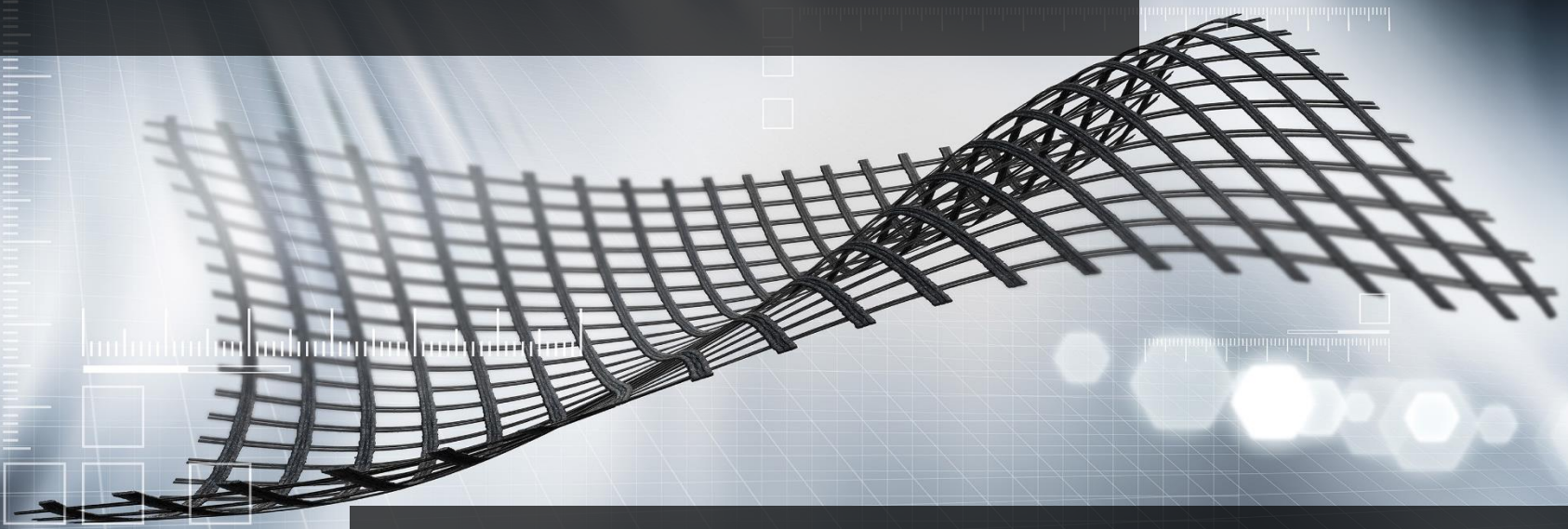
Embankment construction by means of a membrane foundation



Oliver Detert, HUESKER Synthetic GmbH
Dimiter Alexiew, Geosynthetics & Geotechnics Consulting
Diethard König, Ruhr-Universität Bochum

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Motivation

- Extension of infrastructural facilities in challenging areas
- Foundation for stockpiles, dikes etc.

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Challenges

- Soft soils
  - Low stiffness
  - Low permeability
  - Low shear strength
  - High degree of saturation
- Consequences
  - Inacceptable deformations and/or horizontal thrust on adjacent constructions
  - Insufficient stability

