Piled Raft Foundations : Comparative Approaches and Soil Structure Interaction

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SSI

- **What is SSI ?**

–Interaction of Stiffness and Deformation between Structure and Soil

–Necessary for Adequate Assessment of Stresses and Forces in the Supporting Structure

- **Why SSI ?**

Supporting Soil,

–Generates Loading and

–Provides Resistance to Loading

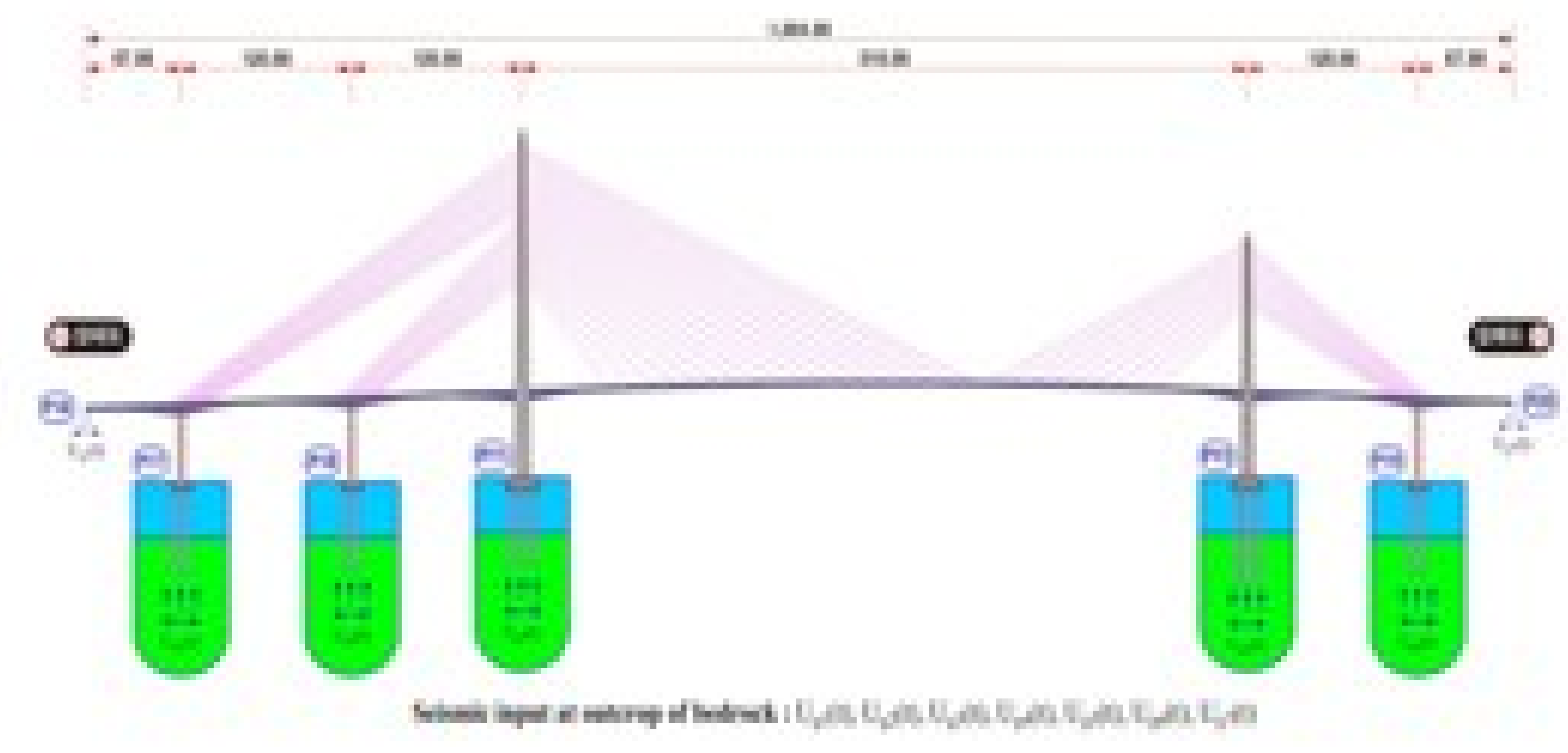
Force on Deck and Pier depends on,

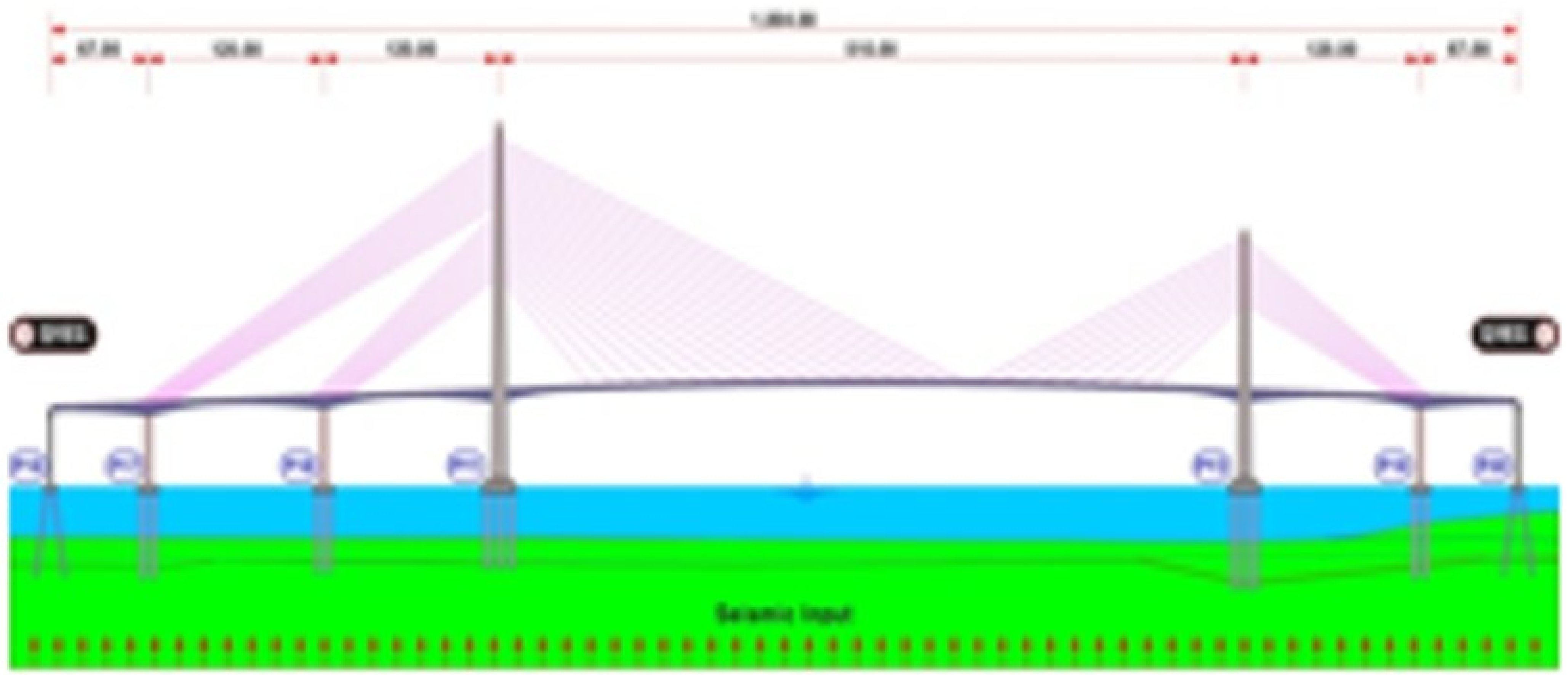
–Location of the foundation

–Flexibility of foundation

–Supporting Soil Behaviour

Broad Classification of SSI Methods





Substructure Method

Based on superposition of events, it separates the problem into two simpler parts.

- Free Field Analysis: The reaction / response of the soil is determined (mainly where the structure will be)
- Structural Analysis: The soil can be modeled as spring damper system(impedance) with that response. The detailed structure is designed with the idealization of soil as independent damper spring

