Slope Stability 2013

Proceedings of the 2013 International Symposium on Slope Stability in Open Pit Mining and Civil Engineering

25–27 September 2013, Brisbane, Queensland, Australia

Editor

Phil M. Dight
Australian Centre for Geomechanics, Australia
Table of Contents

iii Australian Centre for Geomechanics
v Committees
vii Technical Reviewers
ix Preface
xi Sponsors

Keynote addresses

3 Pit slopes in weathered and weak rocks
C.D. Martin, University of Alberta, Canada; P.P. Stacey, Stacey Mining Geotechnical Ltd., Canada

29 Numerical analysis, slope design and in situ stress
J. Sjöberg, Itasca Consultants AB, Sweden

43 Water and slope stability – the application of a new science
G. Beale, Schlumberger Water Services, UK

55 Global slope performance index
T.D. Sullivan, Pells Sullivan Meynink; and The University of New South Wales, Australia

81 Data gathering, interpretation, reliability and geotechnical models
J.R.L. Read, CSIRO Earth Science and Resource Engineering, Australia

91 Excavation control, management of blast damage, and quality control
J.V. Simmons, Sherwood Geotechnical and Research Services, Australia

Geotechnical models

115 Pit slope design in phyllites for the Simandou large open pit project
C. Fietze, Golder Associates Africa (Pty) Ltd, South Africa; A. Creighton, Rio Tinto, Australia; L.M. Castro, Golder Associates Ltd., Canada; R. Hammah, Golder Associates, Ghana

127 Rock mass and structural modelling for the large open pit gold mining project in the Northern Andes: The La Colosa project, Colombia
J. Horner, J. Weil, iC consulenten, Austria; J. Betancourt, A. Naranjo, P. Montoya, J. Sánchez, AngloGold Ashanti Colombia, Colombia

137 An extensional mechanism of instability and failure in the walls of open pit mines
M.C. Bridges, AMC Consultants Pty Ltd, Australia

151 Rapid characterisation of potentially hazardous blocks in open pit mining
M.K. Elmouttie, G.V. Poropat, G. Krähenbühl, P. Dean, CSIRO Earth Science and Resource Engineering, Australia

163 Reliability of strength estimates based on limited laboratory data
M.H. Fillion, J. Hadjigeorgiou, Lassonde Institute of Mining, University of Toronto, Canada

177 Interpreting local critical orientations of structural weakness in relation to stress and dilatancy in rock slopes
J.V. Smith, School of Civil, Environmental and Chemical Engineering, RMIT University, Australia

189 Combining field methods and numerical modelling to address challenges in characterising discontinuity persistence and intact rock bridges in large open pit slopes
Z. Tuckey, Coffey Mining Pty Ltd, Australia; D. Stead, Department of Earth Sciences, Simon Fraser University, Canada; E. Eberhardt, Department of Earth and Ocean Sciences, University of British Columbia, Canada

205 Discussion on how to classify and estimate strength of weak rock masses
L.M. Castro, J. Carvalho, Golder Associates Ltd., Canada; G. Sá, Vale, Brazil

