Modeling the Accumulated Damage in Rock Bed during Saltating Abrasion through Particle Flow Simulation

LI, KUO-WEI (李國維)

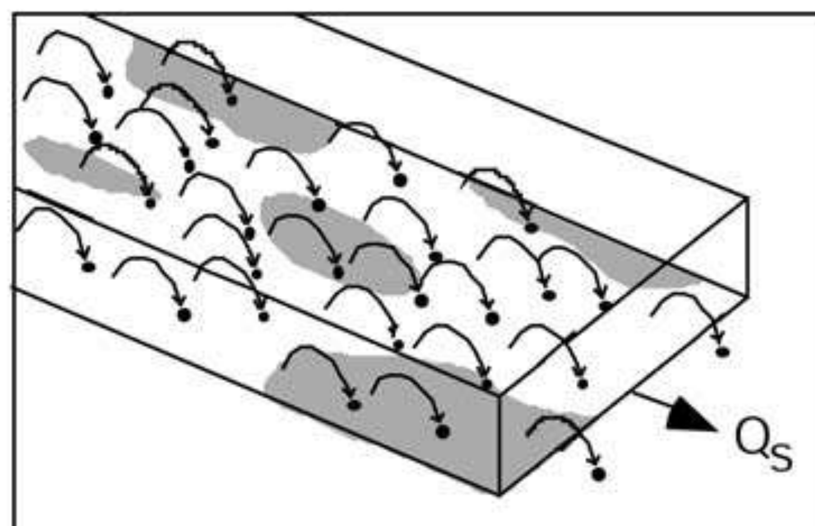
Department of Civil Engineering of
National Chiao Tung University, TAIWAN

Outline

- Literature review
- Research method
- Result and Discussion
- Conclusion

Literature review

- Saltating abrasion mechanistic model (Sklar and Dietrich, 2004)
- $E = V_i I_r F_e$
  - E: erosion rate
  - V_i: volume of rock detached per particle impact
  - I_r: particle impact rate
  - F_e: fraction of exposed bedrock



Research method

- Modeling by PFC3D
  - Rock materical: 11,000 balls
  - Specimen size: 12*12*6 cm

