Modeling large foundation rafts

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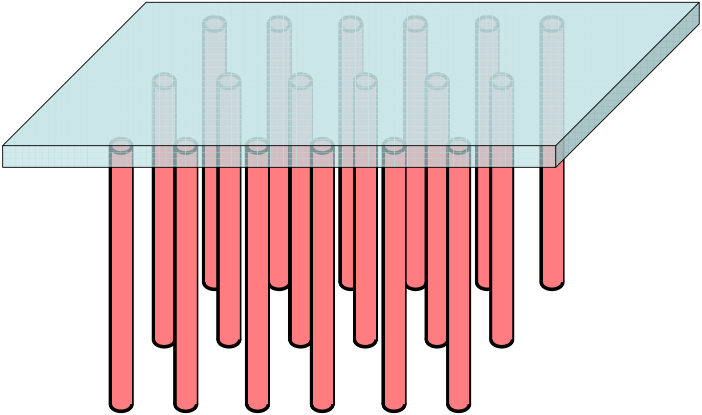
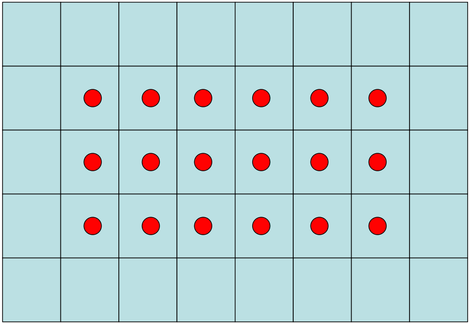
Problem to be solved



Where is the problem ?

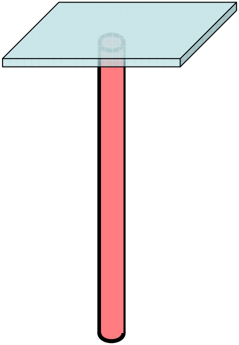
- If we have lot of piles it is almost impossible to
  1. Create 3D compatible FE mesh for plate-piles-interfaces system
  2. Compute the problem on a PC platform
  3. Each redesign of piles generates new complex 3D mesh



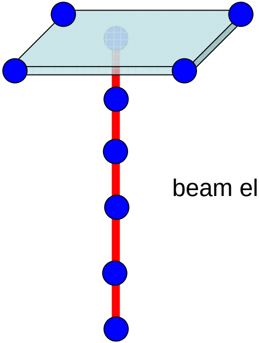
Conclusion: we need absolutely a simplified treatment

Real vs FE model

plate-pile connection



Shell Q4

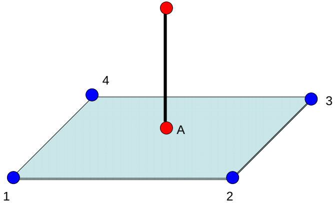


beam elements

Requirements

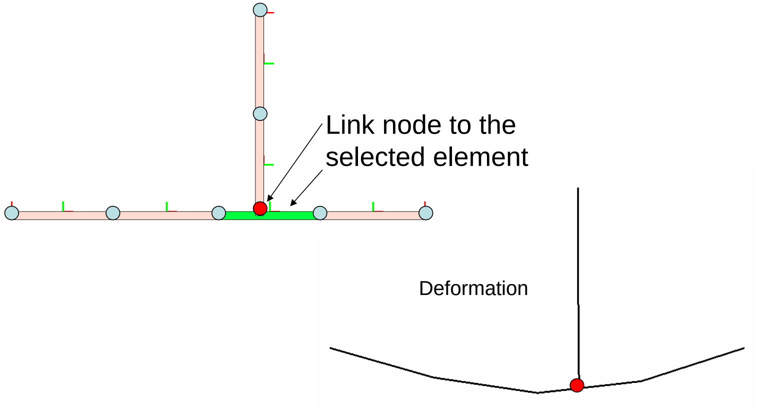
- Piles are modeled with aid of beam elements
- Beams are embedded in continuum without any restriction put on FE meshes
- Beam nodes can be connected to other elements like shells/beams/membranes/continuum not necessarily at element vertices
- Beam nodes can be connected to other elements via selected set of degrees of freedom
- The sliding interface between beam and continuum is created automatically
- The additional interface between bottom of the pile and subsoil can be optionally added
- Nodal forces can be applied at any point on the raft
- Penalty approach is not accepted (except for the frictional contact)

