

Numerical and experimental investigation of a rockfall drapery system

K. Thoeni, A. Giacomini, S.W. Sloan

Centre for Geotechnical and Materials Modelling

The University of Newcastle, Australia

C. Lambert

Department of Civil and Natural Resources Engineering

University of Canterbury, New Zealand



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Content

1. Introduction

2

2. Rockfall Drapery System

3. Experimental Investigation

4. Numerical Investigation

5. Conclusions

1. Introduction

“Improved Management of the Rock Fall Hazard at the Base of Highwalls”

3



1. Introduction



- Severe damage to infrastructure and machinery
- Severe accidents including fatalities
- Interruption of mine operations with financial consequences

1. Introduction

5

Objectives of the study:

- Increase the understanding of rockfall hazard in open pit mining
- Analyse the residual hazard associated with drapery system (block velocity behind drapery)
- Recommendations for mine sites

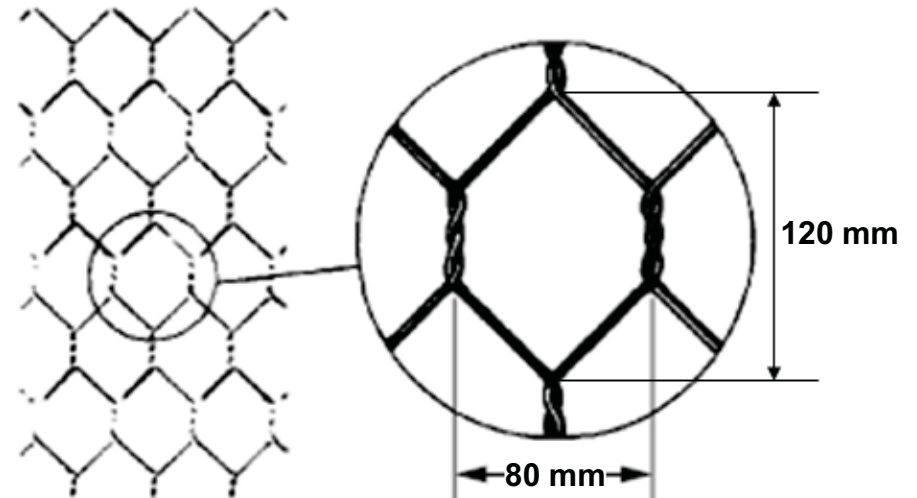
Methodology:

- Rockfall hazard study:
 - DFN modelling and kinematic analysis (Lambert et al. 2012, RMRE)
 - 2D modelling of rockfall motion
- Residual rockfall hazard assessment:
 - experimental testing for calibration of numerical model
 - 3D discrete modelling of rockfall motion including drapery system

2. Rockfall Drapery System

Maccaferri double-twisted hexagonal wire mesh:

6



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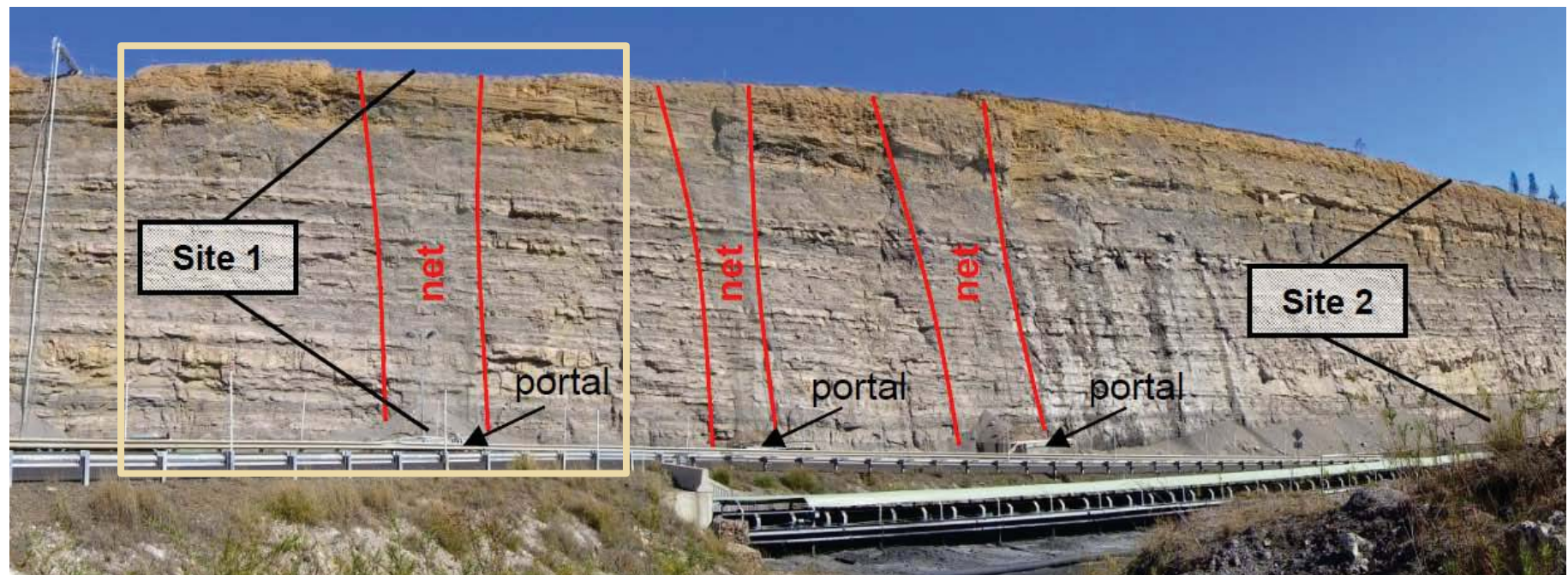