Eg: Wrinkler Springs, Springs from Empirical Equations etc

Direct Method

The soil-structure system is modeled and analyzed in one step directly

Get response with the two simultaneously

Numerical methods: Continuum Methods FEM, FDM

Various SSI Methods

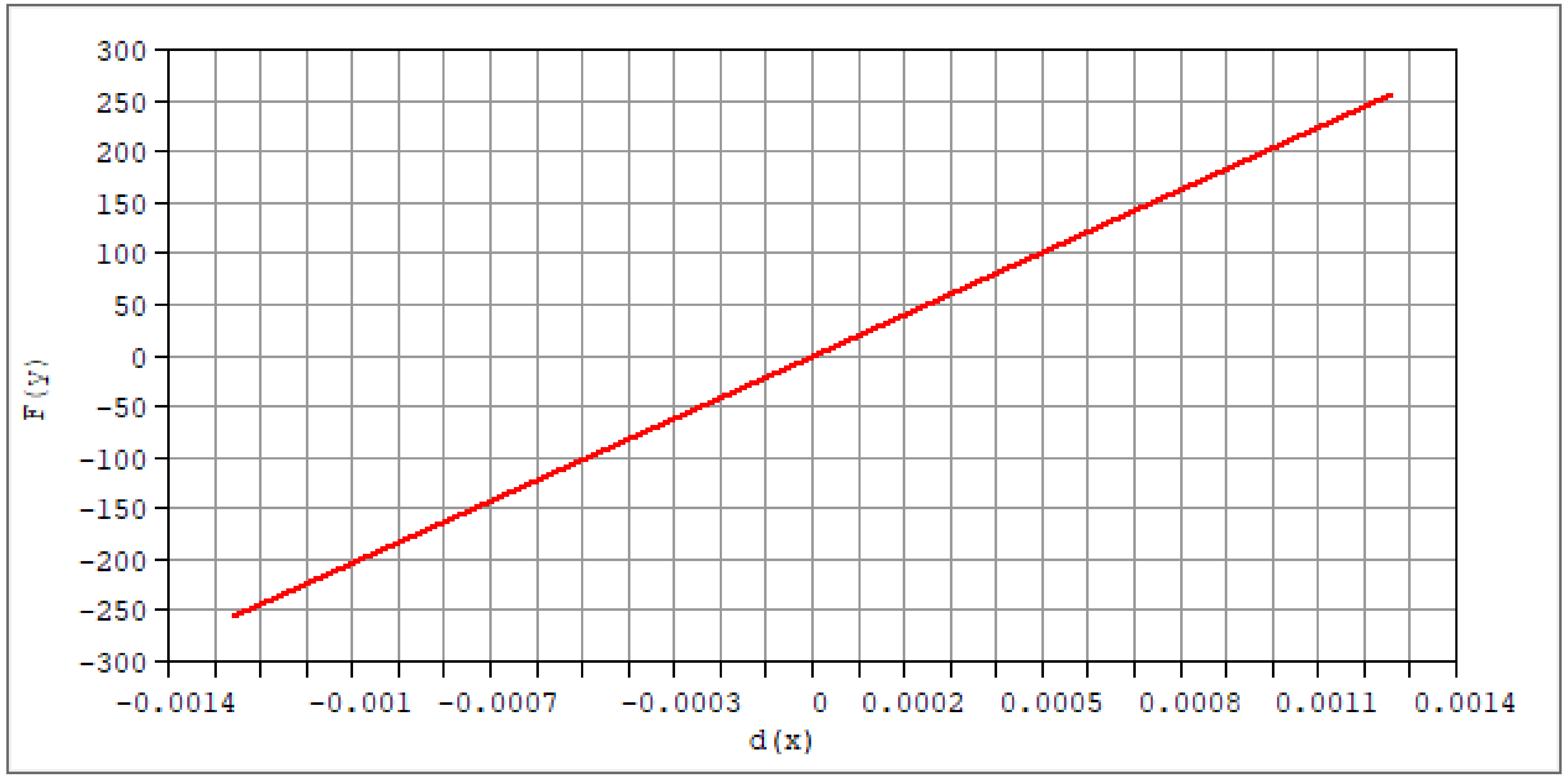
Linear Springs

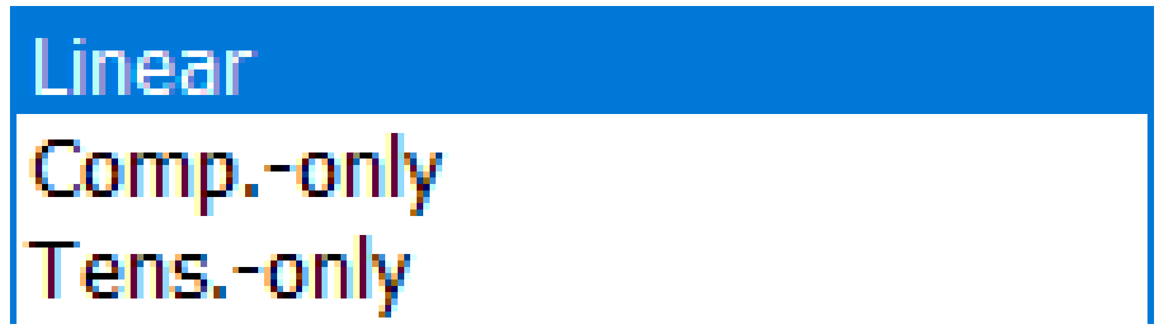
Shallow Foundations:

- Winkler Method
- Terzaghi (1955)
- Bowles
- Vesic (1961, 1973)
- Poulos & Davis (1974)
- Gazetas (1991)
- Kausel & Roesset (1975)

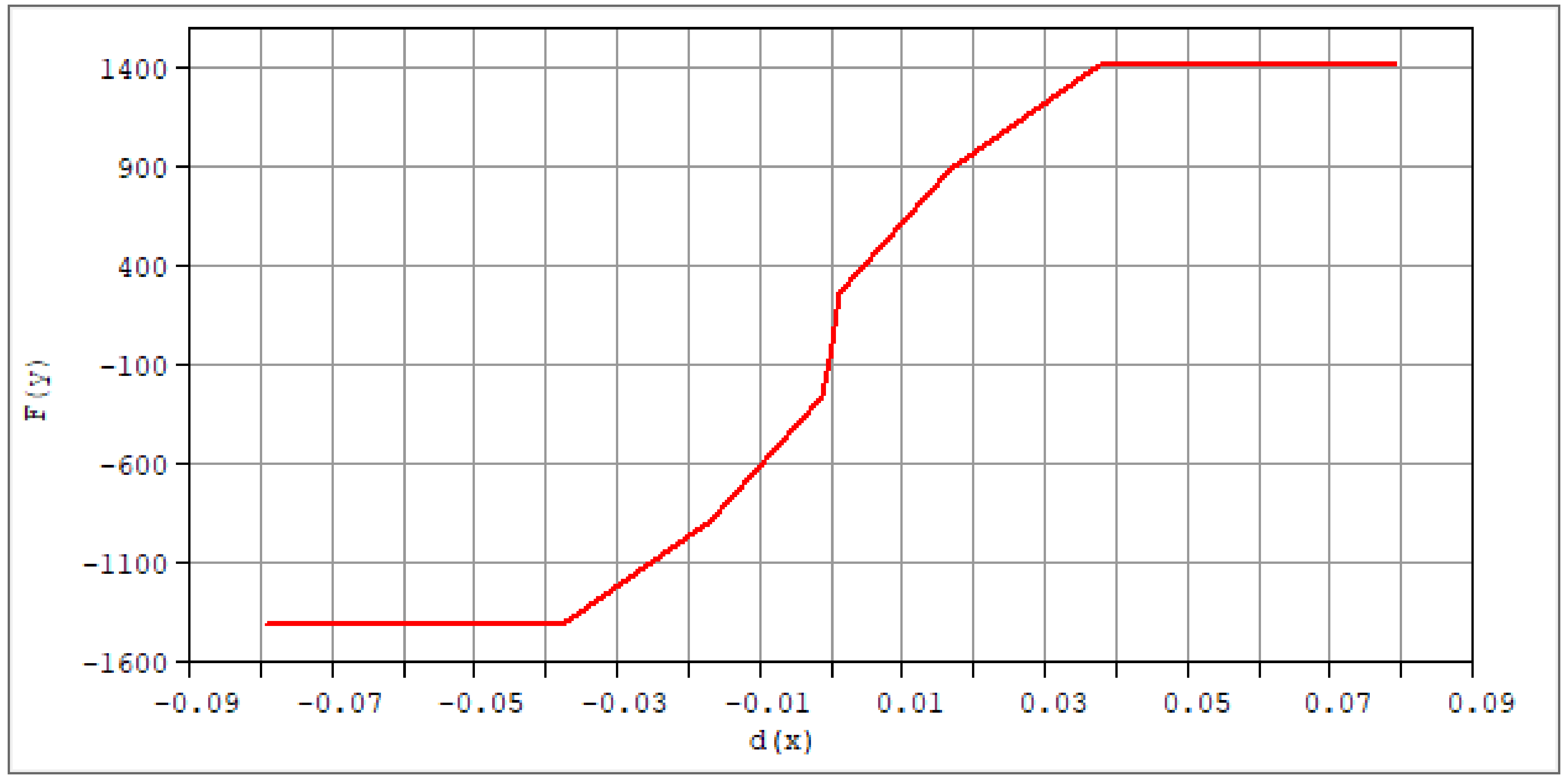
Piles:

- Randolph & Wroth (1978)
- Vesic (1977)
- Poulos & Davis (1974)
- NAVFAC DM-7





Multi Linear or Nonlinear

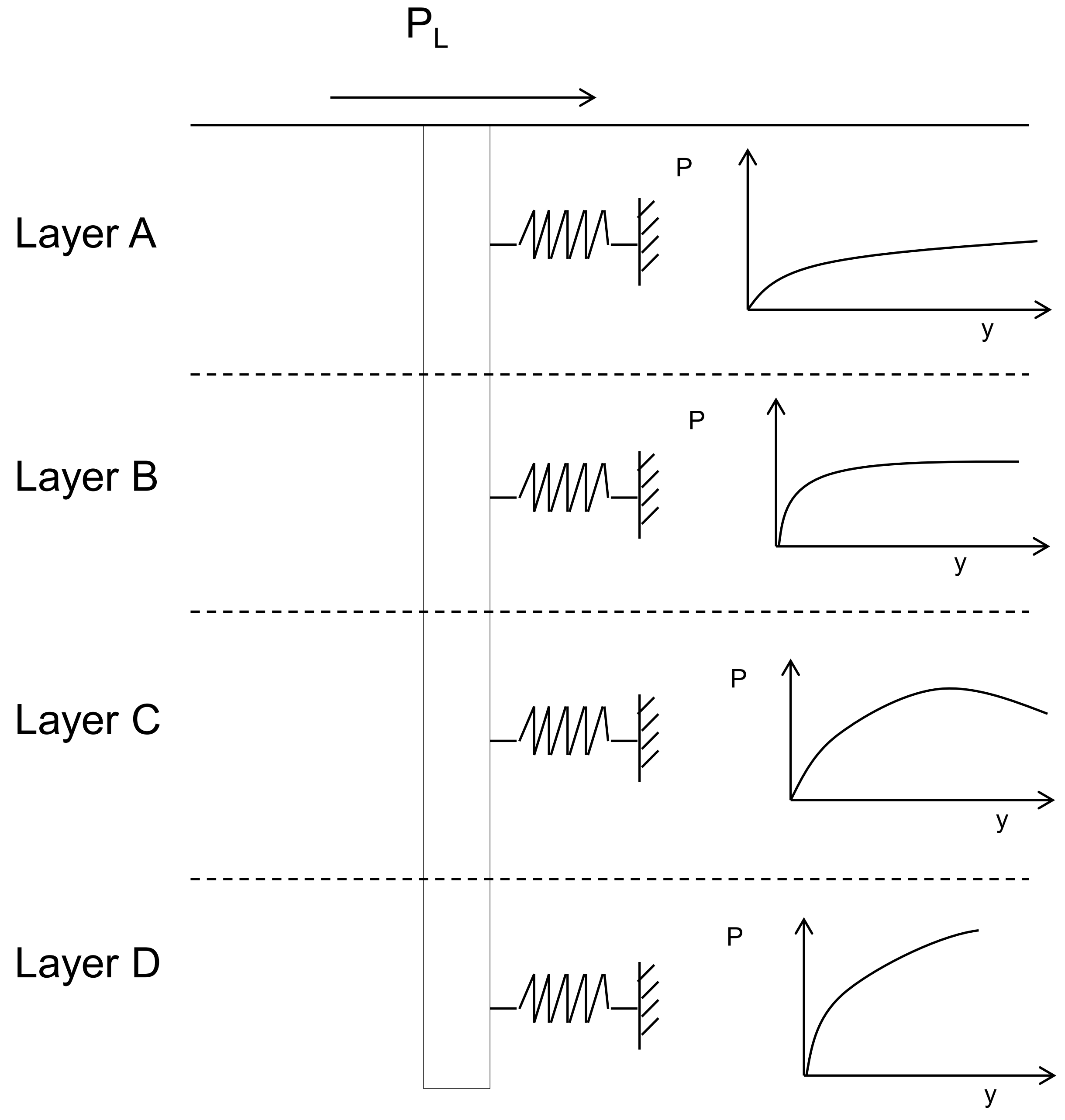


Shallow Foundations:

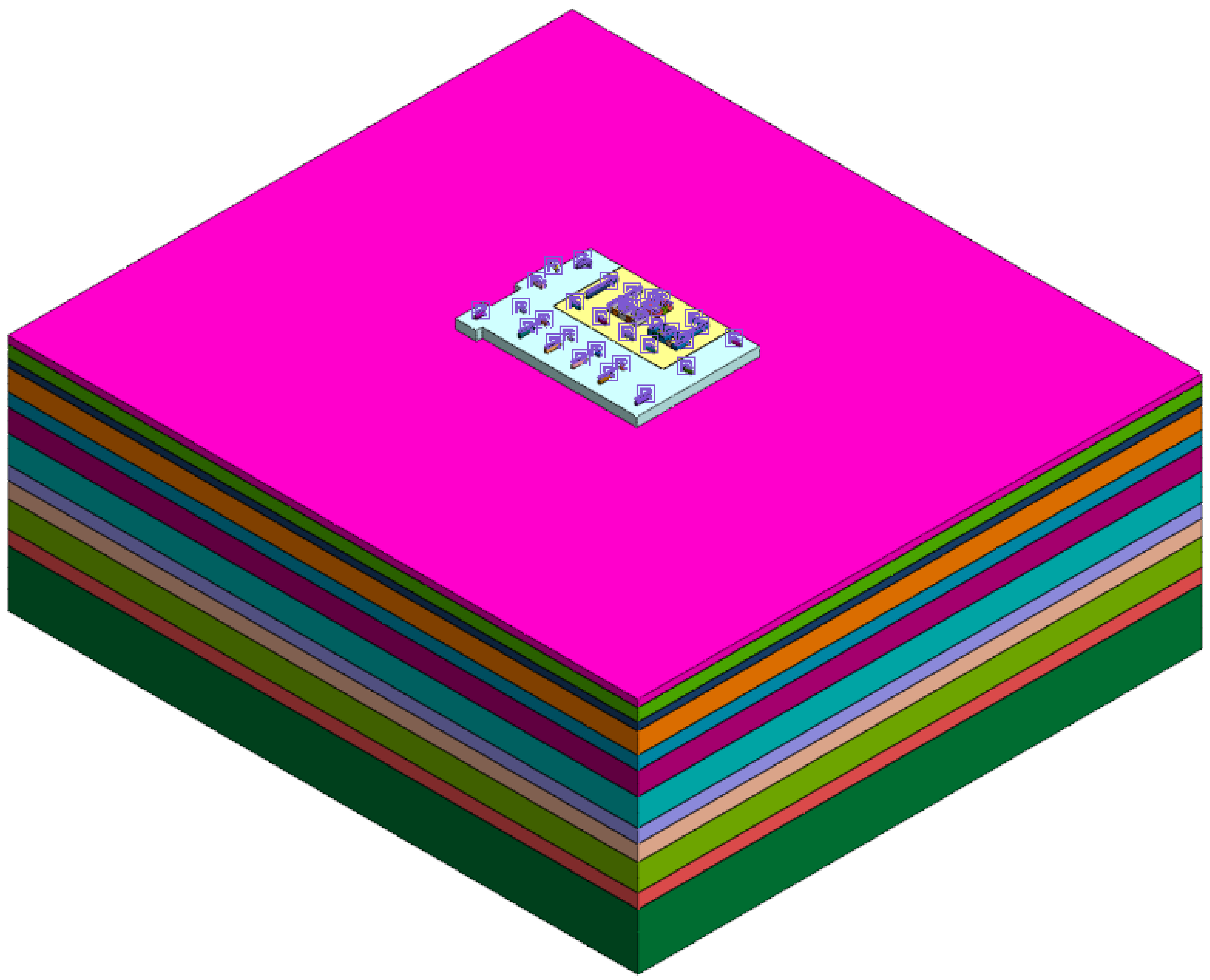
- Meyerhof (1965, 1967)
- Vesic (1973)
- Pressure–settlement curves from plate load tests – inherently nonlinear.
- Code-based nonlinear ks correlations (e.g., IS 2950, Eurocode 7, AASHTO with modulus variation).

Piles:

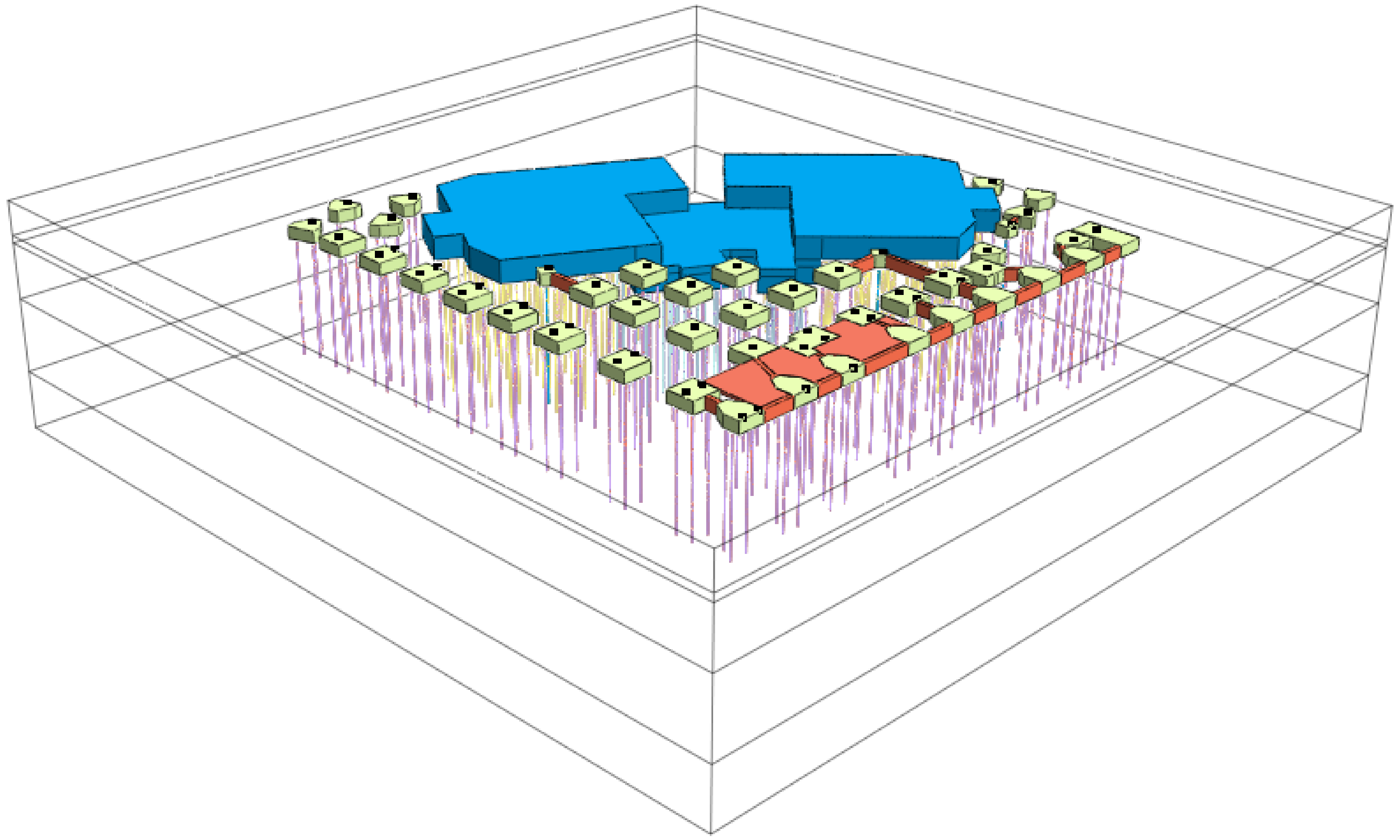
- Matlock (1970)
- Reese, Cox & Koop (1974)
- Reese & Matlock (1974)
- Coyle & Reese (1966)
- Vesic (1977)
- Reese & O'Neill (1987)
- API RP 2A / API RP 2GEO
- DNVGL-RP-C212
- FHWA NHI-05-046



