

Demonstrating granular flow characteristics easily using LEGO bricks

Thomas Heinze

Ruhr University Bochum, Institute of Geology, Mineralogy and Geophysics, Applied Geology, Bochum, Germany
(thomas.heinze@ruhr-uni-bochum.de)

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Motivation

- Gravitational driven mass flows are serious natural hazards all around the world
- Public awareness and education crucial for hazard mitigation techniques
- Especially in higher education required for civil engineers and geoscientists

Problem

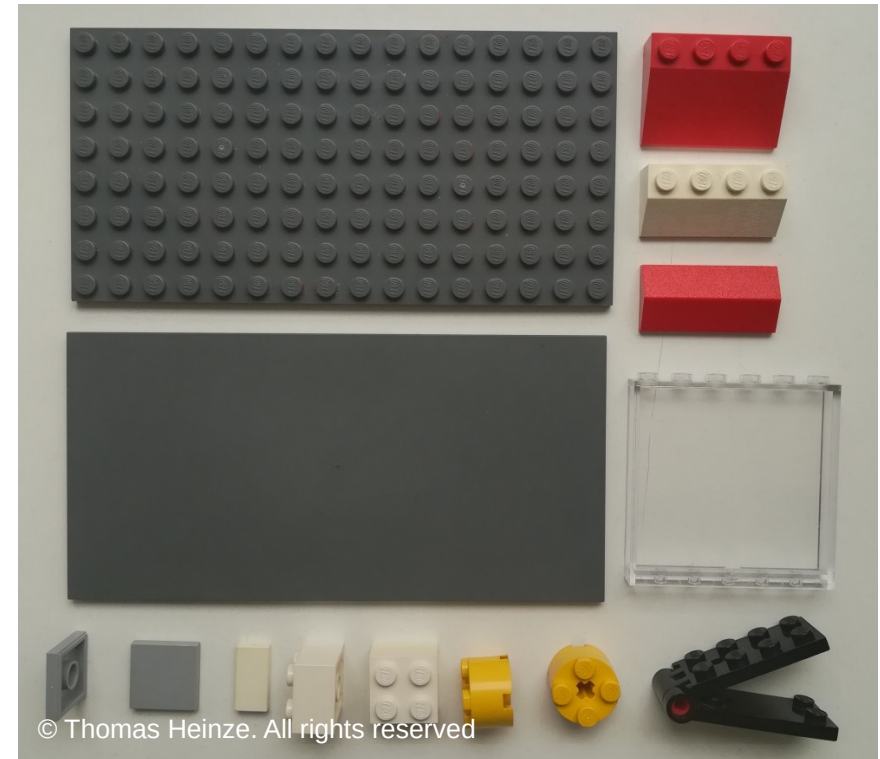
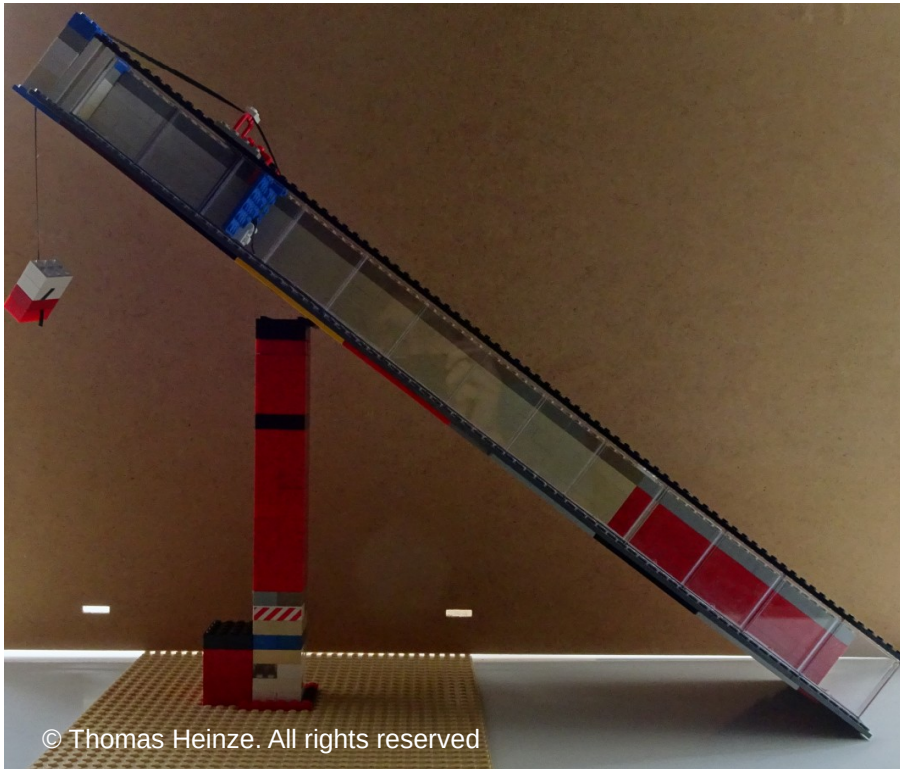
- Mass flows described by complex mathematical equations
- Experimental equipment usually unflexible, expensive or not available in classroom

