STRUCTURAL MECHANICS

MULTIPHYSICS

INTERACTION

LIFECYCLE AND FATIGUE

EXPLICIT DYNAMICS

Optimization of a gravity based foundation for shallow water applications using ANSYS and CAESES

HOLISHIP WP15

Dr. Marco Göttsche

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Content

- Application Cases 9 HOLISHIP Demonstrators
- The aim of our work
- Simulation of the soil structure interaction
- Combination of CAESES and ANSYS
- Conclusion

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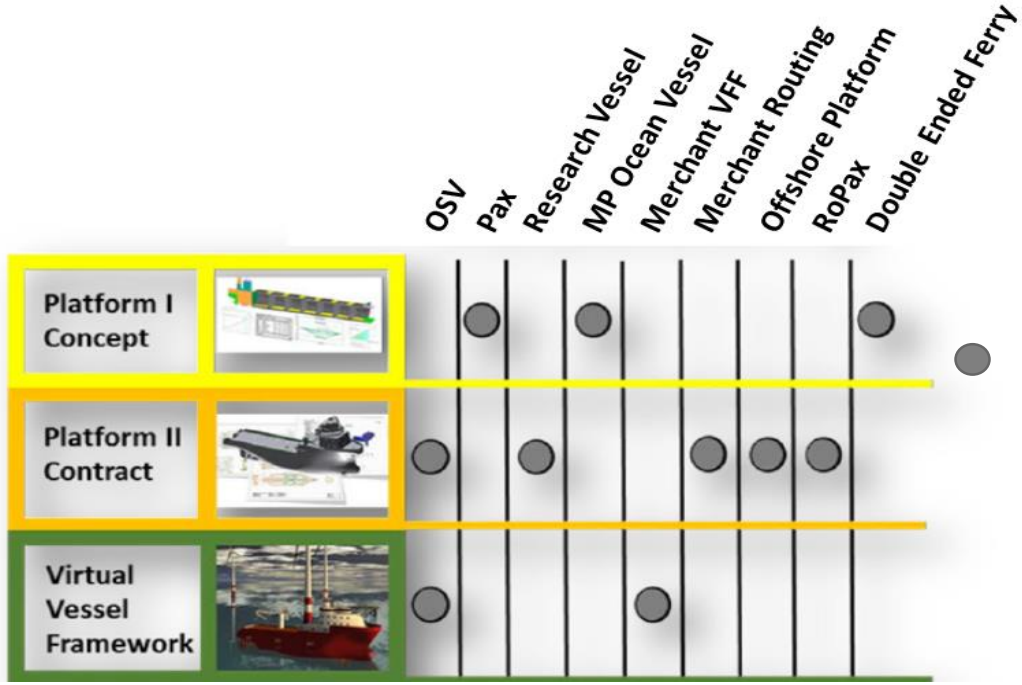
Application Cases 9 HOLISHIP Demonstrators

1. OSV

2. PAX

3. Research Vessel

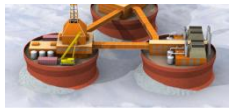
4. MP Ocean Vessel



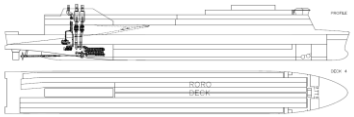
The impact of the tools developed in HOLISHIP will be showcased using 9 different Demonstrators. All of these are characteristic for European Maritime Operations.

5./6. Merchant Vessel

7. Offshore Structure



8. RoPAX



9. Double Ended Ferry

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Application Cases 9 HOLISHIP Demonstrators

Partner:

- ELOMATIC
  - Work package leader
- Center of Maritime Technologies (CMT)
  - Cost and producibility
- S.M.I.L.E.-FEM
  - Structural assessment
- Friendship Systems
- DNV GL
- Hochschule Bremen (HSB)

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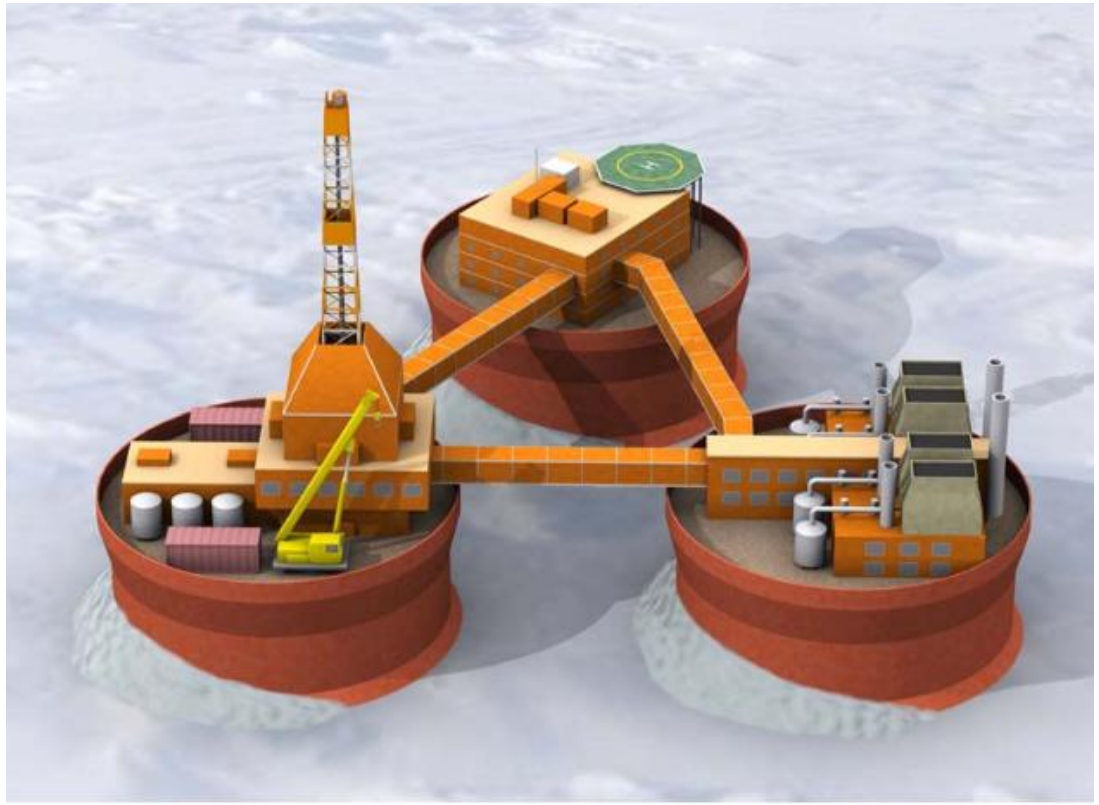
The aim of our work