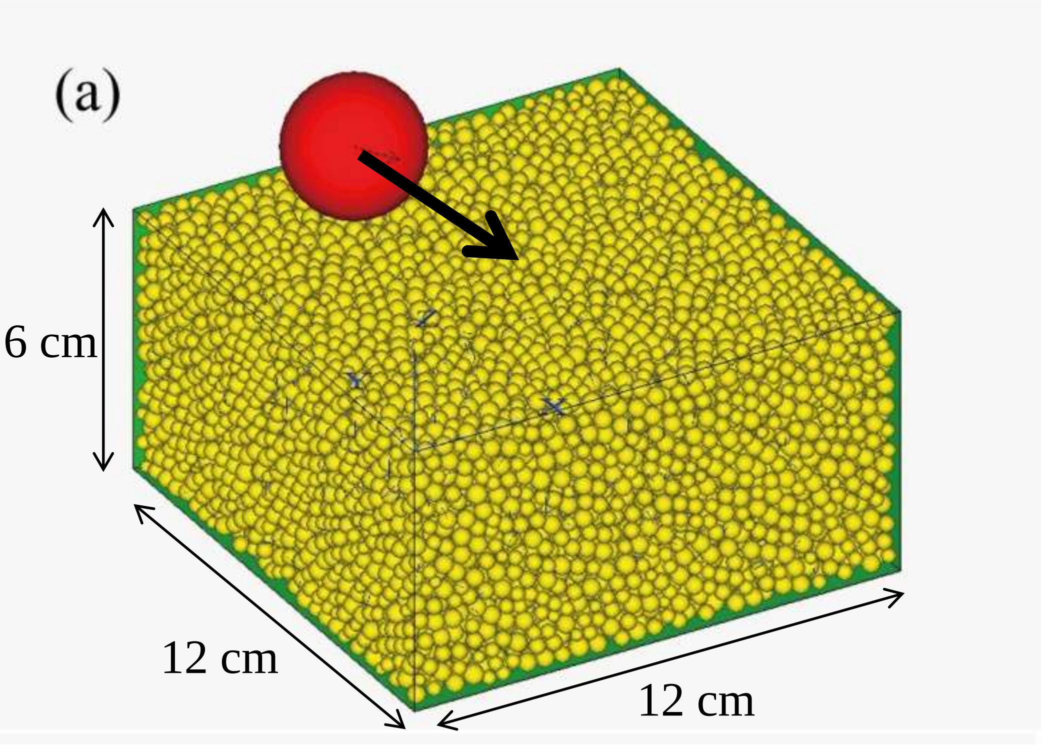


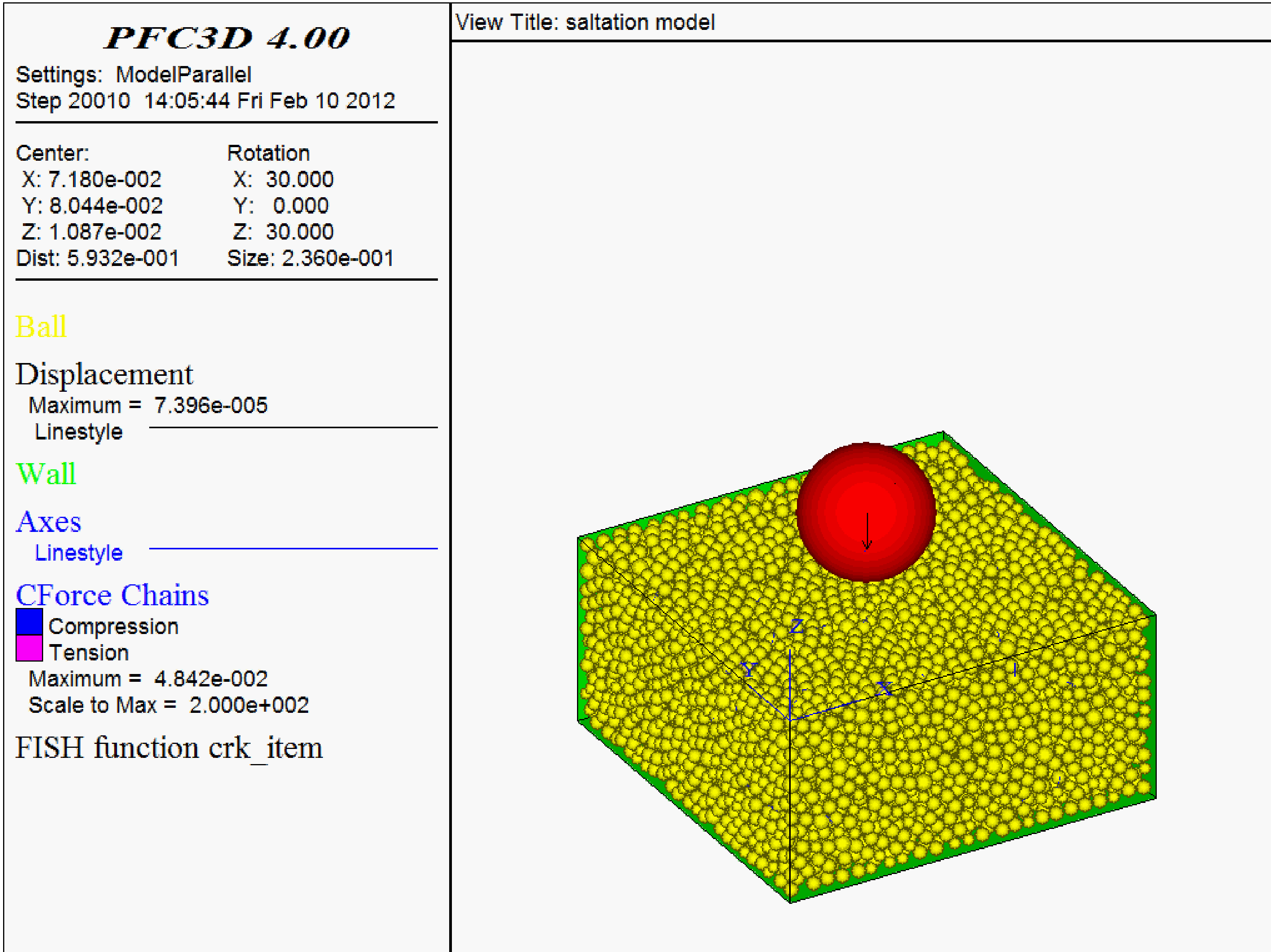
Table 1: Microscopic parameters for soft rock used in simulations.

