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Numerical investigation on the performance of the colluvium slope with retaining piles impacted by rockslides from source area

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Vienna, Austria, NH3.5: Rockfalls, rockslides and rock avalanches, 2023/04/26

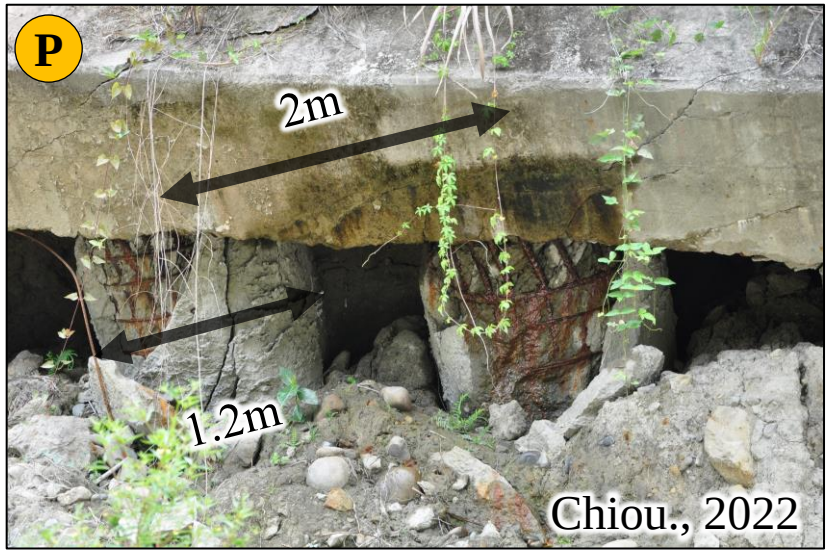
Abstract

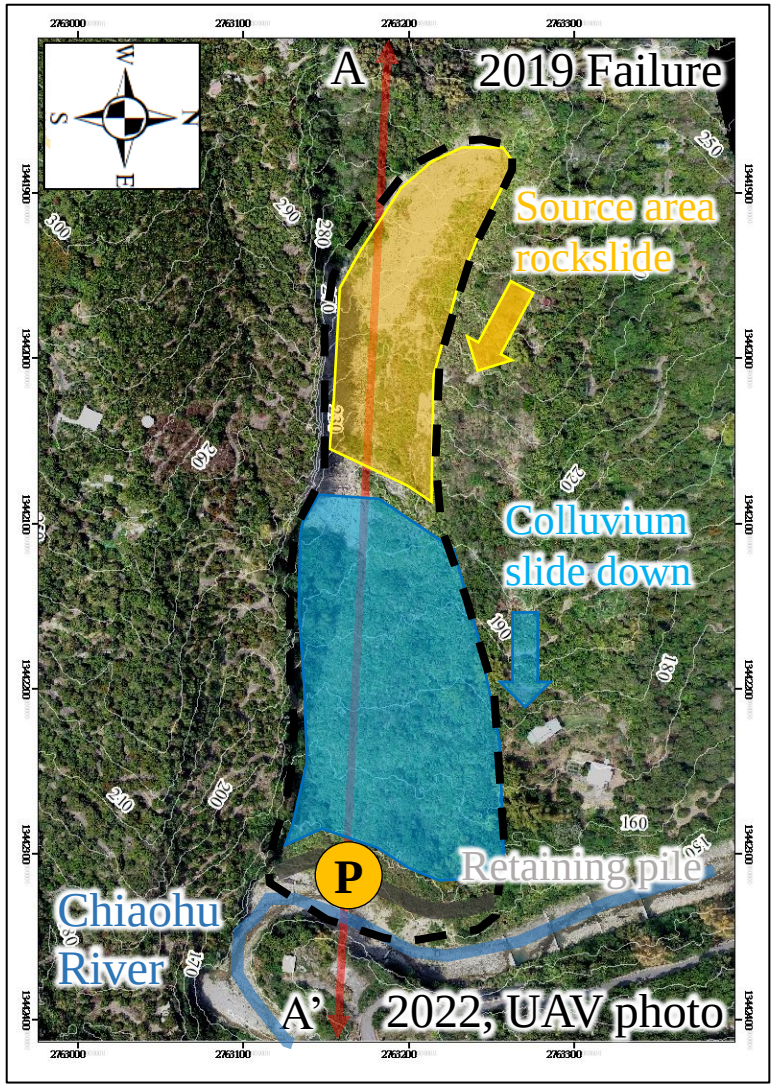
Outline

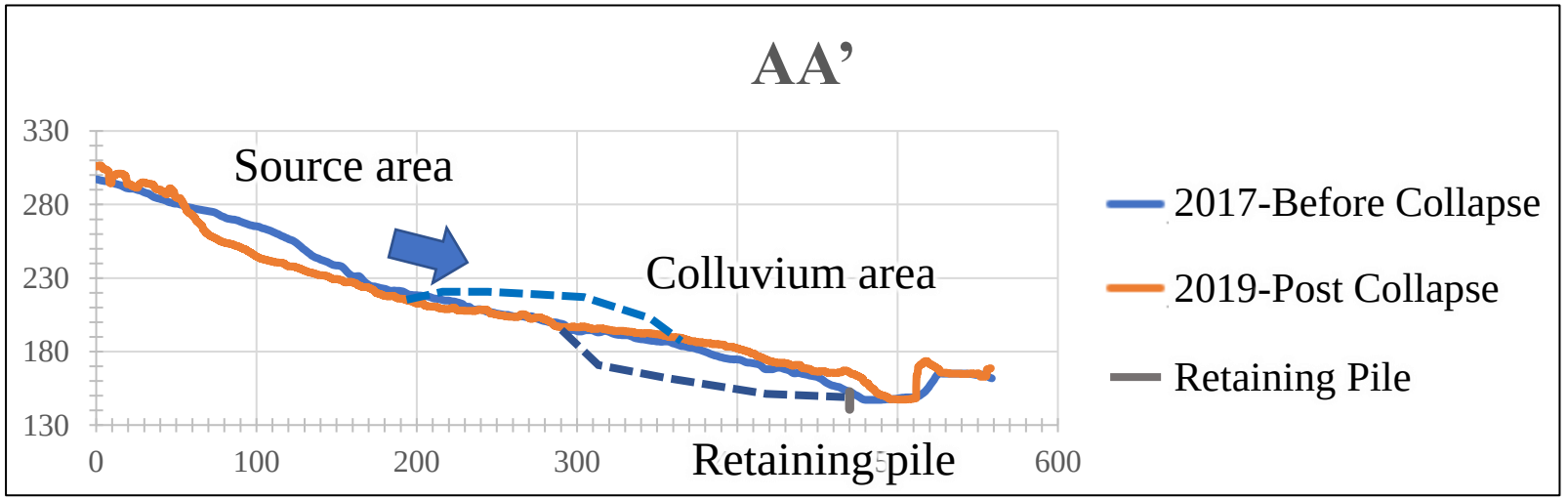
- Introduction
- Methodology
- Results and Discussions
- Conclusions