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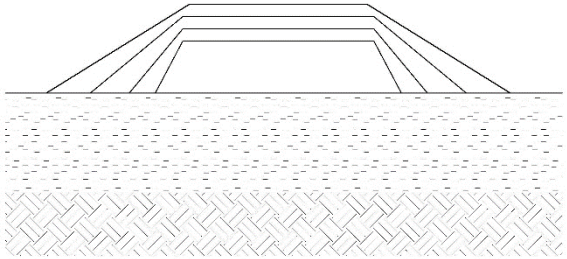
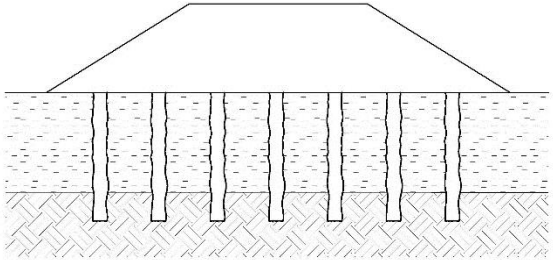
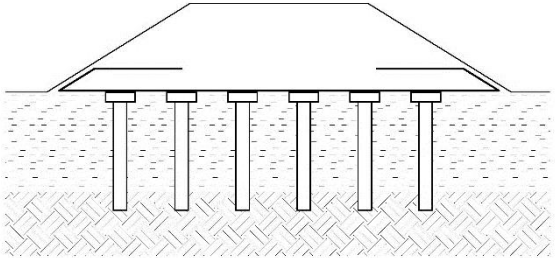
Solutions



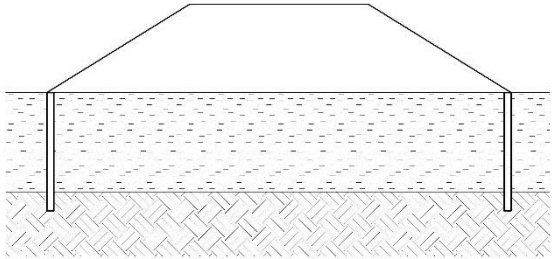
Construction methodology adopted to soil conditions



Soil improvement



Load transfer



Soil confinement

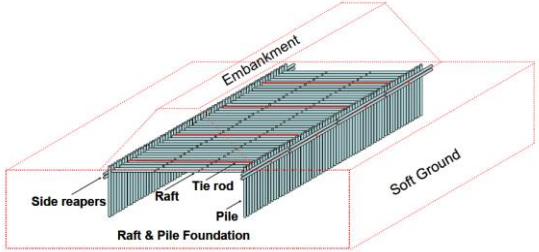
Soil confinement

Temporary to

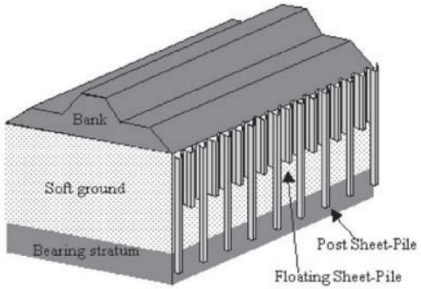
- secure stability during earthquake/ liquefaction

Permanent to

- Secure stability
- Prevents soil extrusion
- Reduce lateral thrust
- Reduce lateral deformation
- Cut-off depression curve