3. Experimental Investigation

7

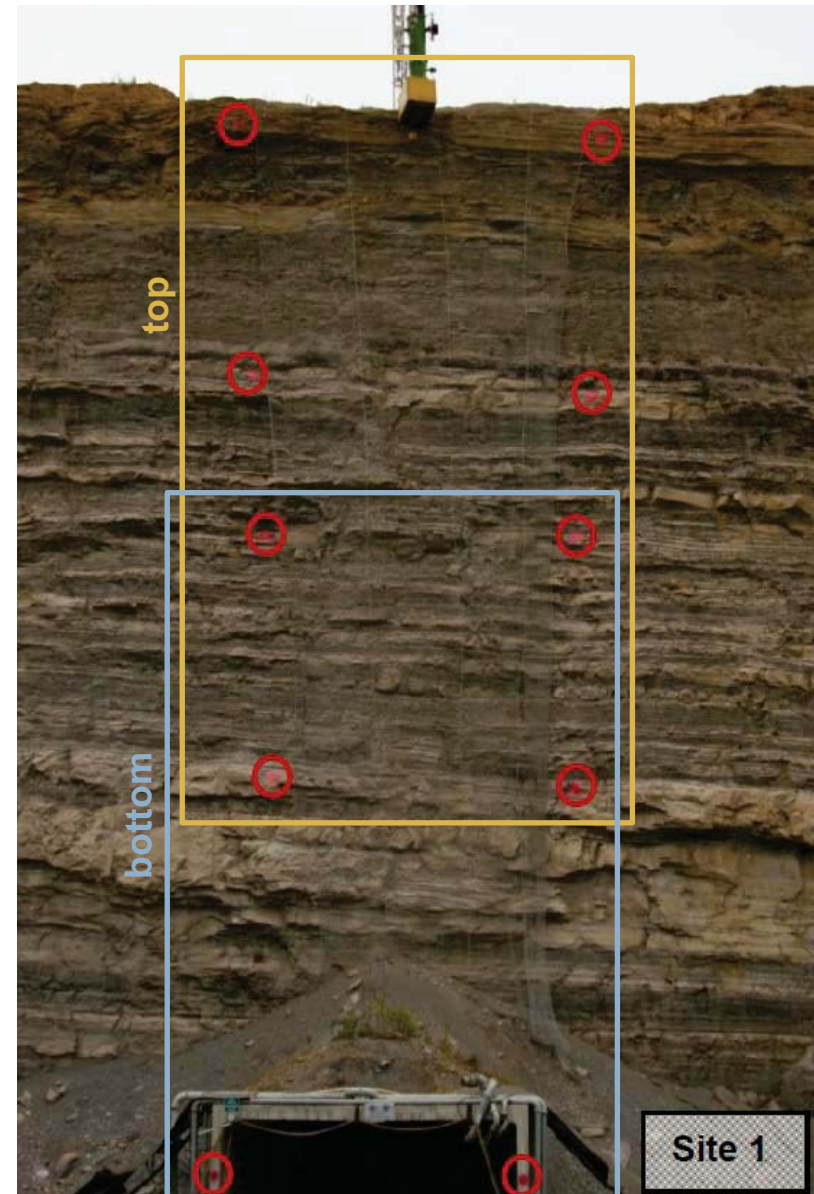
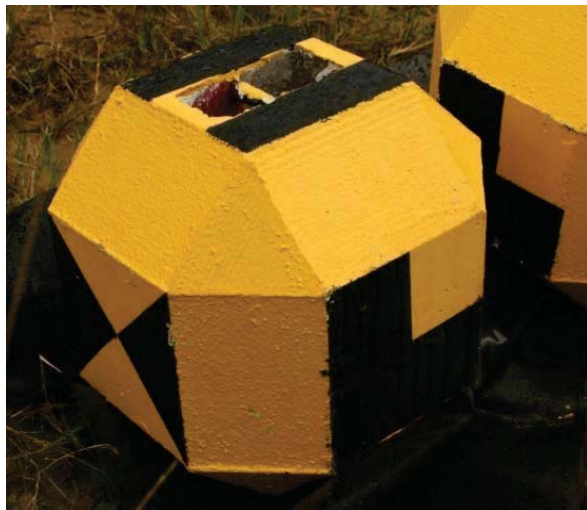
Test procedure (Giacomini et al., submitted IJRMMS):

- Drop concrete blocks from top of the highwall:
 - Site 1: section with drapery (drop block in-between net and rock face)
 - Site 2: section without drapery
- Record motion of blocks with stereo pairs of high speed cameras