Introduction

Introduction

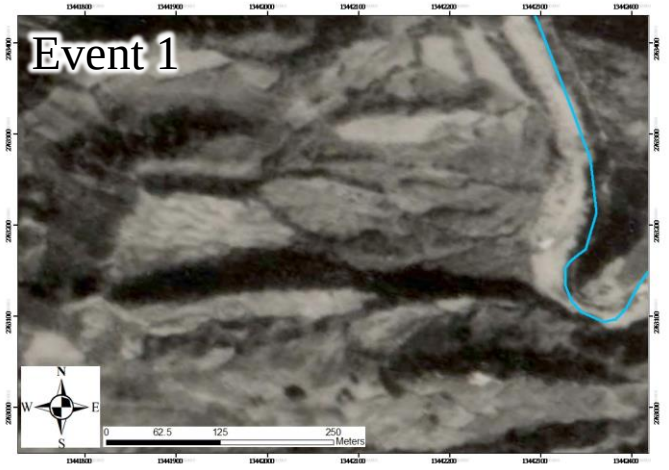




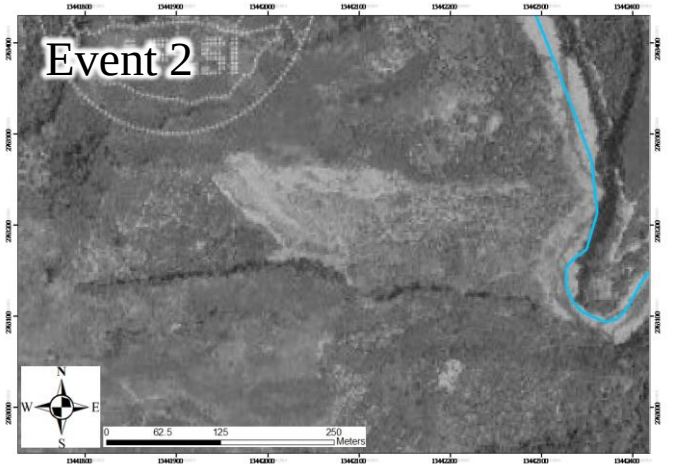


Introduction

1921, Topography map



1948, Aerial photograph



1973, Aerial photograph

2005, SPOT satellite imagery

2013 , SPOT satellite imagery

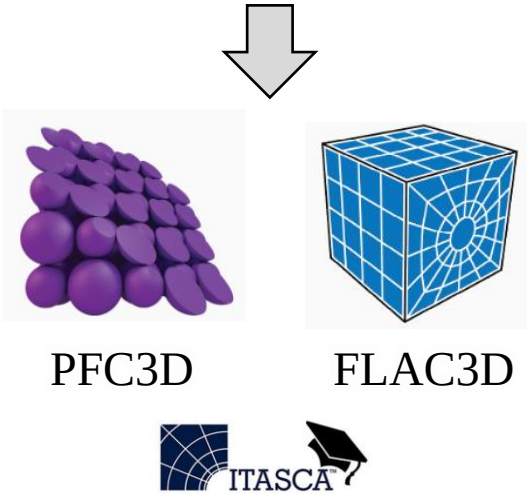
2019, Aerial photograph

Introduction

➢ Objectives:

1. Build a PFC3D numerical model for recreating the history of collapses by using historical imagery and topography data.
2. Using FLAC3D & PFC3D couple model to analyze the damage causes after installation of retaining piles in 2019 disasters.

Event	Year	Sliding Depth(m)	Sliding volume(m^3)
1	Old(~1948)	?	?
2	1973	10	121303
3	2004	12	113311
4	2013	10	168505
5	2019	10	113480