Soil Continuum Method

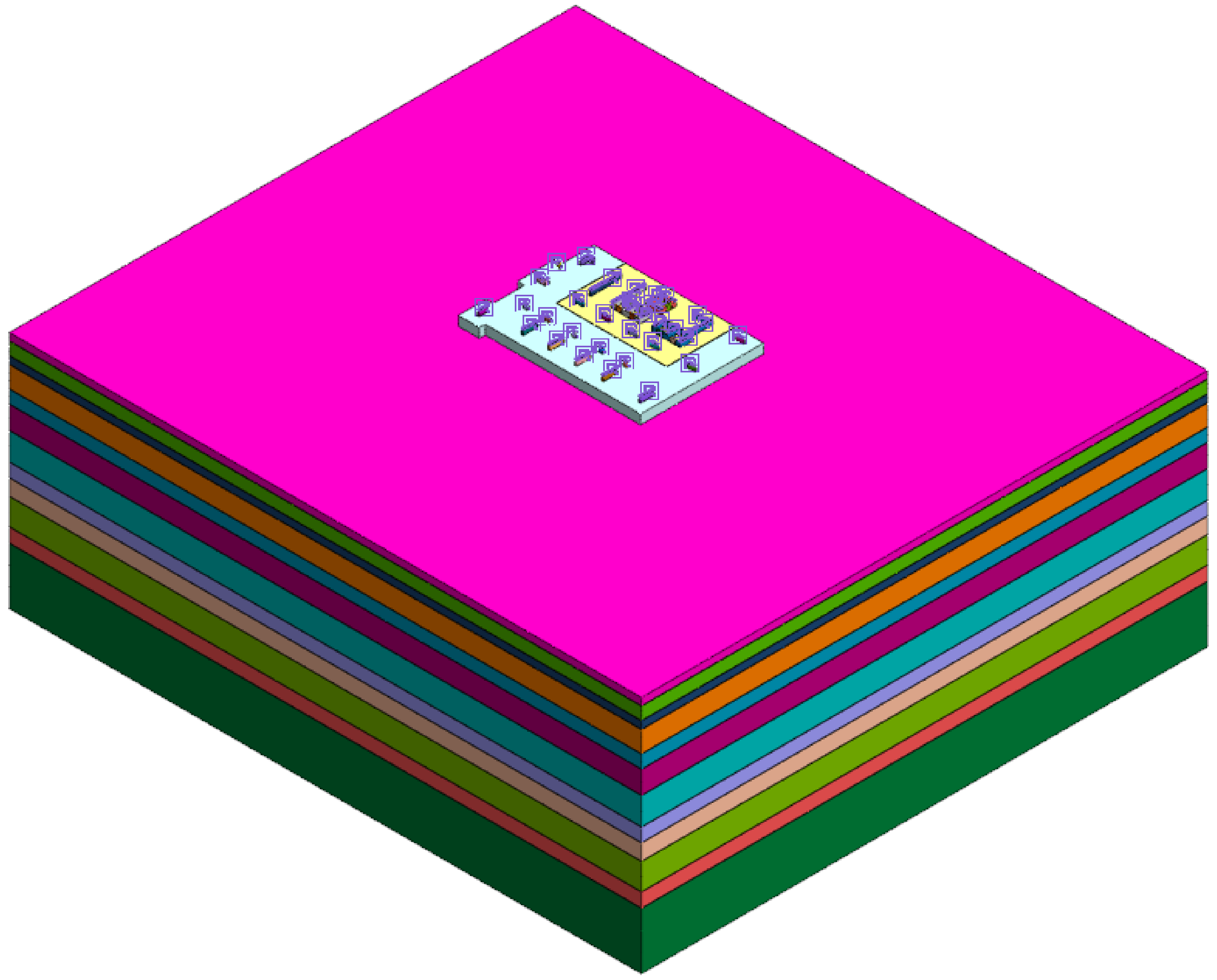


Raft Foundation - Soil Continuum Method

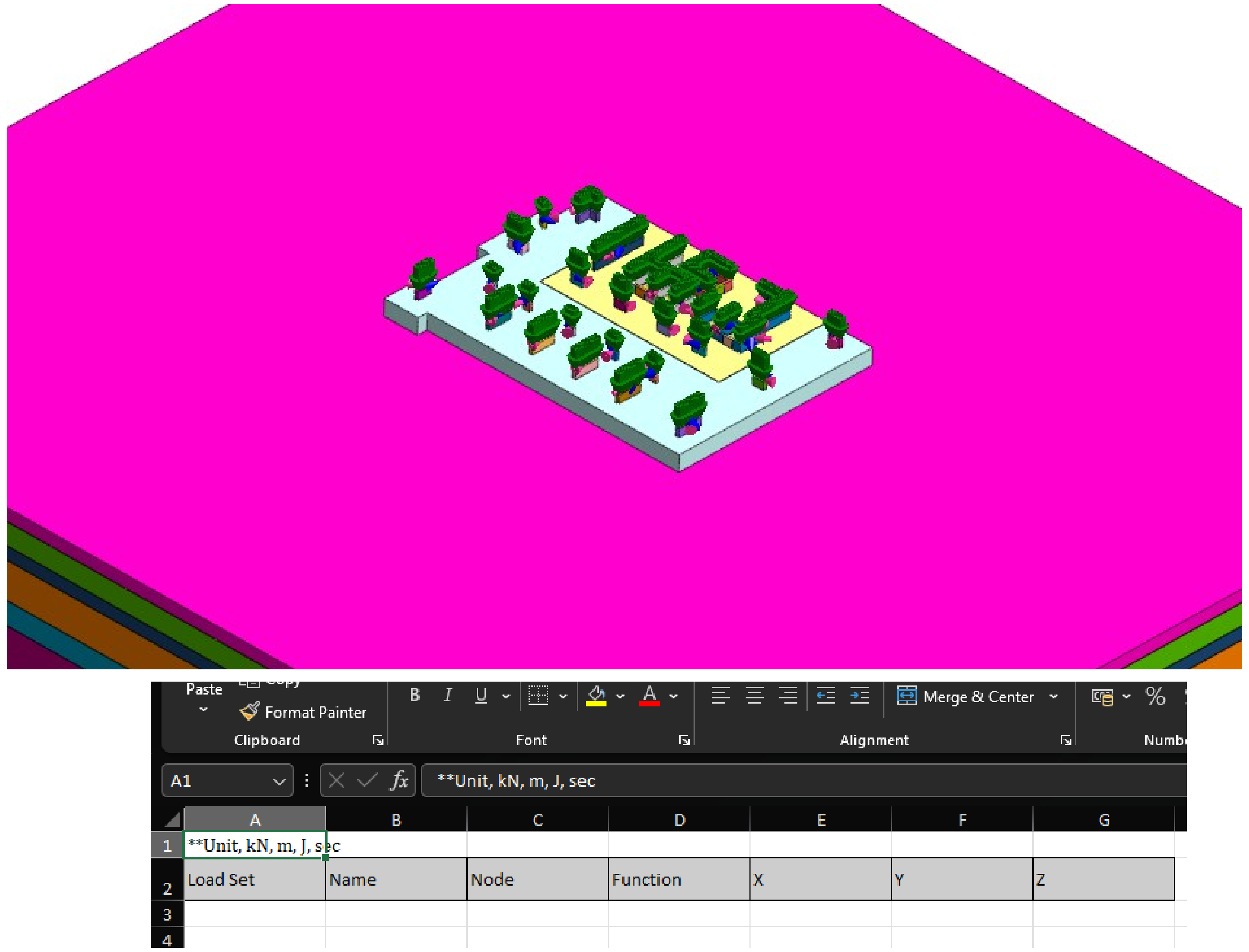


Pile Raft Foundation - Soil Continuum Method

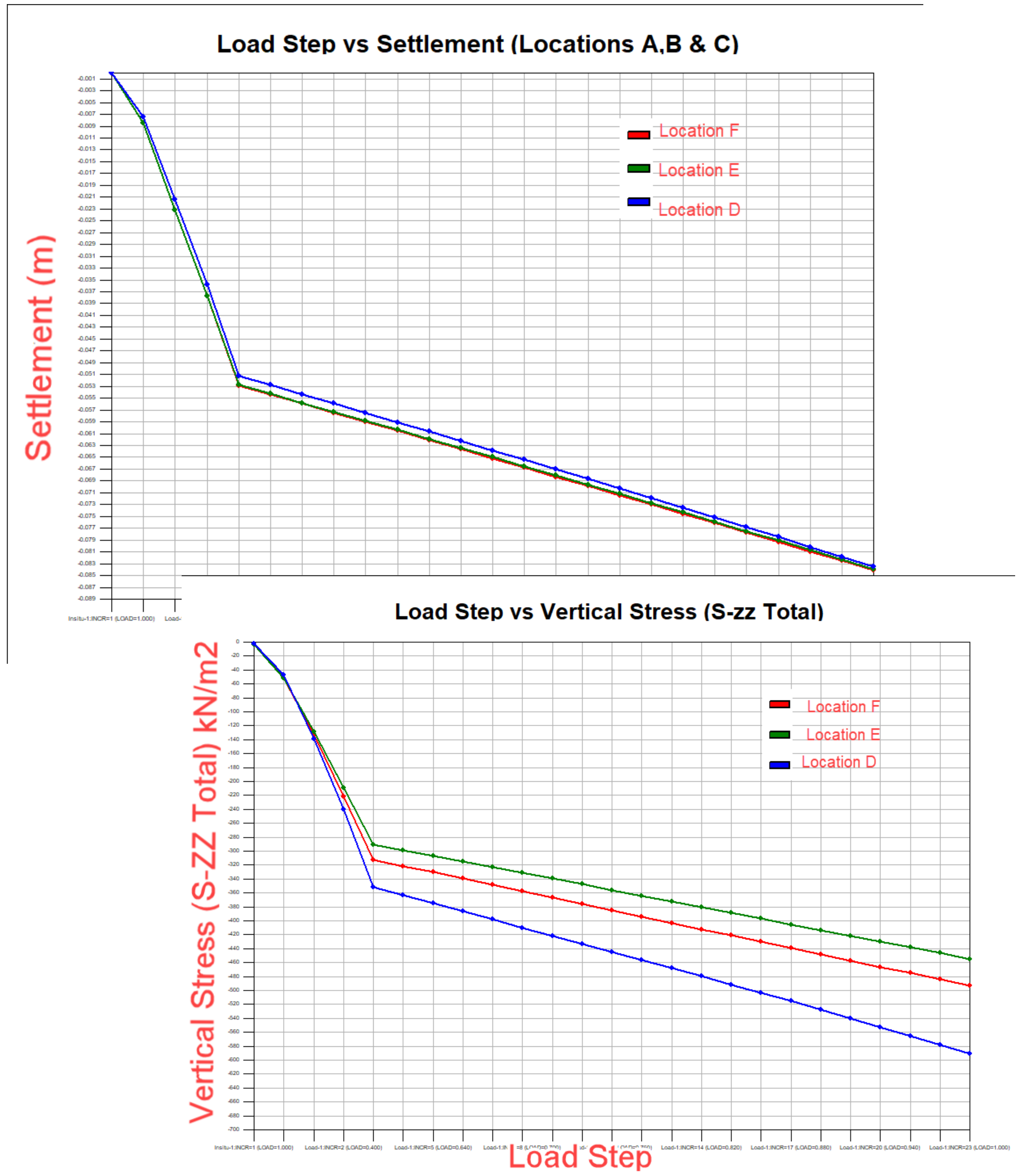
Soil Continuum Method – Application Procedure



