

The use of strain threshold in slope stability trigger action response plans

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Abstract

The measurement of pit slope displacement and the interpretation of subsequent movement and deformation patterns is a well-established industry practice and forms the principal element of a pit slope monitoring program.

The collected displacement data may be interpreted as the total accumulated displacement since the onset of measurement. The average velocity and the velocity delta values (both acceleration and deceleration) can be calculated from the displacement data in order to assist in the identification of slope instability and for the assessment of slope performance.

The strain component of a pit slope, when assessed in the form of the strain criteria for the total or a portion of accumulated displacement, can depict the key stages of instability based on empirical examples from a variety of failure modes and geotechnical settings.

The strain-based approach of assessing slope stability has relied on the traditional strain criteria formula. However, by rearranging the formula to solve the displacement value based on a pre-selected strain percentage and a defined slope height, an indicative displacement value can be applied to proactively evaluate the displacement history of the pit slope. This evaluation can be for a variety of movement and deformation transitions.

It is through this approach that the operation trigger action response plan can be populated to include indicative guidelines for strain threshold alarms utilising displacement measurements as a proxy. The average velocity and velocity delta values can then be determined for hourly or daily limits. This approach allows for a revised strategy for monitoring pit slope performance and instability monitoring and mitigation which incorporates strain.

Keywords: *strain criteria, slope instability, trigger action response plan, relative range, average velocity, velocity delta*

1 Introduction

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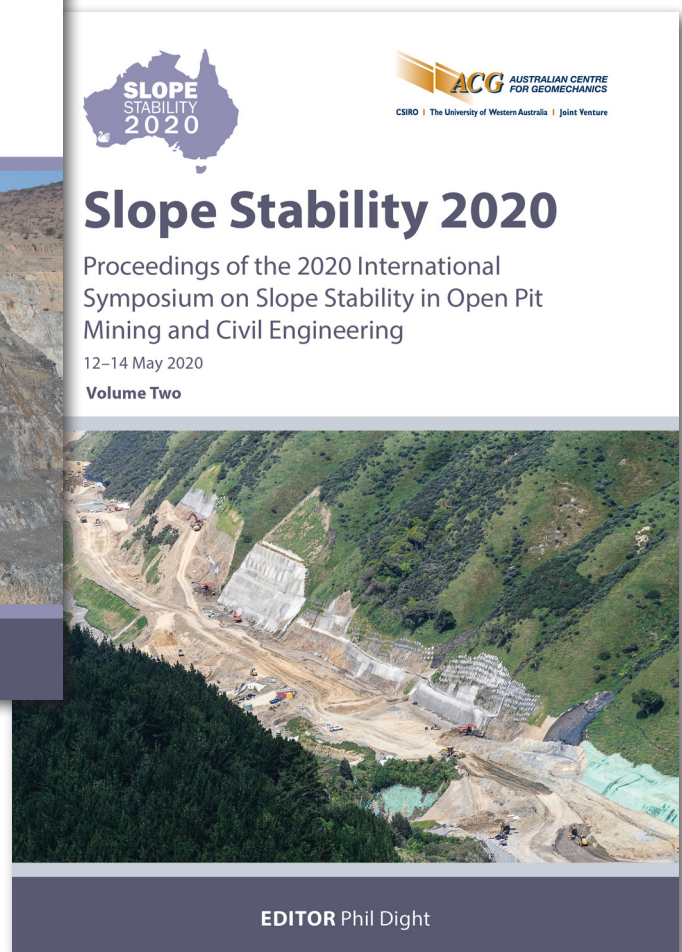
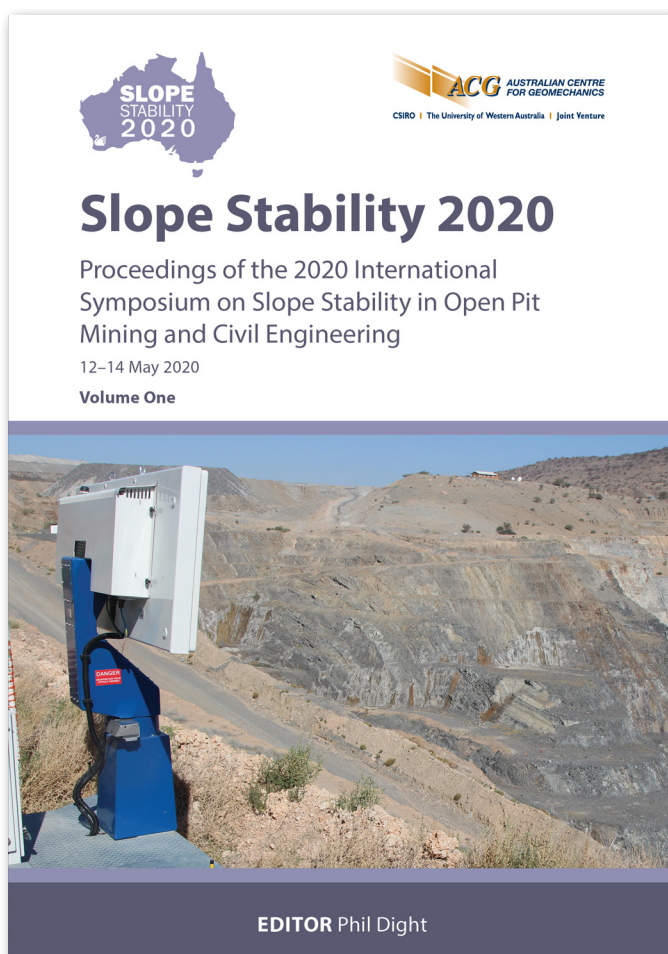
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6 Conclusion