Methodology

Methodology

➢ Rock mass parameters and numerical method

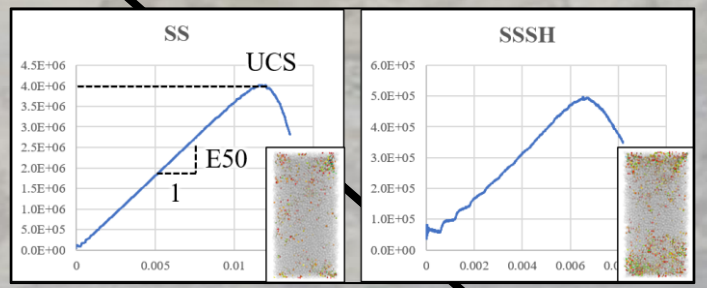
Rock Mass parameters

Q method

Calculate GSI

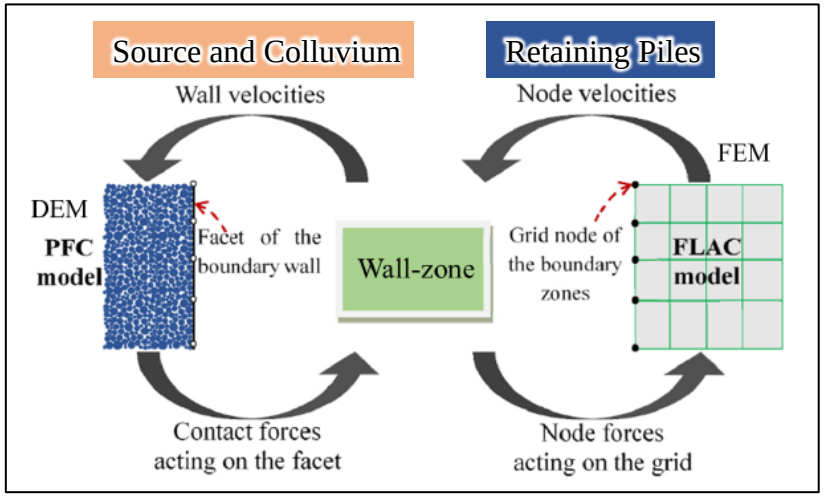
Hoek-Brown parameters transformation

Uniaxial compression test by PFC3D

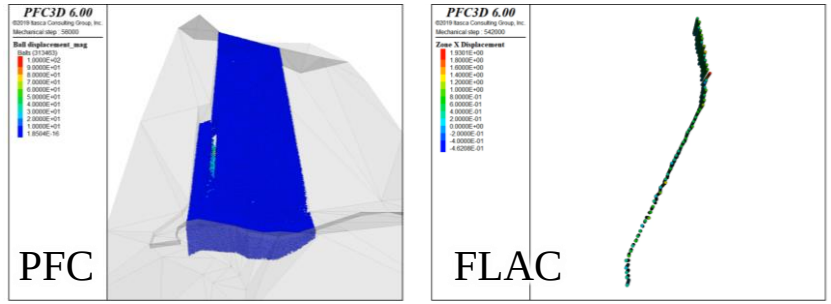


Micro parameters in PFC

Numerical Method



After Jia et al, 2018



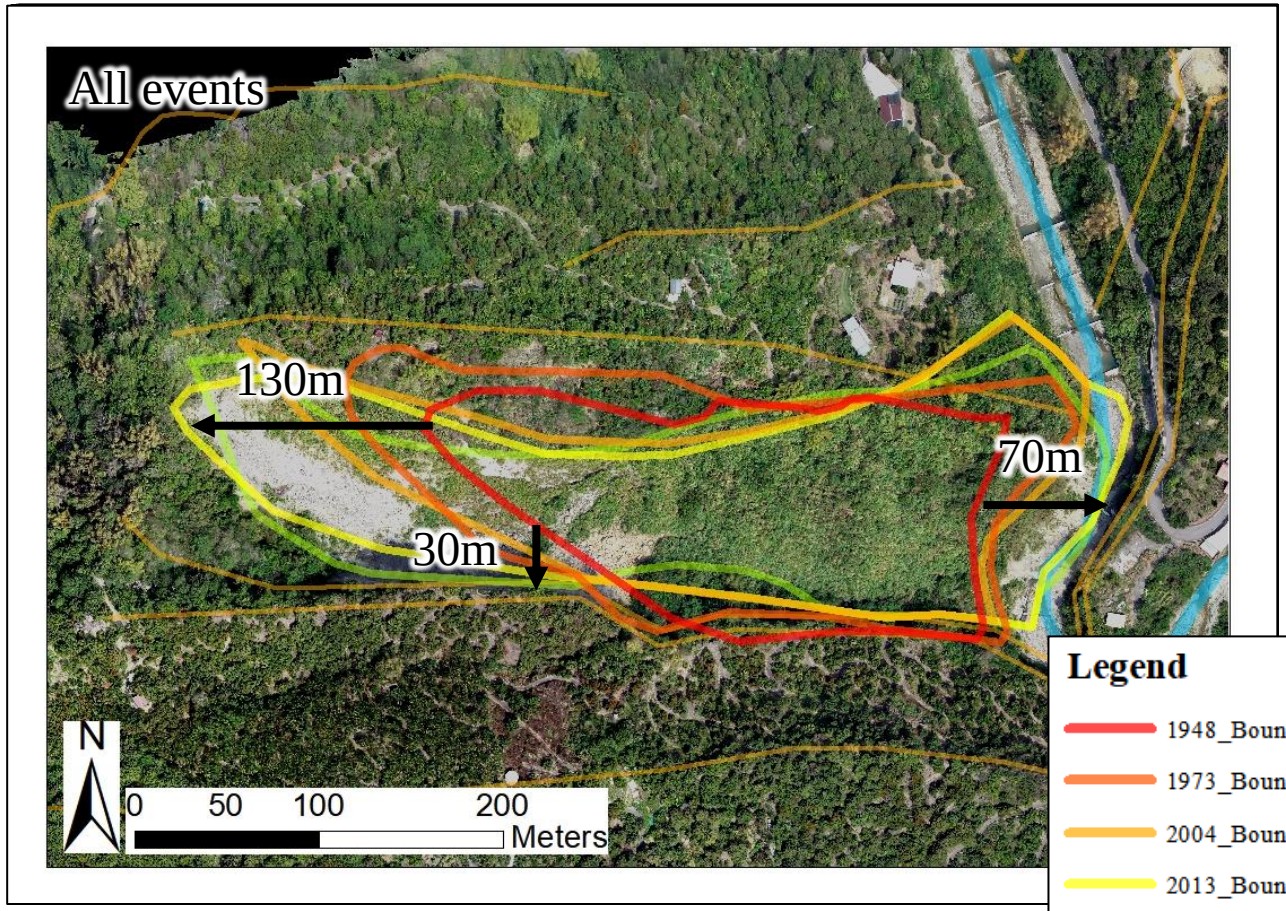
Result and discussion

Result

