SOLID-LIQUID TRANSITION IN FULLY SATURATED GRANULAR MATERIAL

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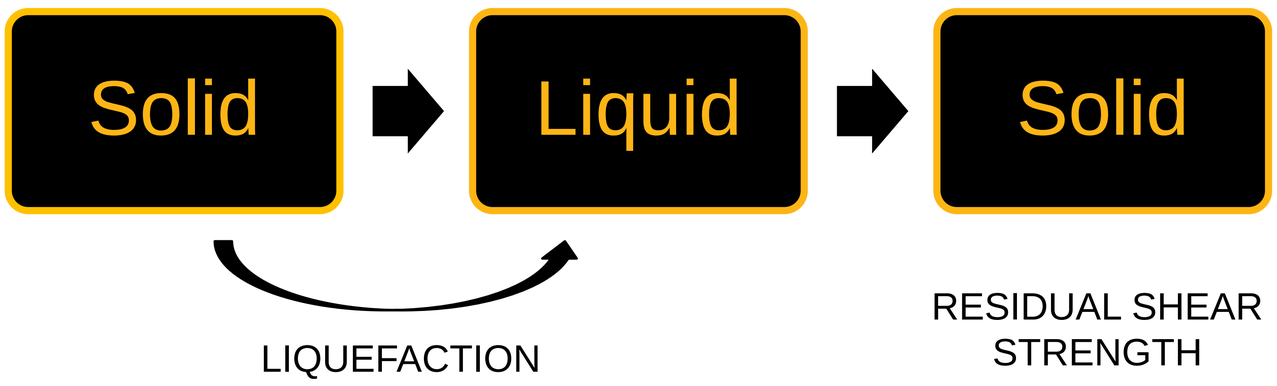
INTRODUCTION

Modeling solid-liquid transition behavior is a challenge. A prime example in geotechnical engineering is liquefaction where a fully saturated granular material (i.e. sand) flow as a liquid. In slope settings, catastrophic flow failure can potentially happen.



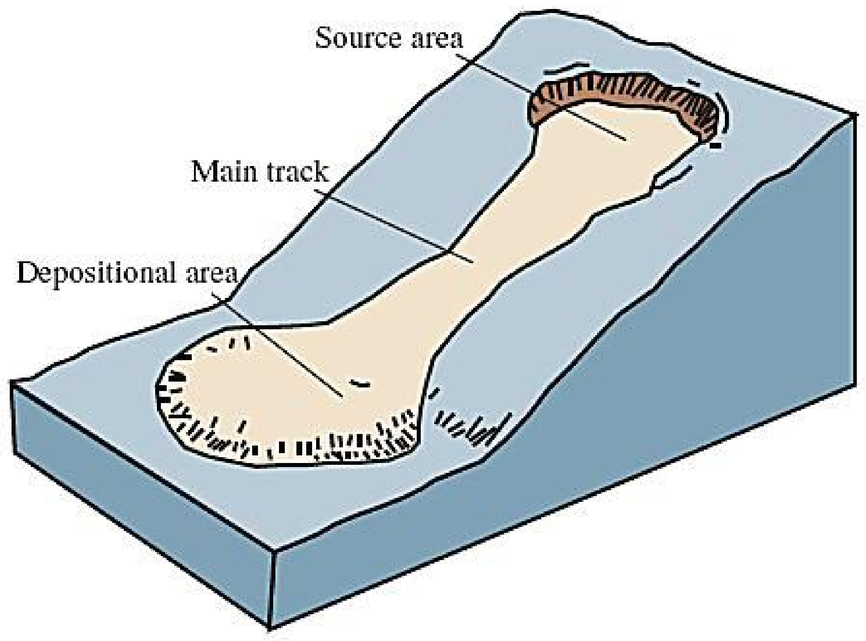


Figure from US Geological Survey (2004)

HOW TO MODEL?

Model as solid?

One way to model liquefaction-induced flow failure is to assume the material as solid. This is well-developed in many other geotechnical applications such as excavation and foundations. However, there are a few shortcomings, including: (1) the flow-like behavior is not captured, (2) finite element and finite difference methods are limited when it comes to large deformation problem like this.

Model as liquid?

Another way is to assume the material as viscous fluid, like using Bingham plastic model. This also has geotechnical applications such as debris flow. However, limitations include (1) the difficulty in predicting flow parameters of liquefied soil, (2) liquid is not stress dependent like solid.