- Outer steel structure
  - to withstand and distribute the lateral loads
  - keep the infill in place
- Infill
  - to transfer the vertical loads
  - to transfer the horizontal loads
- Soil replacement (if needed)



Elomatic, Top Engineer, 2-2014

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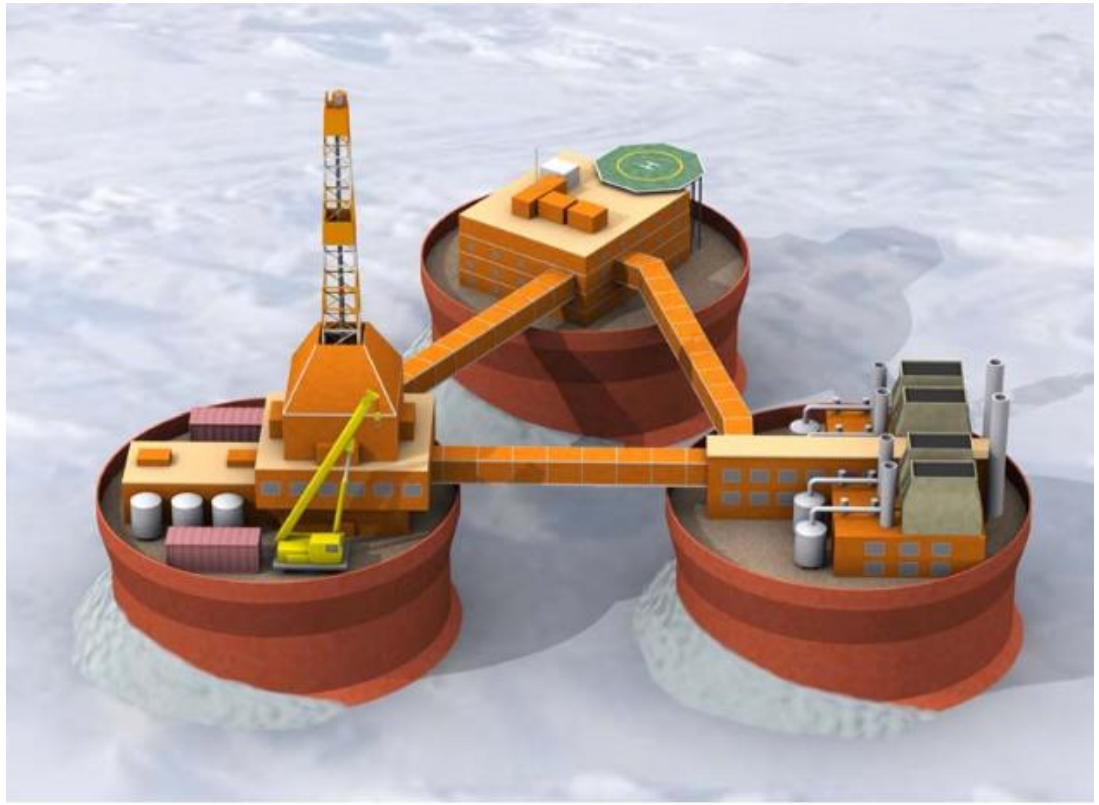
The aim of our work

- Modular Offshore Platform for
  - Shallow water
  - Icy condition
  - Soft soil
- The tool and application should be
  - Modular
  - Variable for erection site
  - Soil structure and environment
  - Dimension of foundation
  - Weight of structure



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The aim of our work

- Cost estimation (CMT)
  - Assess the costs for
    - Material and production
    - Transport and erection
    - …
- Structural simulation
  - Calculate the loads acting on the structure
  - Simulate the behavior of the structure on the soil
    - Sliding
    - Tilting
    - Sinking
  - Decide if design is feasible or not

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Simulation of the soil structure interaction

Simplified approach

+ Very fast modeling and computing
+ Good for optimization
– Only valid for standard applications
– No layered soil considered

Detailed approach

+ Detailed modeling of interaction and load transfer
+ Load distribution within the sediment
+ Layered soil and soil replacement considered
+ Failure criterion (nonlinear MP)
– High effort in modeling
– High effort in computing

