

More Accurate Modelling of Earthquake-induced Liquefaction

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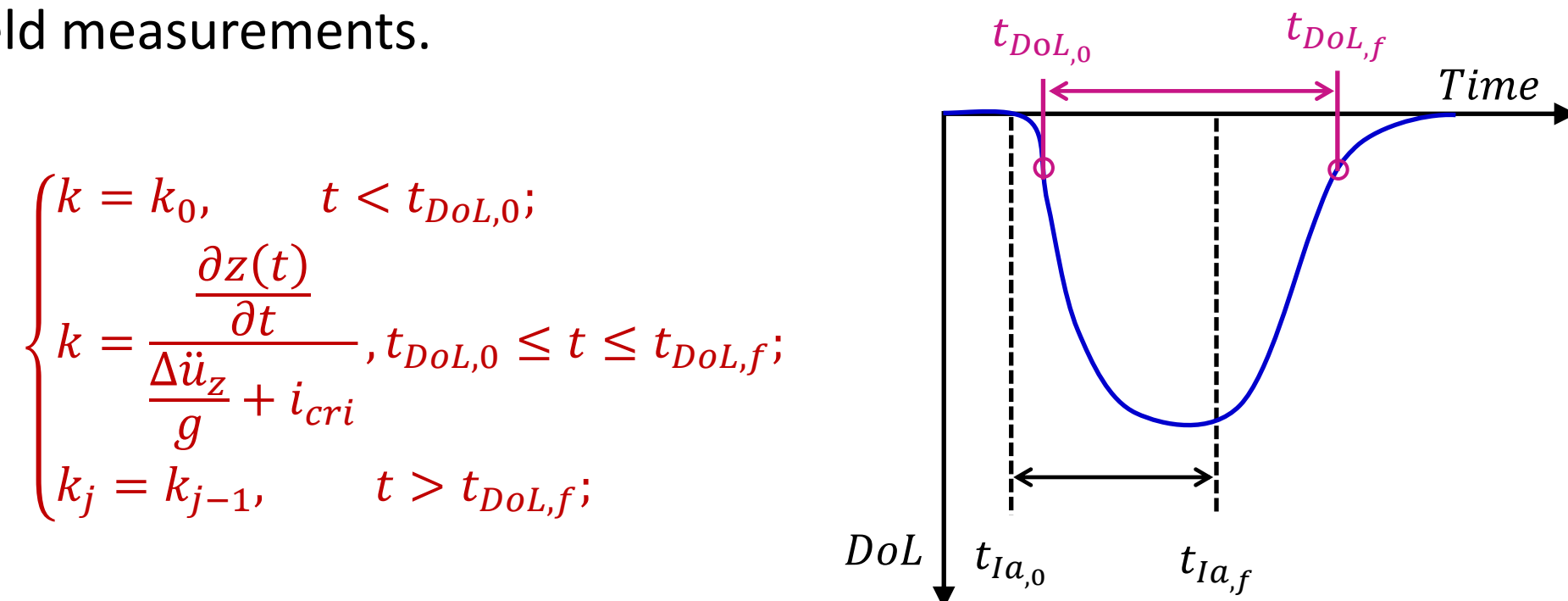
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Why does permeability matter in liquefaction?

Earthquake-induced liquefaction is a complex phenomenon associated with substantial settlements due to the loss of soil shear strength. One of the major challenges in numerically modelling liquefaction is the underprediction of the ground settlement induced by seismically induced liquefaction, primarily due to complexities of soil consolidation and the evolution of soil hydraulic conductivity (permeability) under seismic loading. Accurate modelling of the soil response during liquefaction requires a thorough understanding of the evolution of hydraulic conditions in addition to an appropriate constitutive model (stiffness) for the dynamic response of saturated soils, as these two factors are inherently coupled. This project aims to enhance the accuracy of earthquake-induced liquefaction modelling by developing advanced constitutive models and hydraulic flow models.

