Metro21
Carnegie Mellon University

Toward Landslide Forecasting from Images and Mechanics

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2018: Record year of landslides in our region

- Record **rainfall**: wettest year
- Soil: **red clay**
- Many **hills**
- Not enough **$$$**

Route 30

Greenleaf St. /
West End

Motivation

- Computer vision, machine learning, failure modeling in materials and structures have made great advances in recent years
- We have a large collection of road images
- How can these tools be used to predict and analyze landslides?

=> Collaboration between Robotics and CEE

Classification

Road segmentation

Detection of cracks

Example: Road Crack Detection

using computer vision and machine learning

Possible indicators for impending problems:
Debris on road, change of color of soil, pooling of water, …

Indicator events in images

Debris on road

Cracks: longitudinal, then curving

Persistently wet =>reduced friction

Leaking pipe => Earth movement might cause leak.

3D reconstruction from images

From 80 images:

Indicator events in 3D

Tree

Retaining wall: bulges, tilting, bowing, undermining

Rail guard

Current focus: development of cracks

Example: Spring Run Road

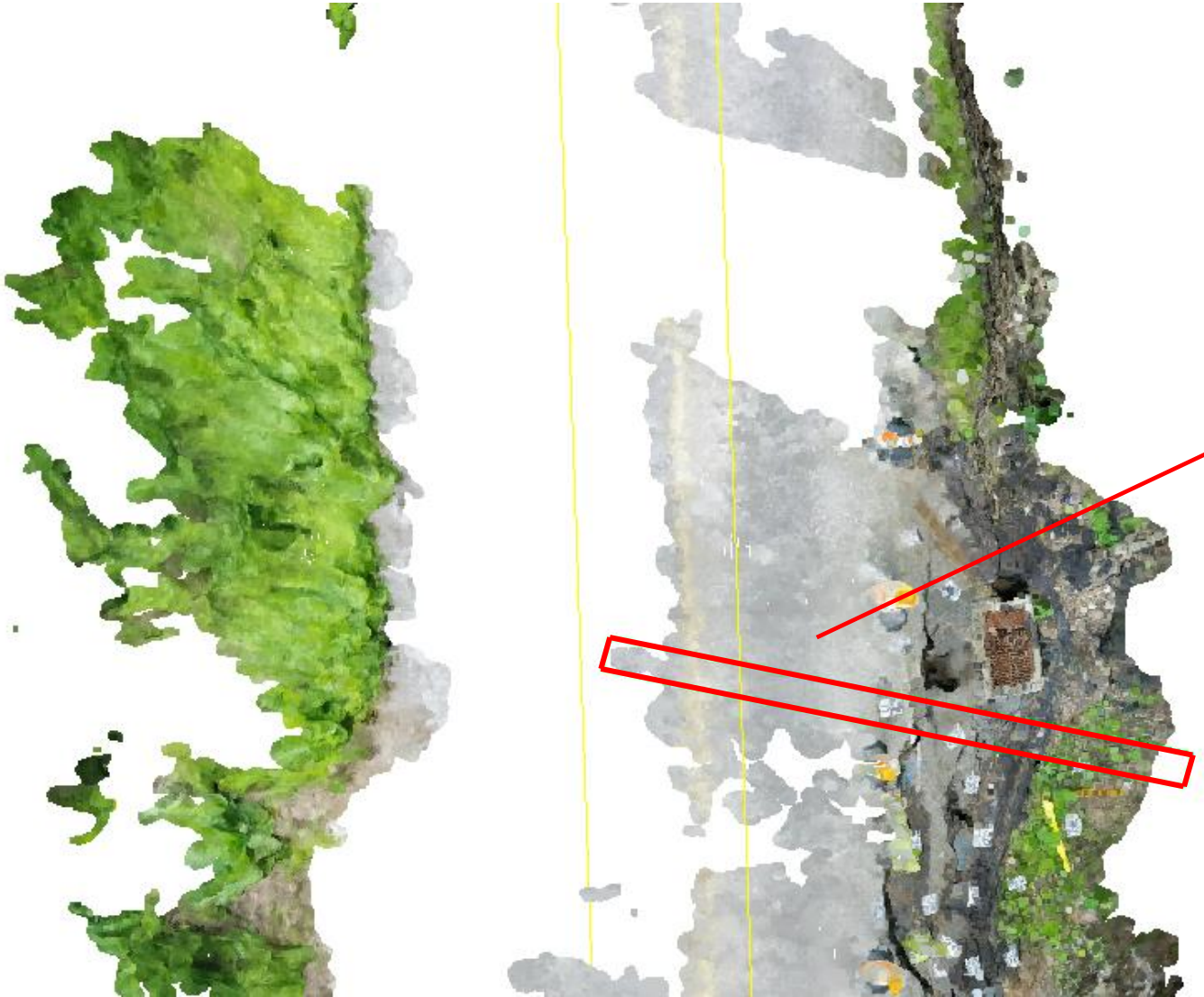
November 11, 2018

March 12, 2019

May 20, 2019

3D model of Spring Run Road landslide

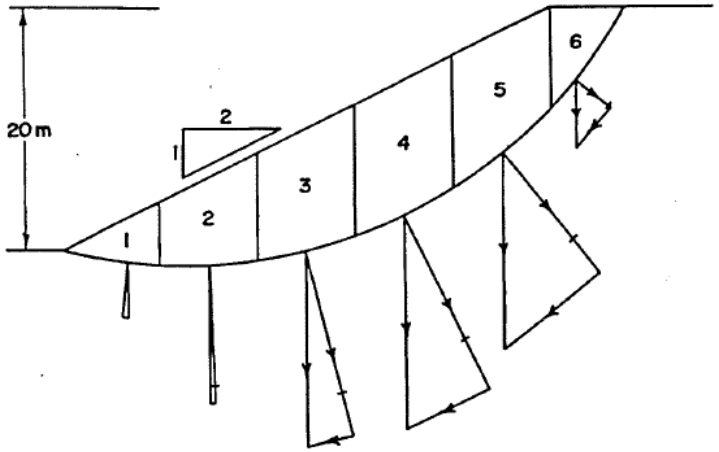
Cross section



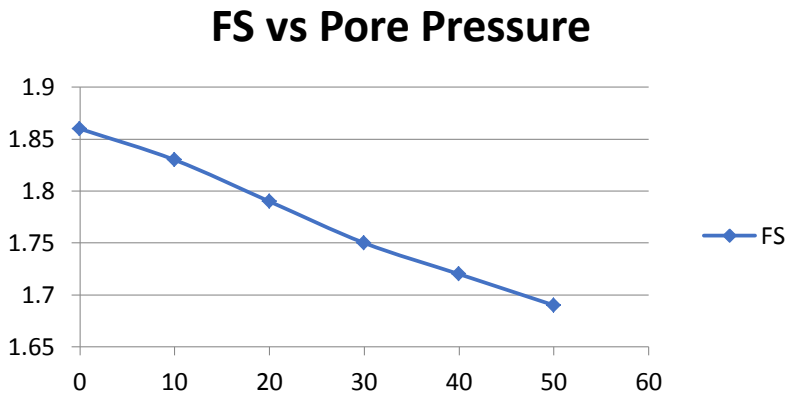
top view

side view (cross section)