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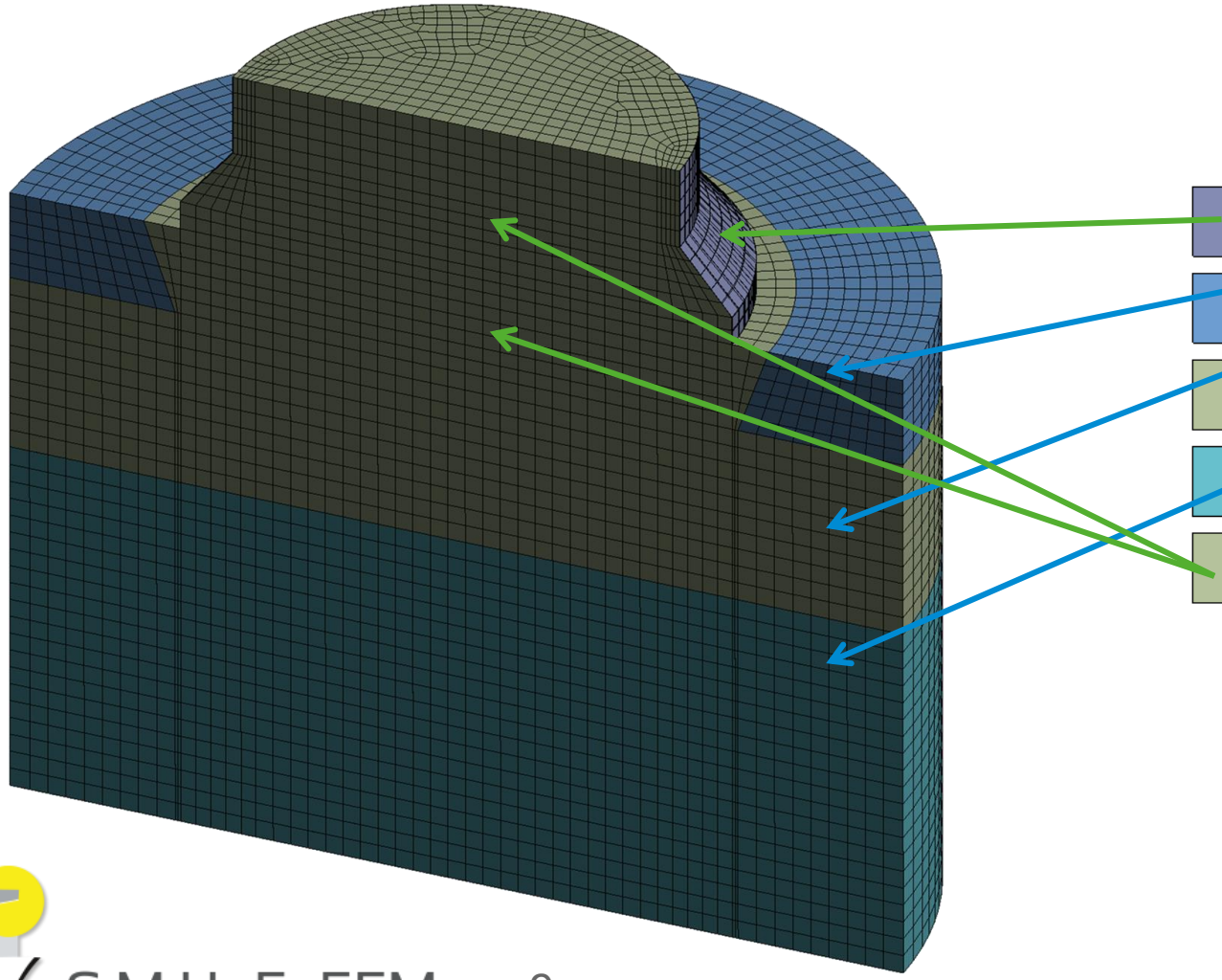
Simulation of the soil structure interaction



- Structural steel
- Soil layer 1
- Soil layer 2
- Soil layer 3
- Infill and soil replacement

Density: 2.3 – 2.6 kg/m^3
E-Mod: 1.2 – 10.8 MPa (soil)
E-Mod: 3000 MPa (Infill)