Particle	Parallel bond	Viscous damping
density = 2.65 t/m^3	pb_kn = 5e11 pb_ks = 2e11	normal damping = 0.1
D_{max} = 5 mm D_{min} = 4 mm	pb_rad = 1	shear damping = 0.03
kn= 5e7, ks = 2e7	pb_nstr = 1.5e7	
μ = 0.577	pb_sstr = 1.5e7	

Table 2: The simulated conditions of saltating abrasion.

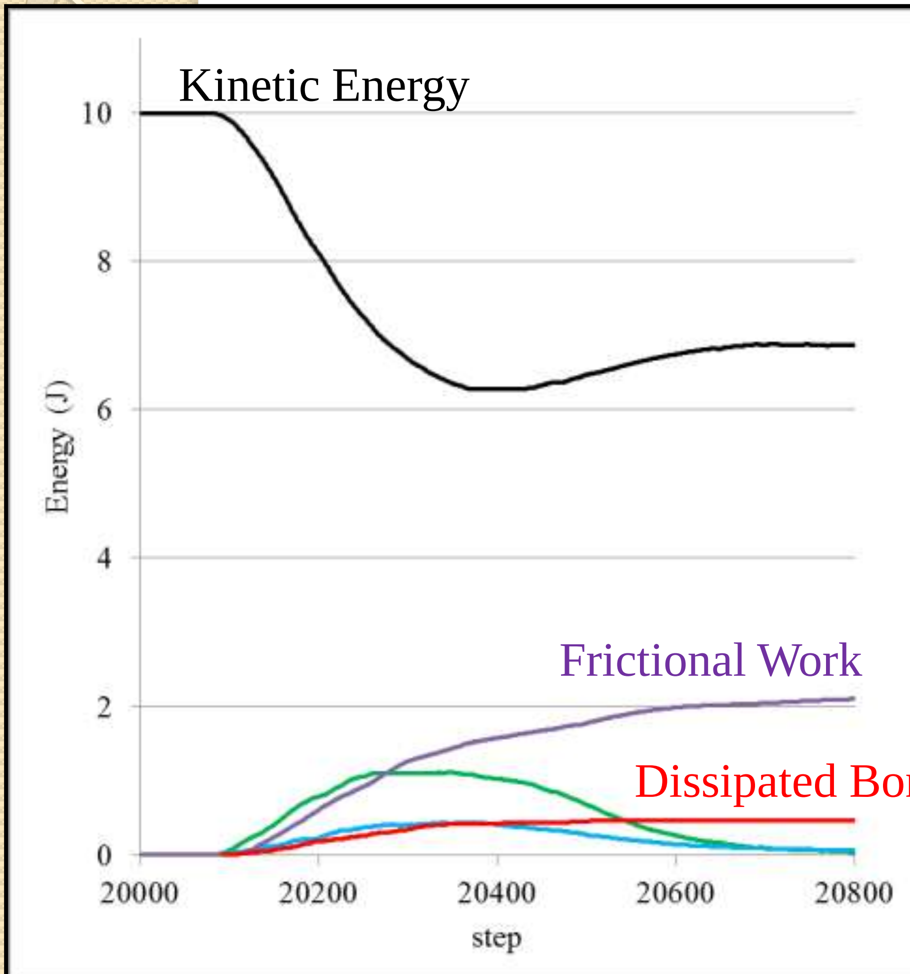
	Initial velocity v_i (m/s)	Impact angle α (degree)	Impact particle diameter (mm)
1	10	90	40
2	15	30	40
3	15	90	40
4	20	90	40

Video (impact angle: 90°)

