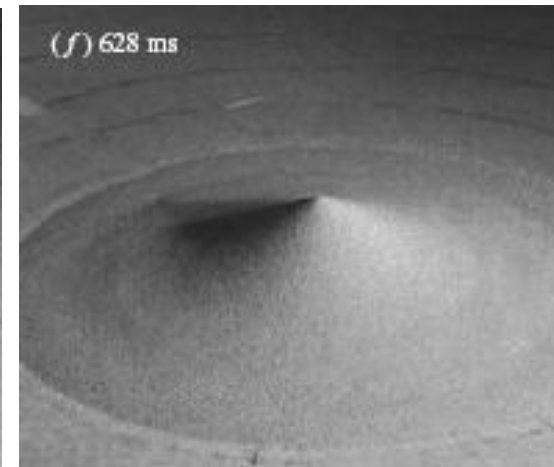
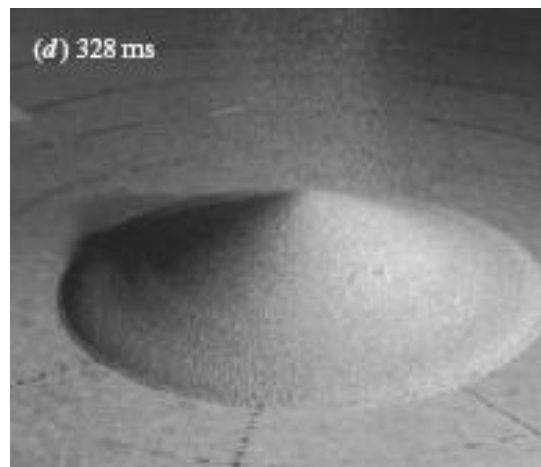
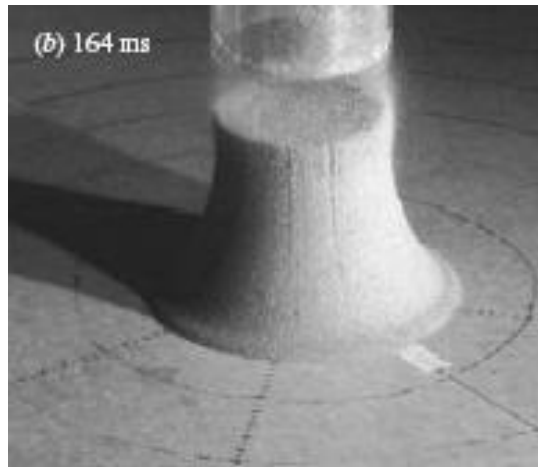

How not to build a sandcastle



C. J. CAWTHORN

Department of Applied Mathematics *and Theoretical Physics*

The only equation in this talk

$$1 + 1 = 2$$

It's not just about sandcastles!



Avalanche at Liberty Wall, WA, and pyroclastic flow at Mt. St. Helens

Applications

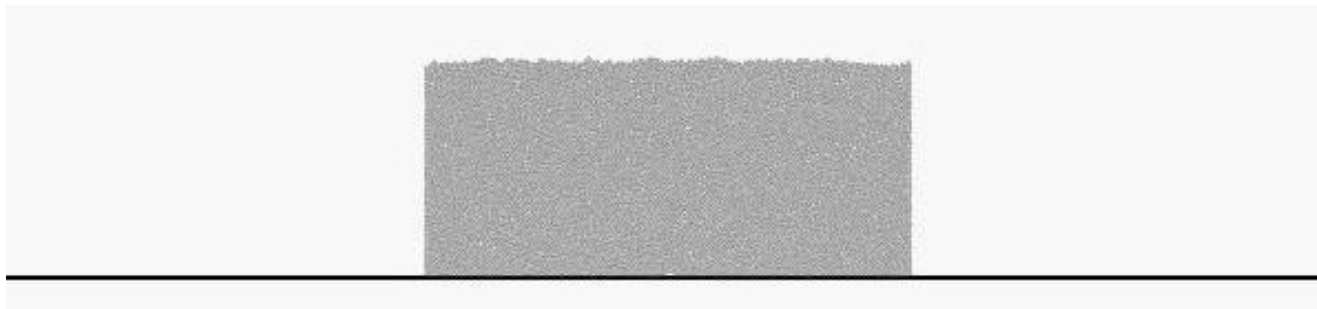
- Geophysical hazards (the cool stuff!)
 - Avalanches
 - Pyroclastic flows
 - Rockslides
- Industrial processes (the profitable stuff!)
 - Grain silos
 - Powder manufacture