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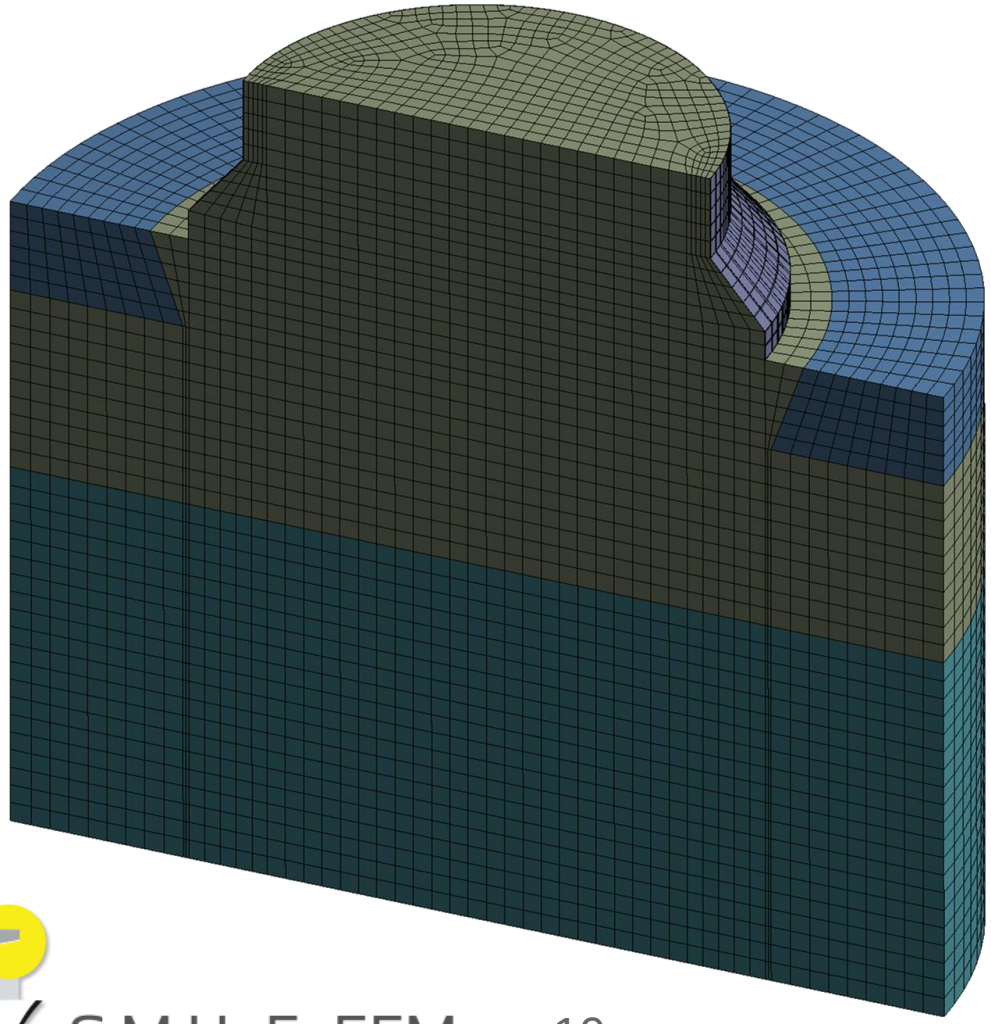
Simulation of the soil structure interaction



Boundary Conditions:

- Fixed support at boundary of soil (different diameter and depths)
- Symmetry conditions