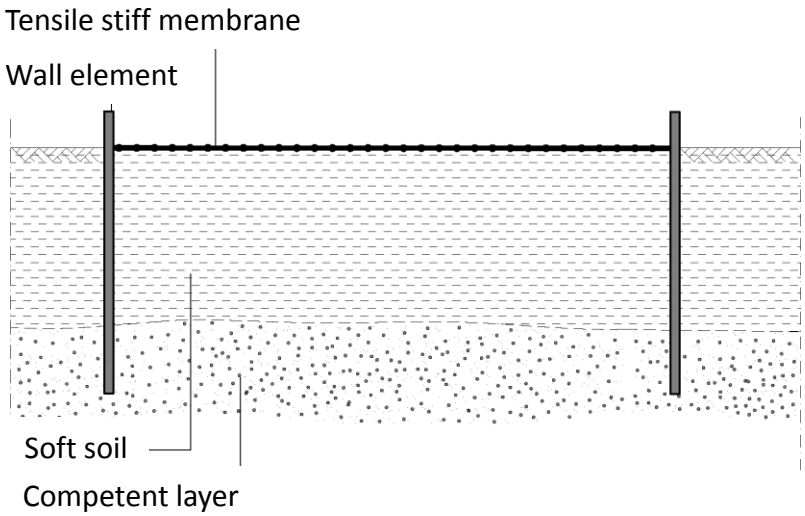
Poungchompu, 2009



Harata et al., 2009

Self-regulating membrane foundation

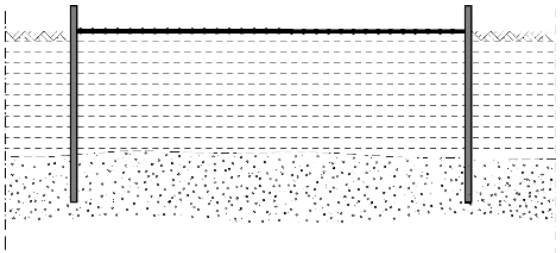
System



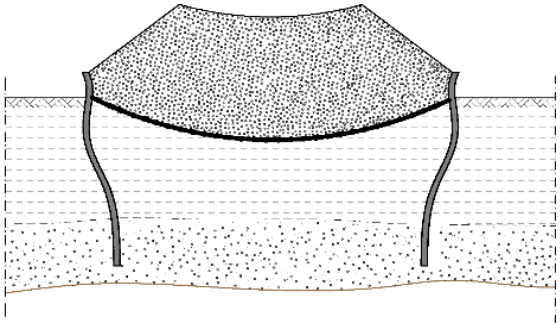
Self-regulating membrane foundation

System behavior

- Increase of horizontal pressure in subsoil due to embankment load → outward movement of vertical walls
- Activation of tensile forces in the membrane → restricting outward movement
- Further activation due to settlement depression of embankment