A new approach to back-analysing permeability

A novel and comprehensive back-analysis methodology has been developed based on the fully coupled u-p formulation, allowing the direct estimation of the variable hydraulic conductivity of a soil deposit during liquefaction based on settlements recorded from centrifuge data or field measurements.



Variable permeability during liquefaction

Employing experimental data from eight different dynamic centrifuge tests, the back-calculated evolution of permeability reveals that permeability increases rapidly during seismic shaking but declines even as liquefaction persists.

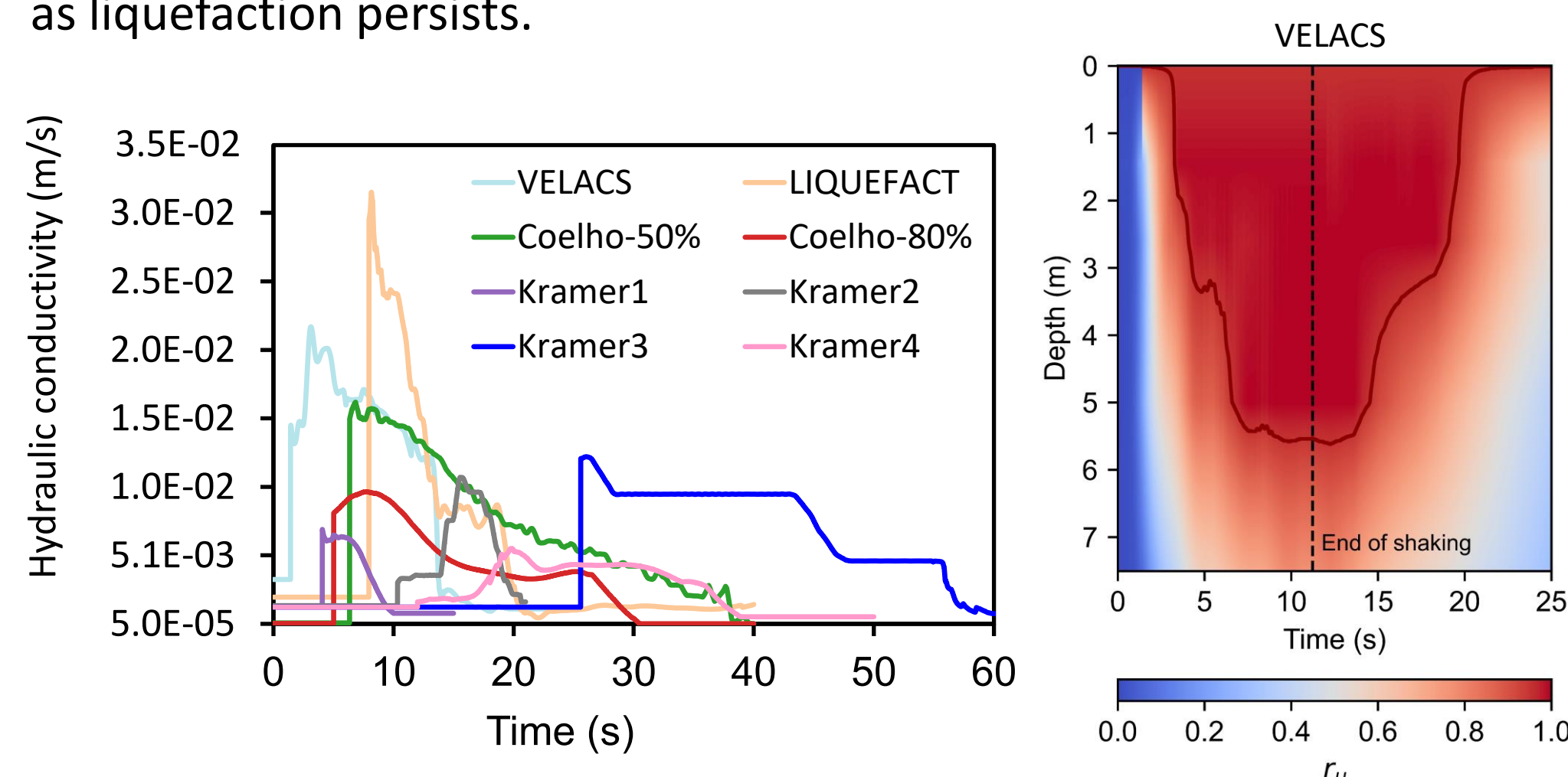


Fig. 2. Variable permeability of eight centrifuge tests Fig.3 Excess pore pressure distribution