Ordinary method of slices calculations



Slicing of soil slope

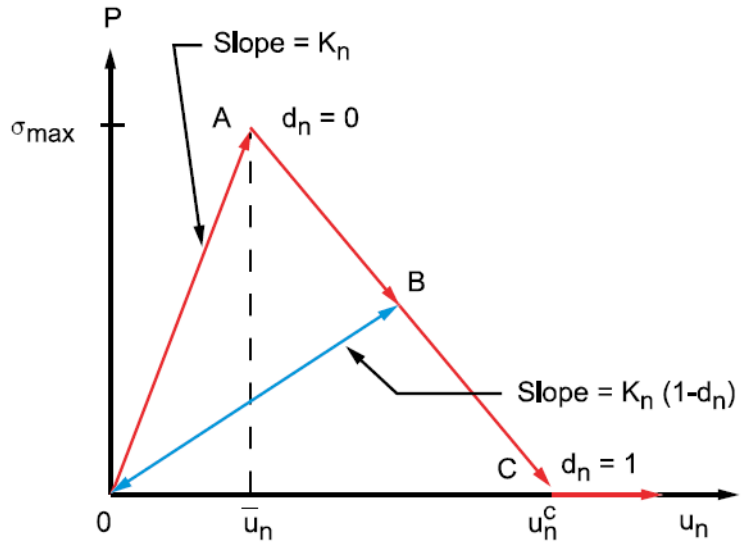


FS variation with pore pressure

Approximate (but useful) analysis: Force balance not satisfied exactly

Cohesive zone model (CZM)

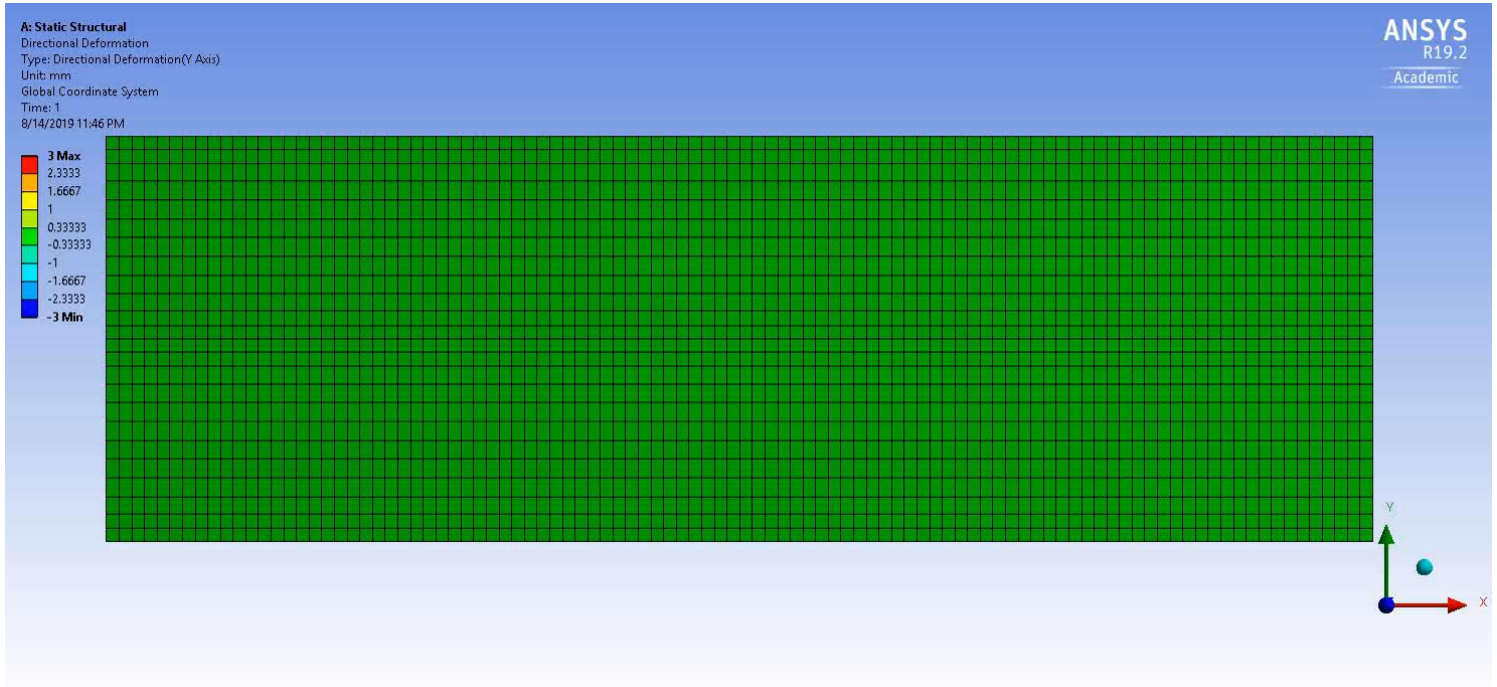
Cohesive zone model in fracture mechanics assumes the propagation of crack along specified path (i.e cohesive zone) defined by traction separation law. The material behavior at the interface is characterized by this assumption.