Aim

- Enable students to do their own experiments
- Introduction into image-based analysis of mass flows (common technique in field application)
- Experiments without oversimplification fulfilling scientific standards
- Allow easy scenario variations

Solution

- LEGO bricks



Benefits

- Usually available in large number already
- A lot of special bricks for various scenarios available
- Well-known to many students already
- Easy to learn system
- unbreakable

Benefits – part 2

- Low costs (< 50€) if you need to buy some at all
- Easy combination with other materials
- washable

Sliding material



Scenario testing I

- Flow down an inclined plane against a fixed wall with variable height
- Study deposition pattern in dependence of wall height
- Comparison with DEM simulation and other lab experiments

This study using LEGO bricks and lenses



Compare to DEM simulation results from: Teufelsbauer, Wang, Chiou, Wu (2009). Flow-obstacle interaction in rapid granular avalanches: DEM simulation and comparison with experiment. *Granular Matter*, 11(4), 209–220. <https://doi.org/10.1007/s10035-009-0142-6>

Scenario testing II

- Flow down an inclined channel against a fixed obstacle
- E.g. compare to:
 - Ng, C. W. W., Choi, C. E., Goodwin, G. R., & Cheung, W. W. (2017). Interaction between dry granular flow and deflectors. *Landslides*, 14(4), 1375–1387. <https://doi.org/10.1007/s10346-016-0794-3>
- Use video footage and particle tracking method to quantify flow velocity, dead zones etc.