219 Structural data bias in the digital age
M.J. Fowler, Pells Sullivan Meynink, Australia
<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>227</td>
<td>Bench berm design using probabilistic key block analysis</td>
<td>E. Hormazabal, SRK Consulting (Chile) S.A., Chile</td>
</tr>
<tr>
<td>237</td>
<td>Ongoing research into anisotropic rock masses using numerical modelling</td>
<td>K.G. Mercer, Australian Centre for Geomechanics, The University of Western Australia, Australia</td>
</tr>
<tr>
<td>249</td>
<td>Geochemistry and geotechnical models — a case study from the proposed Kempfield Silver Project, Bathurst, New South Wales</td>
<td>H. Baxter, T. Rutherford, R. Bertuzzi, Peils Sullivan Meynink, Australia</td>
</tr>
<tr>
<td>261</td>
<td>Combined use of traditional core logging and televiewer imaging for practical geotechnical data collection</td>
<td>X.P. Gwynn, M.C. Brown, P.J. Mohr, SRK Consulting (UK) Ltd, UK</td>
</tr>
<tr>
<td>273</td>
<td>Experimental and numerical assessment of shear surface damage using 3D point clouds</td>
<td>S. Korekal, G.V. Poropat, H. Guo, CSIRO Earth Science and Resource Engineering, Australia</td>
</tr>
<tr>
<td>281</td>
<td>The determination of joint roughness coefficient using three-dimensional models for slope stability analysis</td>
<td>D.H. Kim, I. Gratchev, School of Engineering, Griffith University, Australia; G.V. Poropat, CSIRO Earth Science and Resource Engineering, Australia</td>
</tr>
<tr>
<td>291</td>
<td>Geotechnical and geological model applied to crushing processes in open pit mines</td>
<td>P. Peña, Ingeniería de Rocos Ltda., Chile; R. Fuenzalida, TECK Carmen de Andacollo, Chile; R. Villarroel, P. Merina, Ingeniería de Rocos Ltda., Chile; M. Tapia, TECK Carmen de Andacollo, Chile; P. Casanova, Geotacama, Chile</td>
</tr>
<tr>
<td>303</td>
<td>Maximising geotechnical data and characterisation of critical units through targeted field work</td>
<td>A.J. Phillips, H.F. Wilson, Coffey Mining Pty Ltd, Australia</td>
</tr>
<tr>
<td>325</td>
<td>A statistical approach to account for elevated levels of uncertainty during geotechnical design</td>
<td>R.D.H. Thomas, Coffey Mining Pty Ltd, Australia</td>
</tr>
<tr>
<td>337</td>
<td>Preliminary review of the geotechnical characteristics and shear strength estimates of small scale anisotropic waveform formations of the Pilbara, Western Australia</td>
<td>S. Tokimoto, School of Civil and Resource Engineering, The University of Western Australia; K.G. Mercer, Australian Centre for Geomechanics, The University of Western Australia, Australia</td>
</tr>
<tr>
<td>349</td>
<td>Dissection of a pit — case study</td>
<td>A.J. Troy, Terra Firma Australia Pty Ltd, Australia</td>
</tr>
</tbody>
</table>

**Remediation**

<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>365</td>
<td>A strategic approach to the design and implementation of an effective mine dewatering system</td>
<td>M. Bester, E. Nel, G.M. Mc Gavigan, Anglo American Kumba Iron Ore, South Africa</td>
</tr>
<tr>
<td>381</td>
<td>Water management for slope stabilisation — an example from Peru</td>
<td>C. Pérez, Schlumberger Water Services, Peru; V. Pérez, Minera Yanacocha S.R.L., Peru; G. Beale, Schlumberger Water Services, UK; D. Rios, F. Soto, Minera Yanacocha S.R.L., Peru</td>
</tr>
<tr>
<td>393</td>
<td>Cockatoo Island stage 3: seawall failure and remediation</td>
<td>P.K. Wong, Coffey Geotechnics Pty Ltd, Australia; P. Petropulos, Coffey Mining Pty Ltd, Australia</td>
</tr>
<tr>
<td>409</td>
<td>Case history: deep-seated slope failure in weak rocks, El Tapado pit north wall, Yanacocha operation</td>
<td>G.A. Becerra Abregu, E. Valencia Jeri, E. Garcia, Minera Yanacocha S.R.L., Peru; P. Yuan, Golder Associates Inc., USA; T. Byers, Newmont Mining Corporation, USA</td>
</tr>
<tr>
<td>425</td>
<td>Pit slope depressurisation investigation for an open cut iron ore mine in the Pilbara</td>
<td>A. Dodman, G. Beale, Schlumberger Water Services, UK; J. Rodriguez, Schlumberger Water Services, Australia; A. Cottrell, J. Youngs, BHP Billiton, Australia</td>
</tr>
<tr>
<td>433</td>
<td>Approach to groundwater and pore water pressure modelling for different geotechnical conditions in open pit slope stability analysis</td>
<td>H. El-Idrissi, SRK Consulting (UK) Ltd, UK</td>
</tr>
<tr>
<td>445</td>
<td>A case study on actual water pressure measurements at an open pit excavated in strong, tight rock and the implications for slope design</td>
<td>M. Rougier, L.M. Castro, Golder Associates Ltd., Canada; D. Birchall, Barrick Gold, Canada</td>
</tr>
</tbody>
</table>
Uncertainty in design

457 An application of a reliability based method to evaluate open pit slope stability
M. Valeria, C. Clayton, S. D'Ambra, C. Yan, Golder Associates Ltd., Canada

473 Risk evaluation of slope considering mechanical and hydraulic characteristics of unsaturated soils
Y-K. Song, J-R. Oh, M.S. Jung, Y.J. Son, National Disaster Management Institute, Korea

