



Paste 2024

Proceedings of the 26th International Conference on Paste, Thickened and Filtered Tailings

16–18 April 2024 | Melbourne, Australia



Paste 2024

26th International Conference on Paste, Thickened and Filtered Tailings

16-18 April 2024

Editors

Andy Fourie

The University of Western Australia, Australia

David Reid

The University of Western Australia, Australia



Copyright

© Copyright 2024. Australian Centre for Geomechanics, The University of Western Australia. All rights reserved. No part of this publication may be reproduced, stored or transmitted in any form without the prior permission of the Australian Centre for Geomechanics, The University of Western Australia.

Disclaimer

The information contained in this publication is for general educational and informative purposes only. Except to the extent required by law, the Australian Centre for Geomechanics, The University of Western Australia, makes no representations or warranties express or implied as to the accuracy, reliability or completeness of the information stored therein. To the extent permitted by law, the Australian Centre for Geomechanics, The University of Western Australia, exclude all liability for loss or damage of any kind at all (including indirect or consequential loss or damage) arising from the information in this publication or use of such information. You acknowledge that the information provided in this publication is to assist you with undertaking your own enquiries and analyses and that you should seek independent professional advice before acting in reliance on the information contained herein. While all care has been taken in presenting this information herein, no liability is accepted for errors or omissions. The views expressed in this publication are those of the authors and may not necessarily reflect those of the Australian Centre for Geomechanics, The University of Western Australia.

The papers contained in this publication are for general information only, and readers are cautioned to take expert advice.

Front cover, back cover, and section page photos courtesy of ATC Williams, Australia.

Production team: Garth Doig, Candice McLennan, Christine Neskudla, Josephine Ruddle, and Stefania Woodward, Australian Centre for Geomechanics.

ISBN 978-0-6450938-8-9 ISSN 2208-830X



Australian Centre for Geomechanics

The University of Western Australia 35 Stirling Highway (M600)
CRAWLEY, WESTERN AUSTRALIA AUSTRALIA 6009
Telephone: +61 8 6488 3300 publications-acg@uwa.edu.au acg.uwa.edu.au

ABN 37 882 817 280

Australian Centre for Geomechanics

The Australian Centre for Geomechanics (ACG) was formally established in 1992 as a University of Western Australia not-for-profit research centre in order to promote research excellence and continuing education in geomechanics, with particular emphasis on its application to the mineral and energy extraction sections of Australia's resources industry.

The Australian Centre for Geomechanics is an unincorporated Joint Venture involving:

- CSIRO Mineral Resources
- The University of Western Australia Civil, Environmental and Mining Engineering

The ACG draws together staff knowledge, experiences and expertise from within the two groups forming the Centre and facilitates a multi-disciplinary approach to research and education in geomechanics. Research undertaken by the ACG attracts both national and global support and the outcomes of the projects are utilised to promote safer mining and environmental geomechanics practices, operating efficiencies and to meeting community expectations for sustainable mining practices.

With the guidance of strong industry representation on the Board of Management, and close collaboration with senior representatives of the mining industry, research, training and further education activities are tailored directly to the needs of industry. The ACG Board expects the Australian Centre for Geomechanics to be the focal point for industry on geomechanics issues and to address the needs of industry through a collaborative interdisciplinary approach.

Online Repository of Conference Proceedings



Accessing geomechanical excellence

Launched in 2017, the ACG Online Repository of Conference Proceedings provides the global mining community with open access, peer-reviewed conference papers that may assist industry practitioners to maintain and develop their skills, knowledge and capabilities. This highly interactive and searchable repository provides importable citation information in various forms, links to the paper authors' profiles on ResearchGate and LinkedIn, as well as the ability to share papers on social media.

With the recent addition of the Paste 2024 papers, 46 Paste conference papers are now freely available. Setting a high standard for technology transfer and accessibility, this valuable online resource will continue to develop and grow with future conferences.



Scan the QR code to view the Paste 2024 conference proceedings papers.