➢History of Chiaohu river landslide

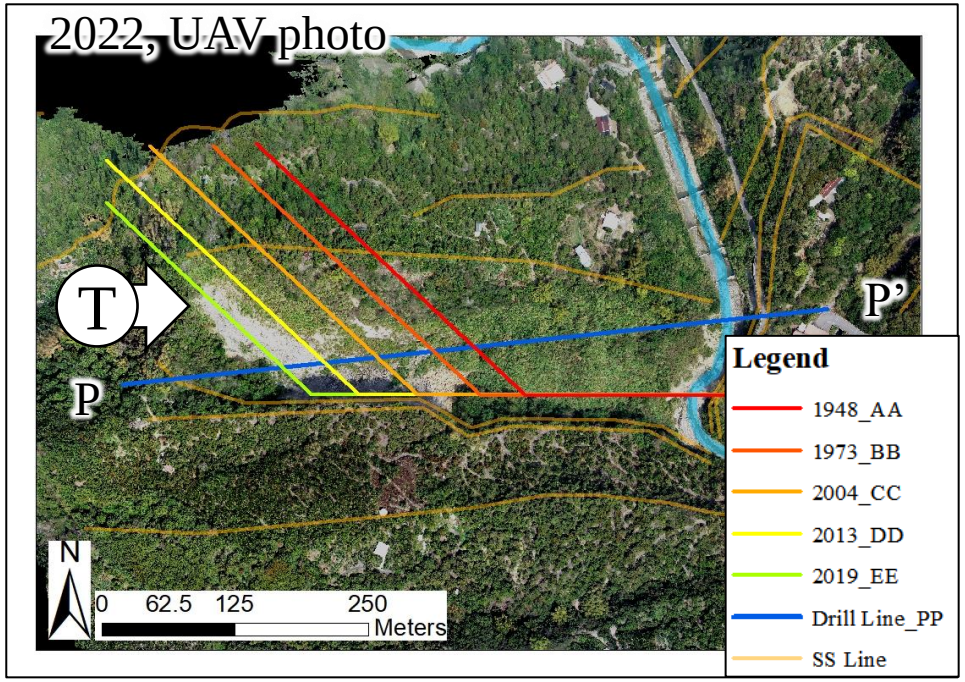
- Using satellite images and aerial photos to draw the sliding boundary of large sliding events.
- The boundary of the collapsed area continued to move southwest, and gradually reduced the river channel.

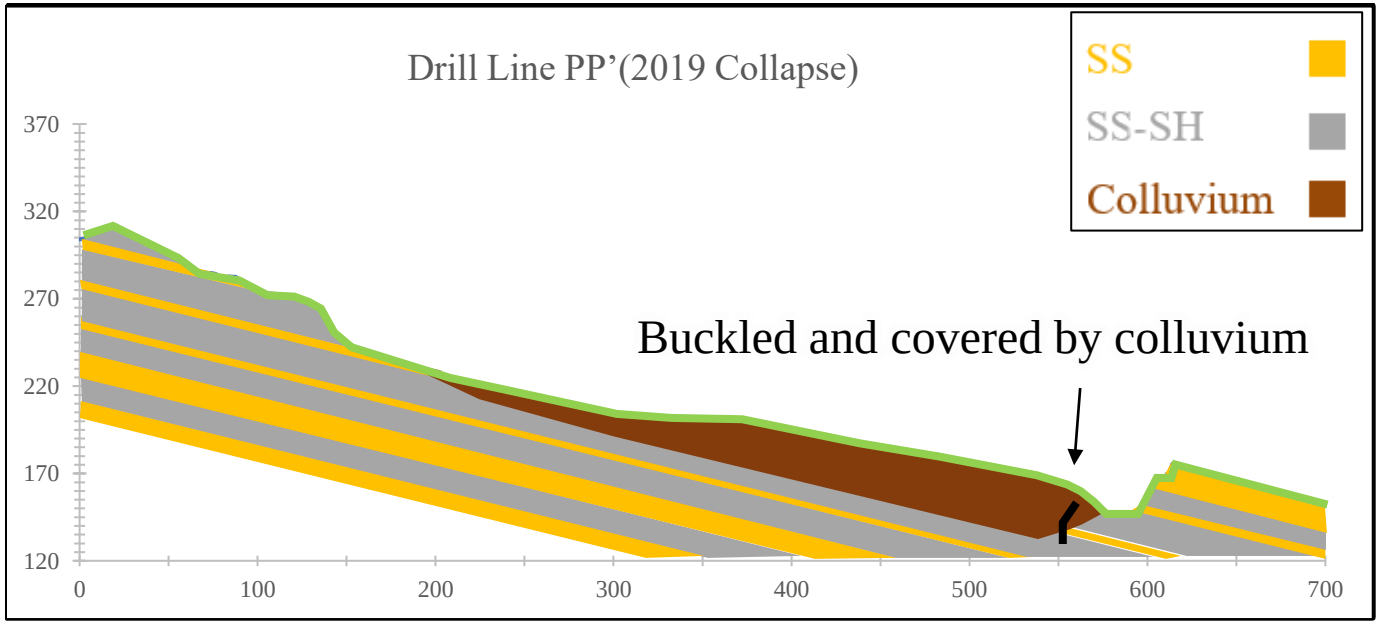
Event	Year	Sliding depth(m)	Sliding volume(m^3)
1	Old(~1948)	?	?
2	1973	10	121303
3	2004	12	113311
4	2013	10	168505
5	2019	10	113480