a



b



c



d



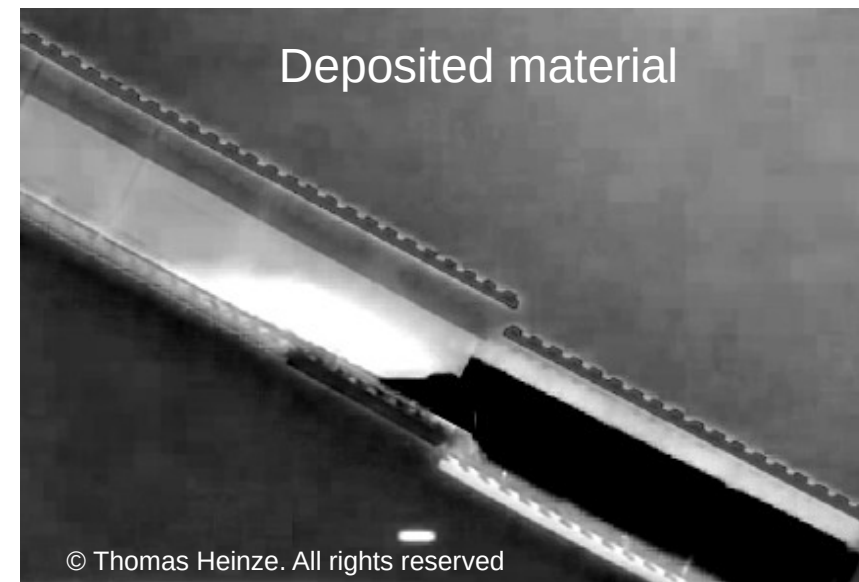
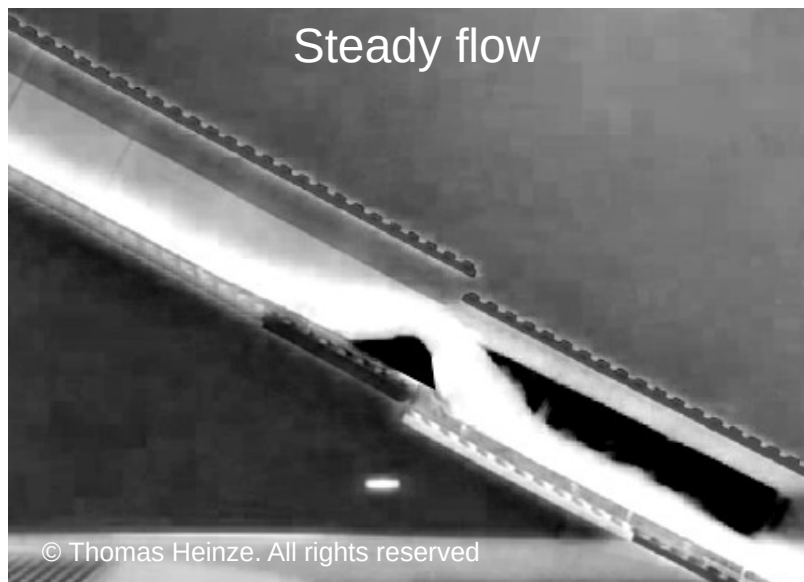
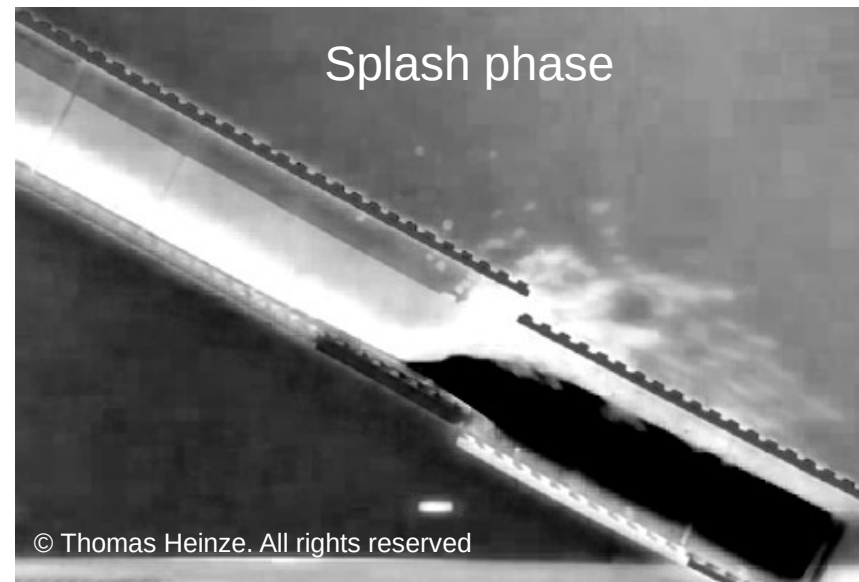
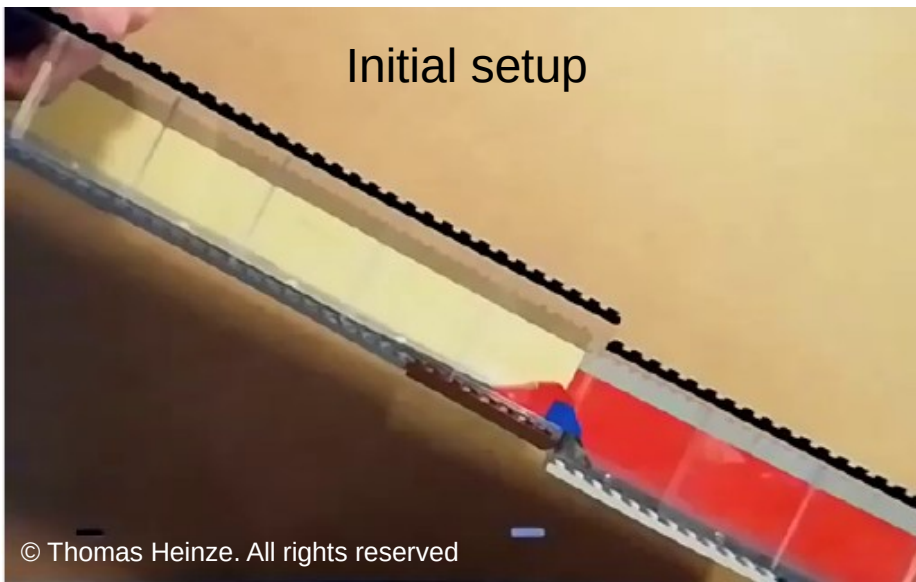
e



f

Scenario testing III

- Flow on a bumpy surface
- E.g. compare to:
 - Viroulet, S., Baker, J. L., Edwards, A. N., Johnson, C. G., Gjaltema, C., Clavel, P., & Gray, J. M. N. T. (2017). Multiple solutions for granular flow over a smooth two-dimensional bump. *Journal of Fluid Mechanics*, 815, 77–116. <https://doi.org/10.1017/jfm.2017.41>



Conclusions

- LEGO bricks allow study of various scenarios in the classroom reproducing recent scientific experiments
- Transparent bricks allow image analysis tools
- Great “fun”-factor for students
 - high motivation level
 - Supports complex mathematical concepts
- Extension towards submarine flow, curved pipes etc possible