Step-1:
Foundation and Soil Modeling

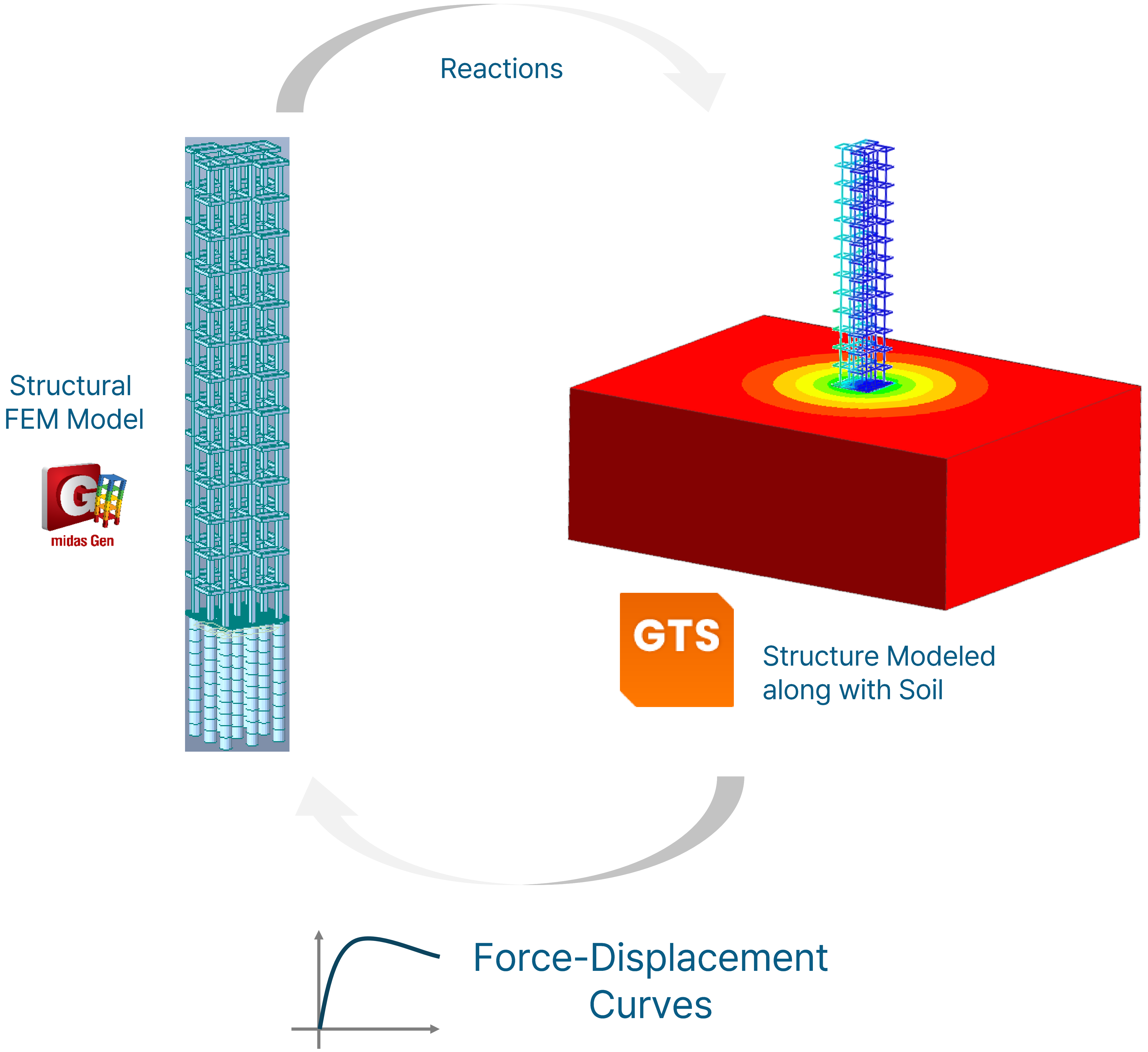


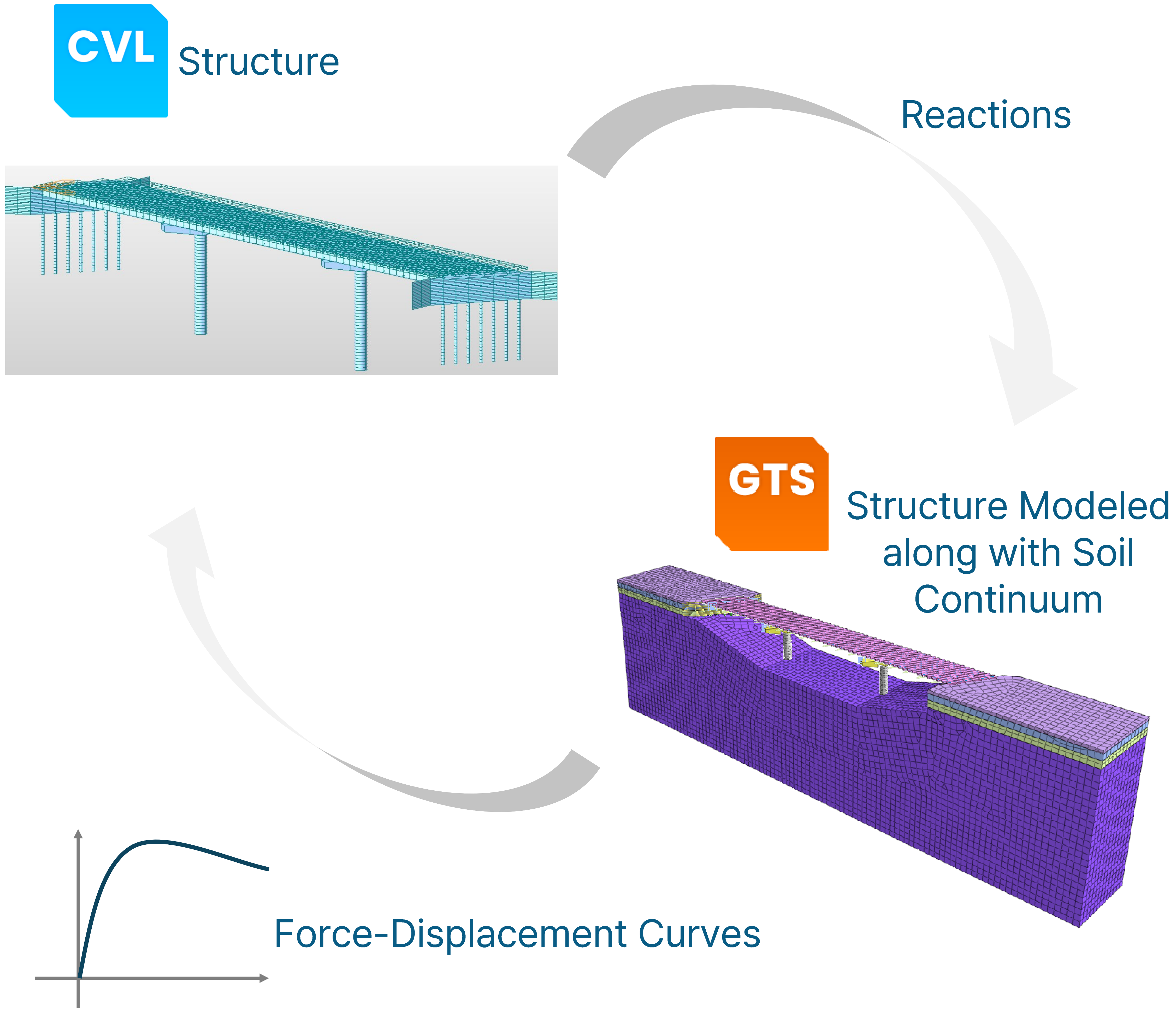
Step-2:
Load Table Import/Export Option.
(Load imported into GTS NX via excel sheet from any Structural tool)



Step-3:
Export the Stiffnesses back to Structural tool

Soil Continuum Method – Application Procedure – Fully Automated in MIDAS Products





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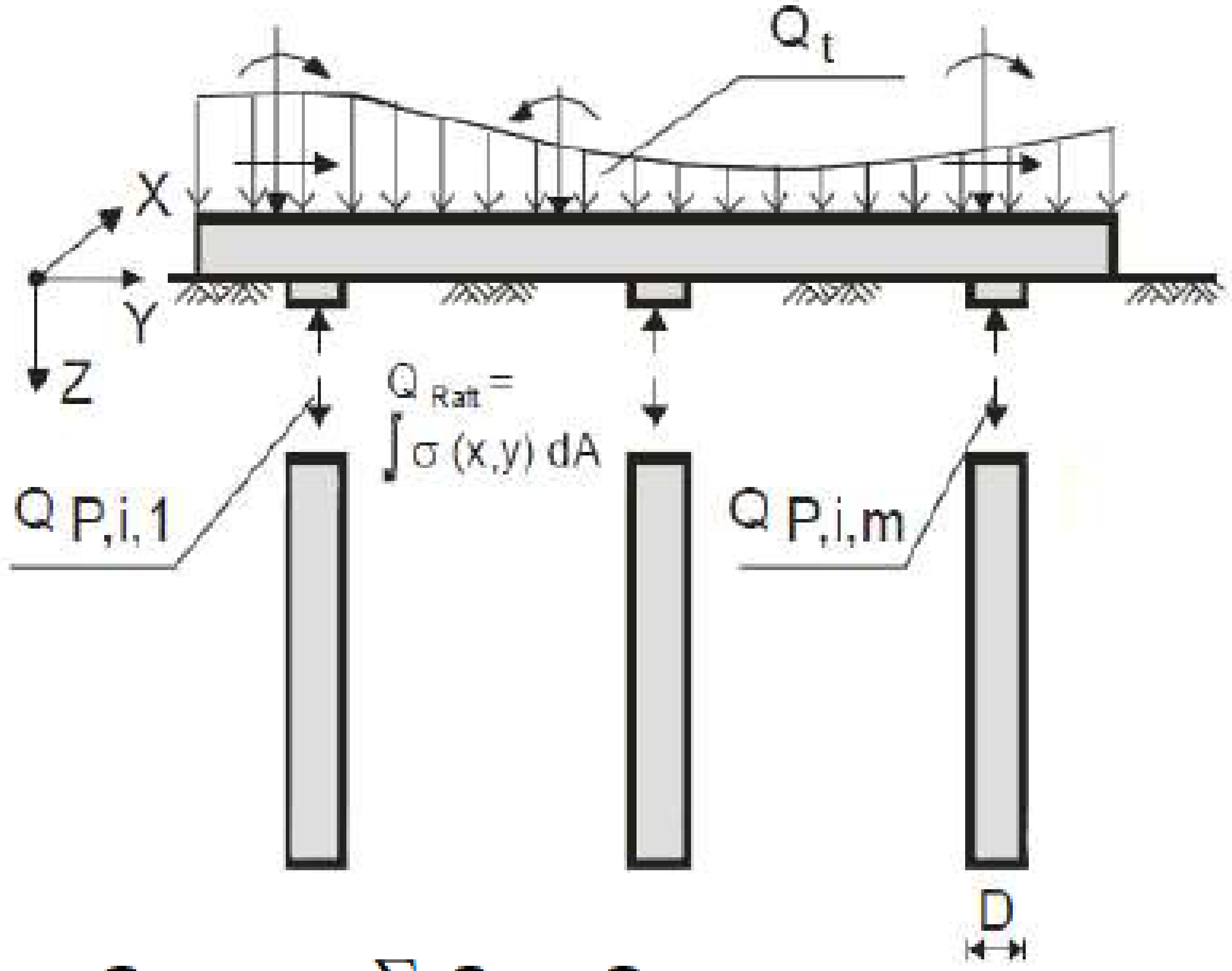
Pile Raft Foundation