3. Experimental Investigation

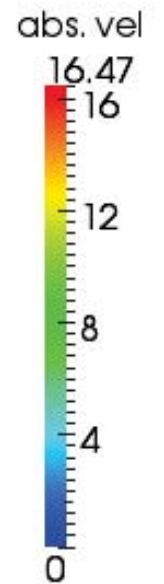
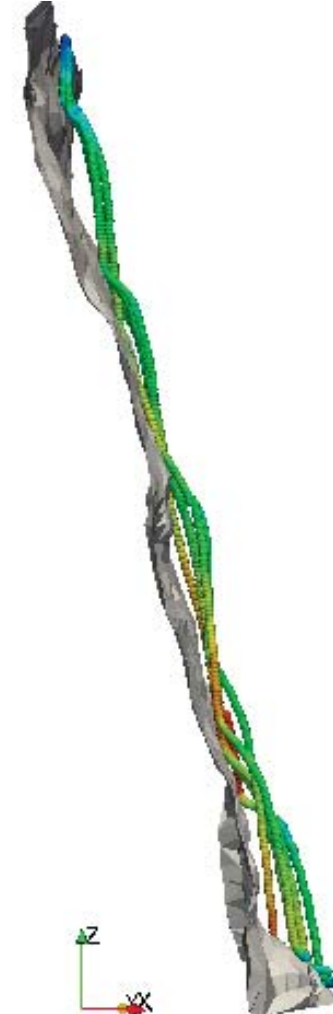
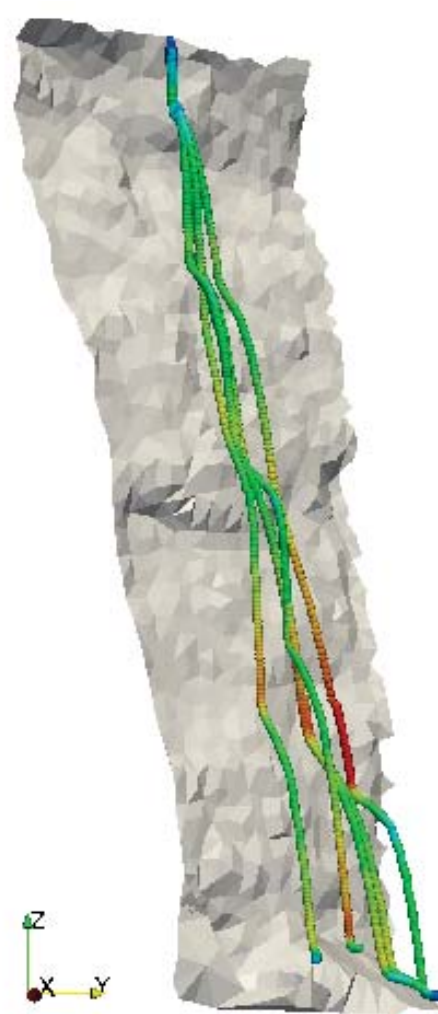
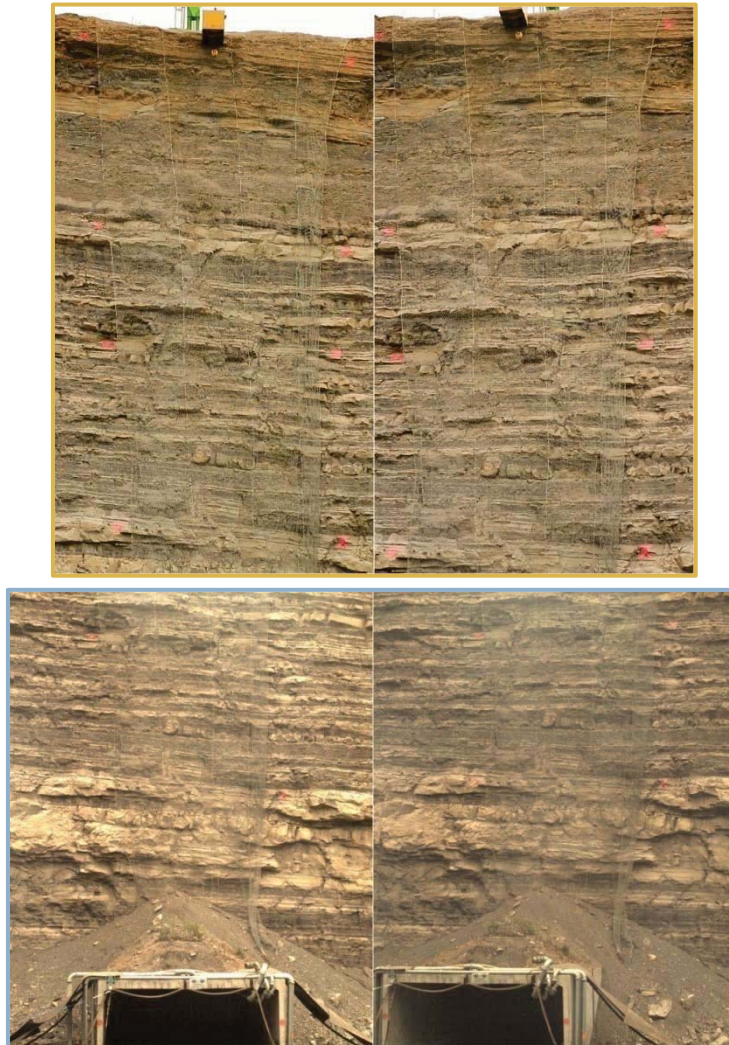
- 60 ton all terrain crane with man basket positioned on top of highwall
- Control points on highwall provide scale for stereo-photogrammetry
- Concrete block shape according to EOTA (30 cm, 44.5 kg) with different pattern on each side



3. Experimental Investigation

Results Site 1:

9



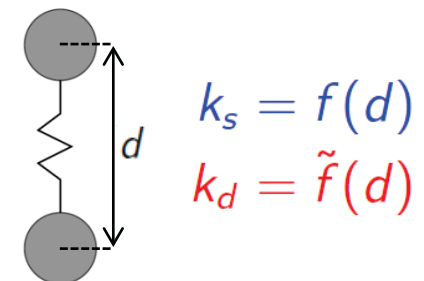
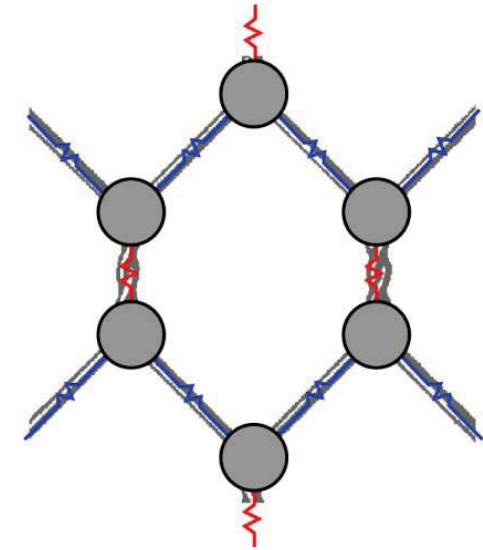
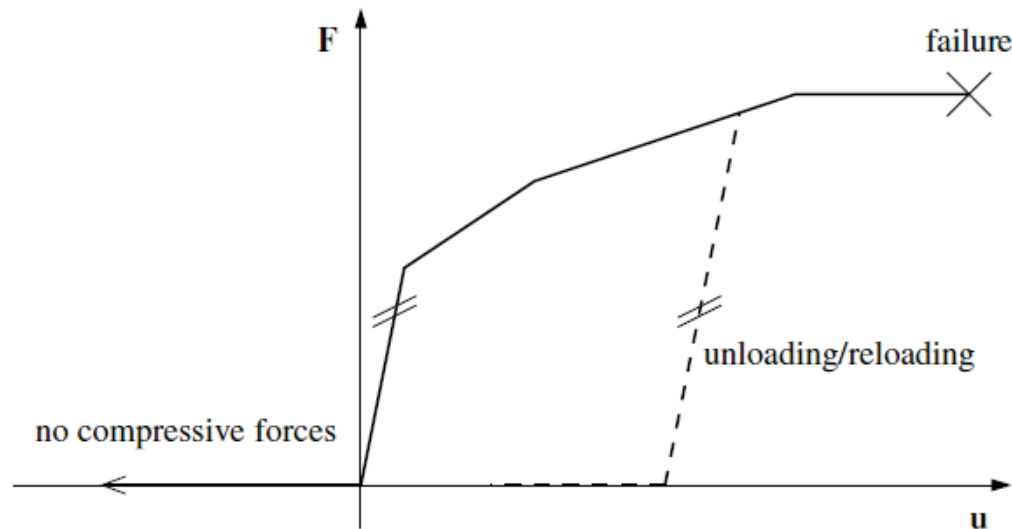
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4. Numerical Investigation

Discrete model for the wire netting:

- Generation of particle at physical nodes of mesh
- Interactions between particles exist without contact
- Contact law based on stress-strain curve
- Contact stiffness depends on inter-particle distance d and is not constant



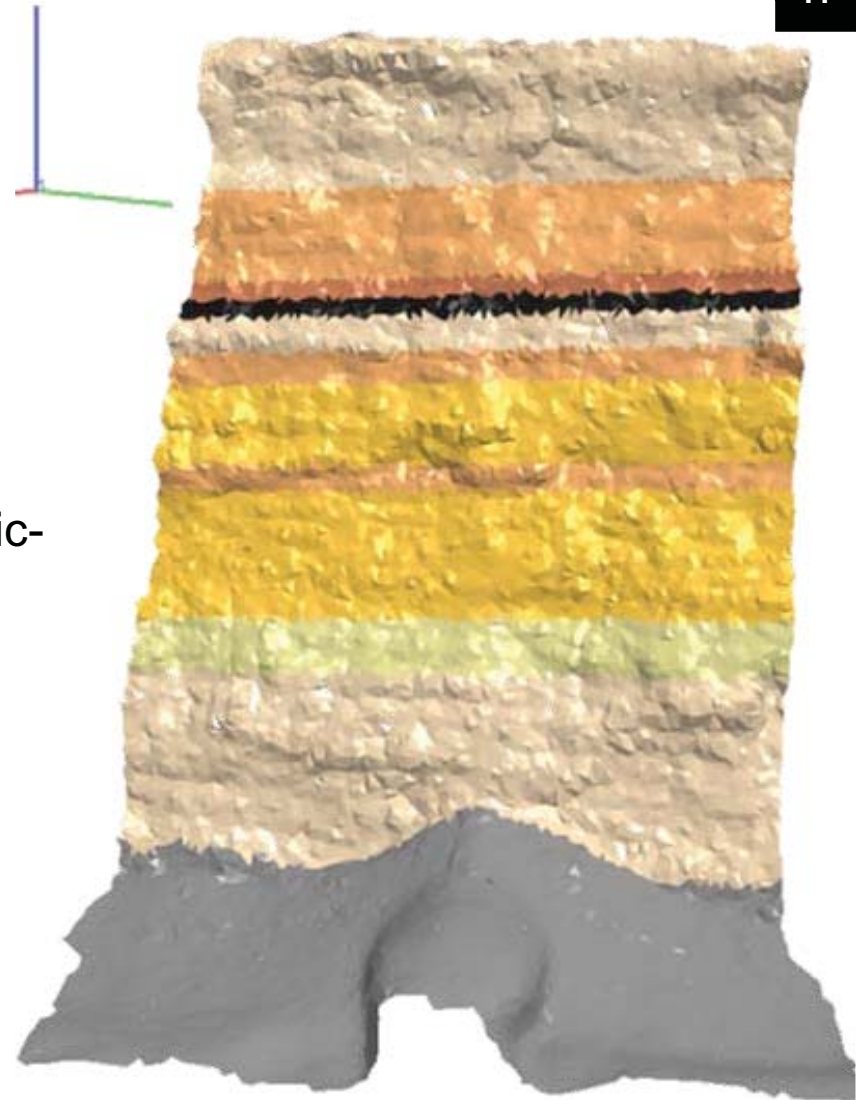
4. Numerical Investigation

Highwall representation:

- Triangulated surface
- Material layer according geotechnical survey

Discrete model for the block:

- Rigid assembly of uniform spheres
- Contact block-net: classical linear elastic-plastic law with friction
- Contact block-wall: classical linear elastic-plastic law with friction and viscous damping in normal direction

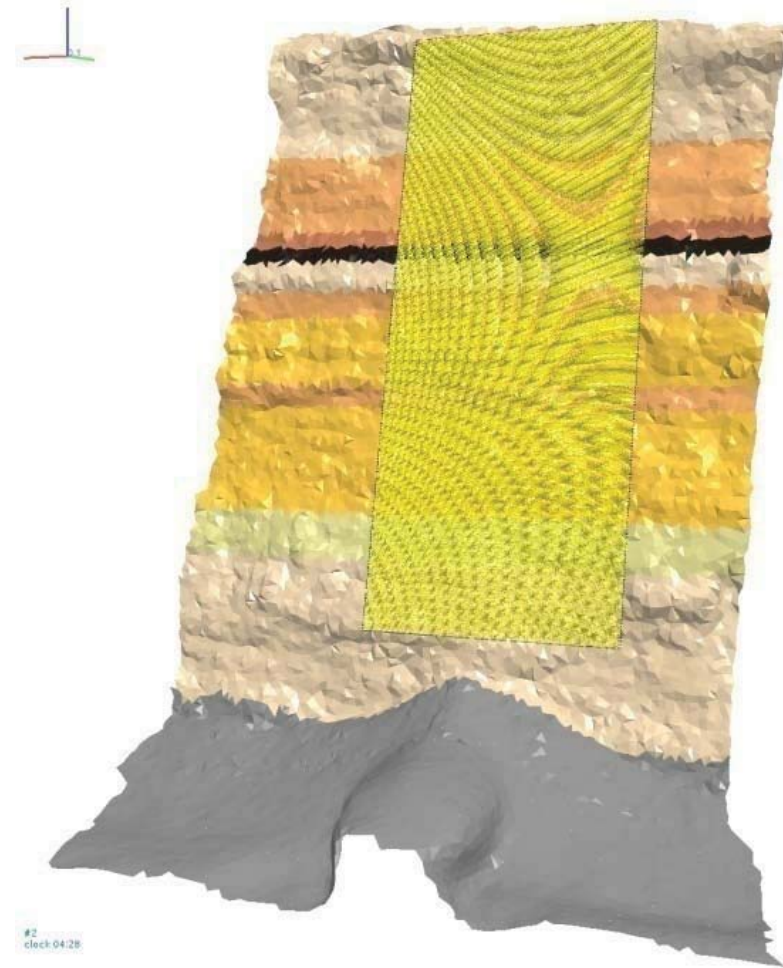


11

4. Numerical Investigation

Simulation with drapery system (Site 1):