New tools: Nodal link option

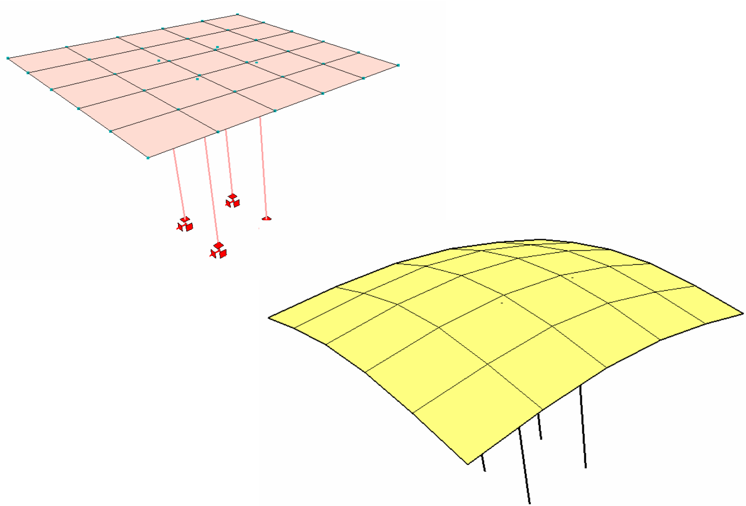


- Constraint equation(s): $u_A = \sum_{i=1}^{4} N_i \; u_i$
- Hence: stiffness, force vector from node A of a beam element is dispatched on shell degree of freedom
- DOF's of node A are dependent on other DOF's
- Attention: constraints cannot be nested (!)

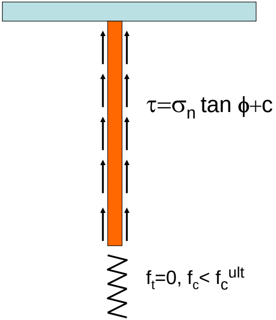
Nodal link: example of beam-beam connection



Nodal link: example of beam-shell connection



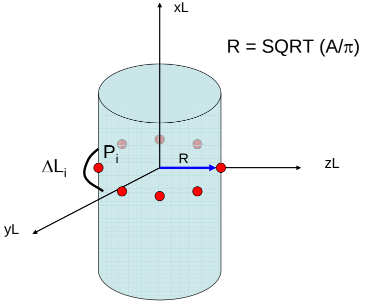
Sliding interface



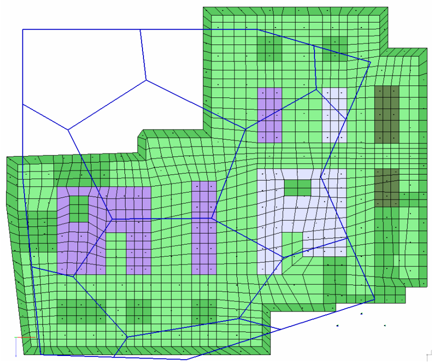
How to estimate σ_n ?

NB. We can leave $\phi = 0$ and make contact purely adhesive like in codes for pile design

Sliding interface: σ_n estimation

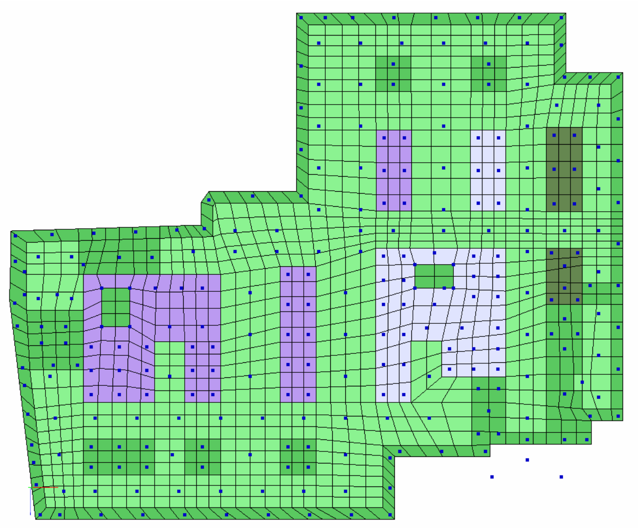


- $\sigma_n = \dfrac{\int_L \min(\sigma_{ni}, 0)\mathrm{dl}}{\int_L \mathrm{dl}}$
- σ_{ni} is computed by effective stress transformation from the continuum elements in which interface and beam is embedded