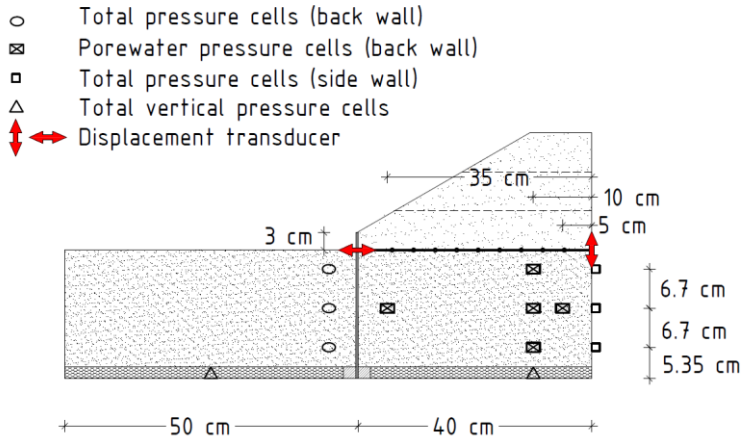
Unloaded and undeformed



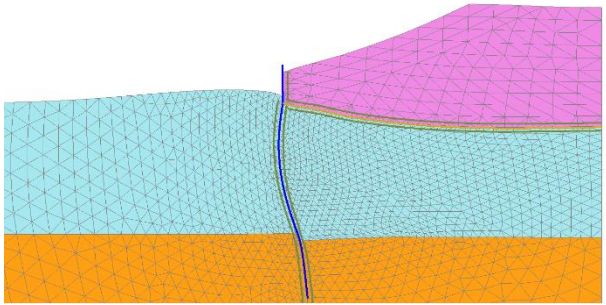
Loaded and deformed

Self-regulating membrane foundation

Investigation



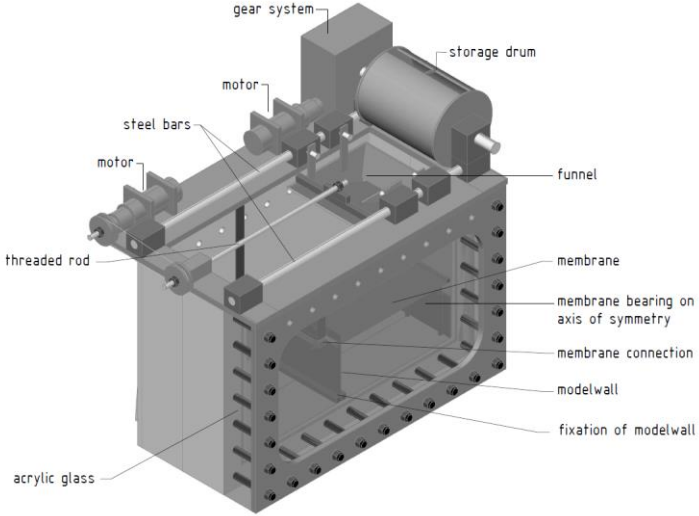
Centrifuge model set-up



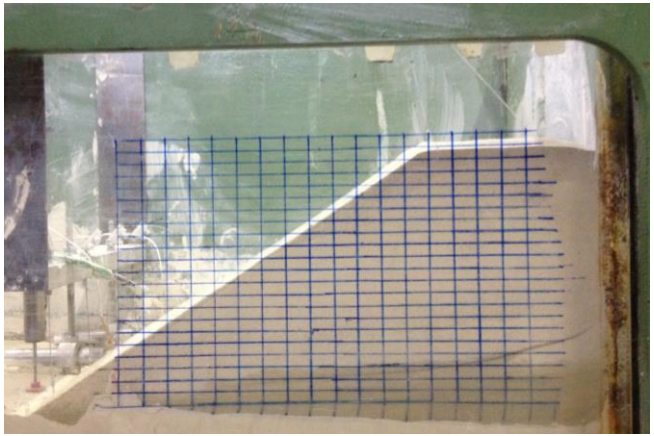
Numerical model

Self-regulating membrane foundation

Investigation



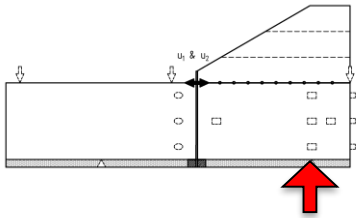
In-flight refillable sand hopper