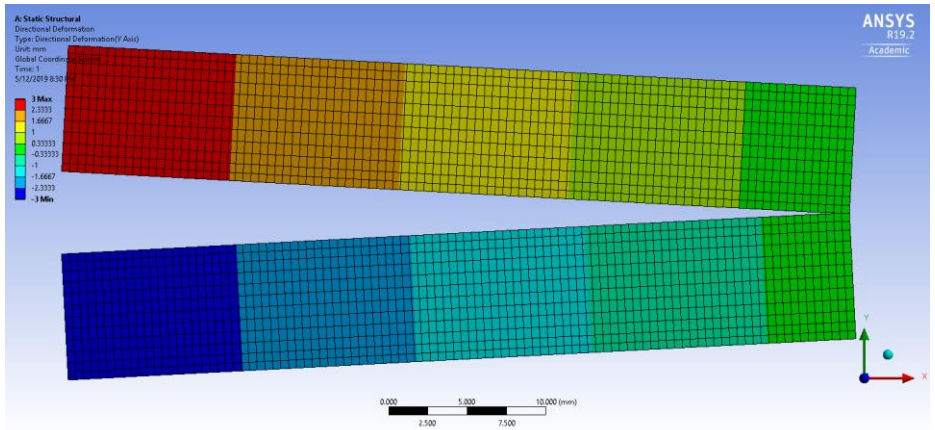
Traction separation law

$$P = K_n u_n (1 - d_n)$$

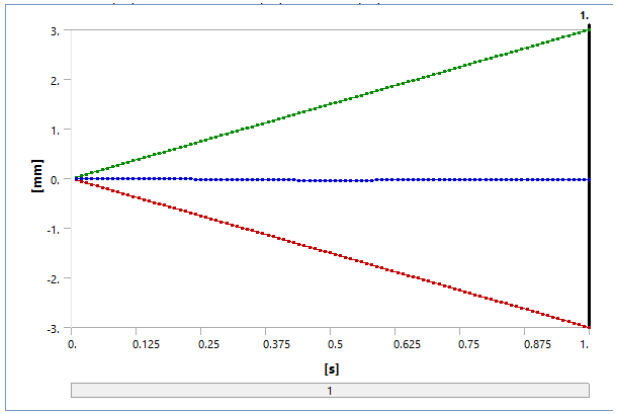
CZM of a cantilever beam (Video)