483 Analysis of failures in open pit mines and consideration of the uncertainty when predicting collapses
A.G. Cabrejo-Lievano, GroundProbe Pty Ltd, Australia

499 Managing slope performance in uncertain geological conditions at Meandu Mine, Queensland
J.V. Simmons, Sherwood Geotechnical and Research Services, Australia; D.C. Edwards, Downer EDI Mining Pty Ltd, Australia; N. Ferdinands, Stanwell Corporation Limited, Australia

513 Iterative geotechnical pit slope design in a structurally complex setting: a case study from Tom Price, Western Australia
D.S. Lucas, Mining One Consultants, Australia; P.J.H. de Graaf, Rio Tinto Iron Ore, Australia

527 Slope design at Cuajone Pit, Peru
E. Hormazabal, SRK Consulting (Chile) S.A., Chile; R. Veramendi, J. Barrios, Southern Peru Cooper Corporation, Peru; G. Zuhiga, F. Gonzalez, SRK Consulting (Chile) S.A., Chile

541 Three-dimensional limit equilibrium analysis of open pits
H.H. Lu, M.D. Fredlund, SoilVision Systems Ltd., Canada; D.G. Fredlund, Golder Associates Ltd., Canada

555 Integrated slope stability assessment in a complex geotechnical and hydrogeological setting
R. Campbell, SRK Consulting (UK) Ltd, UK; D. Mackie, SRK Consulting (Canada) Inc., Canada; W.S. Anderson, Teck Resources Ltd., Canada

569 Geotechnical reliability assessment of a large counterfort retaining wall
W. Deng, K. O’Neill, K. Luu, Aurecon Pty Ltd, Australia; K. Little, Boulderstone Construction, Australia

583 Towards developing a more rigorous technique for bench scale slope stability analysis in hard rock
R. Teet, A. Vakili, A. de Veth, AMC Consultants Pty Ltd, Australia

Numerical analysis

595 Characterisation and stability modelling in weak rock masses of the Robinson Mine
M. Fournier, R. Mercer, D. Yang, Knight Piésold Ltd., Canada; J. Miller, KGHM Inc., USA

611 The use of numerical modelling, slope monitoring and operational procedures to manage slope deformations at the Ranger 3 Pit
D.R. Wines, Itasca Australia Pty Ltd, Australia; I. Hulls, Mining One Consultants, Australia; E. Woods, Energy Resources of Australia Ltd, Australia; A. Creighton, Rio Tinto, Australia

625 Incorporating brittle fracture into three-dimensional modelling of rock slopes
M. Havaej, A. Wolter, Simon Fraser University, Canada; D. Stead, Department of Earth Sciences, Simon Fraser University, Canada; Z. Tuckey, Coffey Mining Pty Ltd, Australia; L. Lorig, Itasca Consulting Group Inc., USA; E. Eberhardt, Department of Earth and Ocean Sciences, University of British Columbia, Canada

639 Open pit numerical model calibration using a pseudo three-dimensional radar monitoring technique
J. Severin, SRK Consulting (Canada) Inc., Canada; E. Eberhardt, Department of Earth and Ocean Sciences, University of British Columbia, Canada; S. Fortin, Teck Resources Ltd., Canada

653 Two-dimensional and three-dimensional distinct element numerical stability analyses for assessment of the west wall cutback design at Ok Tedi Mine, Papua New Guinea
I.A. de Bruyn, SRK Consulting (Australasia) Pty Ltd, Australia; M.A. Coulthard, M.A. Coulthard and Associates Pty Ltd, Australia; N.R.P. Boczyński, Ok Tedi Mining Ltd, Papua New Guinea; J. Mylvaganam, SRK Consulting (Australasia) Pty Ltd, Australia

669 Three-dimensional numerical stability analysis of the Oyu Tolgoi open pit
M. Smithyman, H. Puebla, A. Chance, R. Beddoes, Golder Associates Ltd., Canada; A. Creighton, Rio Tinto, Australia
Three-dimensional analysis of pit slope stability in anisotropic rock masses
D.P. Sainsbury, Mining One Consultants, Australia; B. Sainsbury, Castlemaine Goldfields Ltd, Australia

UDEC and RFPA simulations on the influence of the geometry of partially-spanning joints on rock mechanical behaviour
P.L.P. Wasantha, P.G. Ranjith, Civil Engineering Department, Monash University, Australia; T. Xu, Northeastern University, China

