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Innovation and Networking for Fatigue and Reliability Analysis of Structures – Training for Assessment of Risk

From Micro to Macro: a validation of a multiscale coupling FEM-DEM

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Research question

Is the multiscale coupling FEM-DEM [1] applicable to solve common geotechnical problems?

- Validation of the method in term of cyclic and monotonic loadings

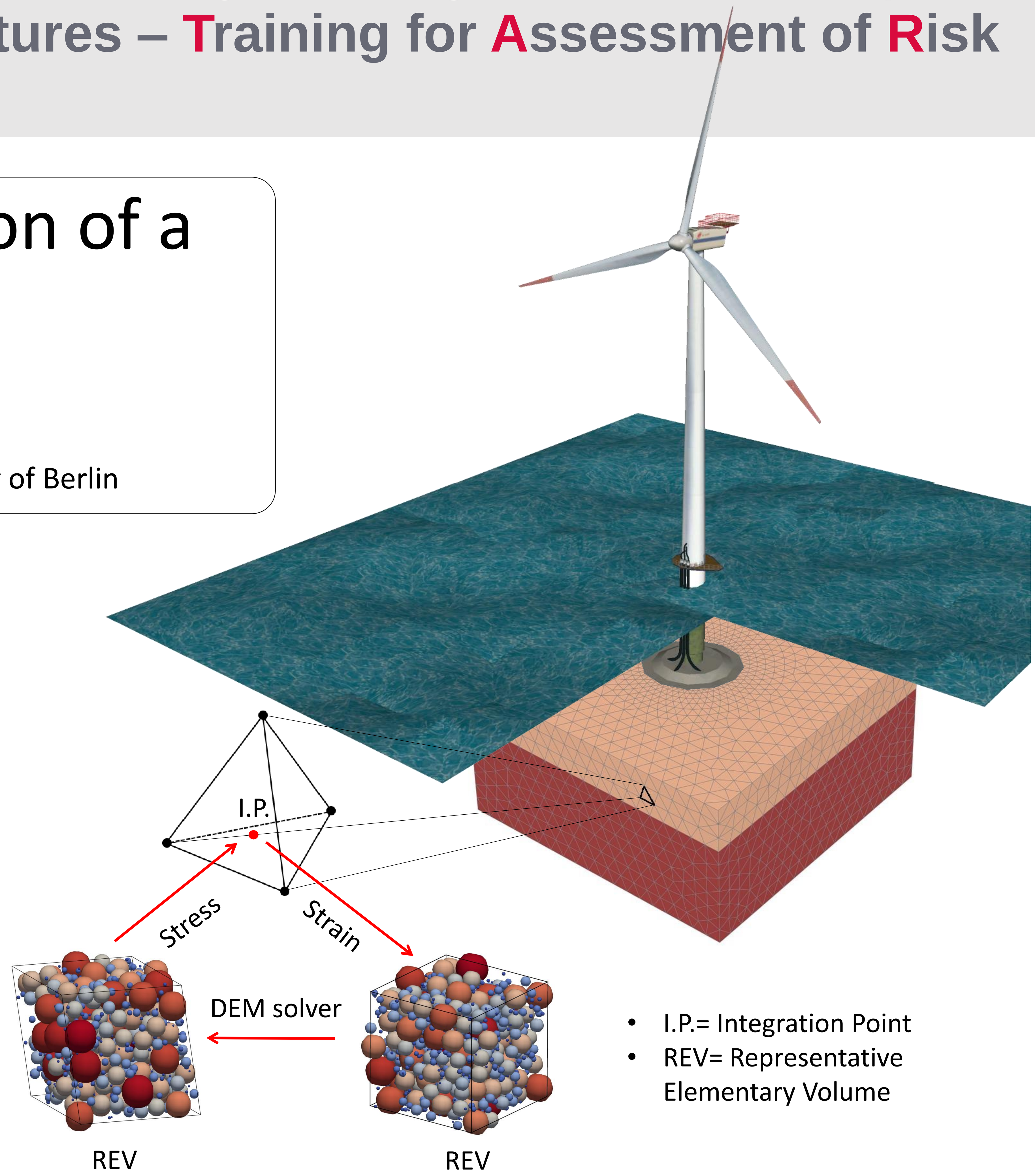
Where to start

Validation with common laboratory tests:

- Triaxial test with glass ballotini
- Triaxial test with Sand

How does the multiscale coupling FEM-DEM work?