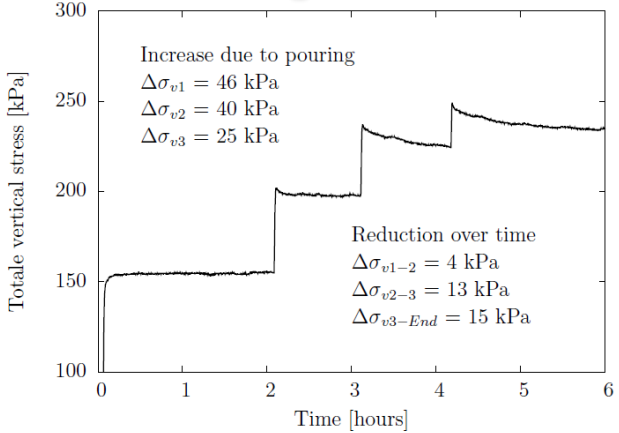


In-flight constructed embankment

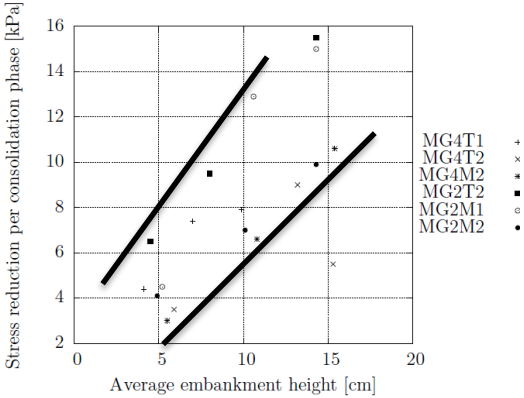
Self-regulating membrane foundation

Results of physical analysis





Total vertical stress over time



Stress reduction over embankment height

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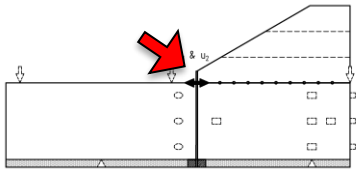
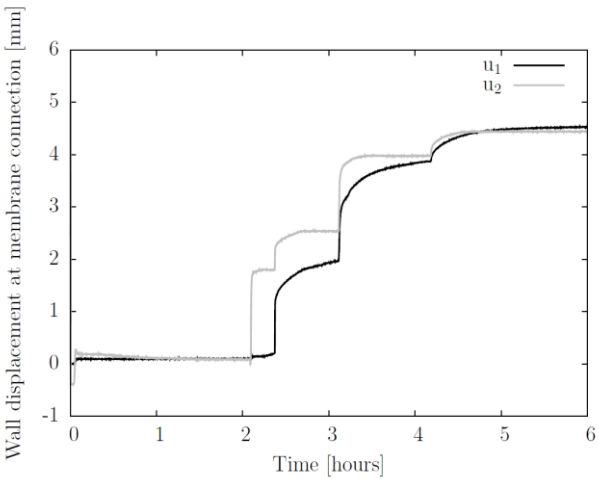
Results of physical analysis