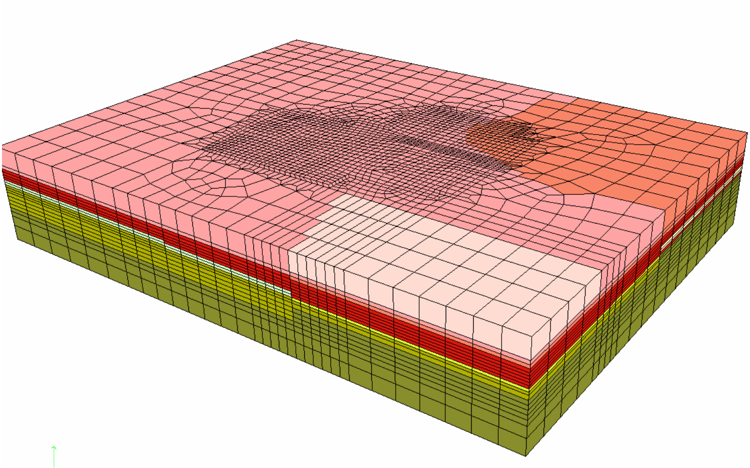


Goal: Estimate settlements using MC and HS-small models

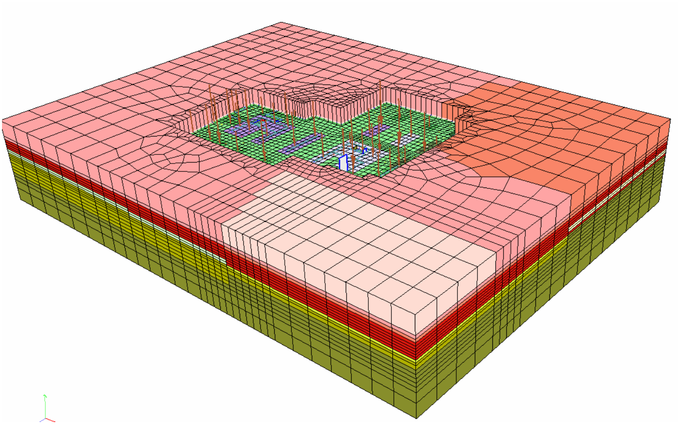
Practical example: positioning of CFA piles