Slope stability analysis at Siilinjarvi Mine
S. Mononen, Yara Suomi Oy, Finland; H. Kuula, M. Lamberg, Pöyry Finland Oy, Finland

The effect of slope curvature in rock mass shear strength derivations for stability modelling of foliated rock masses
S. Narendranathan, R.D.H. Thomas, J.M. Neilsen, Coffey Mining Pty Ltd, Australia

Stability analyses for a large landslide with complex geology and failure mechanism using numerical modelling
B. Wentzinger, D. Starr, S. Fider, Golder Associates Pty Ltd, Australia; Q. Nguyen, ATC Williams Pty Ltd, Australia; S. Hencher, Steve Hencher Associates Ltd, UK

Slope performance

A web-based GIS decision support system for slope stability monitoring data interpretations and visualisation management
A.B. Firman, C.D. Wiratno, S. Bahri, H. Timbul, PT Adaro Indonesia, Indonesia

Can full waveform technology enhance the use of terrestrial laser scanning to monitor rock slope deformation?
J.G. Williams, N.J. Rosser; Department of Geography, Durham University, UK; A. Afana, Department of Geography, Durham University; and 3D Laser Mapping Ltd, UK; G. Hunter, 3D Laser Mapping Ltd, UK; R.J. Hardy, Department of Geography, Durham University, UK

Experience using terrestrial remote sensing techniques for rock slope performance assessment
M. Sturzenegger, D. Willms, Klohn Crippen Berger Ltd., Canada; K. Pate, Seattle City Light, USA; B. Johnston, Tetra Tech Inc., USA

Powerful rockfall incidents at Al-Hada descent and remedial measures
B.H. Sadagah, Faculty of Earth Sciences, King Abdulaziz University, Saudi Arabia; M.S. Aazom, A. Al-Amri, O. Al-Hoseiny, A. Al-Harbi, Ministry of Transportation, Saudi Arabia

Innovative use of slope monitoring radar as a support to geotechnical modelling of slopes in open pit mines
A.E.E. Escobar, Codelco El Teniente, Chile; P. Farina, L. Leoni, C. Iasio, N. Coli, IDS Ingegneria Dei Sistemi, Italy

Slope monitoring and data visualisation state-of-the-art – advancing to Rio Tinto Iron Ore’s Mine of the Future™
P.J.H. de Graaf, S.D.N. Wessels, Rio Tinto Iron Ore, Australia

Application of ground penetrating radar to identify the locations of sub-surface anomalies at Kansanshi Mine, Zambia
N.K. Smith, First Quantum Minerals Ltd, Zambia

Application of advanced InSAR techniques to detect vertical and horizontal displacements
J. Morgan, TRE Canada Inc., Canada; S. Raval, The University of New South Wales, Australia; B. MacDonald, G. Falorni, TRE Canada Inc., Canada; J. Iannacone, University of Modena and Reggio Emilia, Italy

Geotechnical risk management at Teck Coal
A. Bidwell, A. Knight, Teck Coal Ltd., Canada; W.S. Anderson, Teck Resources Ltd., Canada

Undrained behaviour in spoil piles
A. Duran, Pells Sullivan Meynink, Australia

Shear strength parameters for assessing geotechnical slope stability of open pit coal mine spoil based on laboratory tests
A.K. Kho, D.J. Williams, N. Kaneko, N.J.W. Smith, School of Civil Engineering, The University of Queensland, Australia

Flow failure in coal stockpiles – how to reduce risk
P. Davies, S. Zargarbashi, L. McQueen, Golder Associates Pty Ltd, Australia