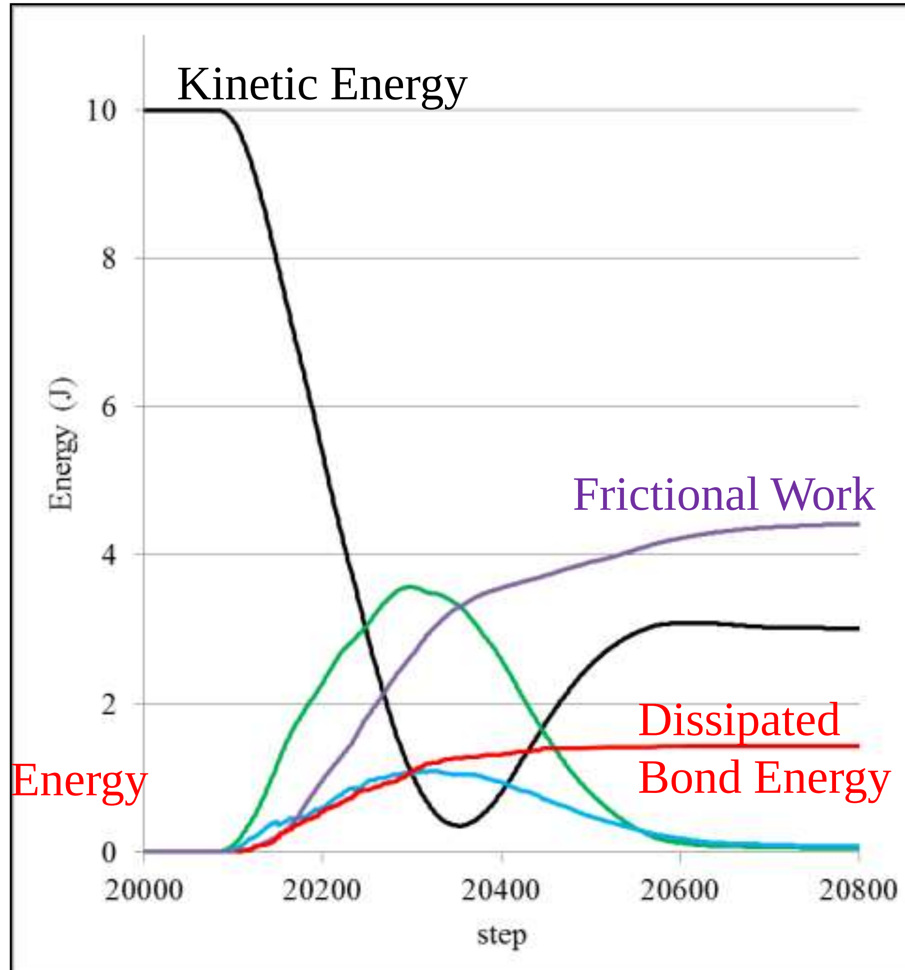


Result and Discussion

Tracing of various energy terms



$\alpha = 30°$



$\alpha = 90°$

Impact velocity versus dissipated bond energy and frictional work

