Impact of Earthquakes on Geotechnical Barriers

Christian Müller & Philipp Herold
BGE TECHNOLOGY GmbH, Research and Development, christian.mueller@bge.de

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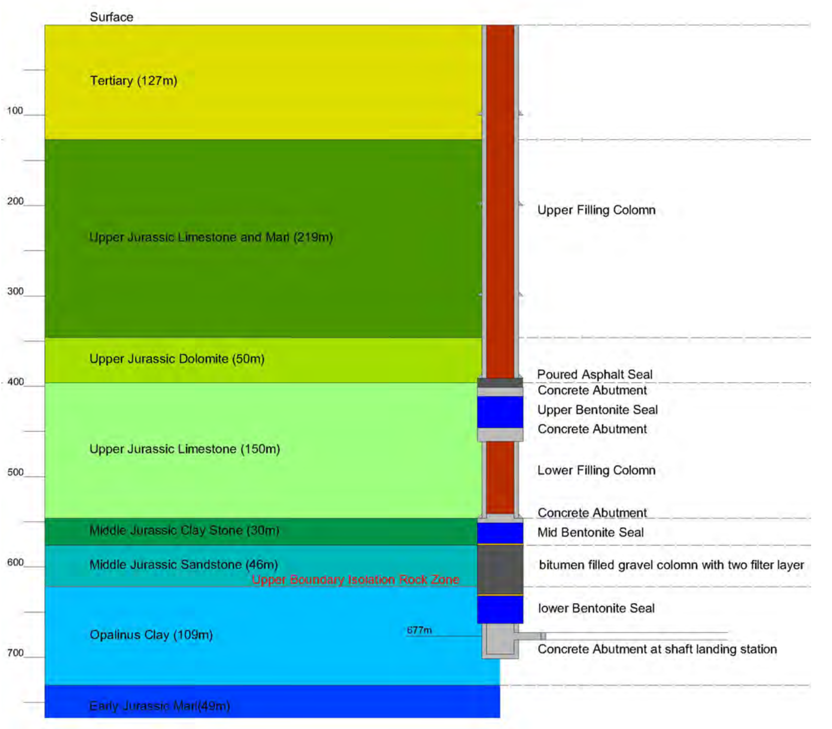
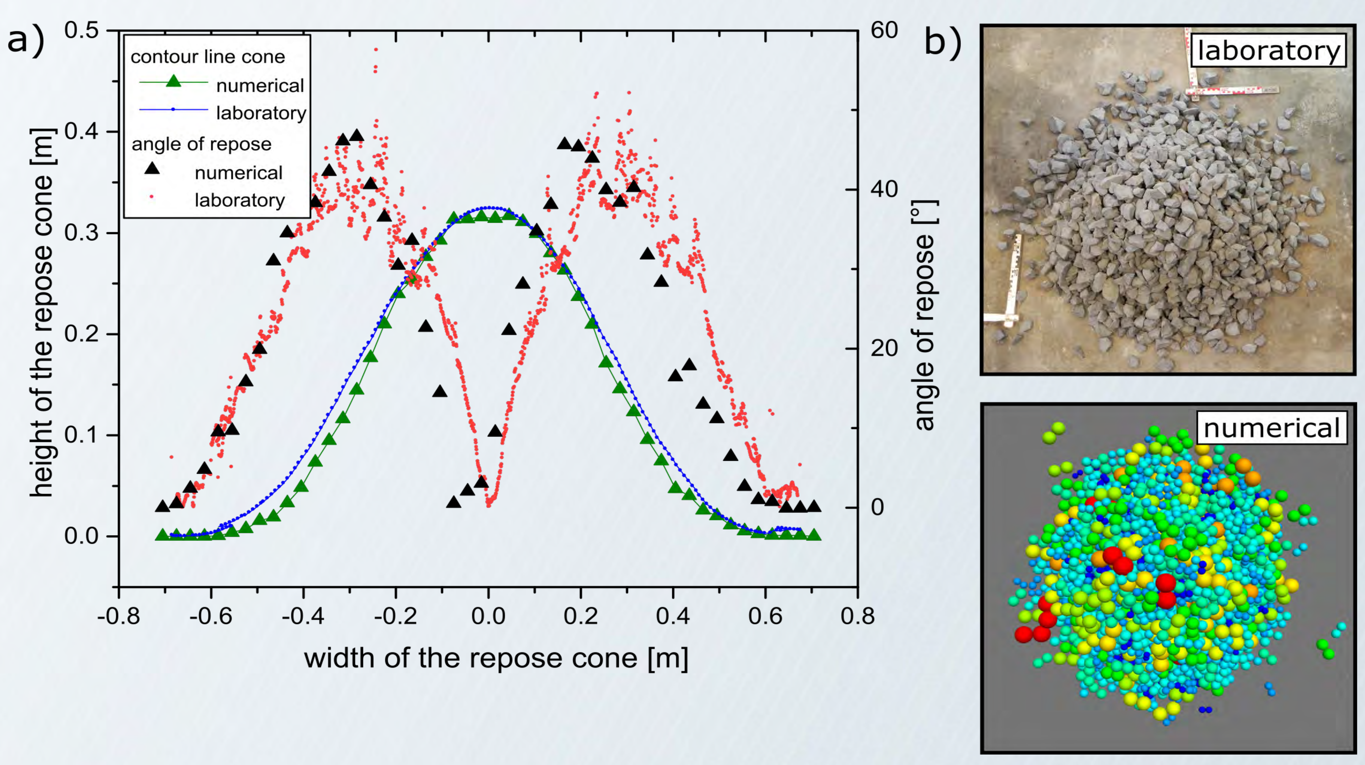
I Introduction