Integration of full waveform terrestrial laser scanners into a slope monitoring system
A. Afana, 3D Laser Mapping Ltd; and Durham University, UK; G. Hunter, J. Davis, 3D Laser Mapping Ltd, UK; N.J. Rosser, R.J. Hardy, J.G. Williams, Department of Geography, Durham University, UK
<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>911</td>
<td>2011 Manawatu Gorge landslide-technical challenges faced during remediation</td>
<td>M.B. Avery, S. Bourke, Geovert Ltd, New Zealand</td>
</tr>
<tr>
<td>921</td>
<td>Mt Owen Mine barrier pillar</td>
<td>W.D. Bartlett, Thiess Pty Ltd, Australia; I.H. Clark, GEONET Consulting Group, Australia; D.E. McCormack, G.D. Johnson, A.N. Brown, Thiess Pty Ltd, Australia</td>
</tr>
<tr>
<td>935</td>
<td>Quarry wall stability and design optimisation using photogrammetric mapping and analysis techniques</td>
<td>P.W. Booth, G.E. Meyer, Golder Associates Pty Ltd, Australia</td>
</tr>
<tr>
<td>949</td>
<td>Early detection of impending slope failure in open pit mines using spatial and temporal analysis of real aperture radar measurements</td>
<td>G.J. Dick, E. Eberhardt, Department of Earth and Ocean Sciences, The University of British Columbia, Canada; D. Stead, Department of Earth Sciences, Simon Fraser University, Canada; N.D. Rose, Piteau Associates Engineering Ltd., Canada</td>
</tr>
<tr>
<td>963</td>
<td>Geohazard mitigation in remote and rugged terrain</td>
<td>U.K. Gunasekera, Rio Tinto Australia, Australia</td>
</tr>
<tr>
<td>981</td>
<td>Stabilisation of landslides using gravity fed siphon and electro-pneumatic pumped wells: two examples of slope stabilisation projects from the United Kingdom and Czech Republic</td>
<td>J.K. Holliday, Aurecon Australia Pty Ltd, Australia; A.R. Clark, Independent consultant, UK; D.S. Fort, Atkins, UK; A. Gillarduzzi, High Point Rendel, UK; S. Boman, TPCEO, France</td>
</tr>
<tr>
<td>1011</td>
<td>Application of radar monitoring at Savage River Mine, Tasmania</td>
<td>G.K. Macqueen, E.I. Salas, B.J. Hutchison, Grange Resources (Tasmania) Pty Ltd, Australia</td>
</tr>
<tr>
<td>1021</td>
<td>Slope stability study in open pit and underground mines by means of forensic analysis and radar interferometry</td>
<td>O. Mora, Altamira Information, Spain; L. Alvarez, Universidad de Oviedo, Spain; E. Amor Herrera, Hullera Vasco-Leonesa, Spain</td>
</tr>
<tr>
<td>1033</td>
<td>Stability analysis and remedial design of two road cuttings in North Queensland based on remote geotechnical mapping using digital photogrammetry</td>
<td>P.W. Booth, J. Darras, Golder Associates Pty Ltd, Australia</td>
</tr>
<tr>
<td>1045</td>
<td>Hangingwall and footwall slope stability issues in sublevel caving</td>
<td>B-M. Stöckel, K. Mäkitalova, Luossavaara-Kiirunavaara AB, Sweden; J. Sjöberg, Itasca Consultants AB, Sweden</td>
</tr>
<tr>
<td>1061</td>
<td>An evaluation of the CUSUM and inverse velocity methods of failure prediction based on two open pit instabilities in the Pilbara</td>
<td>J. Venter, A. Kuzmanovic, S.D.N. Wessels, Rio Tinto Iron Ore, Australia</td>
</tr>
<tr>
<td>1077</td>
<td>Slope stabilisation program at West Gully, PT Freeport Indonesia</td>
<td>E. Widijanto, I. Setiawan, K. Afrizal, M. Stawski, P. Warren and B. Utama, PT Freeport Indonesia, Indonesia</td>
</tr>
</tbody>
</table>

**Hydrogeology**

<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1091</td>
<td>Integrating complex hydrogeological and geotechnical models – a discussion of methods and issues</td>
<td>G. Fagerlund, SRK Consulting (Canada) Inc., Canada; M. Royle, Schlumberger Ltd., Canada; J. Scibek, SRK Consulting (Canada) Inc., Canada</td>
</tr>
<tr>
<td>1103</td>
<td>Three-dimensional pore pressure prediction in dual phase conditions for slope stability assessment</td>
<td>E.R. De Sousa, M.J. Fowler, G.E. Swarbrick, Pells Sullivan Meynink, Australia</td>
</tr>
<tr>
<td>1111</td>
<td>Mine design for below water table clay detritals mining: Marandoo Mine, Western Australia</td>
<td>D. McInnes, C. Haberfield, Golder Associates Pty Ltd, Australia; P.J.H. de Graaf, Rio Tinto Iron Ore, Australia; C. Colley, Golder Associates Pty Ltd, Australia</td>
</tr>
<tr>
<td>1125</td>
<td>The hydro-geotechnical decision cycle – having mine design and planning decisions made by the right people</td>
<td>J.W. Hall, RPS Aquaterra, Australia</td>
</tr>
<tr>
<td>1131</td>
<td>The hydrogeology of a moving cut slope and real time modelling of groundwater movement</td>
<td>I. Gray, J. Wood, B. Neels, A. O'Brien, Sigma Pty Ltd, Australia</td>
</tr>
</tbody>
</table>
Rockfall