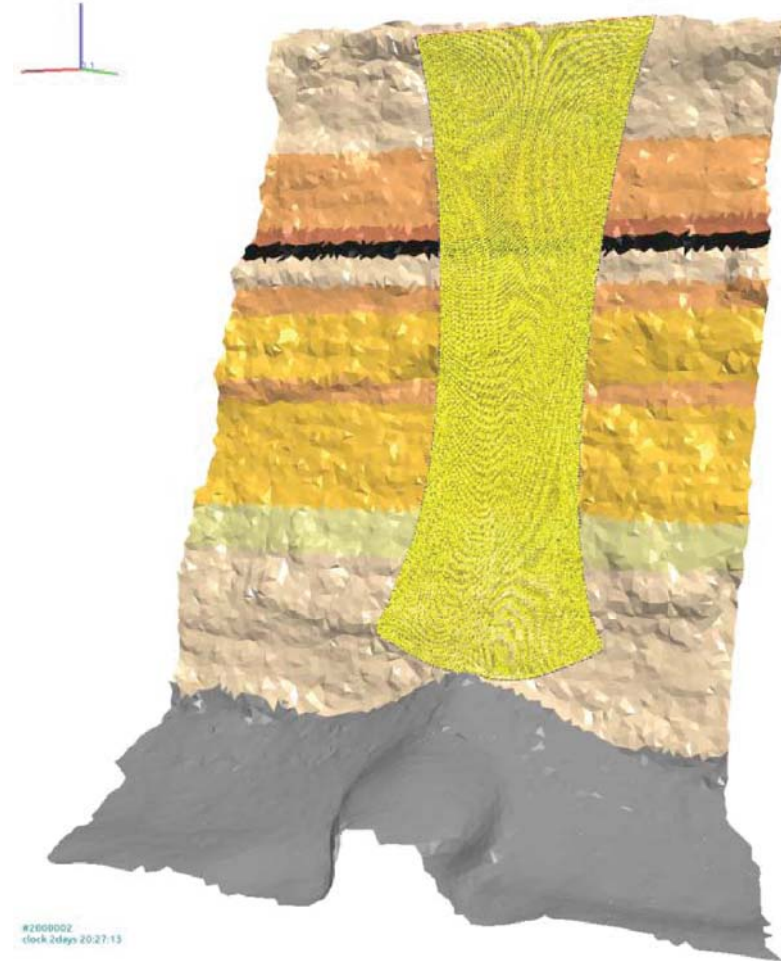
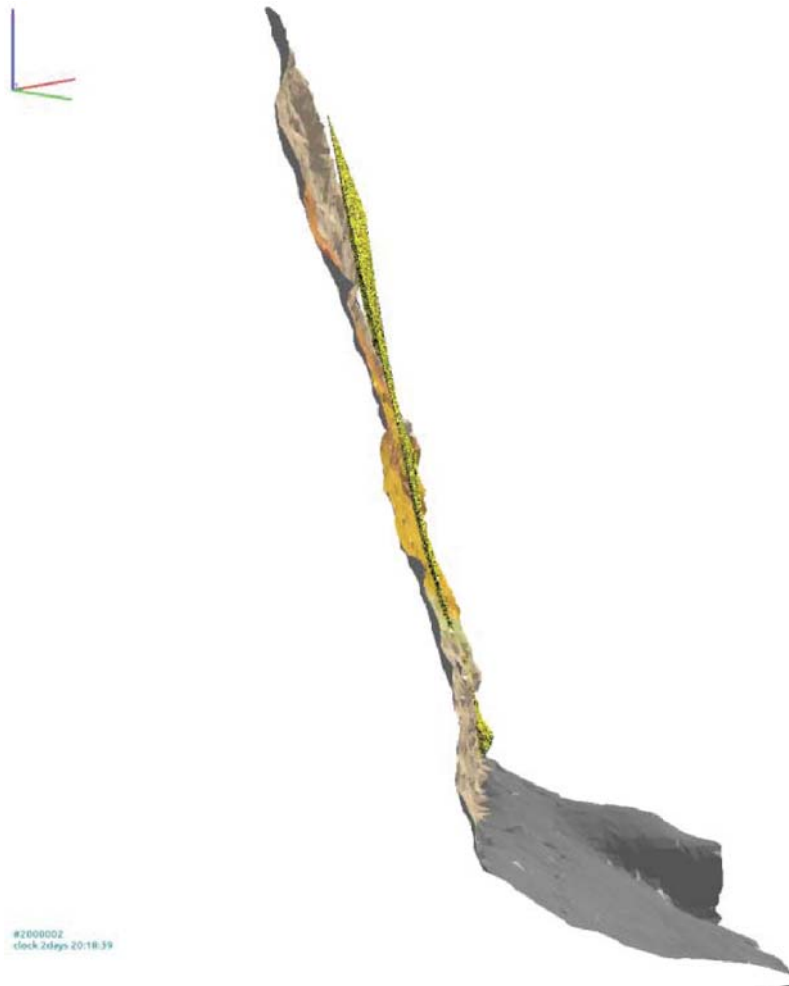
- Positioning of rockfall netting



4. Numerical Investigation

Simulation with drapery system (Site 1):