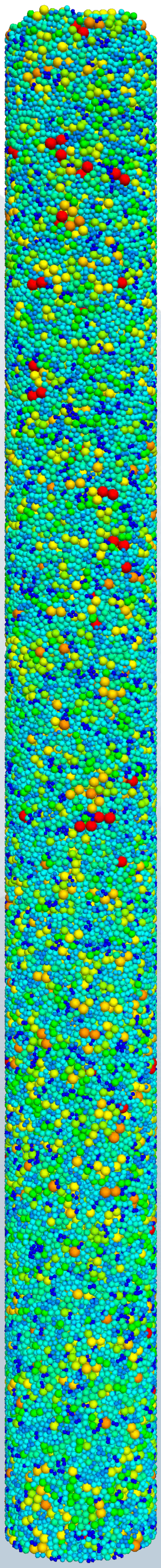


To prevent the penetration of fluid into an emplacement area in an underground repository, the integrity of the geotechnical barriers under different safety-relevant scenarios, e.g. impact of an earthquake, needs to be considered. Gravel is to be implemented in several sections of the shaft sealing elements to act both as porous reservoir and as abutment for sealing elements installed on top of it. The objective (as part of the project ELSA, FKZ02E11193) is to determine to what extent the settling of a gravel column due to an earthquake can be estimated by means of numerical modelling.