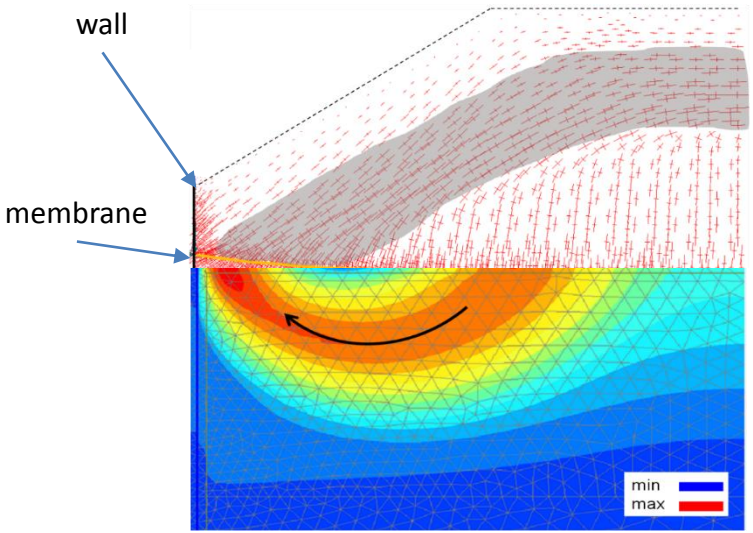




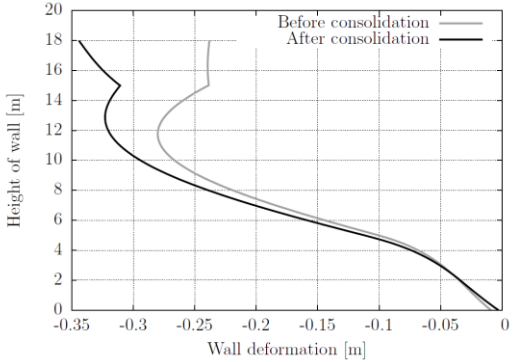
Wall deformation over time

Self-regulating membrane foundation

Results of numerical analysis



Arching in embankment and rotational failure mechanism in subsoil



Wall deformation before and after consolidation

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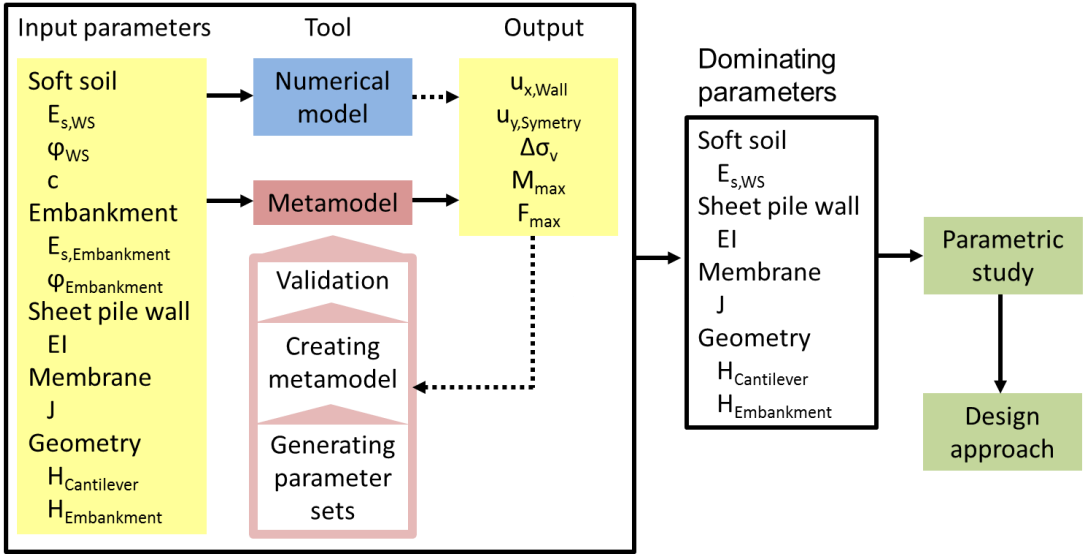
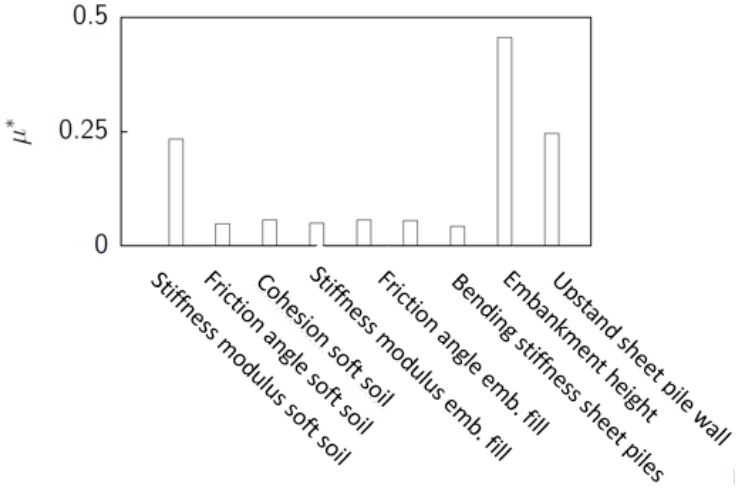
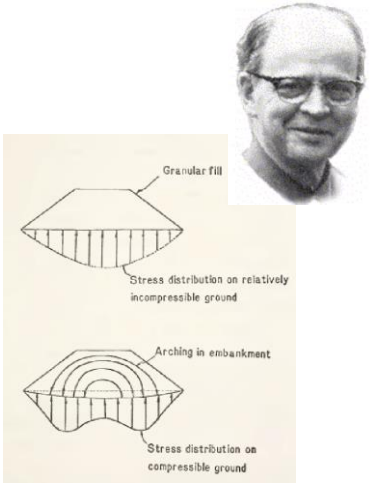
Numerical simulation