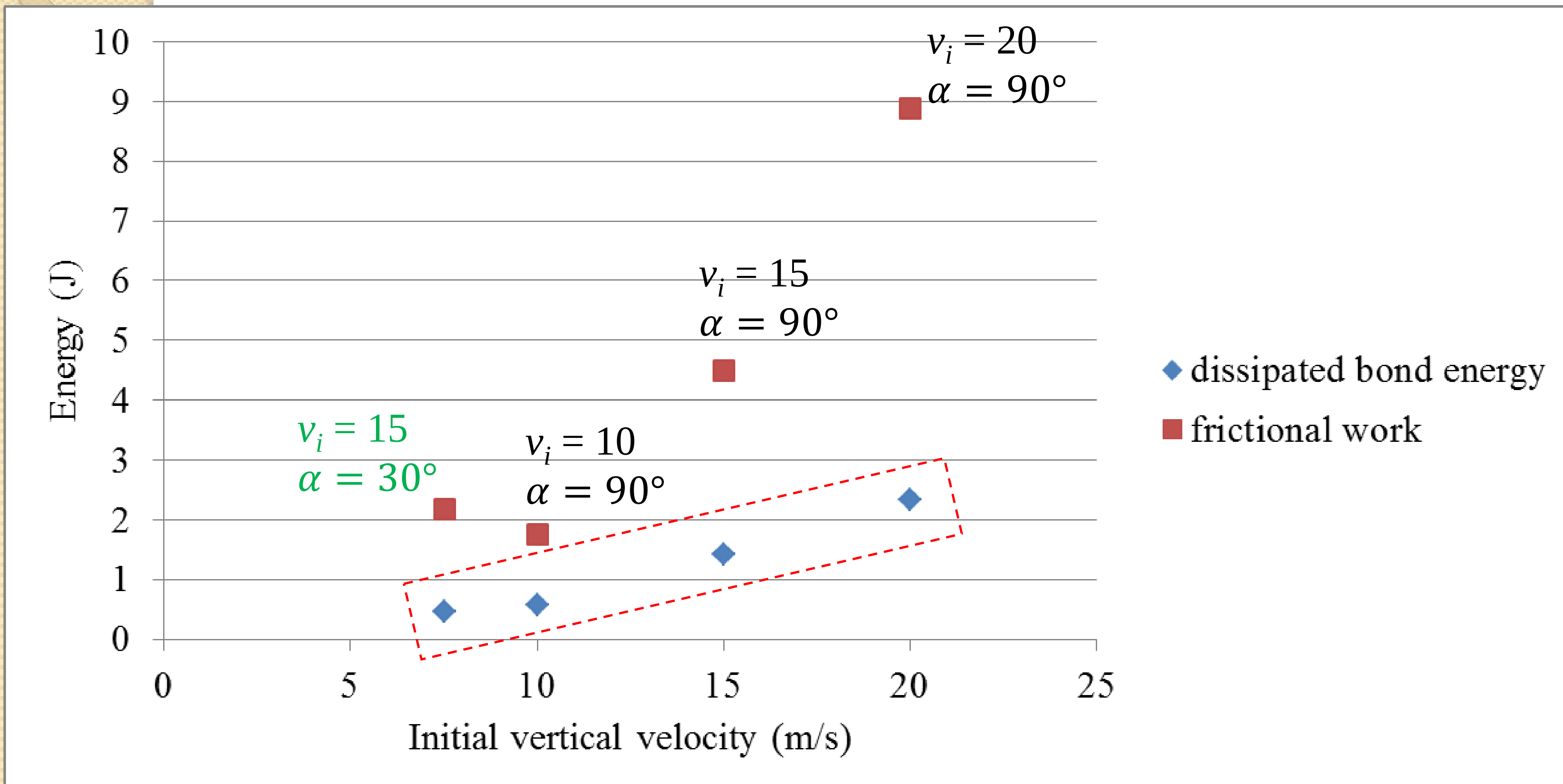
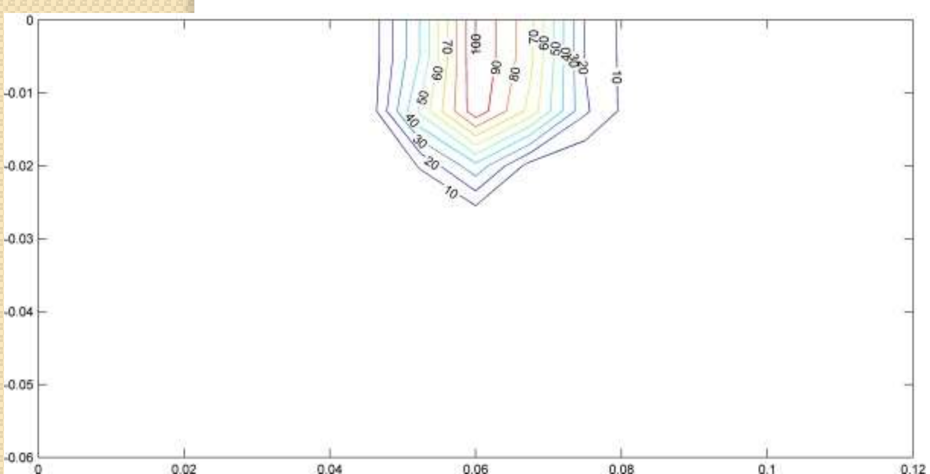


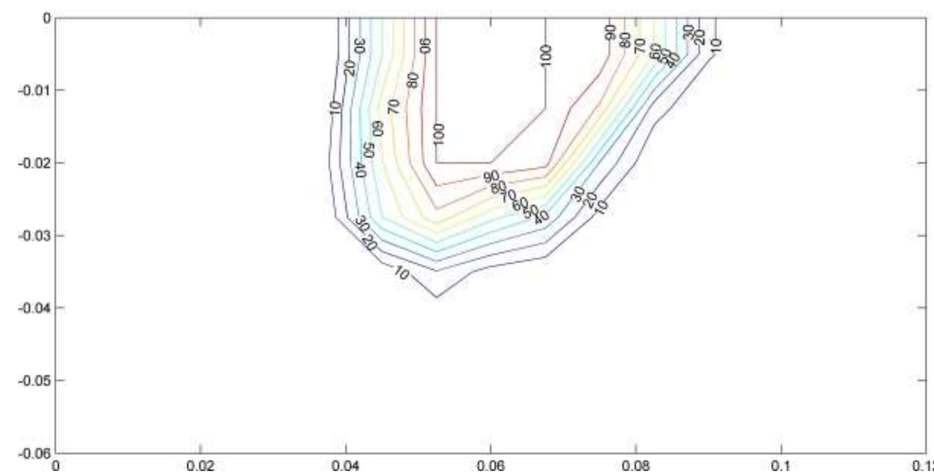
Figure 3: Impact velocity versus dissipated bond energy and frictional work.