II Model Generation and Calibration

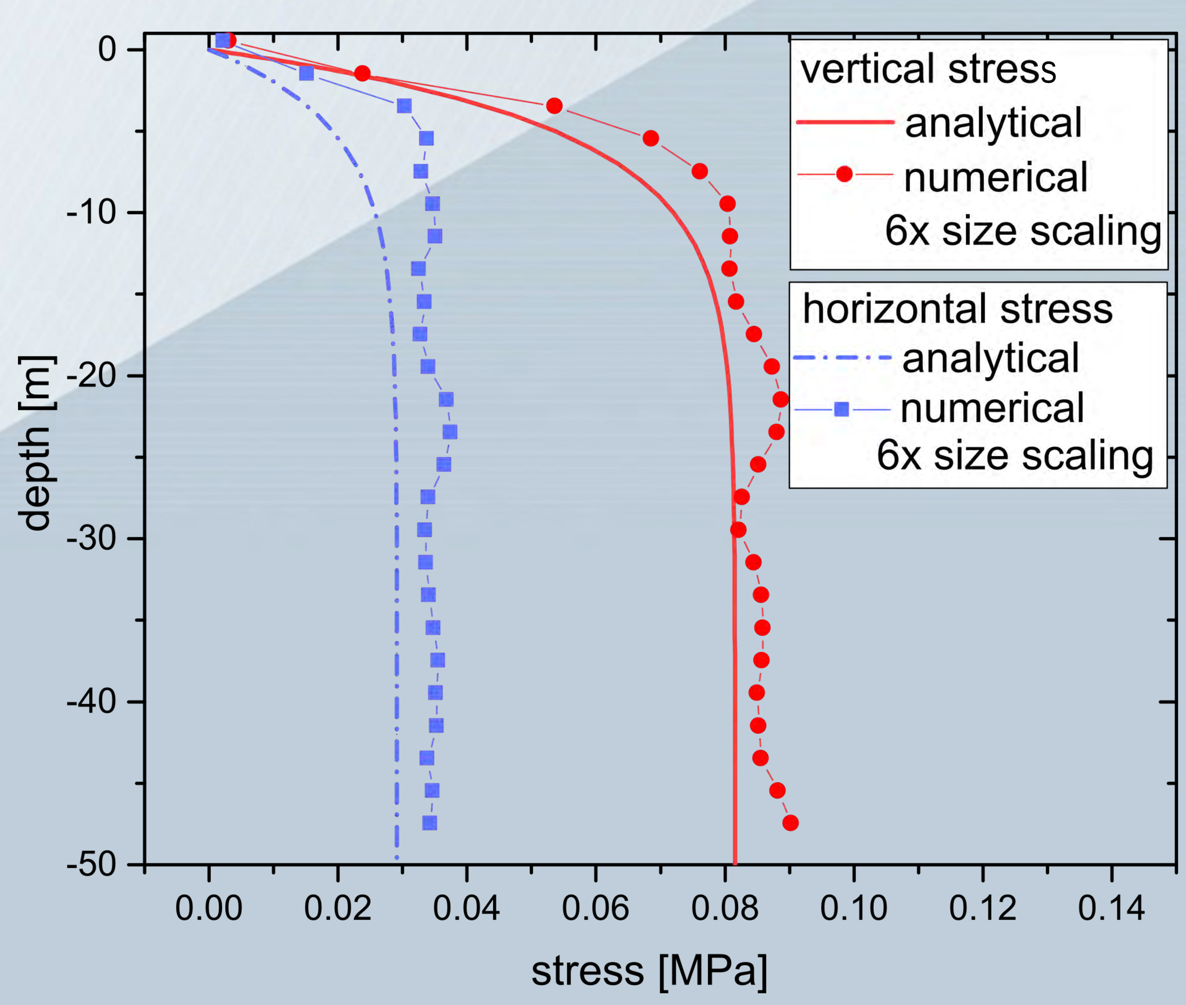
To realistically simulate the mechanical properties of gravel particles, the general purpose DEM framework PFC3D was used. Representative particle samples of different sizes were generated based on a grain size distribution of track ballast. Each particle consists of two spheres of the same size, and a linear contact model simulates the friction and displacement behaviour. Calibration tests (e.g. repose tests) were carried out to determine the relevant input parameters of the constitutive model.