Loads

- Weight of superstructure
- Gravity
- Current and wave
- Ice
- Wind

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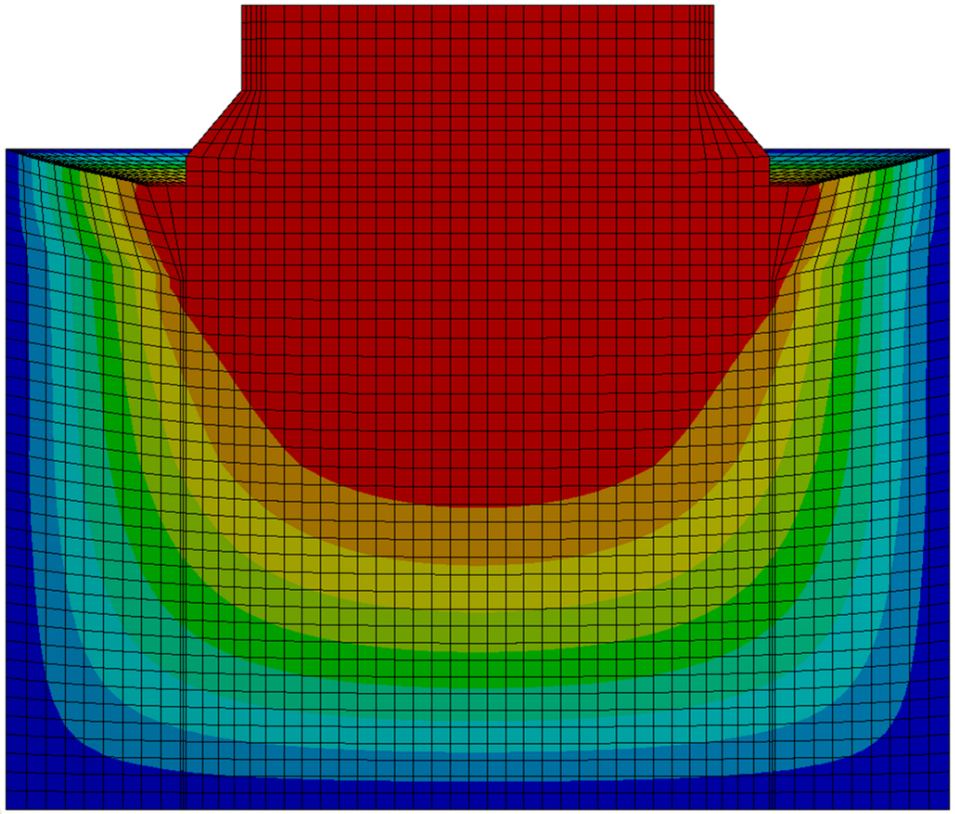
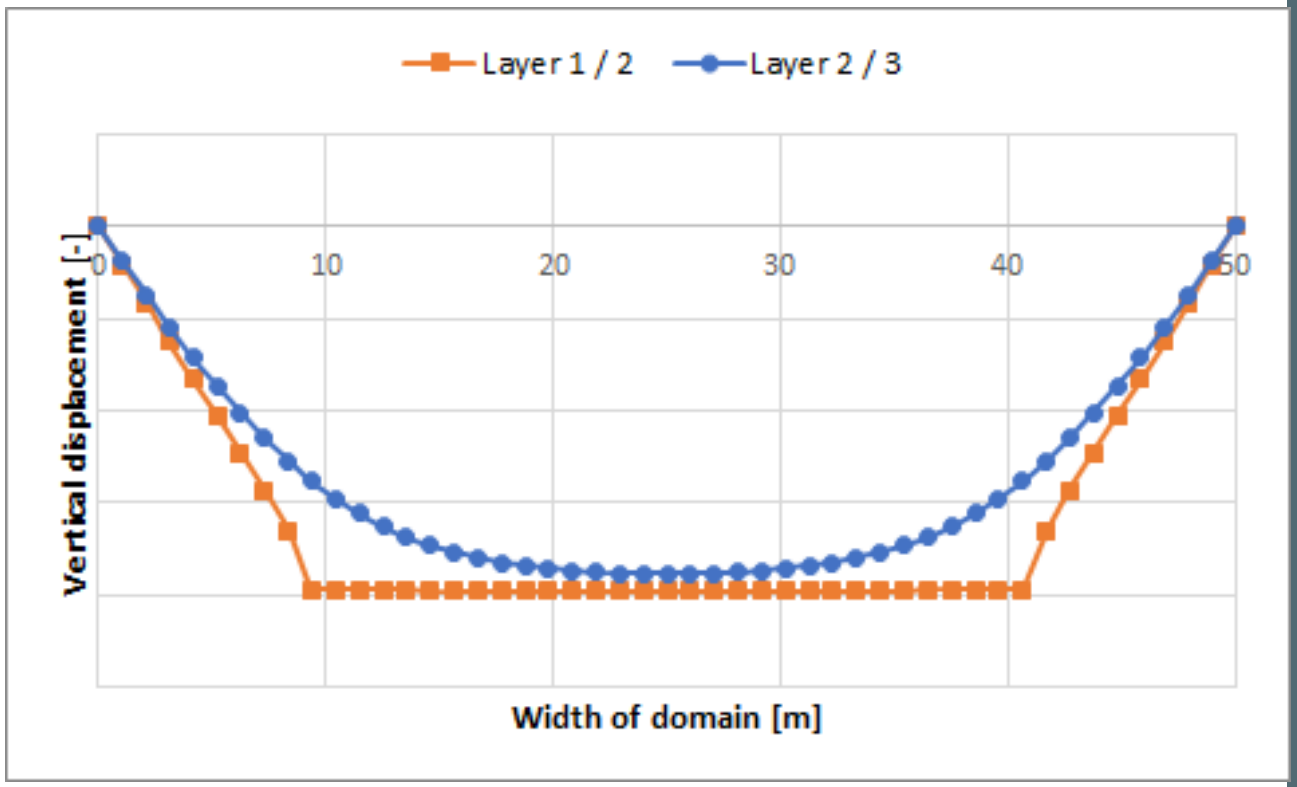
Simulation of the soil structure interaction

Total displacement
under gravity loads





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Simulation of the soil structure interaction

Problems unsolved:

- Nonlinear material properties (Drucker Prager / Mohr-Coulomb)
  - Show very poor convergence
  - Abort at load being not analytically proven
  - Poor convergence for horizontal loadings
- Analytical validation of the deflection shows differences, probably due to the definition of the E-Mod

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Combination of CAESES and ANSYS

- Easy to use since ANSYS entirely works in batch mode
- Limitation to important input
- Feedback with relevant output and interpretation
- Direct link with the cost estimation tool
- An Optimization process can be implemented
  - Regarding structural performance
  - Regarding cost
  - The results from the other position is calculated automatically