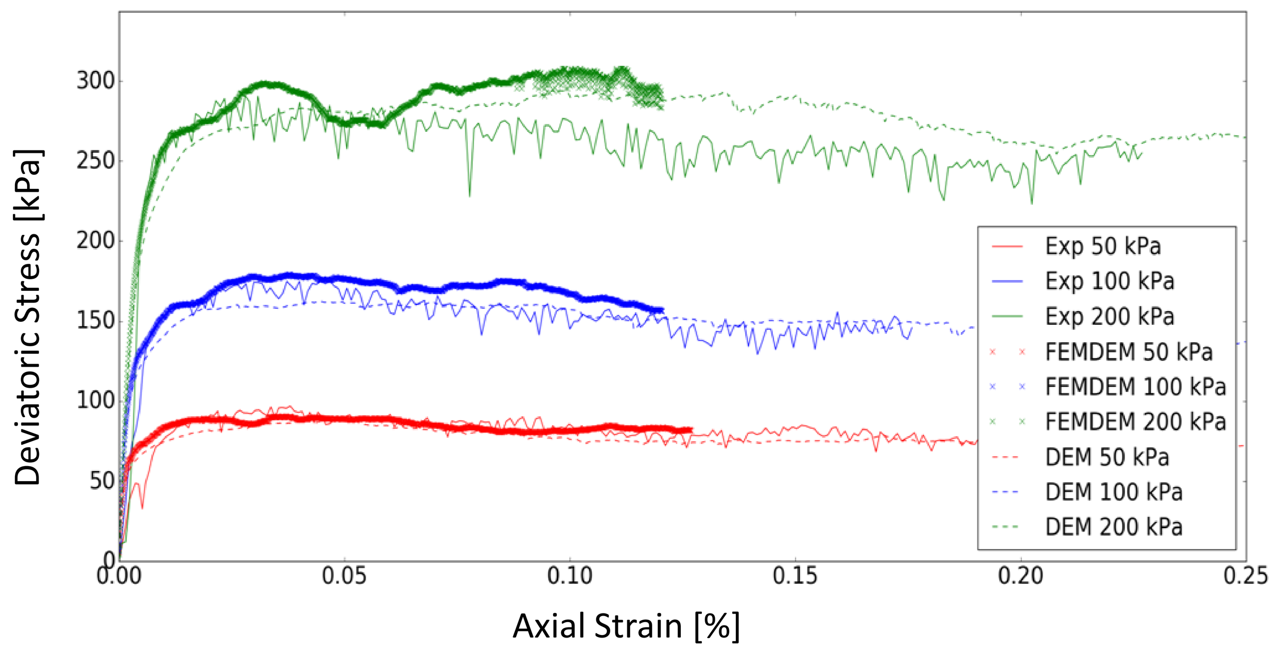
- Finite Element Method (FEM) solves the boundary value problems
- Discrete Element Method (DEM) derives the characteristic macroscopic behaviour of granular materials from the mutual interaction of a representative number of discrete elements.
- The micromechanical parameters in DEM are calibrated with a pure DEM REV on different boundary conditions (confining pressure)