The applied mathematician's toolkit

- Direct numerical simulations
- Continuum theories
- Experiments

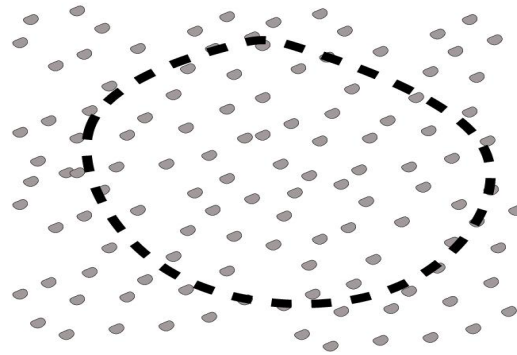
Direct numerical simulations

- Conceptually straightforward
- Newton's laws applied to every grain
- Computationally very difficult and costly
- Limited to 2D



Simulation by L. Staron, DAMTP.

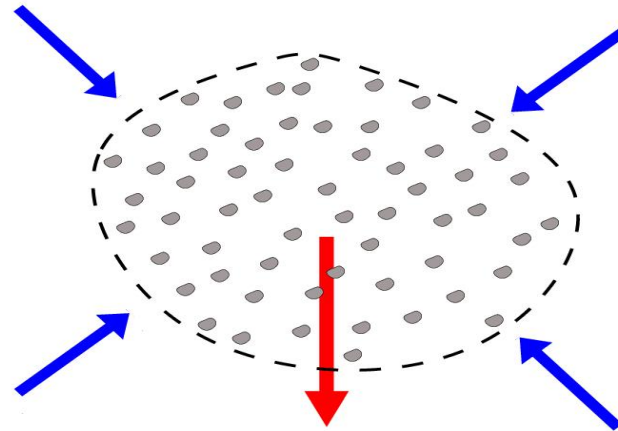
Continuum mechanics 101 (I)



- Forget about individual particles!
- Consider averages over groups of particles
- Fine for fluids, but for grains...?

Continuum mechanics 101 (II)

- Conservation of mass
- Conservation of momentum
 - Body forces (e.g. gravity)
 - Surface forces (e.g. pressure, drag)
- *Navier-Stokes equations for Newtonian fluids*



A zoo of fluids

- Newtonian fluids
 - Water, air, honey, syrup, ...
- *Non-Newtonian fluids*
 - Shampoo (polymers), corn flour, lava, oil, ...
grains?
- Differ only by internal forces

Grains vs. Fluids

- Internal forces unknown for granular materials.
- The “*Janssen effect*” in vertical containers
 - Fluids must support their own weight
 - Grains can be supported by friction on the walls
- Effect of air, moisture, packing, ...

Moral

Theory is difficult, but very
interesting!

Experiments

- Good for verifying theoretical results
- Good for building intuition
 - Identify key properties
 - Make reasonable assumptions
- Frustratingly difficult with grains!
 - MANY key properties
 - Opaque material

What do you get if you cross
320,000 ping-pong balls
with a ski slope?



How not to build a sandcastle

LeckSoc Talk - 30 January 2007

So, in conclusion...

- Numerical simulation - *Difficult*
- Continuum theory - *Difficult*
- Experiments - *Difficult*

- Why am I doing this...?

How not to build avalanche defences



Picture from Hákonardóttir et al.

Thank you for listening!

For more details, try:

- The Ping-Pong Avalanche -
Google for “Ping-pong avalanche”
- <http://www.damtp.cam.ac.uk/user/cjc77>