in the United States, where he oversaw the blind boring of a shaft utilizing flooded reverse circulation technology.

His technical contributions are further highlighted by several successful R&D milestones, most notably the testing of the Patented “W” shape cutter head in 2019 and the 2024 deployment of the GEN1 Shaft Boring Machine, which successfully completed a 50-meter-deep shaft in hard rock conditions.

As a named inventor on multiple patents, Nicol is driven by a passion for complex problem-solving and the development of inventive, first-of-their-kind solutions. Currently serving as the Lead Project Engineer for Shaft Boring, he continues to push the boundaries of mechanical excavation and industrial engineering.