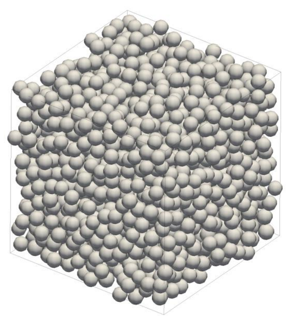


Triaxial Tests validation with Glass Ballotini

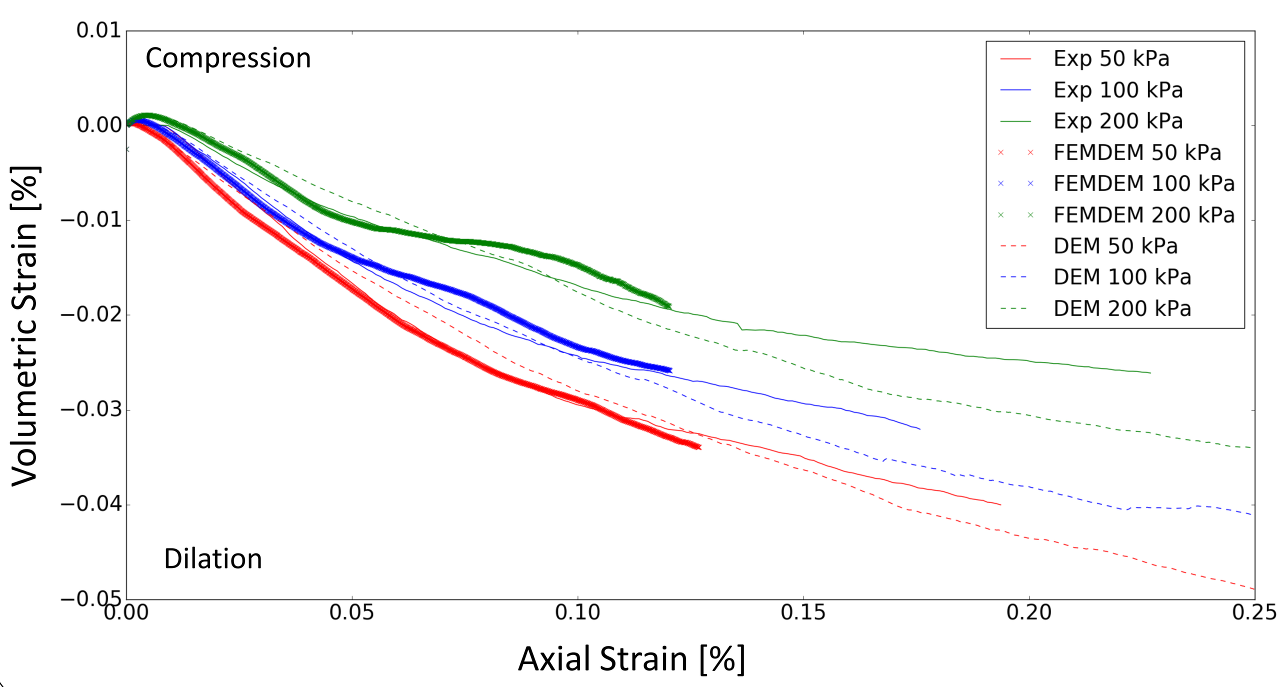
- Glass Ballotini diameters 2 mm
- Porosity of 40%
- Contact constitutive law: classic elastic-plastic with rolling and twisting stiffness

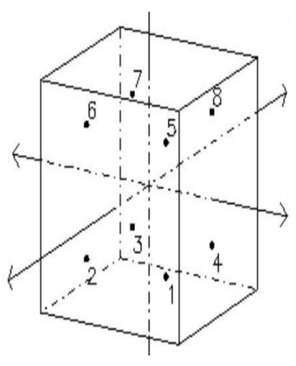
Experimental test 5x5x10 cm [3]