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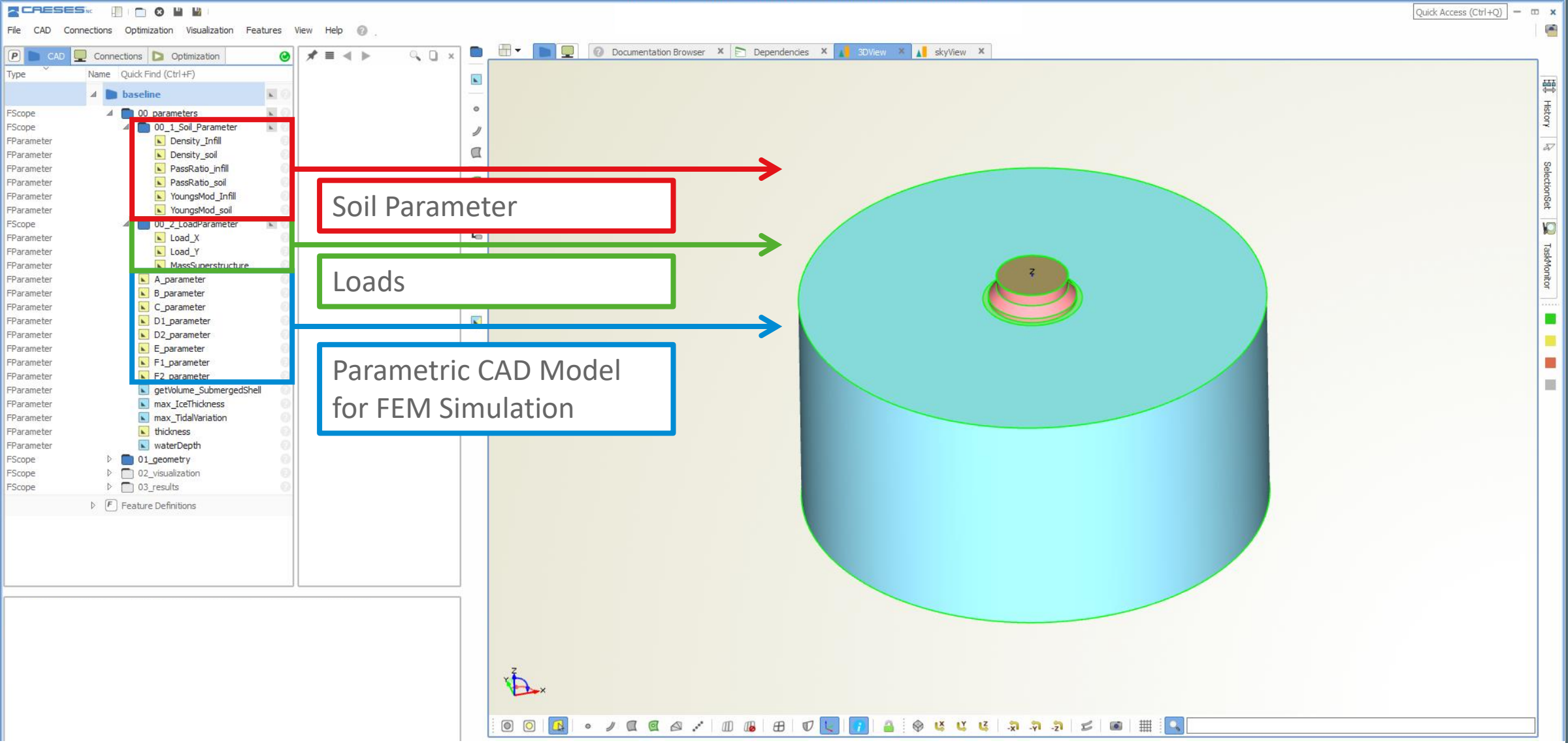

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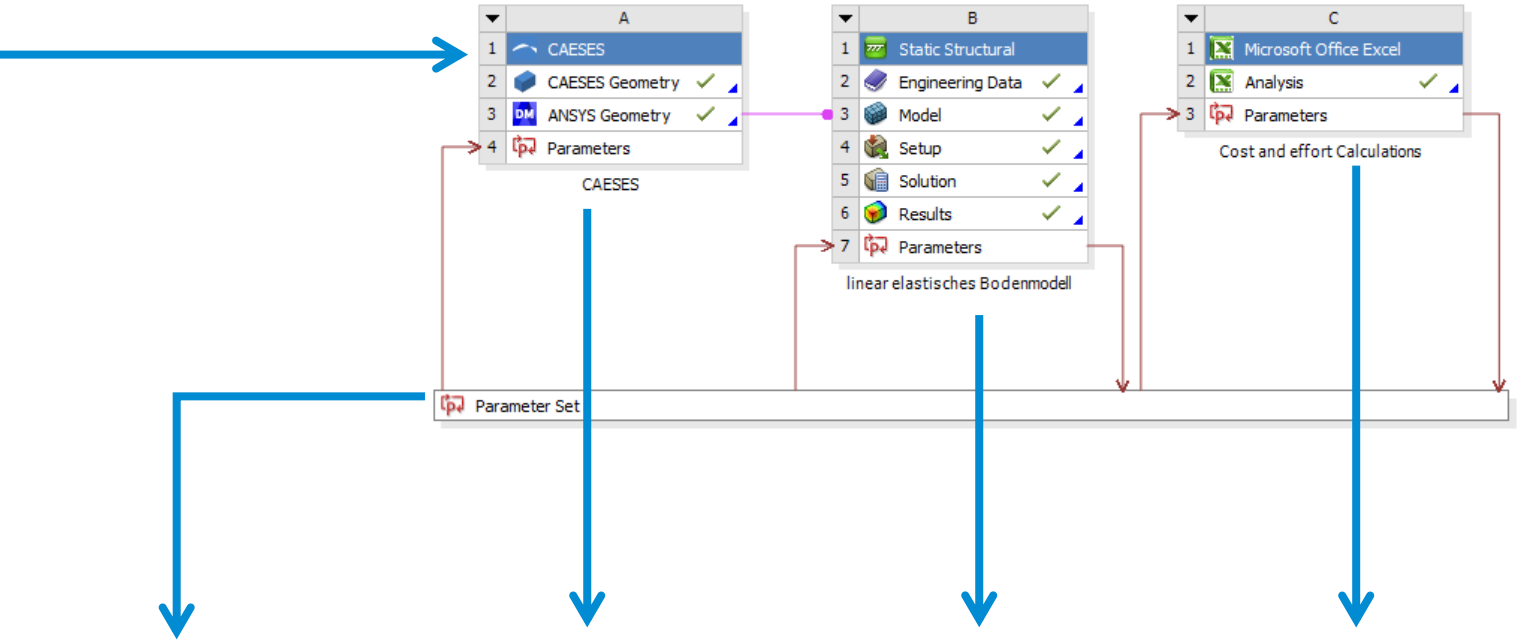
Combination of CAESES and ANSYS