1149 An integrated approach for rockfall analysis with drapery systems
K. Thoeni, Centre for Geotechnical and Materials Modelling, The University of Newcastle, Australia; C. Lambert, Civil and Natural Resources Engineering, University of Canterbury, New Zealand; A. Giacomini, S.W. Sloan, J.P. Carter, Centre of Excellence for Geotechnical Science and Engineering; and Centre for Geotechnical and Materials Modelling, The University of Newcastle, Australia

1161 Coefficient of restitution for rigid body dynamics modelling from onsite experimental data
F.R.P. Basson, R. Humphreys, A. Temmu, Newmont Asia Pacific, Australia

1171 Spatial and temporal aspects of slope hazards along a railroad corridor in the Canadian Cordillera
R. Macciotta, D.M. Cruden, C.D. Martin, N.R. Morgenstern, M. Petrov, Department of Civil and Environmental Engineering, University of Alberta, Canada

1187 Earthquake stability assessment for open pit mine slopes
J.C.W. Toh, D.K.E. Green, G.E. Swarbrick, M.J. Fowler, B.E. Estrada, Pells Sullivan Meynink, Australia

1203 Seismic stability of large open pit slopes and pseudo-static analysis
B. Damjanac, Varun, L. Lorig, Itasca Consulting Group, Inc., USA

1217 Three-dimensional rockfall modelling and rockfall protection — Port Hills
M.B. Avery, Geovert Ltd, New Zealand; H. Salzmann, Freefall ZTGmbH, Austria; A. Teen, Geovert Global Pte Ltd, Singapore

1231 Verification of Trajec3D for use in rockfall analysis at Newmont Boddington Gold
C.C. Graf, T. Peryoga, G. McCartney, T. Rees, Newmont Boddington Gold, Australia

Wall control

1245 West Gully Upper – innovative rockfall and debris flow protection systems
H.P. Anderson, Geovert Pty Ltd, New Zealand; A. Teen, Geovert Global PTE, Singapore; H. Salzmann, Freefall Geotechnical Engineering ZTGmbH, Austria

1261 Rockfall stabilisation of a steep and high slope at West Angelas Mine using pre-tensioned anchored mesh
P.I.G. Lopes, T.T. Le, Geovert Pty Ltd, Australia

1273 Rock and soil slope protection using a high stiffness geocomposite mesh system
D. Cheer, Maccaferri S.p.a., Italy; G. Giacchetti, Alpigeo, Italy

1285 Landslide risk management in Australia 2013 – status of resources available to practitioners
A. Leventhal, GHD Geotechnics, Australia; A. Miner, AS Miner Geotechnical, Australia; B. Walker, JK Geotechnics, Australia

1301 Design and construction of an anchored soil nail wall close to movement sensitive structures
A.K. Kho, Cardno Pty Ltd, Australia; M. McAuley, GHD Pty Ltd, Australia

Excavation control

1315 Blast induced damage mechanism on final walls and the blasting methods to minimise damage
W.W. de Graaf, Mining Engineering Department, University of Pretoria, South Africa; S.J. Etchells, AEL Mining Services, South Africa

1327 Measurements of dynamic surface strains induced by blasting near a highwall of a coal mine — a preliminary assessment
K.N. Henley, A.T. Spathis, Orica Australia Ltd, Australia

1335 Blasting vibration assessment of rock slopes and a case study
K.W.K. Kong, MWH Australia Pty Ltd, Australia

1345 Drape mesh protection at the Savage River Mine, Tasmania
B.J. Hutchison, G.K. Macqueen, S.L. Dolting, Grange Resources (Tasmania) Pty Ltd, Australia; A.T. Morrison, Geobrugg Australia Pty Ltd, Australia

1359 Understanding the blast damage mechanisms in slopes using observations and numerical modelling
S.J. Etchells, AEL Mining Services, South Africa; E.J. Sellers, JK Tech Pty Ltd, Australia; J. Furtney, Itasca Consulting Group Inc., USA

1373 Author Index