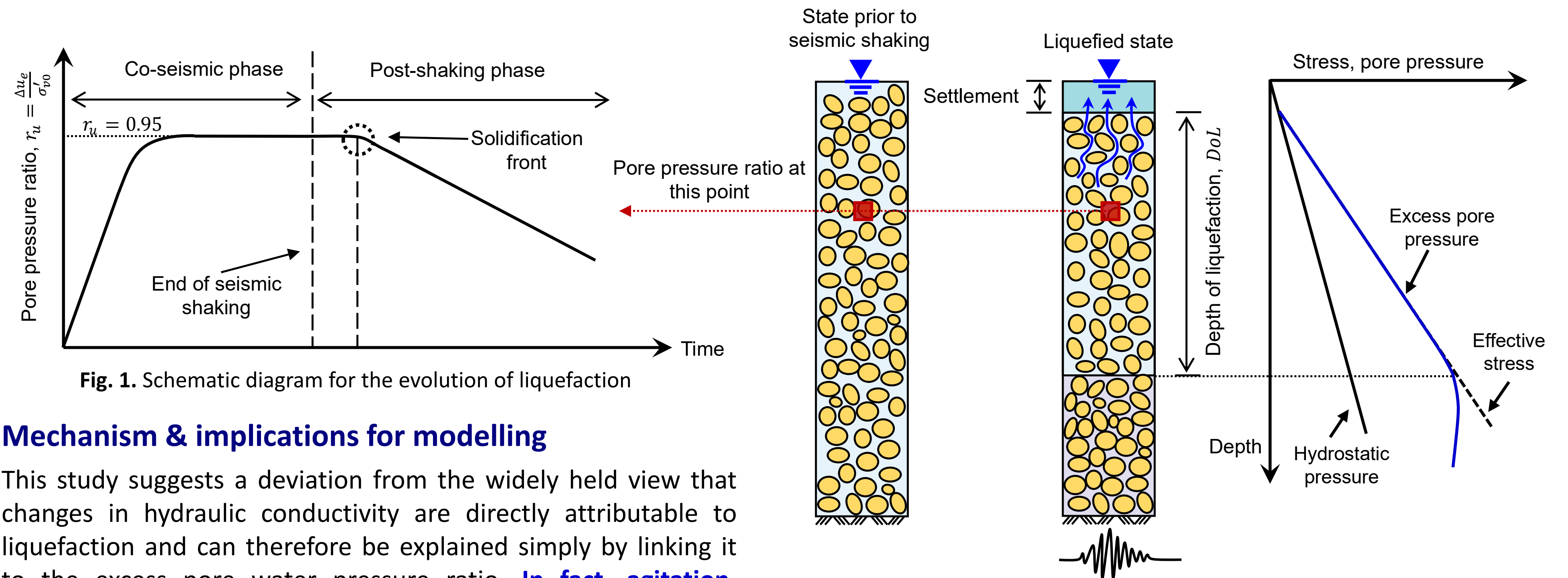
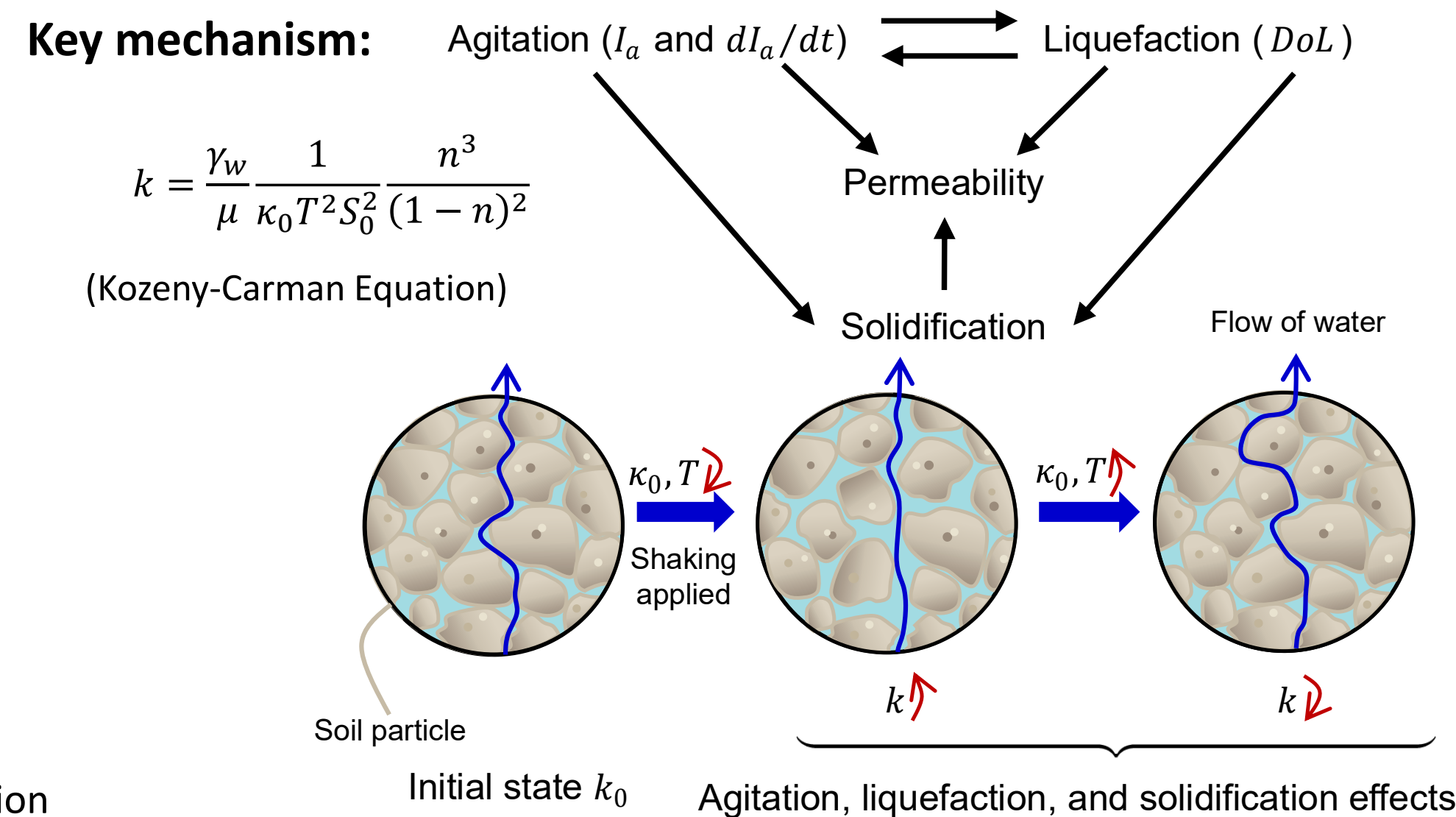


Fig. 1. Schematic diagram for the evolution of liquefaction

Mechanism & implications for modelling

This study suggests a deviation from the widely held view that changes in hydraulic conductivity are directly attributable to liquefaction and can therefore be explained simply by linking it to the excess pore water pressure ratio. **In fact, agitation, liquefaction, and solidification effects govern permeability variations during liquefaction.**



Redefining the modelling of liquefaction

- This methodology enables the direct calculation of the **time-varying permeability** of saturated soils using only centrifuge or field settlement data, capable of capturing both co-seismic and post-shaking phases.
- The findings introduce a practical, physics-based way to model **realistic permeability evolution** during liquefaction. This supports the development of more accurate variable permeability models for liquefaction simulations in engineering applications.

Scan to visualise changes in permeability during level-ground liquefaction →