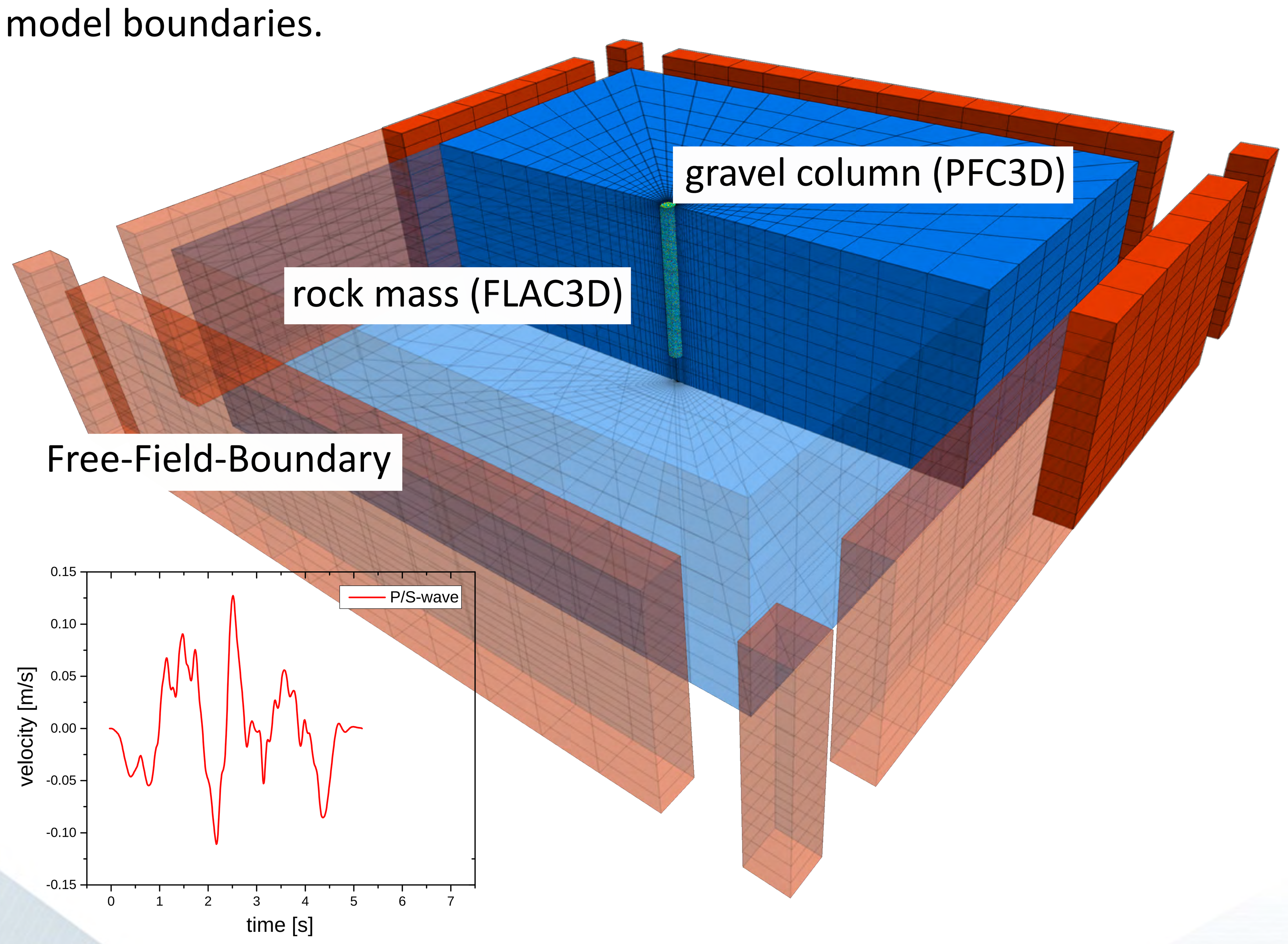
III Validation

The validation of the particle model was done by simulating the gravitational settling behaviour and the silo effect of a 50-meter-high gravel column and comparing it with the analytical solution. The results showed that the processes that are responsible for the silo effect are simulated realistically. The charactersitic stress gradient across the height of the column is comparable with the analytical results based on Janssens's equation.