531 Paste papers available to download



Over 247,000 Paste papers downloaded

Source: ACG internal analytics March 2024

iv

Paste 2024 Organising Committee

JP Coffey Rio Tinto, Australia

AB Fourie The University of Western Australia, Australia

T Gerritsen Rio Tinto, Australia

GI McPhail Water, Waste and Land, Australia

JJ Moreno SRK Consulting, Australia

G New ATC Williams, Australia

D Reid The University of Western Australia, Australia

J Ruddle Australian Centre for Geomechanics, Australia

F Sofrà Rheological Consulting Services, Australia

RL Veenstra Newmont, Australia

Technical Reviewers

The dedicated efforts of the peer reviewers have resulted in the high quality of the technical program and the papers compiled for this publication. The editors thank the following people who contributed their time and expertise as reviewers of manuscripts for the proceedings of the 26th Conference on Paste, Thickened and Filtered Tailings. A technical and critical review of each paper was undertaken by a minimum of two reviewers for the production of these proceedings.

S Barrera

Delfi Ingenieria SpA, Chile

BJ Barsanti

Operational Geotechs Pty Ltd, Australia

DA Benavente Antimil

Paterson & Cooke Chile SpA, Chile

A Braga

Responsible Mining Solutions, Canada

K Brinthan

University of Moratuwa, Sri Lanka

F Canzian da Silva

Rio Tinto, Australia

P Chacon

Arcadis Chile, Chile

University of Science and Technology Beijing, China

AG Chryss

CSIRO, Australia

NC Clarke

Imtech Pty Ltd, Australia

JP Coffey

Rio Tinto, Australia

M Cooks

Live Blue Marble Technology, South Africa

A Copeland

Knight Piésold, South Africa

L Correia

Paterson & Cooke, Canada

W de Oliveira Filho

Federal University of Ouro Preto, Brazil

Independent Consultant, Australia

P Fawell

CSIRO, Australia

Cape Peninsula University of Technology, South Africa

TG Fitton

Fitton Tailings Consultants, Australia

B Gallagher

Electric Power Research Institute, USA

C Gilbert

FLSmidth, USA

P Goosen

Paterson & Cooke, South Africa

L Goudzwaard

Paterson & Cooke, UK

R Guang Paterson & Cooke, Canada

BGRIMM Technology Group, China

Responsible Mining Solutions, Canada

A Henderson

Newmont, Australia

Arcadis Chile SpA, Chile

J Jarufe

University of Santiago, Chile

S Javadi Rudd

ATC Williams, Australia

HAW Kaminsky

Northern Alberta Institute of Technology, Canada

C Kujawa

Paterson & Cooke, USA

J Landriault

Vale Canada, Canada

The University of British Columbia, Canada

S Longo

WSP, Canada

F Maluly Kemeid

Rio Tinto, Australia

L Martinson

MINEXXT Inc, USA

G McKenna

McKenna Geotechnical Inc, Canada

GI McPhail

Water, Waste and Land, Australia

A Mohammadi

University of Québec in Abitibi-Témiscamingue, Canada

Paste 2024, Melbourne, Australia

JJ Moreno

SRK Consulting, Australia

P Newman

Anglo American, UK

C Ovalle

Polytechnique Montréal, Canada

AJC Paterson

Paterson & Cooke, South Africa

J Percv

Operational Geotechs Pty Ltd, Australia

B Pirouz

ATC Williams, Australia

R Pretell

University of Nevada, Reno, USA

K Rao

Rio Tinto, Australia

7 Ruan

University of Science & Technology Beijing, China

O Santiago

Phibion, Australia

F Schoenbrunn

FLSmidth, USA

K Seddon

ATC Williams, Australia

A Sedgwick

Northern Alberta Institute of Technology, Canada

F Sofrà

Rheological Consulting Services, Australia

N Steward

Tailings and Pipeline Solutions Pty Ltd, Australia

D Stone

MineFill Services, USA

F Tomini

Responsible Mining Solutions, Canada

B van der Spuy

Paterson & Cooke, South Africa

RL Veenstra

Newmont, Australia

E Vlot

Weir Minerals, The Netherlands

JA Wates

John Wates Consulting, South Africa

S Webster

Evolution Mining, Australia

J Willis

BHP, Australia

B Xiao

University of Science & Technology Beijing, China

Preface

Since the last Paste conference held in Australia in 2021, a large number of mining companies have reported on their self-assessed conformance with the Global Industry Standard on Tailings Management (GISTM). Achieving conformance with GISTM has required significant evaluation of previously accepted tailings management strategies, often resulting in a determination to evaluate alternative technologies and strategies. This is where the possibilities of high-density thickened and/or filtered tailings options have often become viable.