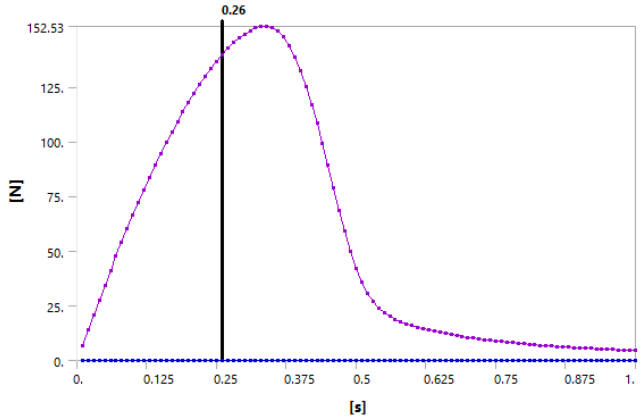
CZM of a cantilever beam



Crack propagation in cantilever beam using CZM

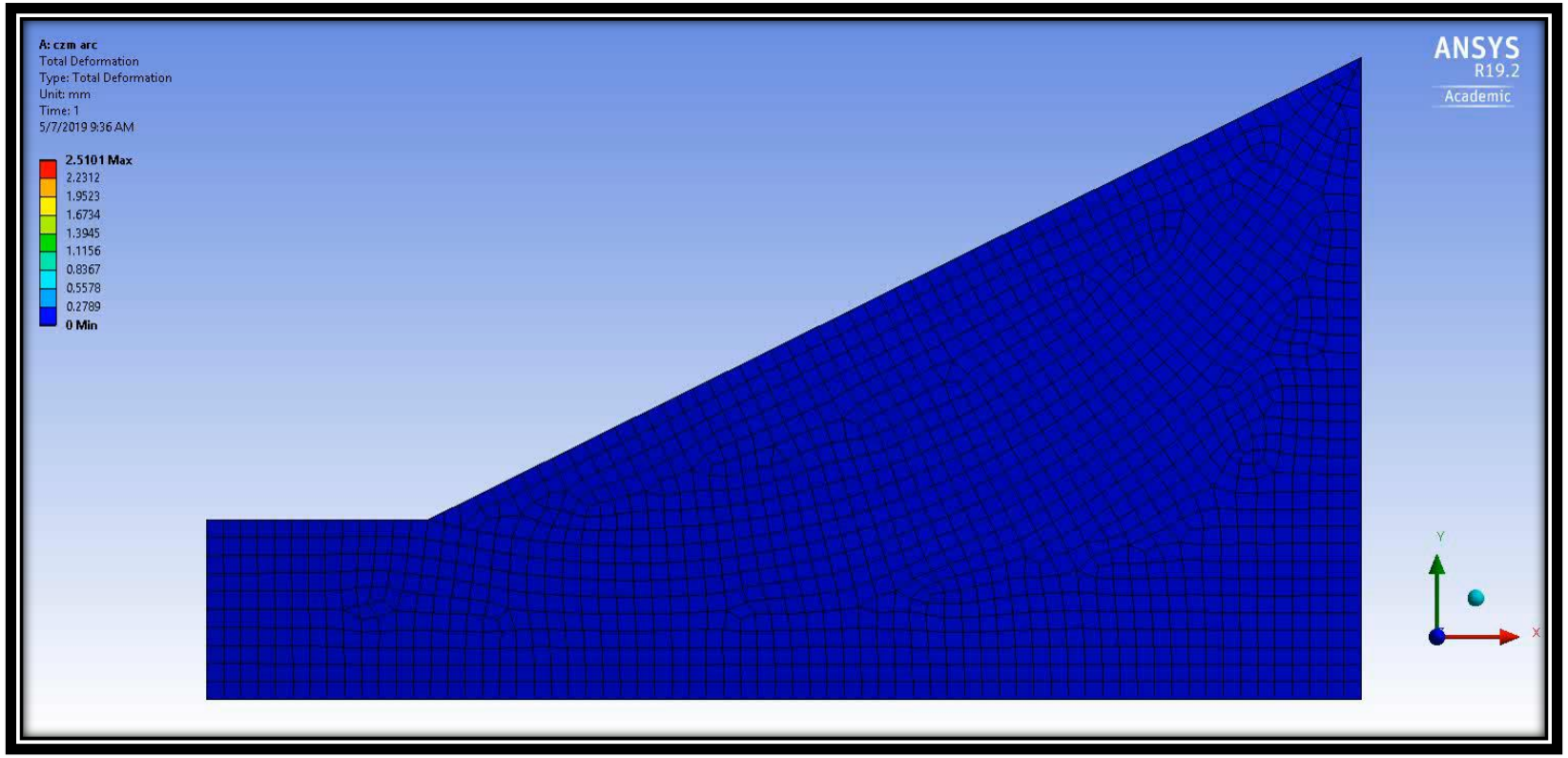


Separation at edge node

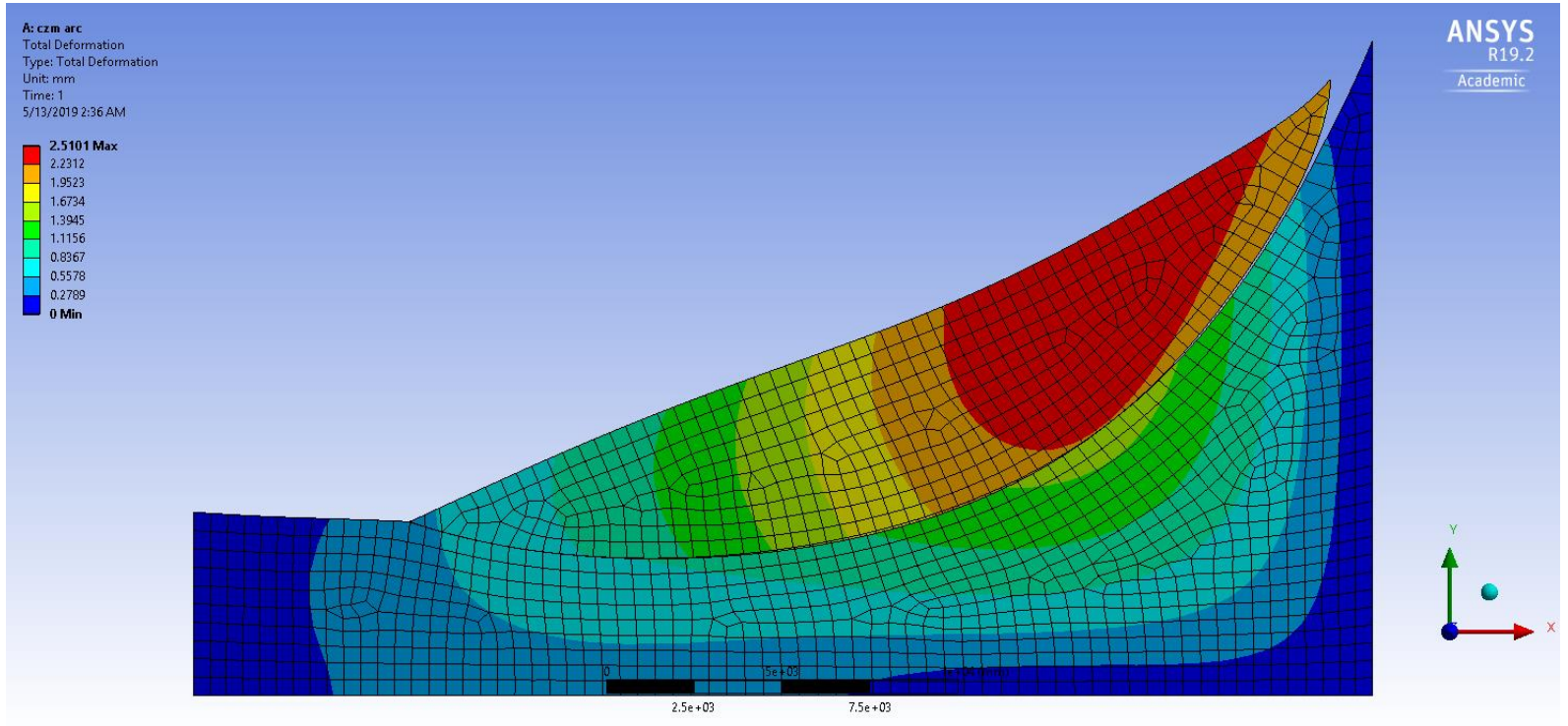


Force reaction vs time

CZM of a soil slope (Video)



CZM of a soil slope



Ansys model showing the sliding of assumed failure surface using CZM

Research Needs

- Improve CZ Finite Element model: Transform Mohr-Coulomb failure envelope to a CZM
- Discrete Element modeling – at realistic time scales – of landslide failure
- Develop software package combining ‘continuous’ image monitoring+analysis and mechanical failure modeling to **predict potential impending/future landslide failure**