An overview of the strain criteria and the identification of key movement phases of slope instability and slope deformation patterns was provided. Using this information, in collaboration with the rearrangement of the strain criteria formula to solve for the deformation, or what can be translated as displacement, this allows for the use of these calculated values to be applied in TARPs. Displacement data collected from prism and radar application can be utilised as a proxy to measure displacement for which strain values may be derived to appreciate the strain being accumulated on the surface of a pit slope, which in turn allows for the assessment of slope performance and instability monitoring.

References

- Bieniawski, Z 1976, 'Rock mass classification in rock engineering', in ZT Bieniawski (ed.), *Symposium Proceedings of Exploration for Rock Engineering*, vol. 1, pp. 97–106.
- Broadbent, CD & Zavodni, ZM 1982, 'Influence of Rock Structure on Stability', *Stability in Surface Mining*, Society of Mining Engineers.
- Brox, D & Newcomen, W 2003, 'Utilizing strain criteria to predict highwall stability performance', *Proceedings of the International Society for Rock Mechanics*, The Southern African Institute of Mining and Metallurgy, Johannesburg, pp. 157–161.
- Coetsee, S 2014, 'An overview of bench design for cut slopes', *Proceedings of the 8th South African Young Geotechnical Engineers Conference*, The South African Institution of Civil Engineers, Stellenbosch, pp. 561–571.
- Hustrulid, WA, McCarter, MK & Van Zyl, DJA 2001, *Slope Stability in Surface Mining*, Society for Mining, Metallurgy & Expoloration, Littleton, pp. 81–87.
- Martin, DC 1993, *Time dependent deformation of rock slopes*, PhD Thesis, University of London, London.
- Newcomen, W & Dick, G 2016, 'An update to the strain-based approach', *Journal of the Southern African Institute of Mining and Metallurgy*, vol. 116, no. 5, pp. 379–385.
- Pluijm, BA & Marshak, S 2004, *Earth Structure*, Norton & Company Ltd, London.
- Read, J & Stacey, P 2009, *Guidelines for Open Pit Slope Design*, CSIRO Publishing, Collingwood.
- Ryan, TM & Call, RD 1992, 'Application of rock mass monitoring for stability assessment of pit slope failure', *Proceedings of the 33rd U.S. Rock Mechanics Symposium*, AA Balkema, Rotterdam, pp. 221–229.
- Savely, JP 1993, 'Slope management strategies for successful mining', *Innovative Mine Design for the 21st Century*, pp. 25–34.
- Sullivan, T 1993, 'Understanding pit slope movements', in T Szwedzicki (ed.), *Proceedings of the Geotechnical Instrumentation and Monitoring in Open Pit and Underground Mining*, Balkema, Rotterdam.
- Sullivan, T 2007, 'Hydromechanical coupling and pit slope movements', in Y Potvin (ed.), *Proceedings of the 2007 Inyernational Symposium on Rock Slope Stability in Open Pit Mining and Civil Engineering*, Australian Centre for Geomechanics, Perth, pp. 3–43.
- Whittall, J, Eberhardt, E, Hungr, O & Stead, D 2015, 'Runout of open pit slope failures using and abusing the Fahrböschung angle', *Proceedings of the 2015 International Symposium on Slope Stability in Open Pit Mining and Civil Engineering*, The Southern African Institute of Mining and Metallurgy, Johannesburg.
- Zavodni, ZM 2001, 'Time-dependent movements of open pit slopes', in WM Hustrulid (ed.), *Proceedings of Slope Stability in Surface Mining*, Society for Mining, Metallurgy & Expoloration, Littleton, pp. 81–87.