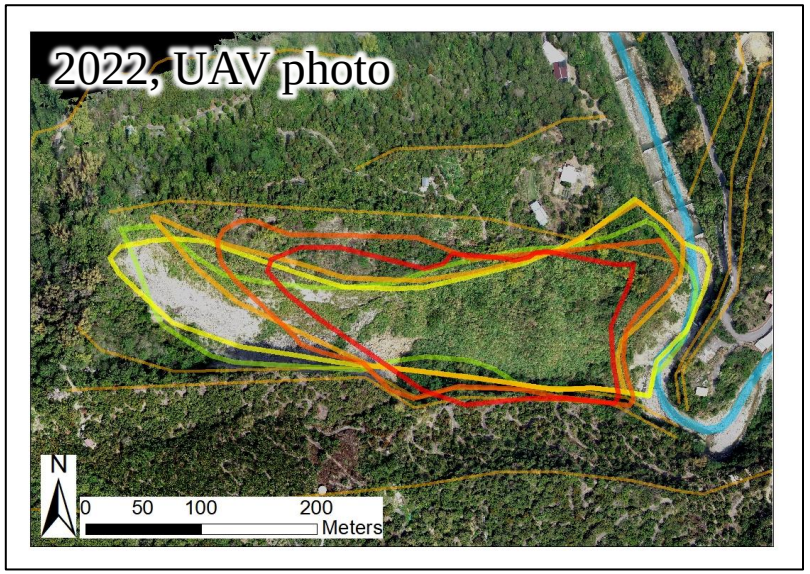
Result

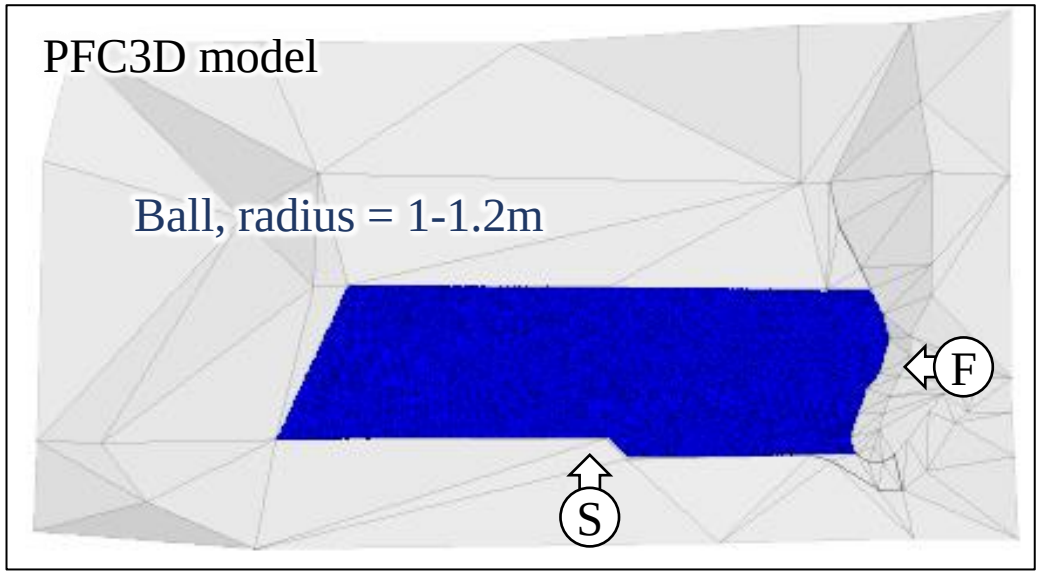
➢Geological model

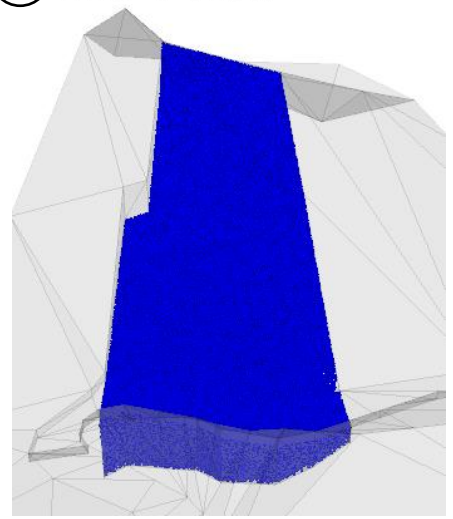


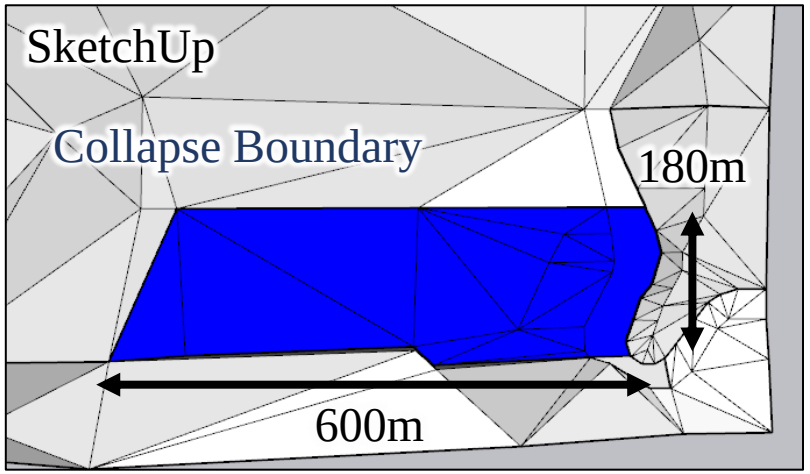


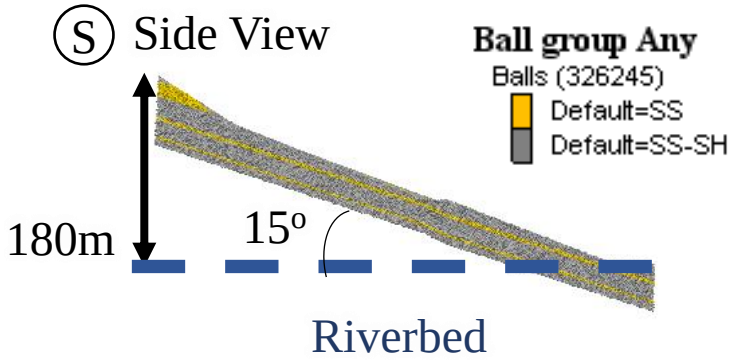
Result ➢ PFC3D Full Scale Model Setup







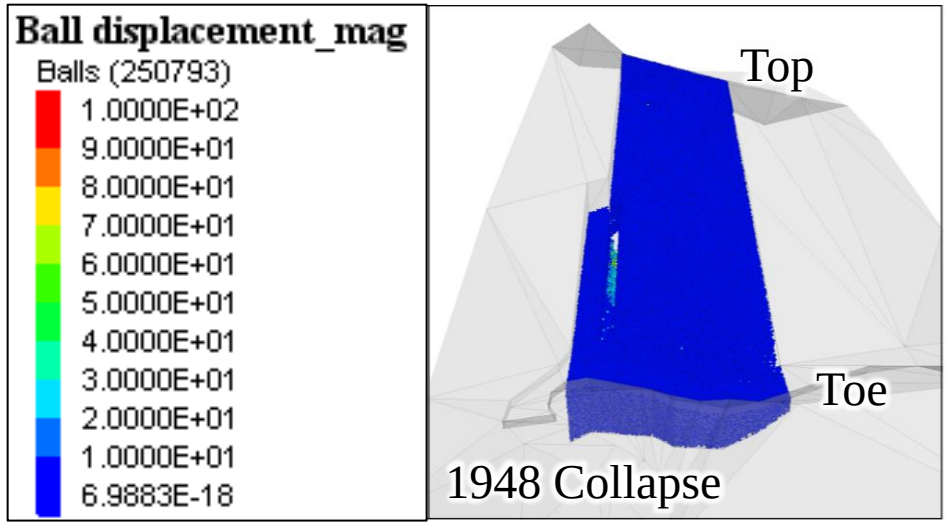


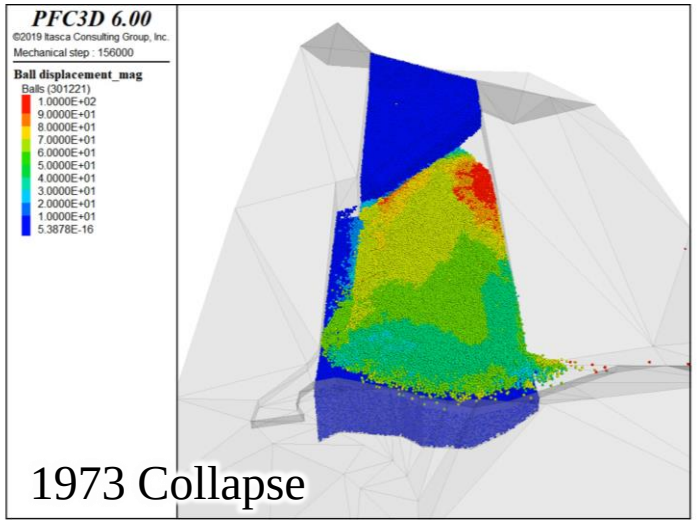


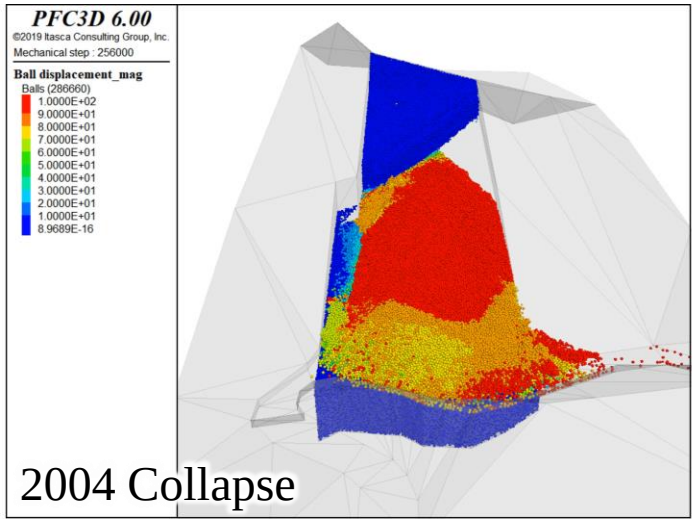
Parallel bond model		
Rock	SS	SS-SH
density(kg/m^3)	2600	2600
pb_kn (N/m)	2.4×10^8	5×10^7
pb_ks (N/m)	9.6×10^7	2×10^7
pb_ten (N)	4.2×10^6	4.5×10^5
pb_coh (N)	2.1×10^6	2.25×10^5