- Positioning of rockfall netting - equilibrium

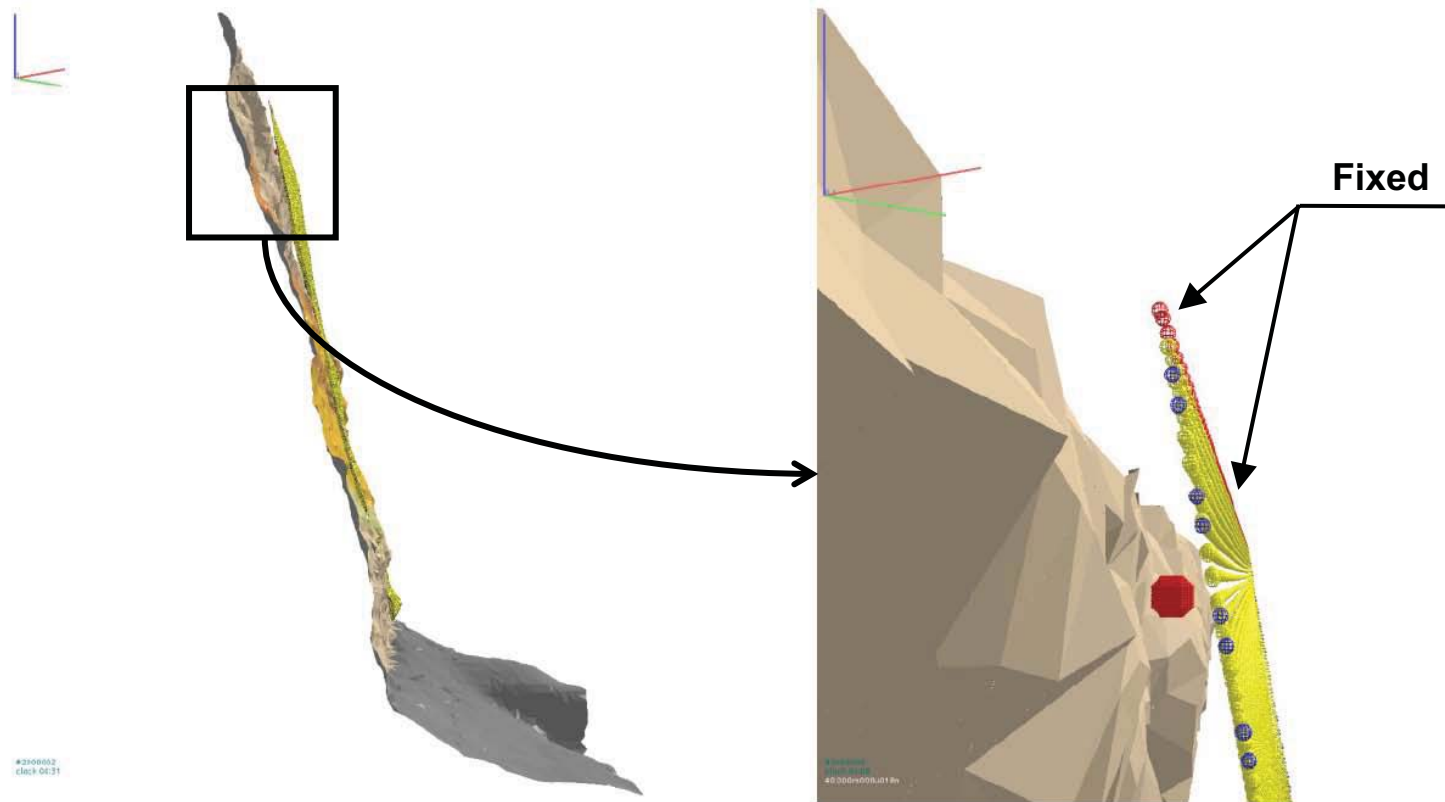


4. Numerical Investigation

14

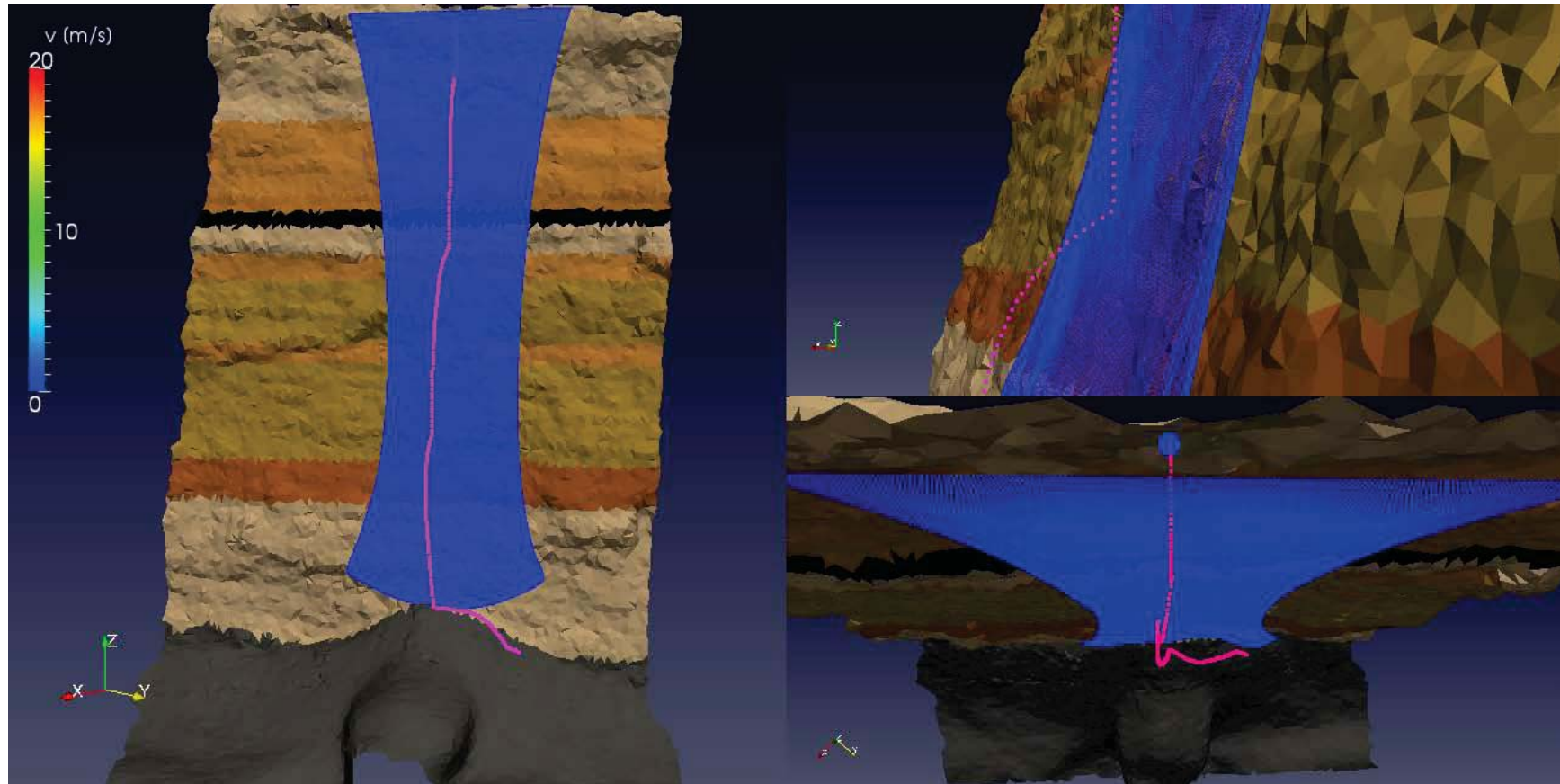
Simulation with drapery system (Site 1):