Many of the papers in these Proceedings of Paste 2024 describe lessons learned during implementation of thickened or filtered tailings solutions. This year sees an increasing percentage of papers dealing with surface disposal using these new technologies, with examples provided from around the world. Sharing these valuable experiences is particularly opportune as the mining industry is experiencing increasing headwinds at present, with sharper focus on operating costs likely in the short to medium term. Tailings management professionals may increasingly be faced with challenges justifying higher costs sometimes associated with high-density thickened or filtered tailings, while at the same time driving down the potential risks associated with adopting a 'business as usual' approach. Real world examples of what works (and what does not work) are thus of immense value.

Another clear focus of the papers in this year's conference proceedings is that related to underground backfilling using tailings. This tailings management option is increasingly being viewed through the lens of reducing risks associated with surface deposition of tailings, rather than solely focusing on improved underground operational strategies. Sharing experiences between the underground applications and surface management of high-density tailings promises to be a valuable aspect of Paste 2024.

On behalf of my co-editor, David Reid, I express sincere thanks to everyone who played a part in assembling these proceedings. This includes the authors, the technical and editorial committees, the reviewers, and the staff at the Australian Centre for Geomechanics (ACG).

Special mention must go to Garth Doig, Candice McLennan, Christine Neskudla, Josephine Ruddle, and Stefania Woodward for their support and effort in ensuring that the proceedings are of the highest quality and for organising the event with meticulous care.

An event such as this could not have taken place without the support of our industry sponsors. Thank you to all sponsors for your involvement in and your support of this conference series.

These proceedings are also freely available from the ACG Online Repository of Conference Proceedings courtesy of the Open Access Sponsor BOKELA GmbH. The papers can be accessed by scanning the QR code or from papers.acg.uwa.edu.au/paste2024.

Professor Andy Fourie
Paste 2024 Conference Co-editor and Co-chair



Conference Sponsors

The Australian Centre for Geomechanics proudly acknowledges the generous contribution by the Principal and Major Sponsors of the 26th International Conference on Paste, Thickened and Filtered Tailings.

PRINCIPAL SPONSOR



MAJOR SPONSORS









Paste 2024, Melbourne, Australia











Metso









iii	Δustralian	Centre for	Geomechanics	•
111	Australiali	centre ror	Geometrianits	3

- v Paste 2024 Organising Committee
- vii Technical Reviewers
- ix Preface
- xi Conference Sponsors

Keynote address

3 The place for filtered tailings and stacking in the search for safe and sustainable tailings management

N Amoah, ATC Williams, Australia

Thickening and filtration

27 Lifecycle cost comparison: modern solid-bowl centrifuge technology outperforms filtration in tailings dewatering

AP Chinchankar, Alfa Laval, Sweden

Innovative product optimisation with the AFP2500 filter: a breakthrough in dewatered tailings solutions by FLSmidth

J Chaponnel, FLSmidth, USA

51 Avoiding dam failures: is filtration the best solution?

TG Fitton, Fitton Tailings Consultants, Australia

- Critical pathways for selecting paste backfill process for Rio Tinto Kennecott mine

 N Pavlovic, Responsible Mining Solutions, Canada; S Timbillah, Rio Tinto Kennecott, USA;

 JL Roberge, Responsible Mining Solutions, Canada; K Moran, Rio Tinto Kennecott, USA; B Sliede,
 Responsible Mining Solutions, Canada; M Hutton-Ashkenny, Rio Tinto Kennecott, USA
- 77 Application of wet tailings pressure filtration for filtered tailings stack and co-disposal with mine waste at various sites including upstream and downstream of the tailings storage facility

K Grohs, M Liu, A Satriawan, S Kunadi, B Simanjuntak, PT Agincourt Resources, Indonesia

- 95 Tailings filtration toward smaller filters with higher efficiency
 E Sommacal, JC Brum, Matec Pacific, Australia; F Doveri, A Boriello, Matec Industries, Italy
- How tailing characteristics affect capex and opex in filtration: two case studies J Hahn, BOKELA GmbH, Germany

A geotechnically derived screening method to assess the filterability of tailings

B Meneses, Geosyntec, Spain; M Llano-Serna, W Dressel, Red Earth Engineering, Australia;

JP Coffey, T Gerritsen, Rio Tinto, Australia

Rheology

131 Admixture impact on rheological properties of a calcined clay binder for cemented paste backfill

S Dhers, D Freimut, Master Builders Solutions, Germany; Z Martic, Master Builders Solutions, Switzerland; R Salter, Master Builders Solutions, Australia