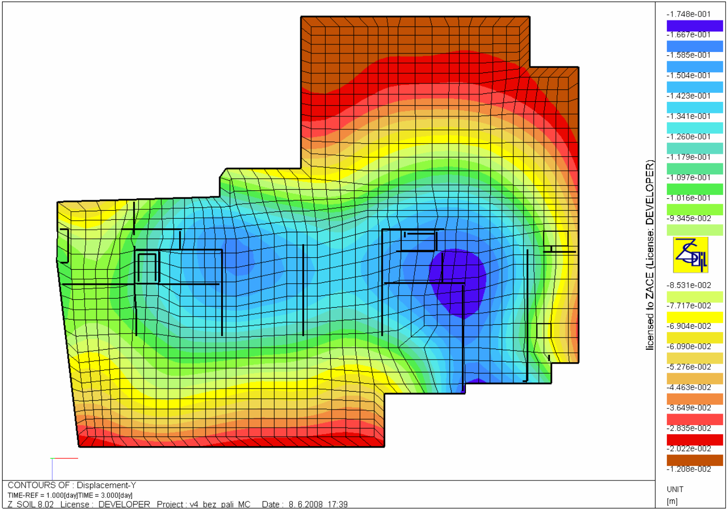
Practical example: FE mesh



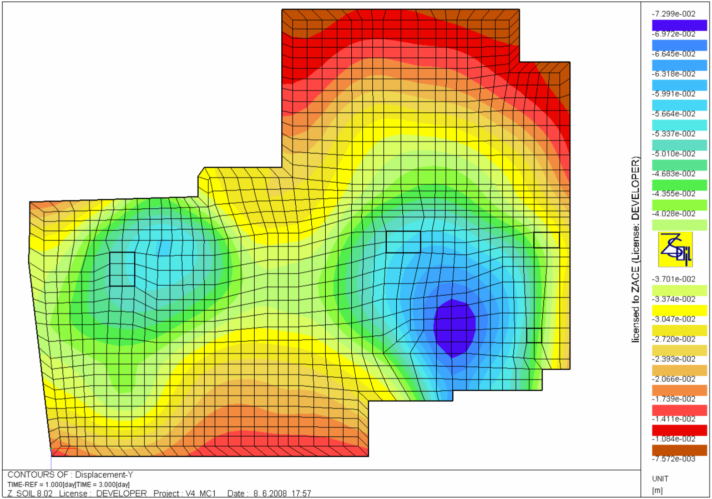
Practical example: loading



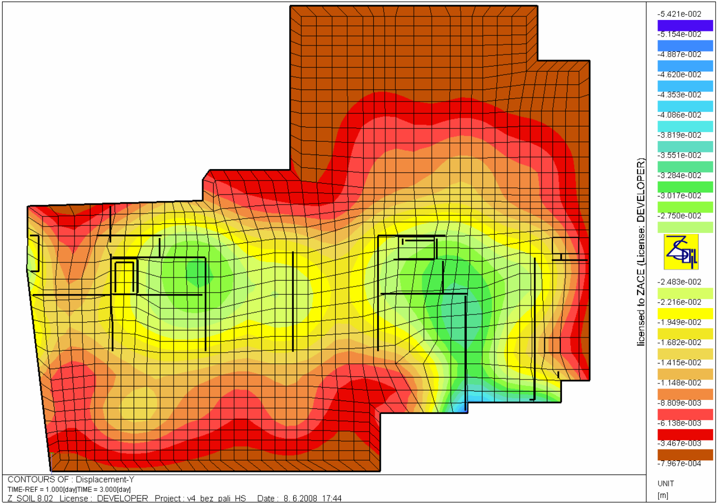
Results: MC model without piles ($u_{max} = 17.5cm$)



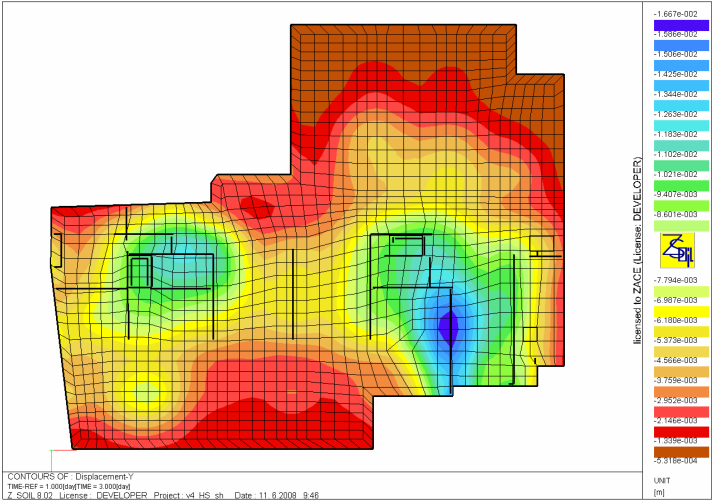
Results: MC model with CFA piles ($u_{max} = 7.3cm$)



Results: HS-small model without piles ($u_{max} = 5.4cm$)



Results: HS-small model with piles ($u_{max} = 1.7cm$)



Conclusions

- This option allows to compute large foundation rafts
- It can be used also for nailing applications
- Redesign of piling is very fast as its disretization is disconnected from subsoil mesh
- This option allows to compute complicated tasks with PC resources