Pure DEM REV
1000 Spheres
1x1x1 cm



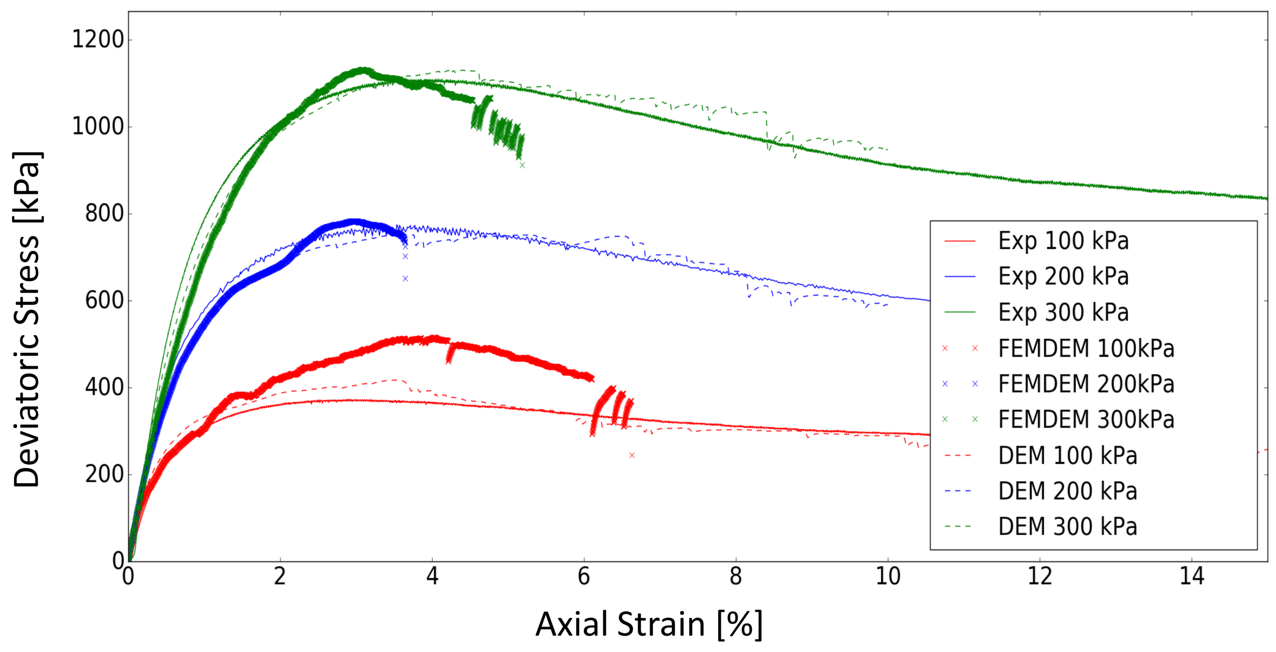


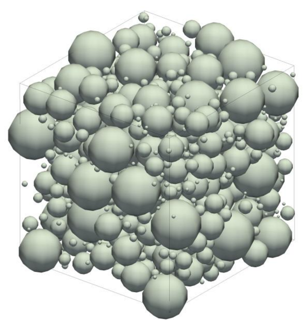
FEMDEM
8 Gauss points
1 Element
5x5x15 cm
500 spheres REV