139 Application of pipe flow lubrication for reactor feeds

L Graham, B Nguyen, J Wu, G Short, D Harris, CSIRO, Australia; D Anglin, CEM, Australia

Emerging issues and technology

- Some observations on the effects of polymer degradation on geotechnical behaviour

 D Reid, The University of Western Australia, Australia; HAW Kaminsky, Northern Alberta

 Institute of Technology, Canada; AB Fourie, The University of Western Australia, Australia
- The use of methylene blue index in mine and tailings planning

 HAW Kaminsky, M Ghuzi, A Sedgwick, Y Li, Northern Alberta Institute of Technology, Canada;

 A Vietti, Vietti Slurrytech, South Africa
- Dewatering capabilities of Terraflowing™ technology for tailings

 JB Kruyswijk, Weir Minerals, The Netherlands; A Kilcullen, Weir Minerals, Australia
- Investigating the transitional behaviour of tailings from a gold mine site in Australia

 PGN Nayanthara, C Gallage, J Rajapakse, Queensland University of Technology, Australia;

 DSSS Biyanvilage, Advisian-Worley Group, Australia; T Rowles, Knight Piésold Pty Ltd, Australia;

 E Tuplin, BHP, Australia

Surface disposal

193 Farmed tailings stacking

H Li, J Hinton, J Navarro, Rio Tinto, Australia

199 Sustainable design for construction and operation of a storage area for filter press bauxite residue in a desert environment

D Webb, F Gassner, WSP, Australia

205 Ultra paste and central thickened discharge: a paradigm shift in tailings management A Roshdieh, K Seddon, B Pirouz, S Javadi Rudd, P Williams, ATC Williams, Australia

- **221 Central thickened discharge scheme for Ma'aden's Mansourah-Massarah Gold Project**A Roshdieh, FC Soo, ATC Williams, Australia; K Zare Al Ahmadi, A Ibnu Hamdani, A Putra
 Ginting, R Gonzales Valdestamon, Ma'aden, Kingdom of Saudi Arabia; S Javadi Rudd,
 M Sedeghipour, ATC Williams, Australia
- 235 Single-phase or two-phase? The impact on tailings dam breach modelling and impact assessment

M Liu, T Ganeson, C Harrington, Red Earth Engineering, Australia

- 247 Advances in dam breach analysis appropriate for dewatered tailings storage facilities

 S Seyedan, Geosyntec, Finland; A Arenas, ATC Williams, Australia; M Llano-Serna, Red Earth
 Engineering, Australia
- 257 Exploring the role of time-dependency in tailings deposition flows

 AM Talmon, Deltares, and Delft University of Technology, The Netherlands; M Nabi, Deltares,
 The Netherlands; E Meshkati, R&D Boskalis (formerly with Deltares), The Netherlands
- 271 Analysing the segregation of coarse tailings particles with a zone-formation differential settling model

Y Li, D van Zyl, The University of British Columbia, Canada

- **Tailings storage: exploiting central thickened discharge for capping and closure** *TG Fitton, Fitton Tailings Consultants, Australia*
- 293 An alternative approach to developing compaction specifications for tailings materials

 T Gerritsen, Rio Tinto, Australia; R Wood, Fugro, USA; M Llano-Serna, Red Earth Engineering,

 Australia; B Meneses, Geosyntec, Spain; W Dressel, Red Earth Engineering, Australia
- 305 A holistic approach to large-scale alternative dewatered tailings management: lessons from case studies

C Crystal, SRK Consulting, USA; R Jansen, Paterson & Cooke, USA

321 Impact of the construction of a filtered tailings stack on top of an existing slurry tailings storage facility at LaRonde gold mine

E Masengo, Agnico Eagle Mines, Canada; EP Ingabire, ArcelorMittal, Canada; J Huza, MR Julien, Agnico Eagle Mines, Canada

Inferring the state parameter from partially drained cone penetration test data using the soil behaviour-type index to adjust drained/undrained correlations

J Ayala, Klohn Crippen Berger, Australia; AB Fourie, D Reid, The University of Western Australia, Australia; M Jefferies, Consultant, UK

Why accelerated mechanical consolidation delivers equal or greater benefits to other tailings management solutions

O Santiago, Phibion, Australia; R Menezes, Phibion, Chile; W McAdam, D Smirk, Phibion, Australia