Interactions

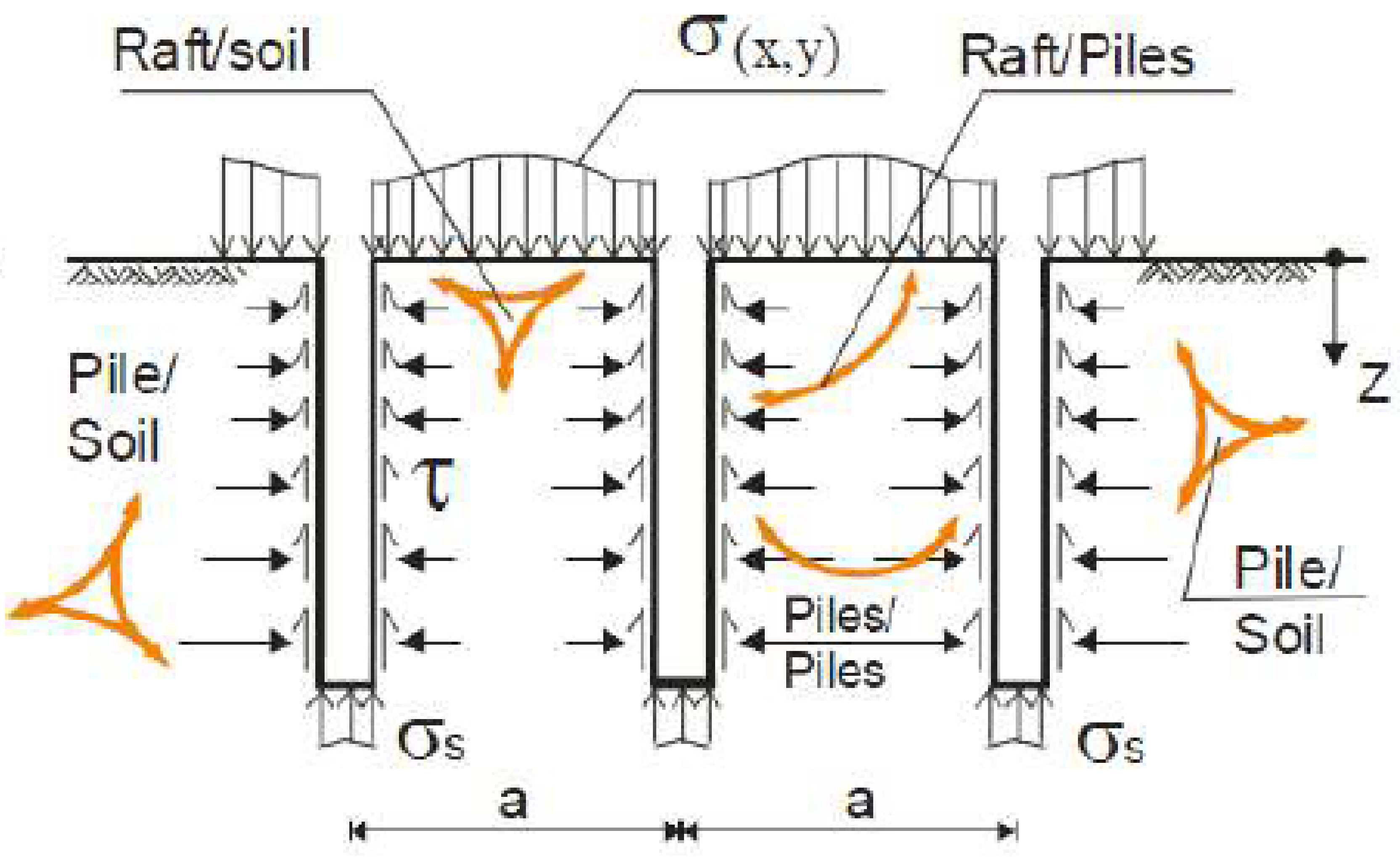


$$Q_{tot} = \Sigma\, Q_P + Q_R$$

$$Q_P = Q_b + Q_s$$

$$Q_R = \int \sigma(x,y)\, dA$$

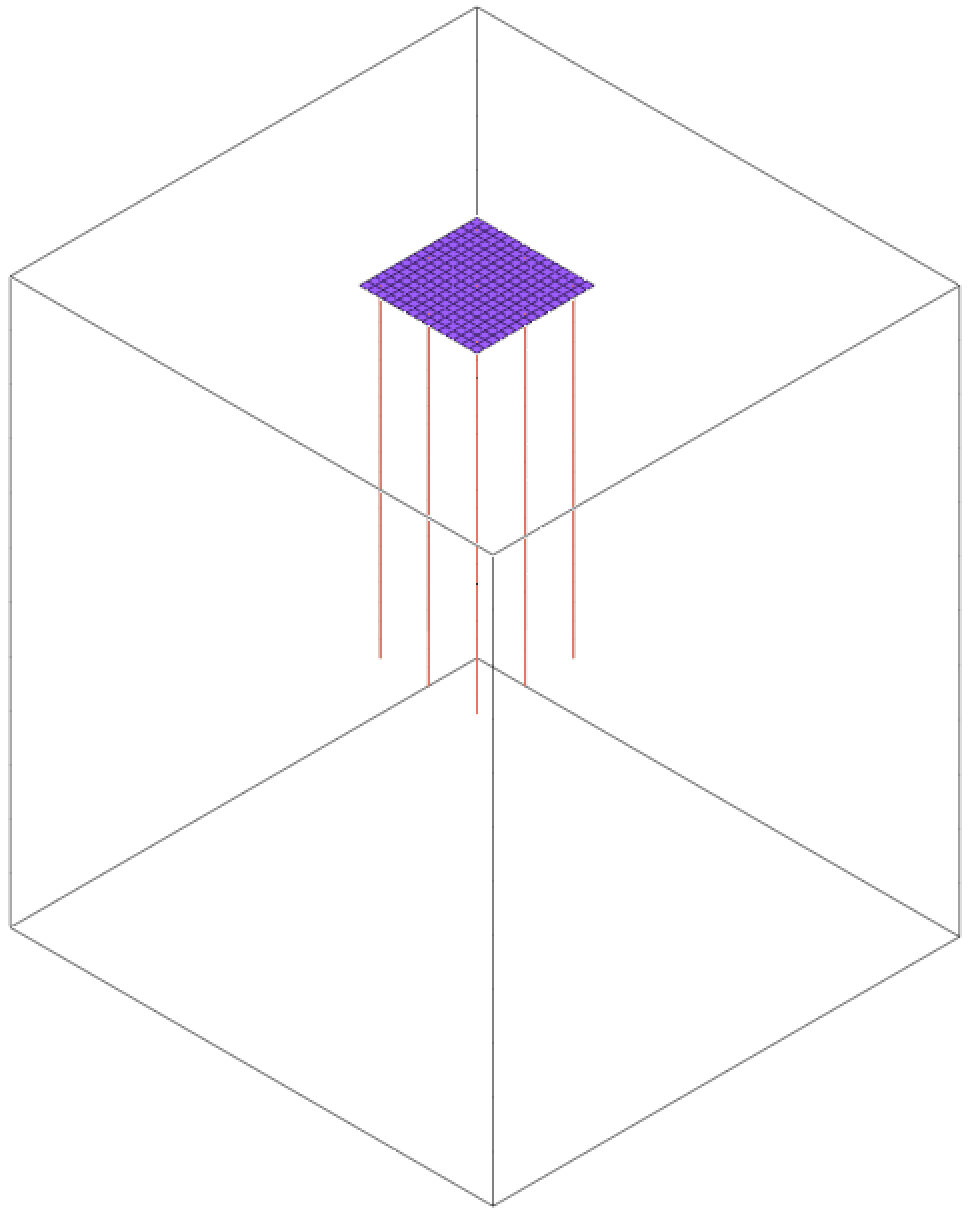
$$Q_{tot} \geq \eta \cdot \Sigma\, S_{tot}$$



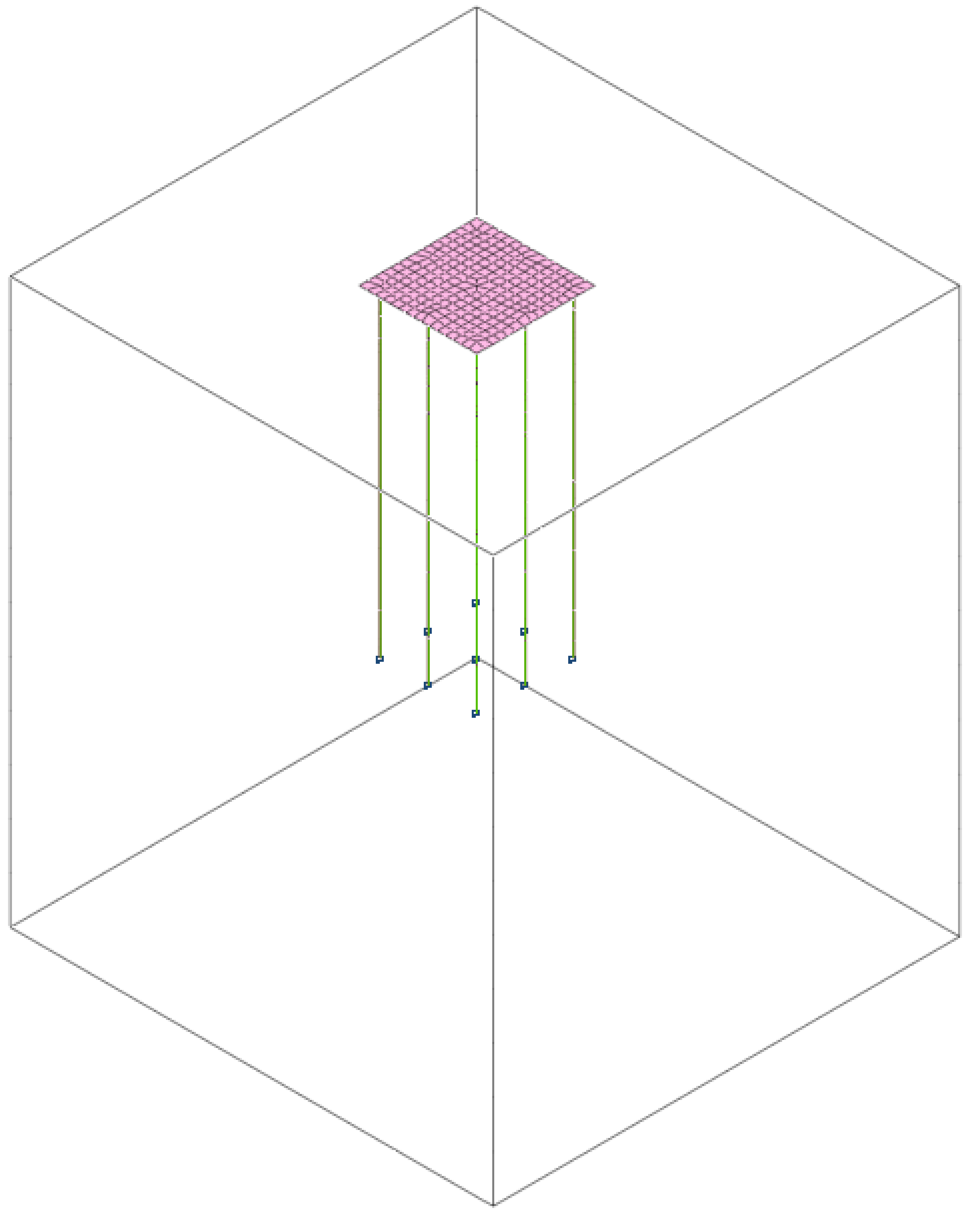
Interaction influences:

- Pile-Soil interaction
- Pile-Pile interaction
- Raft-Soil interaction
- Pile-Raft interaction

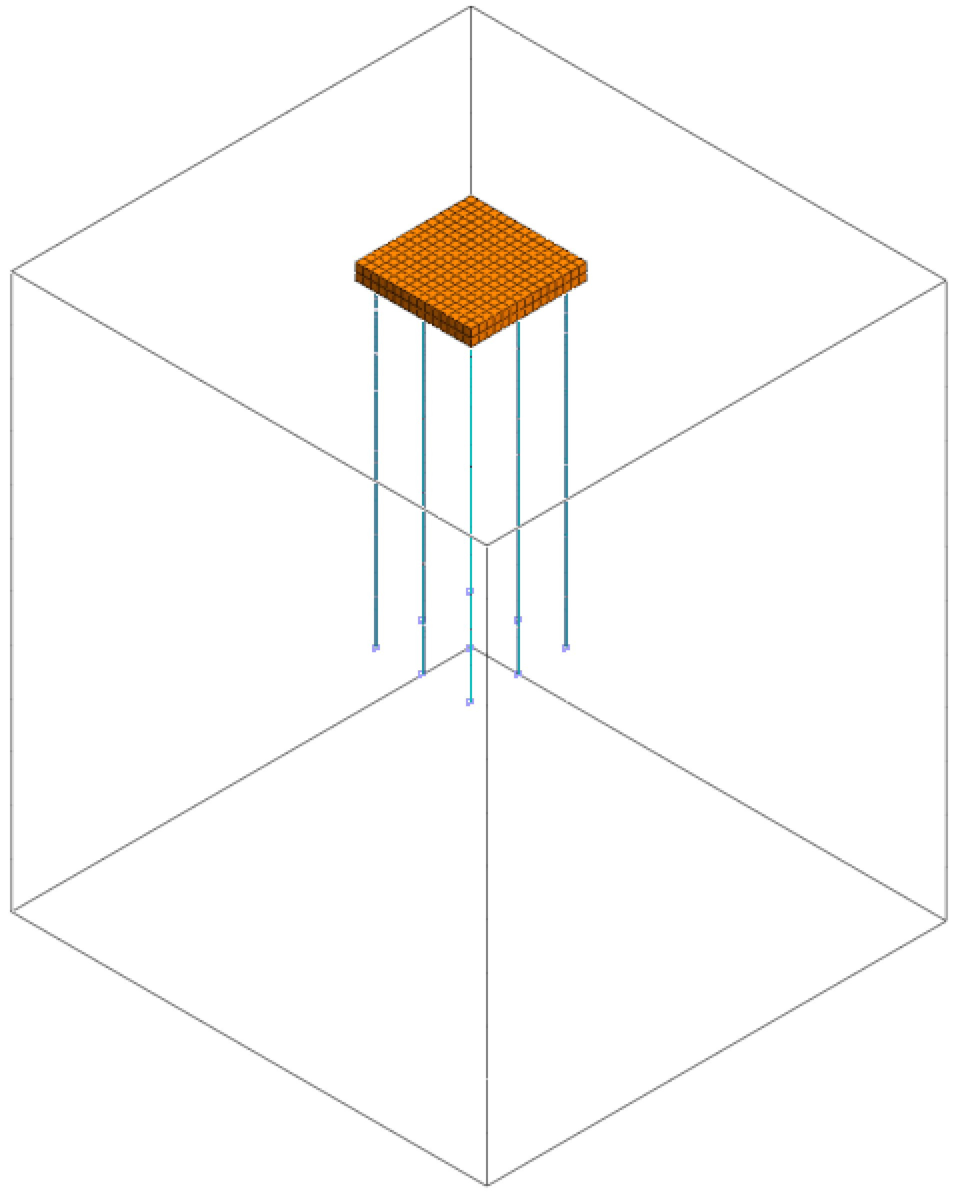
Different Ways to Model Pile Raft Foundation



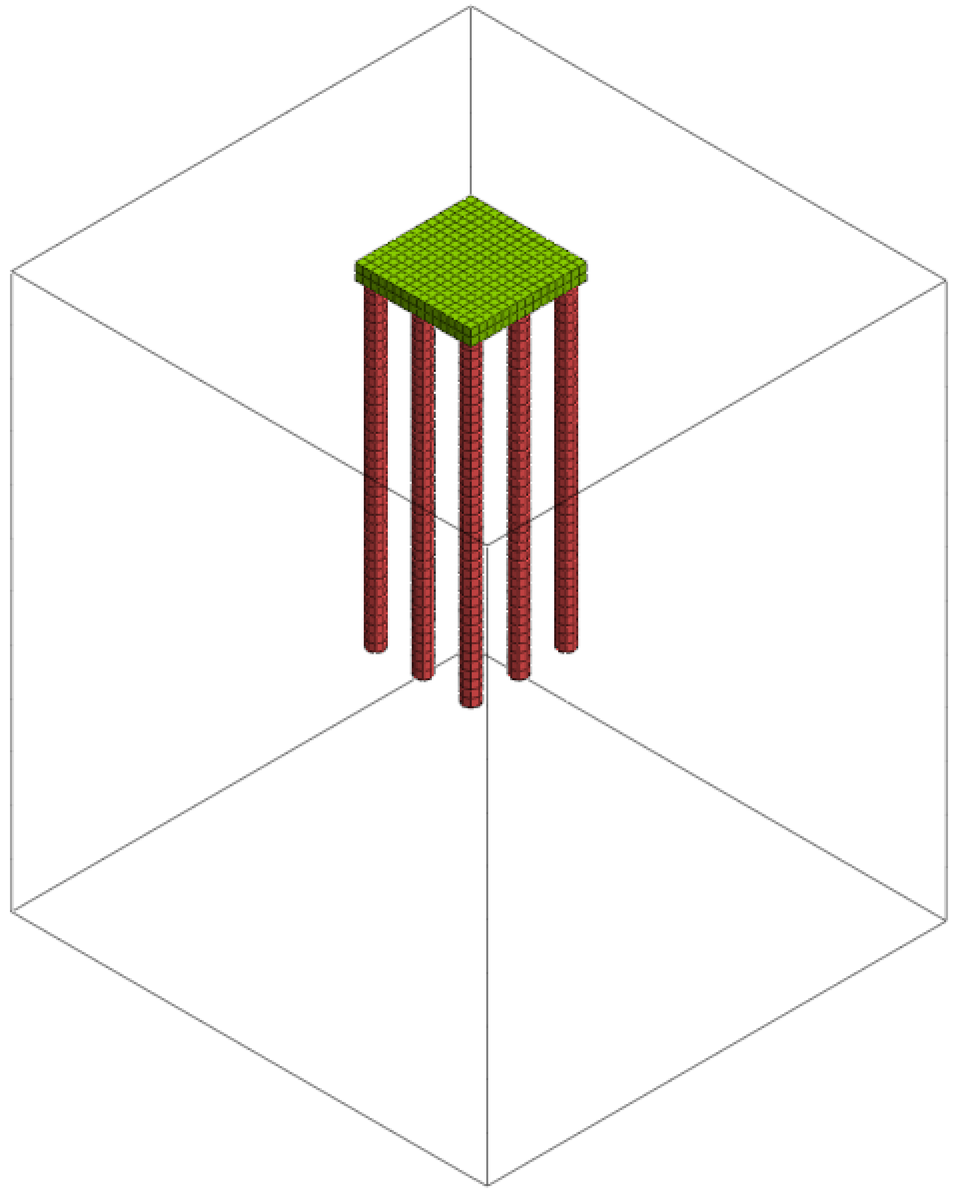
- Pile as Embedded Beam
- Raft as Shell Element



- Pile as Beam element with Skin Friction and End Bearing Definitions
- Raft as Shell Element



- Pile as Beam element with Skin Friction and End Bearing Definitions
- Raft as Solid Element



- Pile as Volumetric Element and Plane Interface is use for Skin Friction Definition
- Raft as Solid Element

In General,

- If **Pile is slender (L/D > 10-15)**, then Modeling it as **Beam is preferred**. For **Non-Slender or Short Pile/Large diameter** such as caissons, drilled shafts, **Volumetric Pile is preferred**
- Raft thickness is small compared to length and breadth; Shell is Preferred. If Raft is thick (t>~1/5 to 1/10 of length), solid raft is preferred.

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Let’s Model!!

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Conclusion

- Though there are multiple method for modeling of the pile raft foundation, the results may not be the same in all the methods.
- The SSI and the stress distribution may not be the same in all the methods.
- Shell and beam elements are preferred for quick assessment; Solids are preferred for detailed assessment.
- It is always necessary to calibrate the inputs with the field tests. Running a Back Analysis or Soil Test features of GTS NX would help in Calibration.

(The recent version of GTS NX offers Back Analysis/Optimization analysis that can help users to optimize the inputs for the given field test data)

Thanks for Attending!!