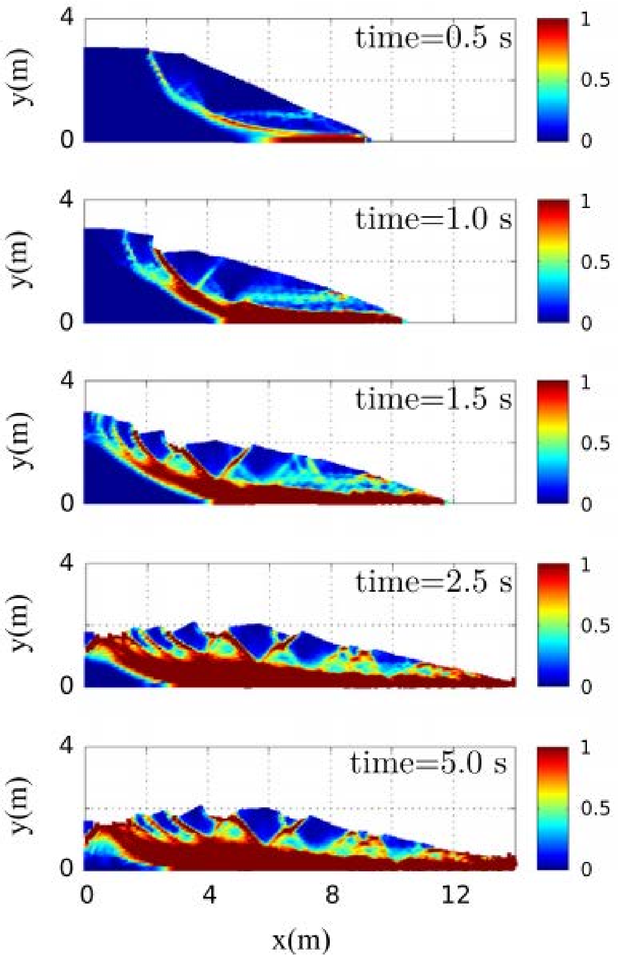
ON-GOING RESEARCH

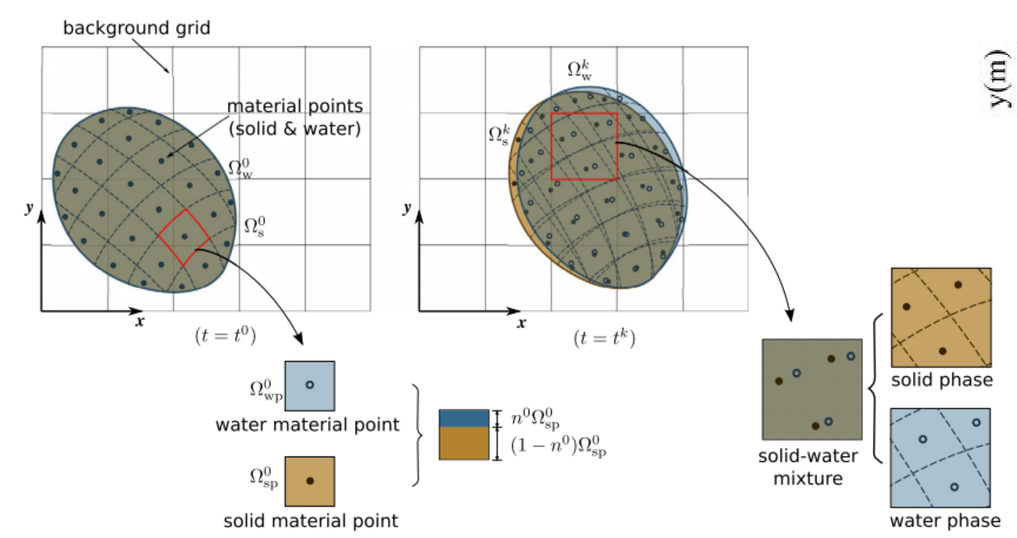
Material Point Method (MPM)

In the MPM, Lagrangian point masses (material points or the soil continuum) are allowed to move through an Eulerian background mesh that does not deform. Thus, it is able to model large deformation problems in geotechnical engineering involving coupling of soil deformation and pore water pressures like liquefaction-induced flow failure.

Research Plan

- Calibration of MPM to flow failure case studies
- Modeling of liquefaction-induced flow failure using MPM
- Potential combination of cyclic constitutive model to predict liquefaction triggering, and the flow behavior post-liquefaction





Contour in figure above is deviatoric shear strain variation
Figures are from Bandara and Soga (2015)

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