361 Calibration of the PM4Silt model for polymetallic fine grained mine tailings based on laboratory testing results

NG Bellido, PG Mendoza, Ausenco Peru SRL, Peru

Backfill

373 Enabling sustainability in mining case study: mine backfill

I Aguilar Sánchez, MT Bellver Baca, Sika Services AG, Switzerland; W Barahona, Sika Ecuatoriana SA, Ecuador; S Arcila-Gut, Sika Canada Inc, Canada; F Erismann, Earth Resource Investment Group, Switzerland; E Avilés, Sika Ecuatoriana SA, Ecuador; A Weinkauf, Sika Services AG, Switzerland; M Hansson, Sika Sverige AB, Sweden; R Contador, Sika SA Chile, Chile

- Characterisation of the geomechanical properties of cemented paste backfill for design

 BL Sainsbury, Deakin University, Australia; D Harty, Northern Star Resources, Australia; F Felipe,
 Agnico Eagle Mines, Australia; M Ruest, Lundin Mining, Canada; D McLoughney, BHP, Australia;
 D Sainsbury, Geotechnica Pty Ltd, Australia
- Enhancing cemented paste backfill using chemical admixtures to create economic and environmentally sustainable paste fill

O Sadler, Master Builders Solutions, Australia; S Ricketts, D Koupriantchik, Northern Star Resources, Australia

Transportation

- **421** Crushed rock-thickened tailings pumping at ultra-high concentrations

 T Wennberg, A Stålnacke, LKAB, Sweden; A Sellgren, Luleå University of Technology, Sweden
- 431 Monitoring bed formation in a pipeline: a comparative study of two measurement methods AG Chryss, E Zheng, CSIRO, Australia
- 441 Effect of paste pump performance on the transient pressures and forces in an underground distribution system

LDC Correia, Paterson & Cooke, Canada; J Jacobs, Paterson & Cooke, USA

453 Availability of piston-diaphragm pump in paste fill: cement savings U Gamboa, ABEL Equipos SA, Spain; A Castilla, Sandfire MATSA, Spain

Case studies

467 Co-disposal of waste rock with unclassified tailings as cemented paste backfill at Jinchuan Nickel mine

AX Wu, PJ Wu, University of Science and Technology Beijing, China; L Zou, Jinchuan Group Co, Ltd, China; ZE Ruan, University of Science and Technology Beijing, China; ZJ Chen, YB Mo, Jinchuan Group Co, Ltd, China; JD Wang, SY Wang, University of Science and Technology Beijing, China

475 Backfilling tailings above an active cave mine

NC Clarke, Imtech Pty Ltd, Australia

Improvement in Big Gossan paste hybrid reticulation system design to optimise gravity flow: a case study

I Febritirtana, D Kuswanto, D Putra, PT Freeport Indonesia, Indonesia

505 Stability assessment and ground support design for drifting through a cemented paste filled stope at the Big Gossan mine, Indonesia

I Haque, Freeport-McMoRan, USA; JPE Hamman, N Rohmadi, G Santosa, PT Freeport Indonesia, Indonesia; J Nguz Tshisens, Freeport-McMoRan, USA

515 ATA® treated tailings for underground backfill: a Harmony Gold case study

C Spagnuolo, Clean TeQ Water, South Africa; AJ Fischmann, Clean TeQ Water, Australia; F Sofrà, Rheological Consulting Services, Australia; R de Kretser, Acclarium, Australia; R Cavalida, Rheological Consulting Services, Australia; E Brooks, Stitchwise, South Africa; J Raath, Harmony Gold, South Africa

Underground and backfill

535 Development of slag alternatives for paste backfill operations

NA Romaniuk, Graymont, Canada; L McFarlane, N Hariharan, Graymont, USA

Reducing CO₂ accumulation in cemented paste backfill with optimised solids—cement equivalency and chemical admixtures

K Sato, R Salter, Master Builders Solutions, Australia; AD Zajac, Newmont, Australia

557 Effect of brine, slag and lime inclusion on Fosterville Gold Mine cemented paste backfill strength

F Sofrà, Rheological Consulting Services, Australia; F Felipe, Agnico Eagle Mines, Australia; R Cavalida, Rheological Consulting Services, Australia

Mechanical behaviours and backfilling performance of cemented tailings-waste rock backfill with various superplasticisers: an experimental study

SH Yin, M Zhang, LM Wang, W Chen, University of Science and Technology Beijing, China

585 Author Index