- Simplified boundary conditions for netting
- Initial position of block



4. Numerical Investigation

15



Real time

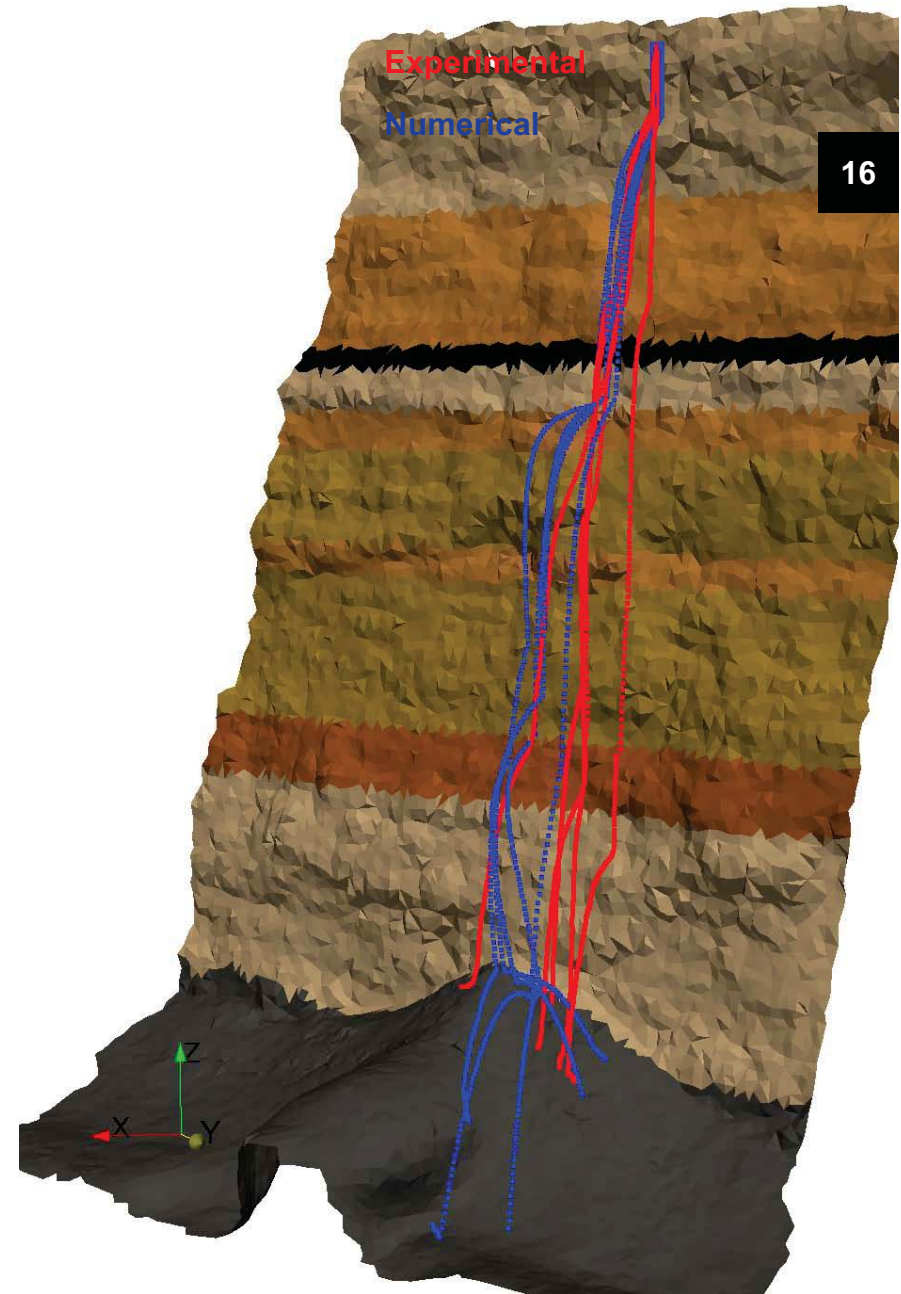
Slow motion

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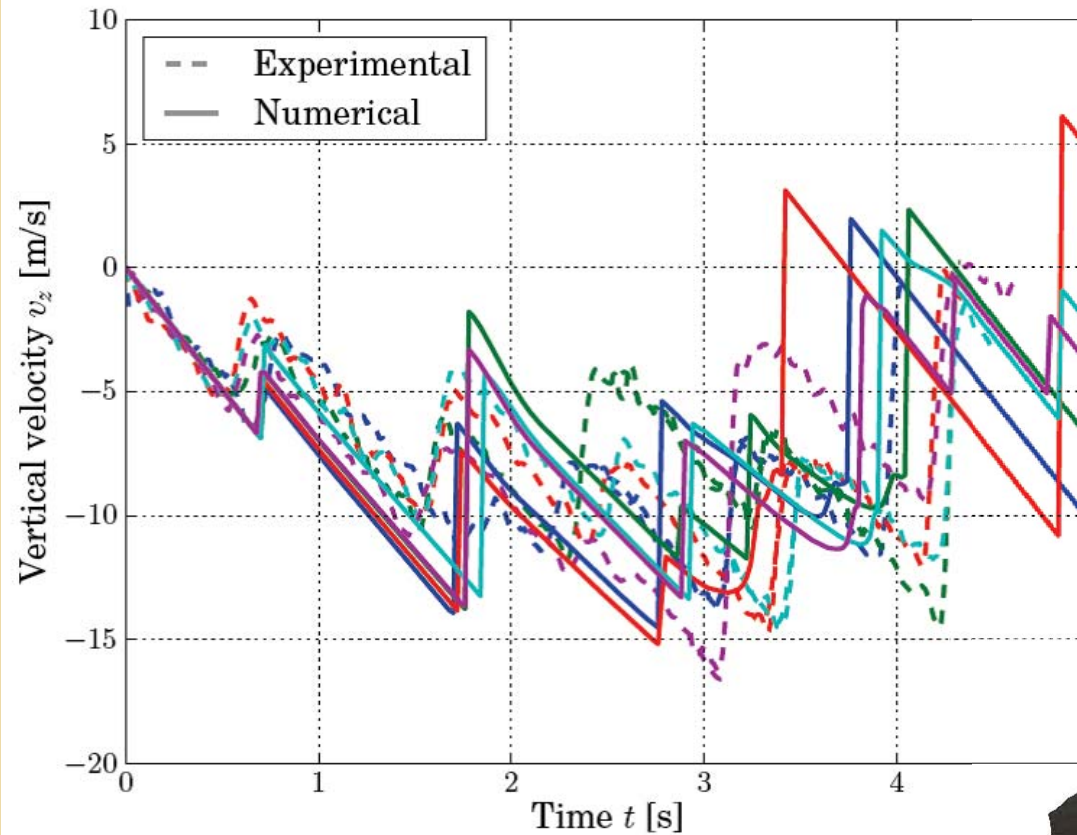
4. Numerical Investigation