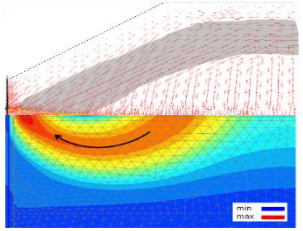
global sensitivity analysis

Numerical simulation – global sensitivity analysis





A. Casagrande (1936)



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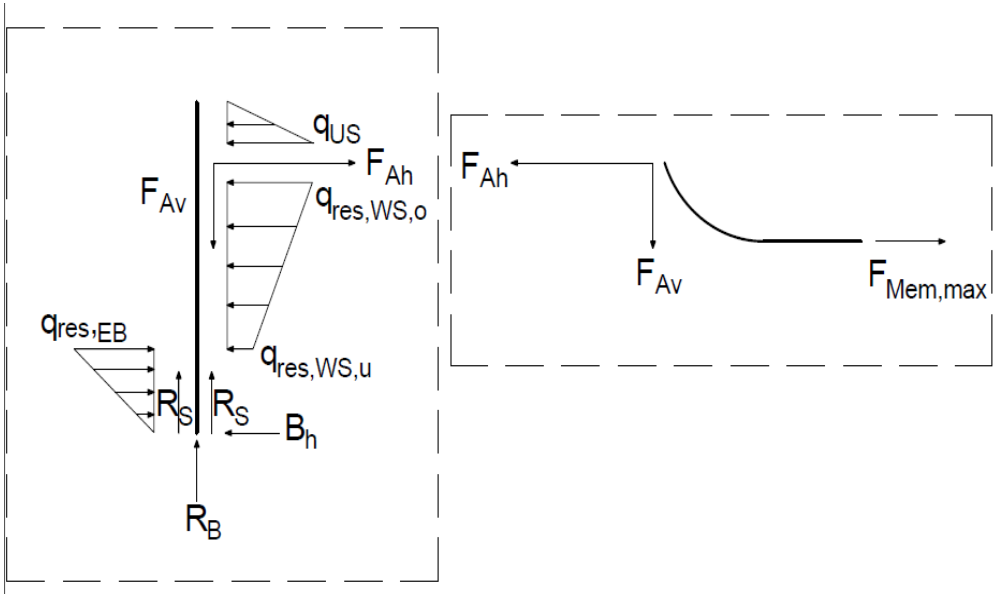
Semi-analytical design approach

- System separation in two coupled sub-systems



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Semi-analytical design approach

- Determination of the system loadings and membrane forces

Loading/force

Influence of geometry

Influence of soft soil stiffness

$$F_i = F_{0.25,i} \cdot A_{geo,i} \cdot A_{\gamma,i} \cdot A_{E_{oed},i} \cdot A_{J,i}$$

Loading of base system

Influence bulk density embankment

Influence membrane tensile stiffness

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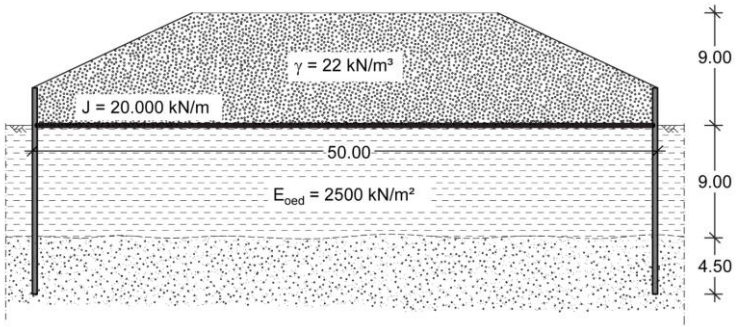
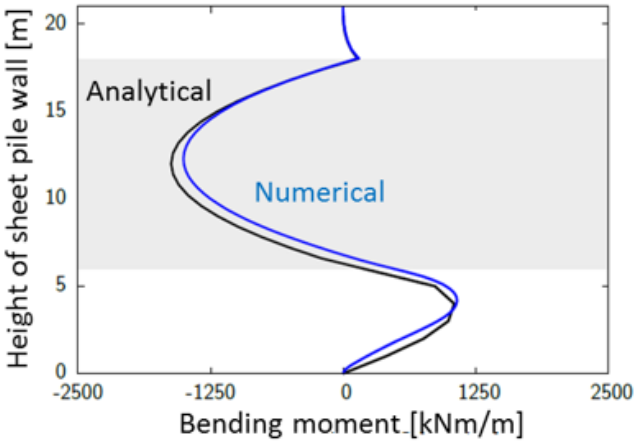
Semi-analytical design approach

Comparison numerical simulation and design approach





Self-regulating membrane foundation

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System properties

- Easy to construct
- Can be loaded directly after construction
- Reduction of lateral thrust
- Cuts the depression curve off
- Reduced footprint, if walls are extending above the ground level
- Can be completely rebuilt
- Control of lateral deformation

Questions


How
How
Why
When
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