Research Project Highlight

Meshfree Large-Strain Framework for Seismic Response of Ground-Structural Systems: Development and Open Source Tool

TSRP Topic – PBE Tools – T2

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Abstract
An effort is proposed to bring the capabilities and advantages of the meshfree method within a dedicated open source framework for use in earthquake engineering applications. Meshfree method, such as the Reproducing Kernel Particle Method (RKPM), is a class of numerical methods designed to inherit the main advantages of the Finite Element Method (FEM), while at the same time overcoming the main disadvantages caused by mesh dependency. As such, RKPM allows for capabilities such as large deformations, high gradients and strain localization, crack propagation, and multi-scale strain localization phenomena, all being mechanisms of much relevance to PBEE assessment frameworks under conditions of strong excitation. As the main deliverable, an open source MATLAB-based RKPM code will be provided, with the extended capabilities of dynamic (seismic) analysis, large-strain formulation, and components of the OpenSees geotechnical seismic soil modeling capabilities.

Deliverables
The main deliverables include:
i) An open-source RKPM 2D MATLAB-based large-strain computational tool for conducting nonlinear 2D static/dynamic analyses for geotechnical and Soil-Foundation-Structure-Interaction (SFSI) earthquake engineering applications.
ii) A series of representative simulations for geotechnical systems such as SFSI and Earthdam applications. In these simulations, emphasis will be placed on effects of the implemented geometric and material nonlinearities with reference to observations from reconnaissance case histories and experimental physical model response.
iii) A user manual, and a Workshop for interested users to exercise the analysis tool and to further adapt its modules for their own applications of interest.

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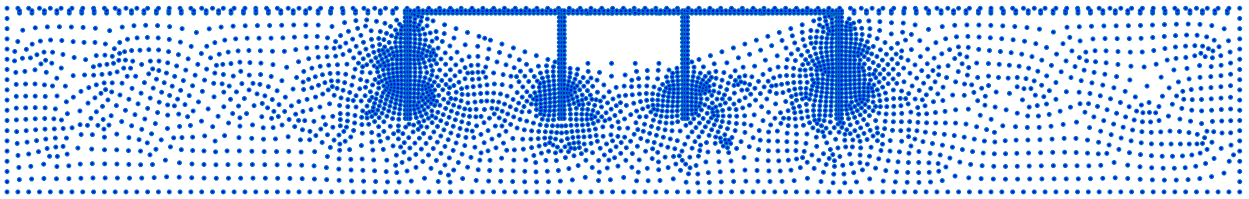
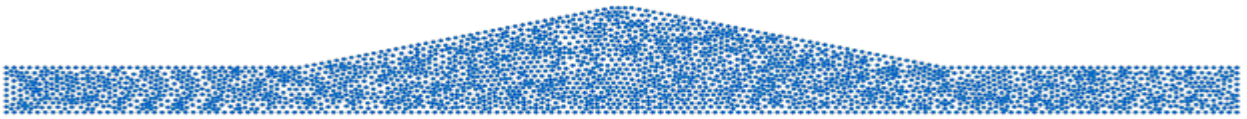
Research Impact

A wide range of practical applications will benefit greatly from this initial effort and potential future developments. The meshfree RKPM approach widens the user-base and horizon of applications for large-displacement and/or large-strain seismic response. Facilitated by the RKPM large-displacement and deformation response characteristics, more accurate consequences of strong shaking are paramount for performance-based engineering (PBE) assessments.

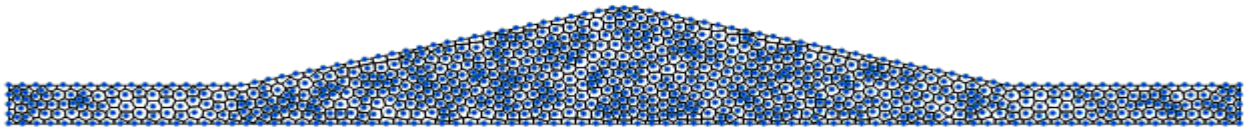
Project Image



(a) Bridge-Foundation-Ground Configuration by RKPM discretization



(b) Earthdam Configuration by RKPM discretization



(c) Earthdam Configuration (Voronoi cell diagram)

RKPM representations of Soil and Soil structure Systems

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