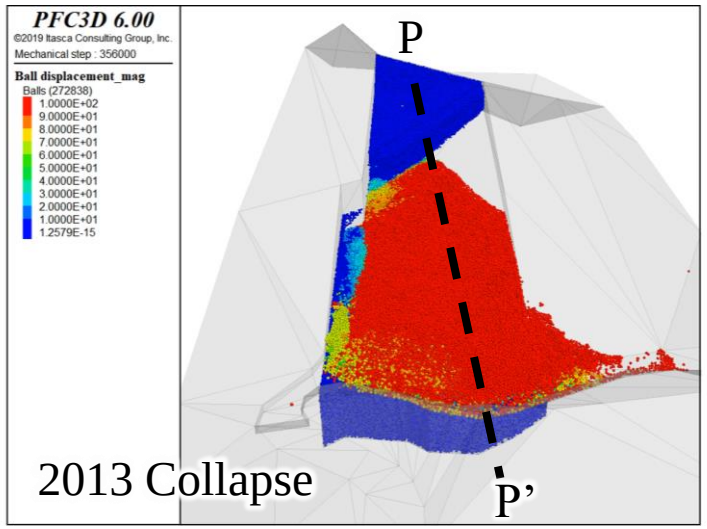
Result

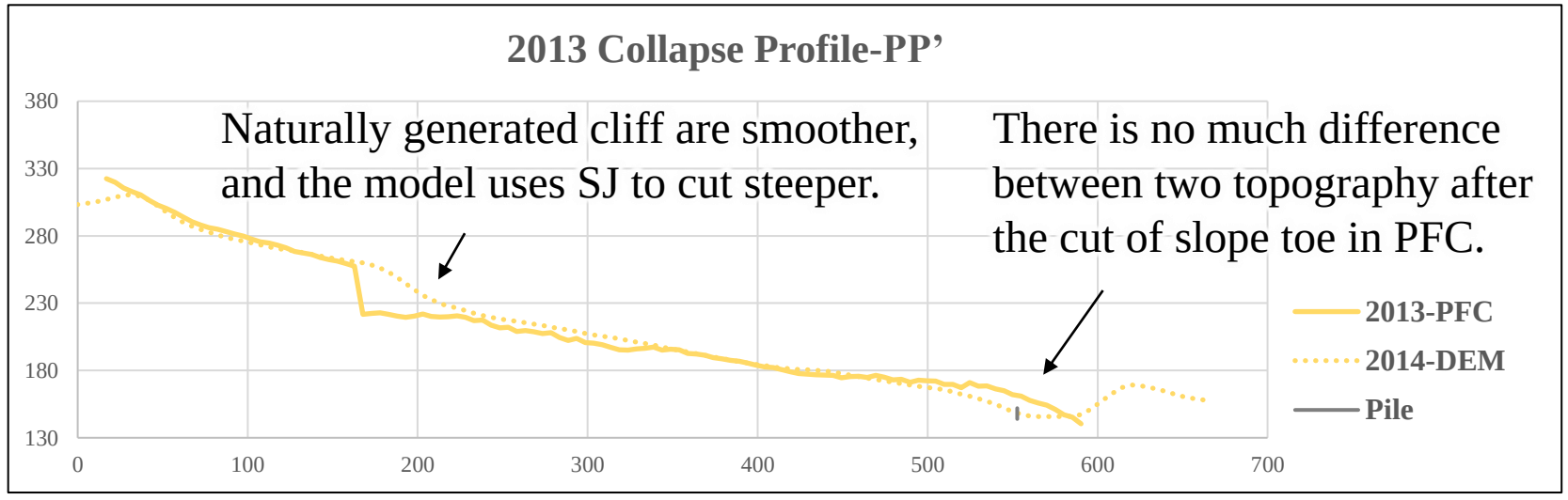
➢PFC3D Full Scale Model Result





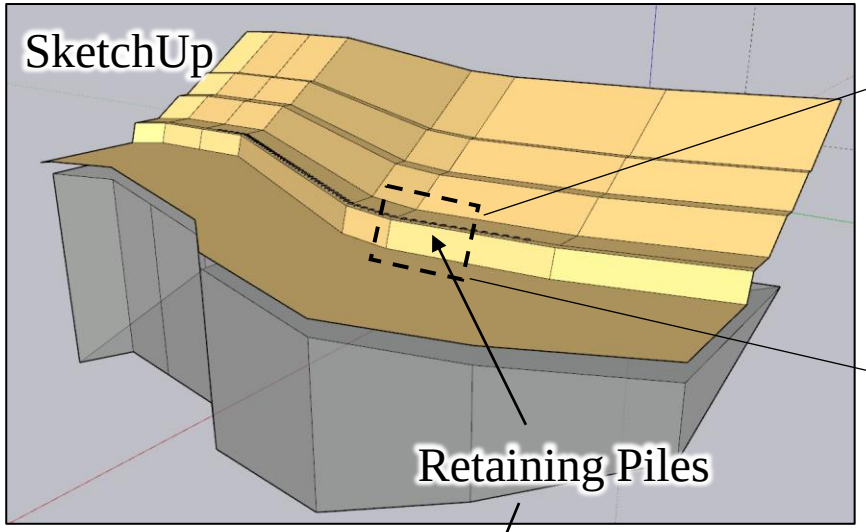


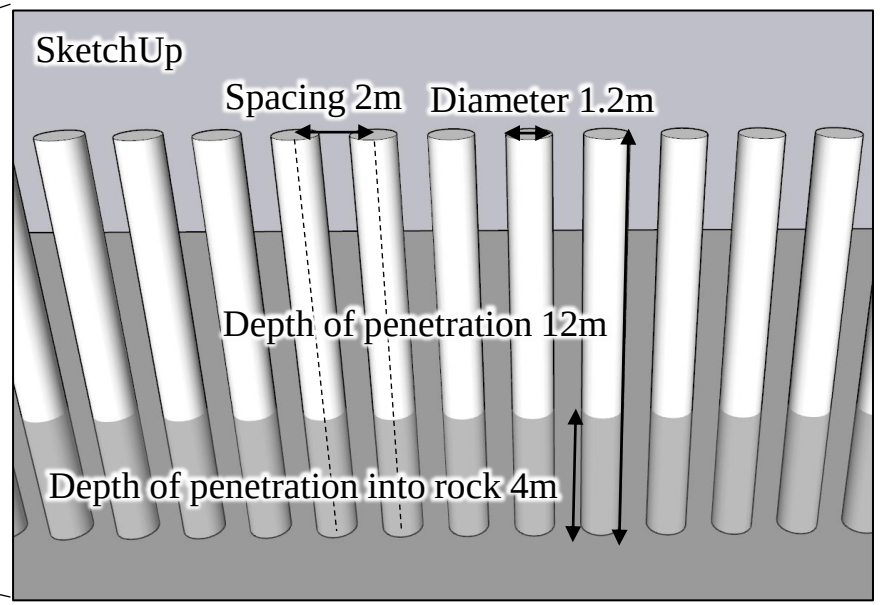




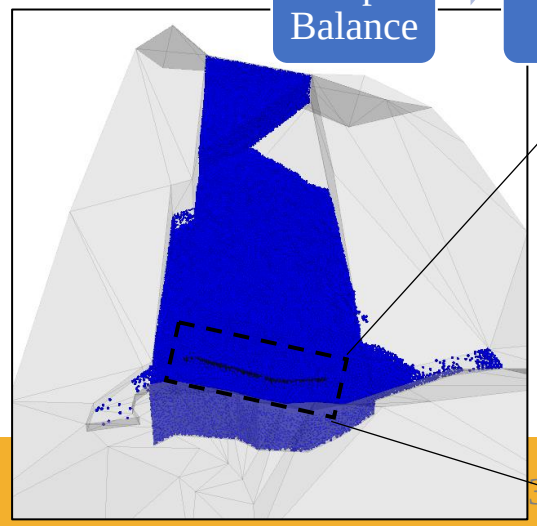
Result

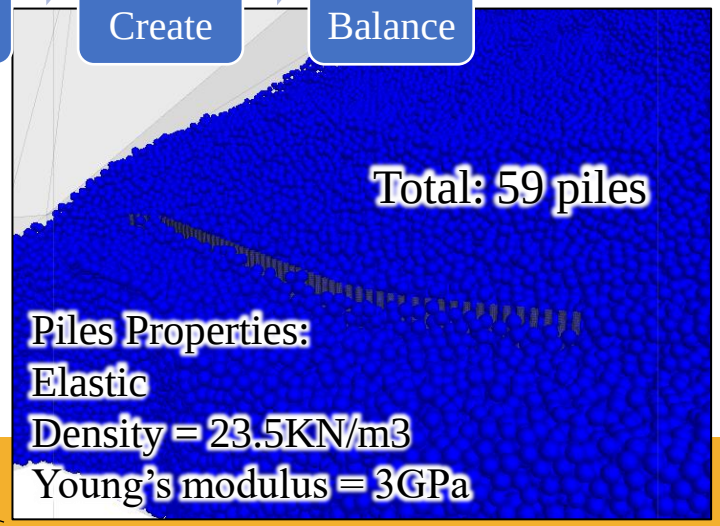
➢ PFC3D Full Scale Model - Pile Setup



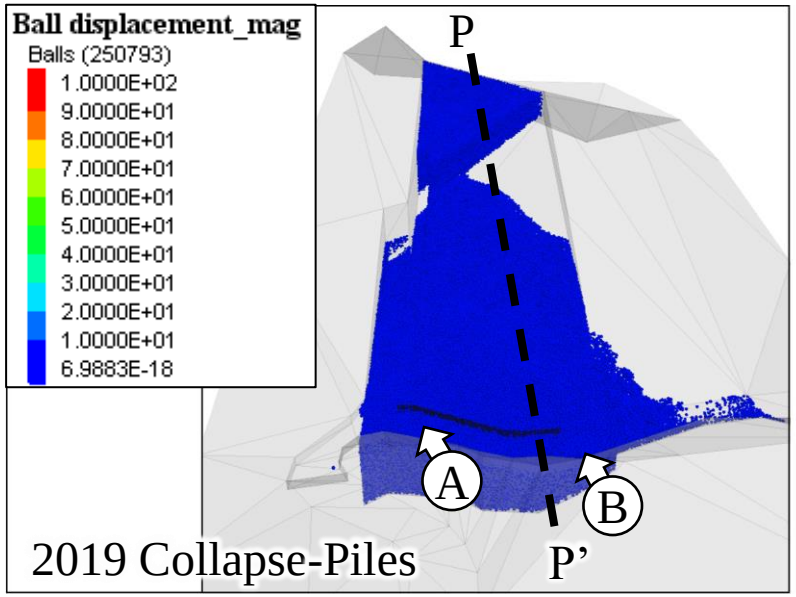


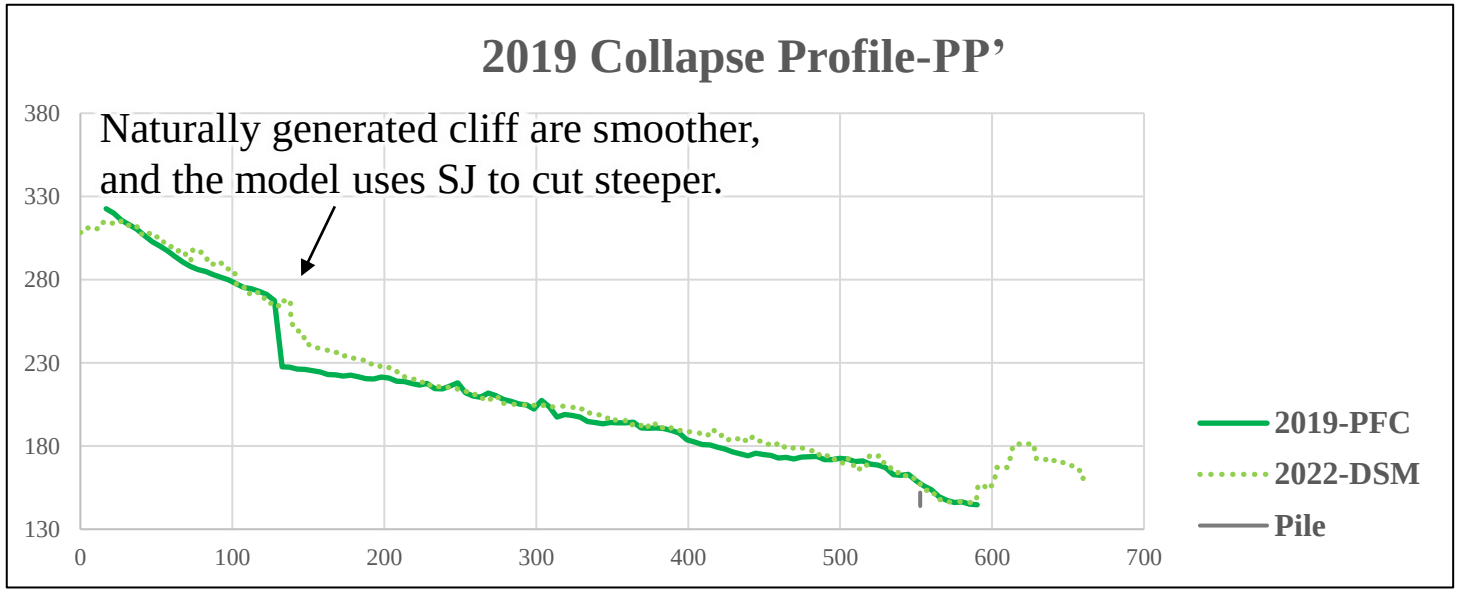