Contours of bond-failure percentage ($\alpha = 90°$)

- 100%: fully damage
  - eroded
- <100%: partially broken region
  - weaken



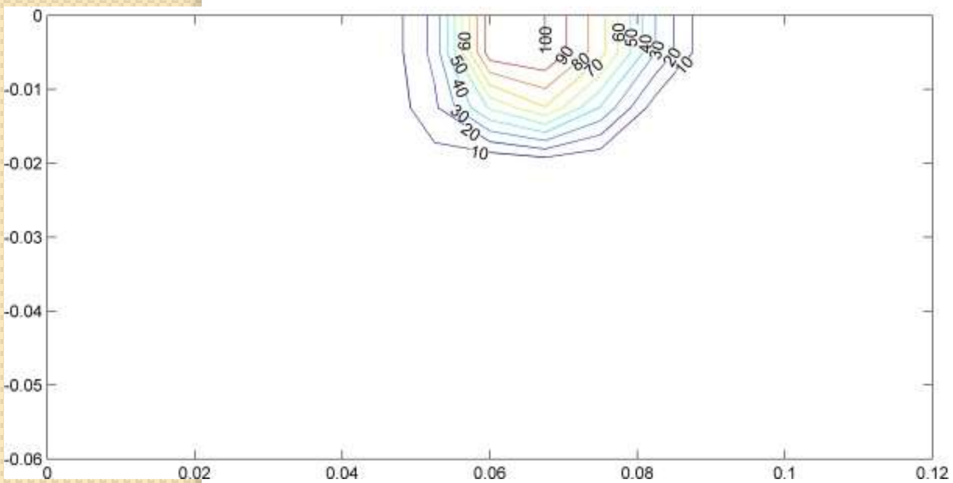
V_i = 10 m/s



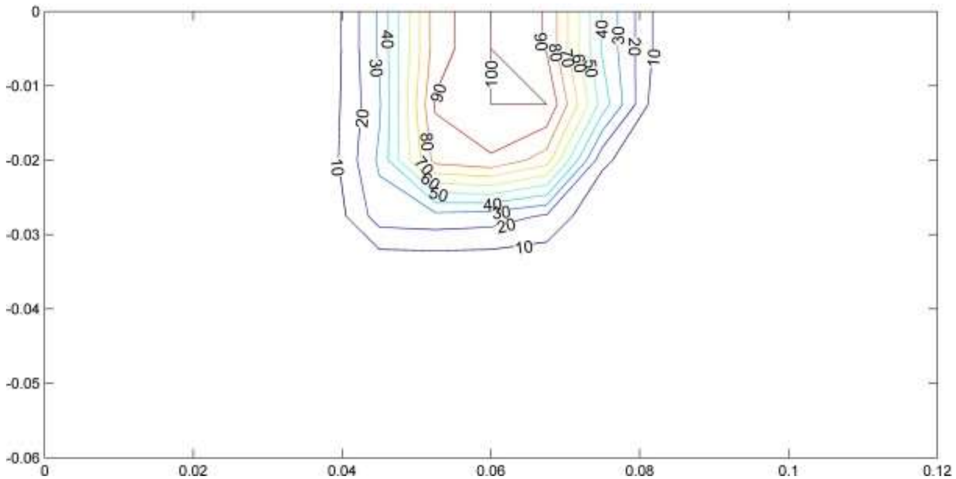
V_i = 20 m/s

Contours of bond-failure percentage (V_i = 10 m/s)

- The density of dissipated bond energy is higher for the case of 90° than 30°



$\alpha = 30°$



$\alpha = 90°$

Conclusion

- The numerical simulations show that the **magnitude of kinetic energy** and the **impact direction** significantly affect the magnitude and type of energy dissipation.

- The **bonding failure percentage** has a good correlation with the impact kinetic energy associated with the **normal component of impact velocity.**

- The **dissipated energy density** seems to be a good index for the accumulated internal damage of rock material.

Thank you for your attention