- Parametric CAD Model
- Parameter for
  - FEM Simulation
  - Cost estimation



Set of parameter

CAESES .fsc file
- Geometry
- Parameter
- Faces

FEM Simulation

Cost estimation tool

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Combination of CAESES and ANSYS

Input Parameters	
CAESES (A1)	
P195	CAESES :00_parameters |00_1_Soil_Parameter|Density_Infill
P196	CAESES :00_parameters |00_1_Soil_Parameter|Density_soil
P197	CAESES :00_parameters |00_1_Soil_Parameter|PassRatio_infill
P198	CAESES :00_parameters |00_1_Soil_Parameter|PassRatio_soil
P199	CAESES :00_parameters |00_1_Soil_Parameter|YoungsMod_Infill
P200	CAESES :00_parameters |00_1_Soil_Parameter|YoungsMod_soil
P201	CAESES :00_parameters |00_2_LoadParameter|Load_X
P202	CAESES :00_parameters |00_2_LoadParameter|Load_Y
P203	CAESES :00_parameters |00_2_LoadParameter|MassSuperstructure

linear elastisches Bodenmodell (B1)	
P179	FE-Kraft X-Komponente
P181	Punktmasse Masse
P194	FE-Kraft Y Y-Komponente
P213	Querkontraktionszahl Infill
P214	E-Modul Infill
P215	Dichte Infill
P216	Dichte Soil
P217	E-Modul Soil
P218	Querkontraktionszahl Soil

Input parameters are coupled

Property	
General	
Expression	P201*1[N]
Usage	Input
Description	
Error Message	
Expression Type	Derived
Quantity Name	Force

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Combination of CAESES and ANSYS

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P196	CAESES :00_parameters |00_1_Soil_Parameter|Density_soil
P197	CAESES :00_parameters |00_1_Soil_Parameter|PassRatio_infill
P198	CAESES :00_parameters |00_1_Soil_Parameter|PassRatio_soil
P199	CAESES :00_parameters |00_1_Soil_Parameter|YoungsMod_Infill
P200	CAESES :00_parameters |00_1_Soil_Parameter|YoungsMod_soil
P201	CAESES :00_parameters |00_2_LoadParameter|Load_X
P202	CAESES :00_parameters |00_2_LoadParameter|Load_Y
P203	CAESES :00_parameters |00_2_LoadParameter|MassSuperstructure

linear elastisches Bodenmodell (B1)	
P179	FE-Kraft X-Komponente
P181	Punktmasse Masse
P194	FE-Kraft Y Y-Komponente
P213	Querkontraktionszahl Infill
P214	E-Modul Infill
P215	Dichte Infill
P216	Dichte Soil
P217	E-Modul Soil
P218	Querkontraktionszahl Soil

Output parameters are calculated

Output Parameters	
linear elastisches Bodenmodell (B1)	
P182	Verschiebungskomponente Minimum
P183	Verschiebungskomponente 2 Minimum
P184	Verschiebungskomponente 3 Minimum
P185	Verschiebungskomponente Maximum
P186	Verschiebungskomponente 2 Maximum
P187	Verschiebungskomponente 3 Maximum