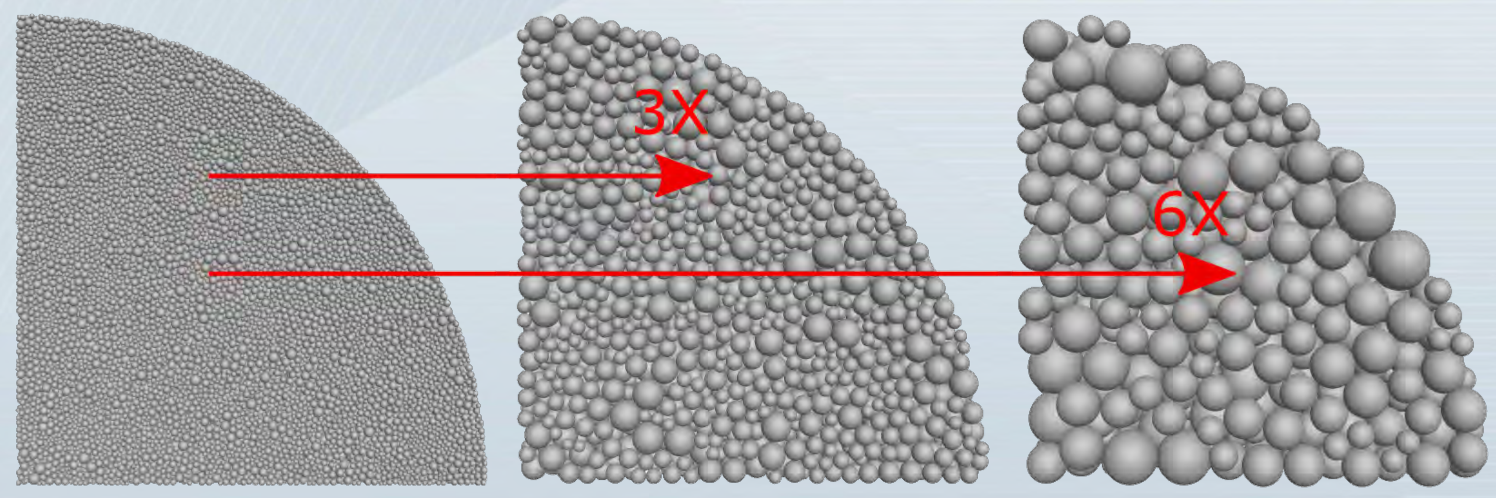


IV Simulation & (First) Results

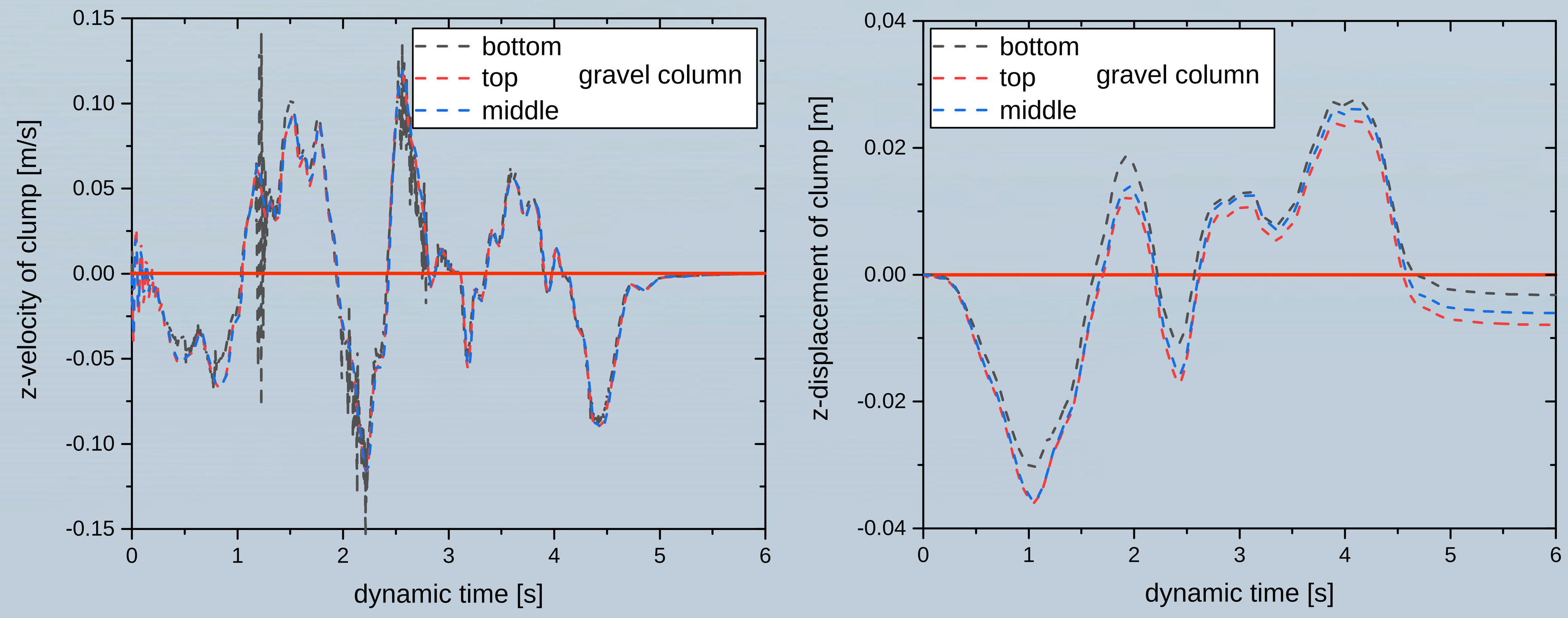
To enable a realistic simulation of the far field during the dynamic calculations, the PFC3D particle code was coupled with the continuum code FLAC3D. FLAC3D simulates the rock mass (200m x 200m x 50m) in which the gravel column is embedded. The seismic load applied at the model boundaries of the FLAC3D model is transferred to the PFC3D gravel column. This approach allows the setting or realistic dynamic boundary conditions (Free-Field-Boundaries) with the aim of absorbing waves at the model boundaries.



To reduce the calculation runtime during the dynamic calculations, it was necessary to decrease the number of particles by using a grain size scaling. Since the size scaling can have an effect on the results, comparative calculations with different scaling factors were carried out. A scaling factor of 6 (127000 particles) was found as a good compromise between calculation runtime and accuracy.



An earthquake impulse with a duration of 5s was generated using seismological parameters recorded from earthquake profiles of northern Germany and applied at the lower boundary of the model by a P-wave and S-wave stimulation. First results show that the earthquake impulse is too low to cause a critical settlement of the gravel column.



Acknowledgements
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