Cut Slope Balance → Create Zone → Wall-Zone Create → Ball-Zone Balance

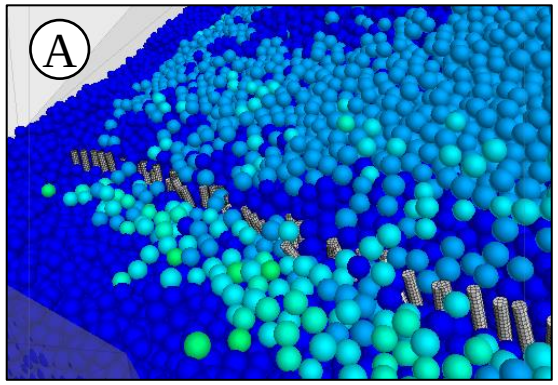




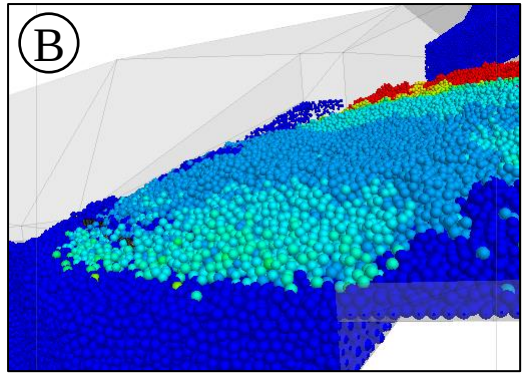
Result ➢ PFC3D Full Scale Model - Pile Result





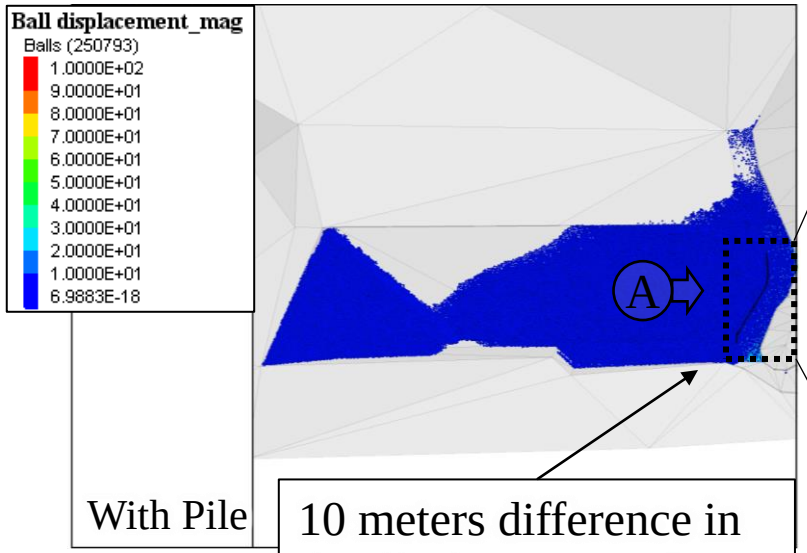


Piles in zone A were exposed on the ground and bending.



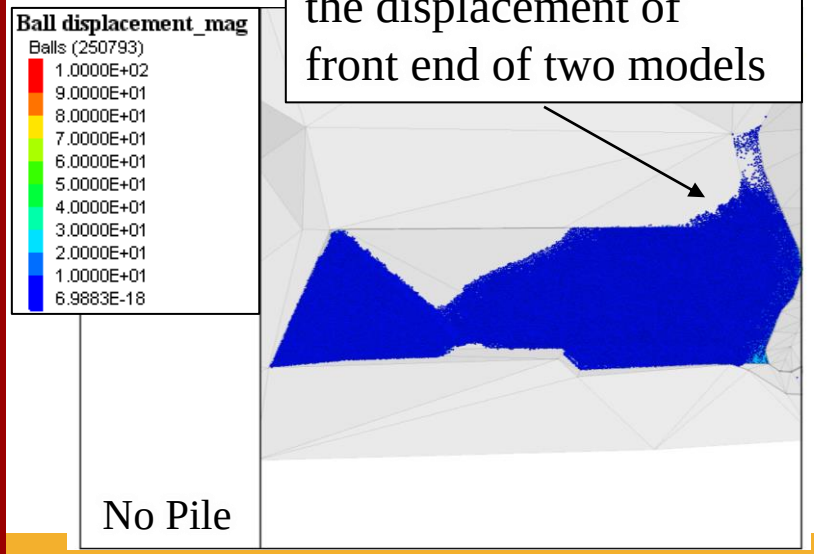
Piles in zone B were covered by colluvium.