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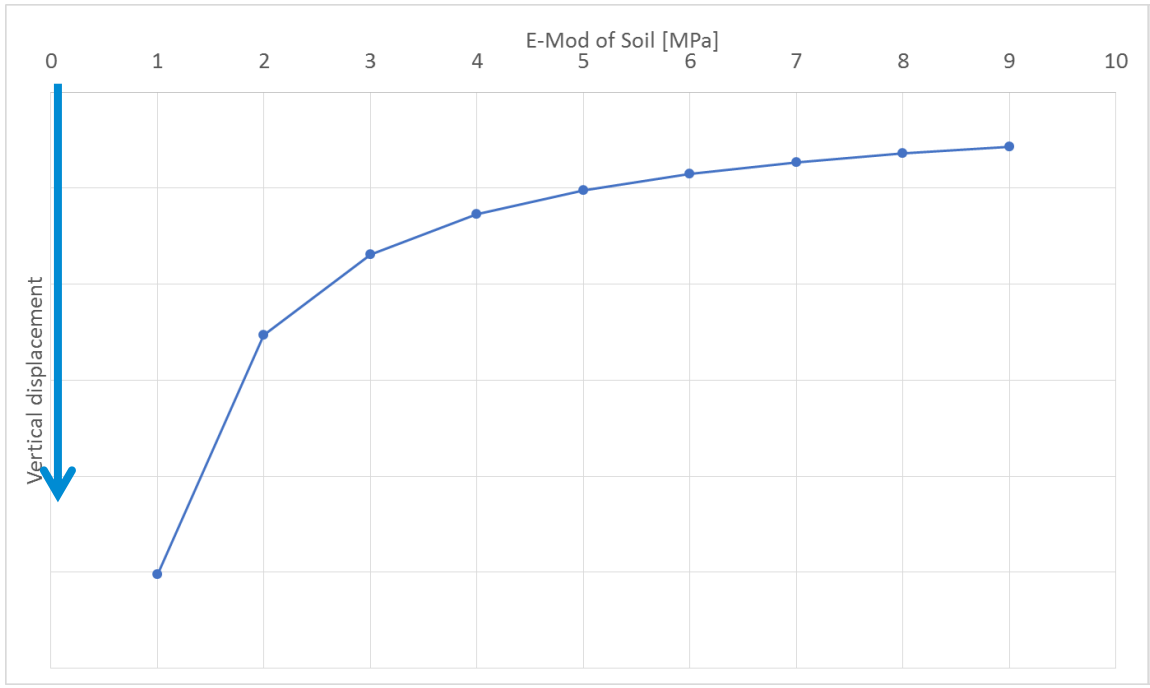
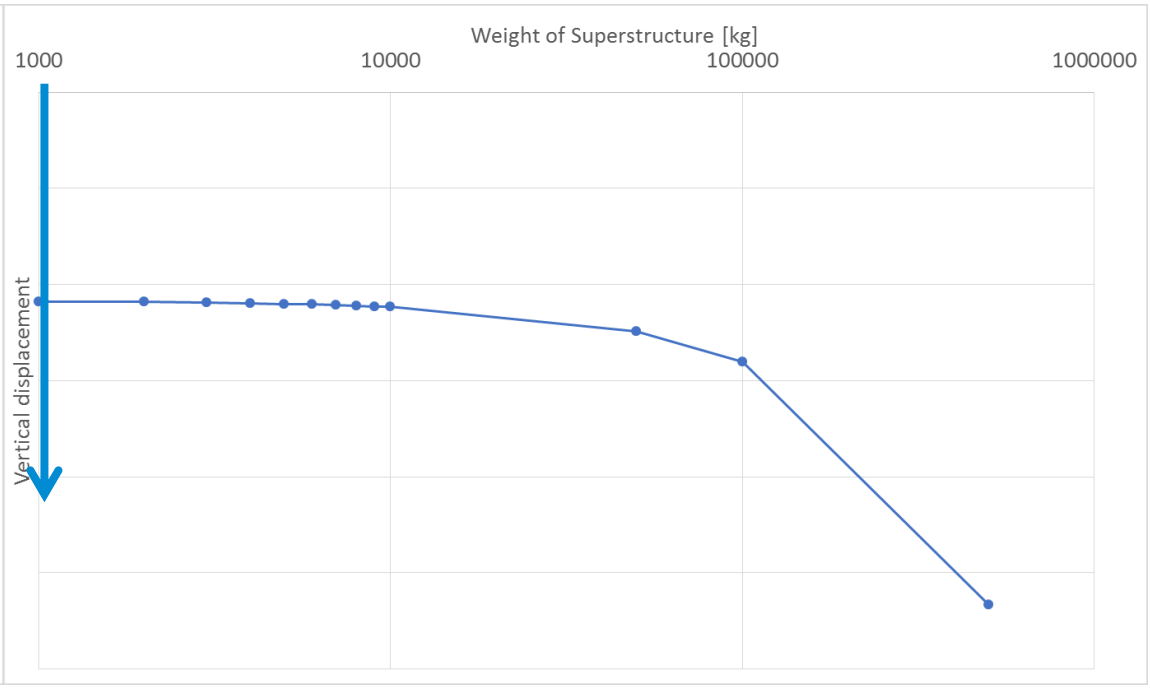
Combination of CAESES and ANSYS



Variation of the soil stiffness



Variation of the superstructure weight

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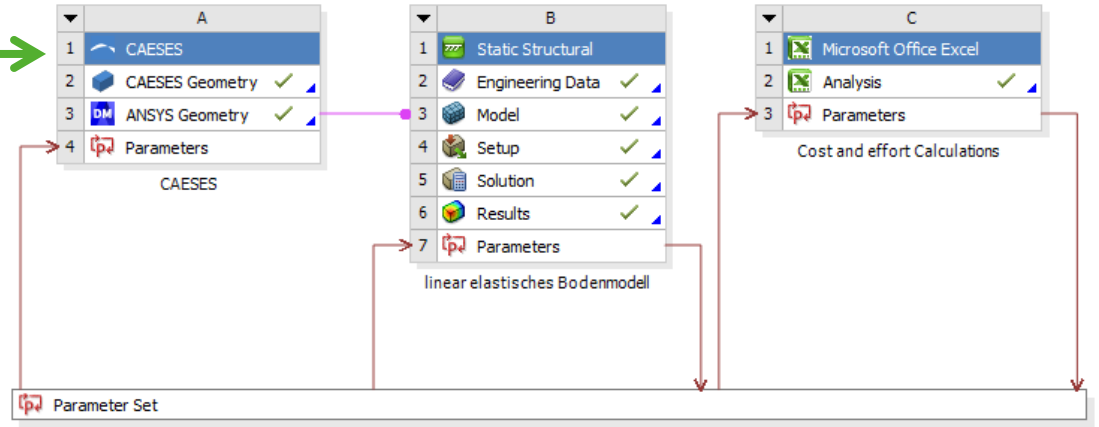
Combination of CAESES and ANSYS – Next step

- Parametric CAD Model
- Parameter for
  - FEM Simulation
  - Cost estimation



Call in Batch mode

Closed Loop

Return of Results

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Conclusion

- We have modeled the soil structure interaction of a gravity based foundation in ANSYS
- CMT built and implemented cost model
- Both simulations are coupled and integrated into CAESES

- However, the simulation results are not satisfying at the moment
- Further research and validation is necessary
- Capability of other software tools might be reasonable

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Acknowledgements

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