Simulation with drapery system (Site 1):

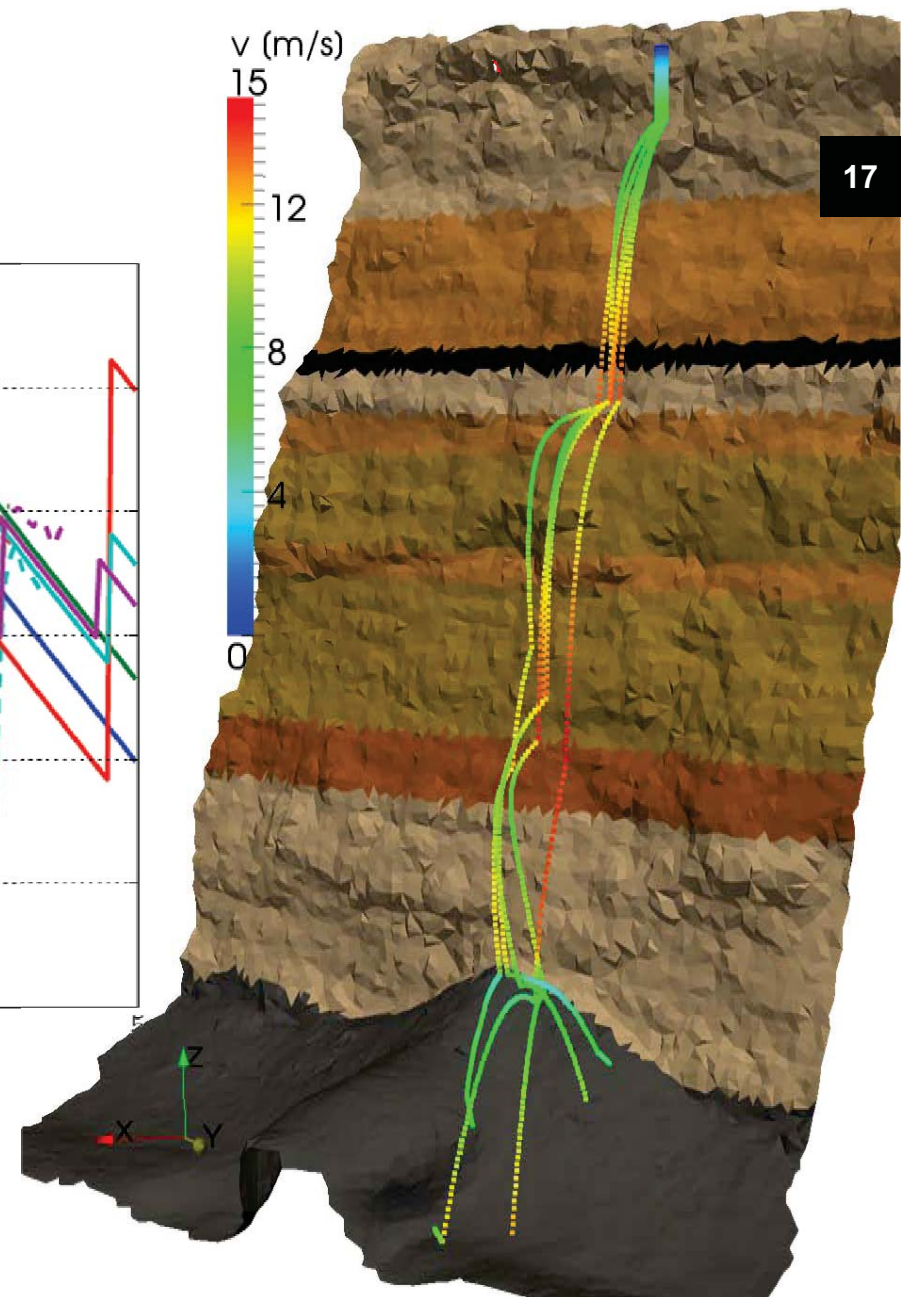


4. Numerical Investigation

Simulation with drapery system (Site 1):



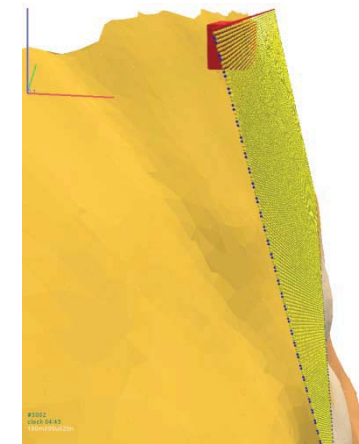
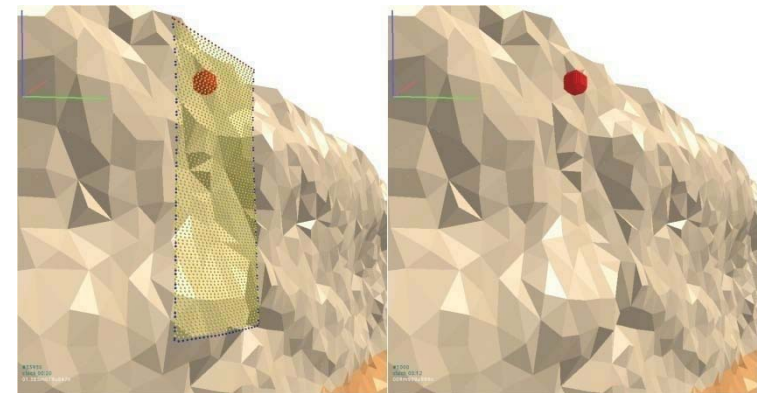
	v_{\max} [m/s]	mean v_{portal} [m/s]
Exp.	16.4	11.9
Num.	15.2	11.4



5. Conclusions

18

- Model for 3D rockfall analysis with drapery system
- Good agreement between experimental and numerical results
- Drapery system influences the motion of the block:
 - reduction of translational velocity
 - reduction of rotational velocity
 - reduction of bouncing height
 - more impacts on wall
- Assessment of final impact energy with drapery system for different scenarios:
 - block size/shape
 - highwall geometry



Acknowledgments

19

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