Result ➢ PFC3D Full Scale Model - Pile Result

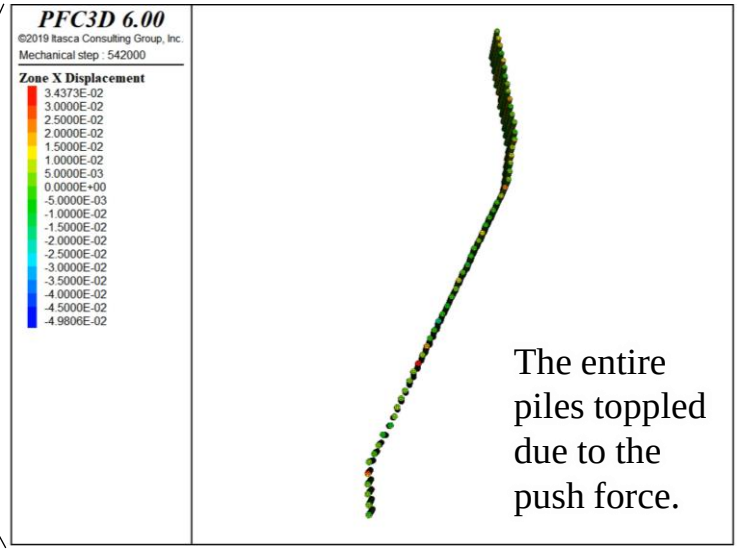


With Pile

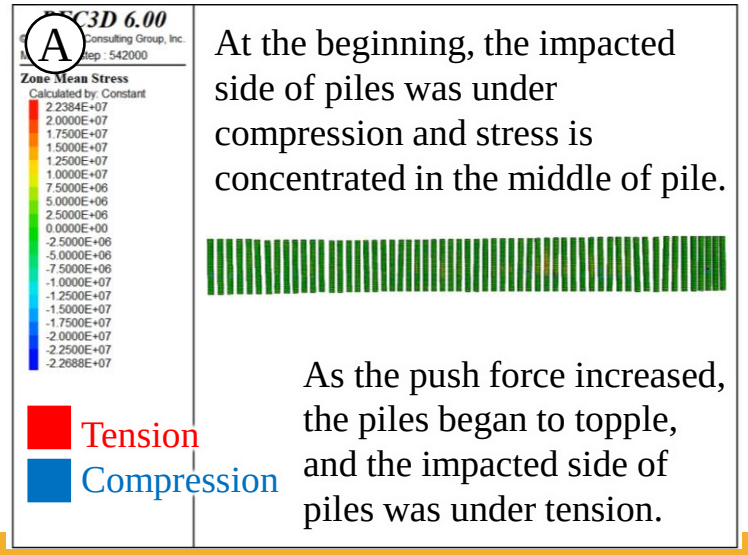
10 meters difference in the displacement of front end of two models



No Pile

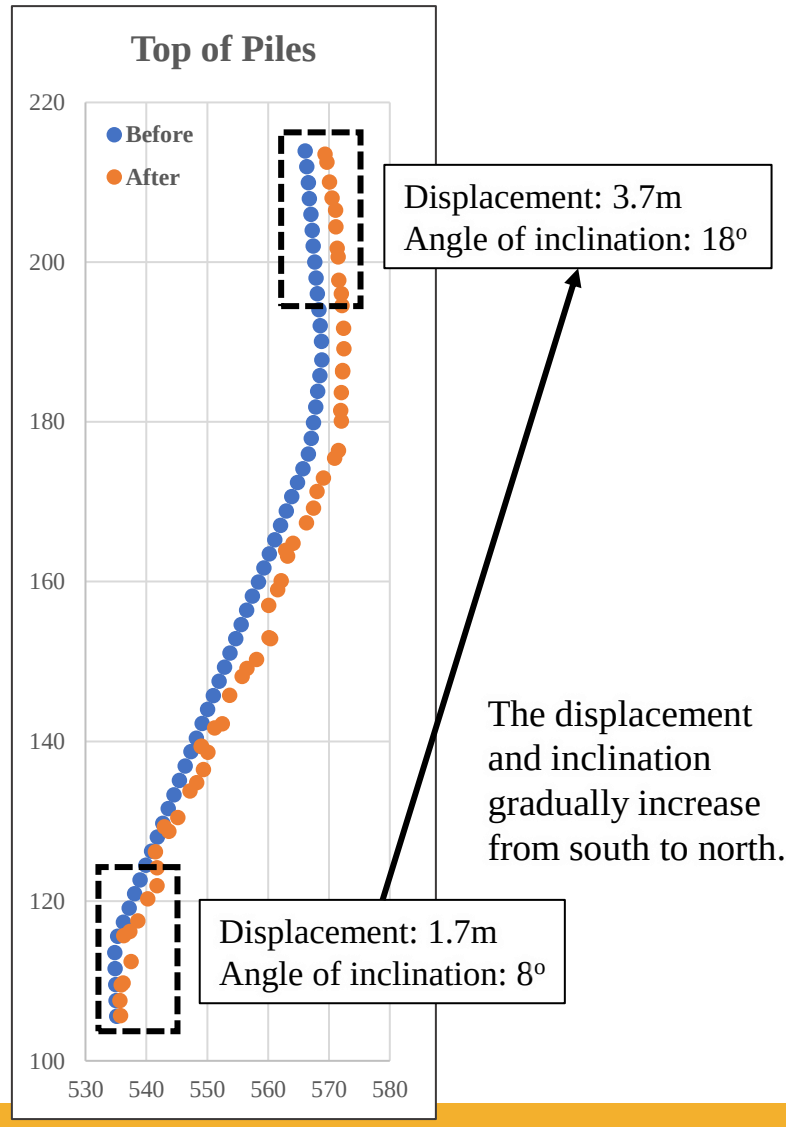


The entire piles toppled due to the push force.



At the beginning, the impacted side of piles was under compression and stress is concentrated in the middle of pile.

As the push force increased, the piles began to topple, and the impacted side of piles was under tension.



The displacement and inclination gradually increase from south to north.

Conclusion

Conclusion

- According to our investigation, this collapse area had at least five collapsed events and the sliding volume of the five events was about 100000 cubic meters. The failure mechanism is that the source area was daylight by gully erosion and dip slide to push the colluvium area below.
- The back-analysis shows that simplified consideration of only colluvium material on the stability of retaining piles underestimate the effects of sliding force of the rockslide on behavior. In this model, the source blocks could slide and push the colluvium blocks larger than 10 times the volume of source blocks.
- This simulation shows that it is feasible to use PFC to simulate the movement of particles and FLAC to simulate the force of piles. This model can not only show the damage of the overall piles, but also show the stress transformation and damage of the piles in different parts or different areas, which can be used to strengthen the piles design.

Reference

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Thanks for listening!

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