Triaxial Tests validation with Berliner Sand

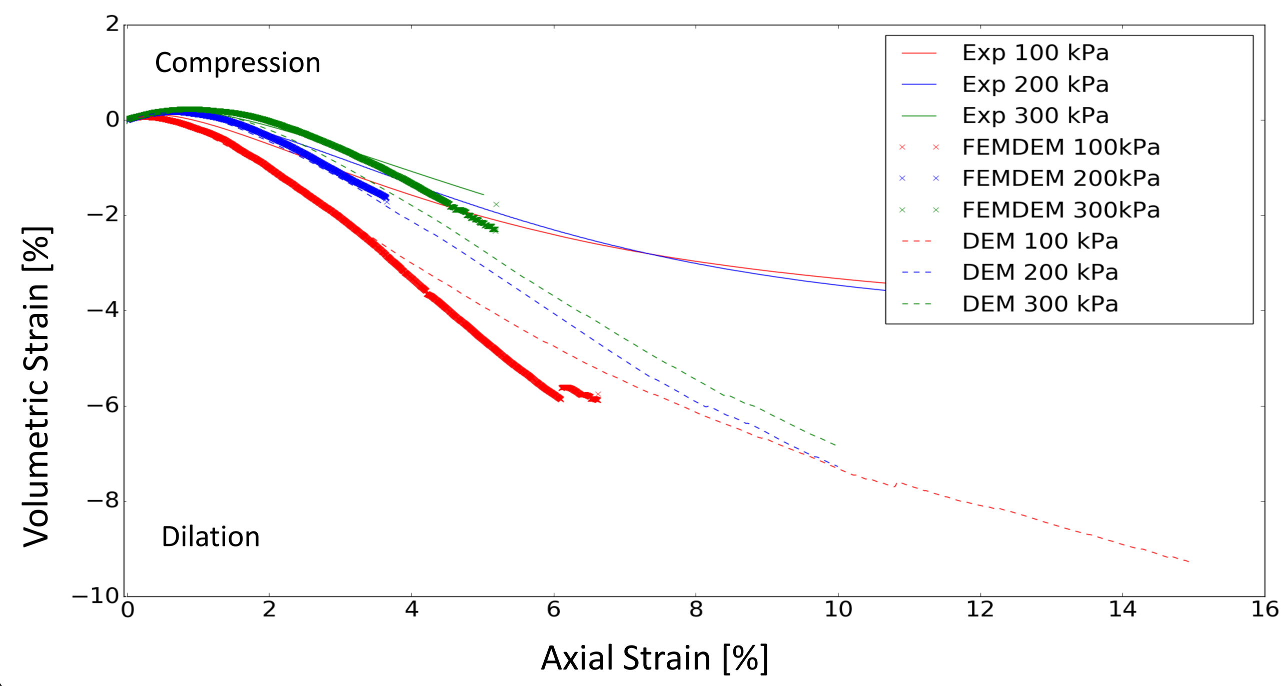
- Spheres generated with the same Particles Size Distribution of the Berliner Sand
- Relative density of 87%
- Contact constitutive law: classic elastic-plastic with rolling and twisting stiffness

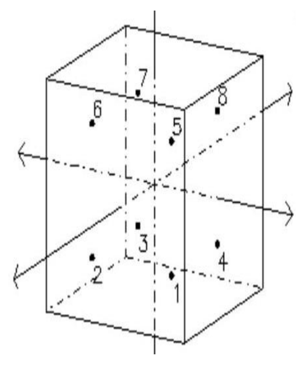
Experimental test 10x10x20 cm [2]





Pure DEM REV
3000 Spheres
3x3x3 cm





FEMDEM
8 Gauss points
1 Element
10x10x60 cm
500 spheres REV

Conclusions

- FEM-DEM is a simple method without complicated and phenomenological constitutive relations
- High congruence in term of stress and strain between the experimental tests and the coupling FEM-DEM
- The gap in the volumetric strain graph for sand is still a challenge due to the approximation of the real grains by means of spheres
- The calculation time is still the main issue of this method when more elements are considered (refining the mesh)

Future works

- Automatic method for the micromechanical parameters calibration
- Other laboratory tests will be simulated and compared with experimental tests
- Cyclic loading conditions will be addressed on a simple shallow foundation

1. N. Guo and J. Zhao, 2014. A coupled FEM/DEM approach for hierarchical multiscale modelling of granular media
2. Viet Hung Le, 2015. PhD thesis, Technical University of Berlin
3. Fabio Gabrieli, Triaxial test on Glass Ballotini. ICEA, University of Padova

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MARIE CURIE ACTIONS

ITN Innovative Training Networks

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