MIDAS GTS NX TRAINING ACADEMY 2025

ADVANCED NUMERICAL MODELLING AND ANALYSIS

MIDAS IT EUROPE

Pragati Saxena

SCHEDULE

Deep Excavation

February 04, 2025

February 18, 2025

Tunneling

Soil Structure Interaction

March 04, 2025

March 18, 2025

Ground Improvement

3. SOIL STRUCTURE INTERACTION
MODELLING AND ANALYSIS

CONTENTS

Session 3. SOIL STRUCTURE INTERACTION

Soil Structure Interaction

- **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

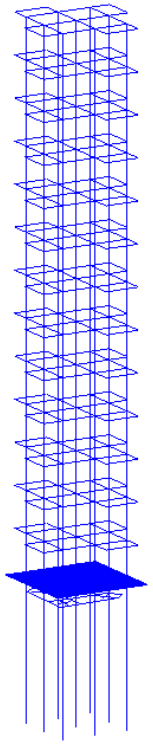
Force on Deck and Pier depends on,

– Location of the foundation

– Flexibility of foundation

– Supporting Soil Behaviour

Soil Structure Interaction Methods



1. Substructure Method

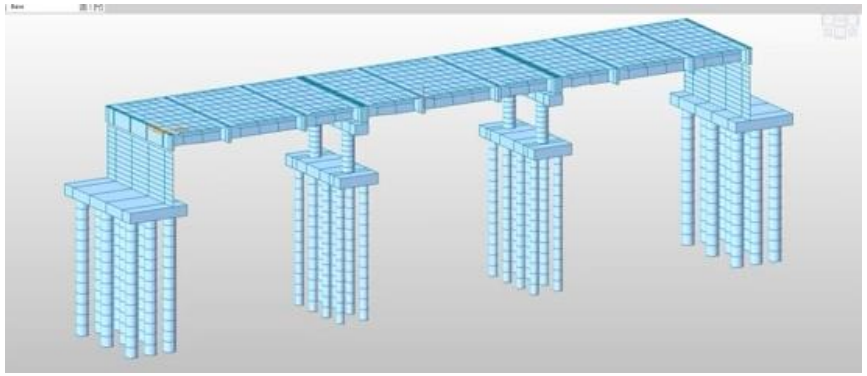
Also known as Indirect or Superposition Method.

Soil and Structure Interaction is analyzed by separating them into two separate structural systems:

1) Free Field Analysis: The reaction / response of the soil is determined
(mainly where the structure will be)

2) 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

Example: Winkler Springs, Springs from Empirical Equations, etc



Soil Structure Interaction Methods

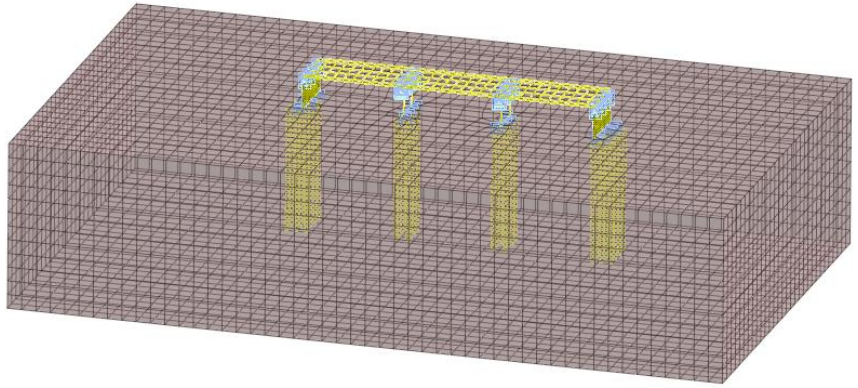
2. Direct Method

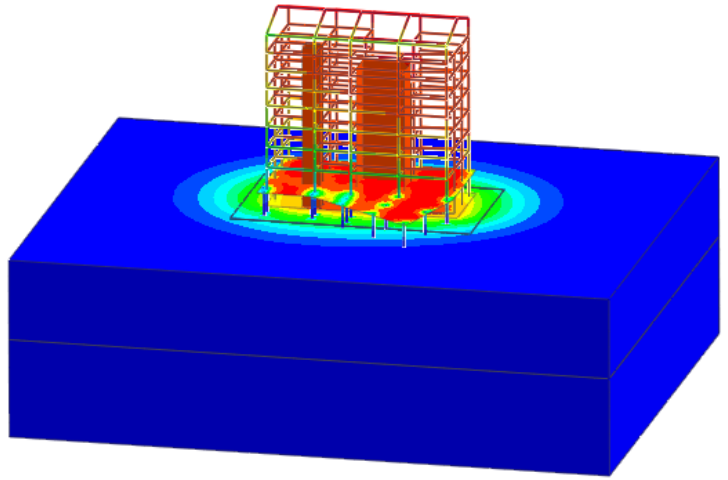
Soil and Structure- Single System

Seismic/ Other forces defined at the outer boundary of the single unified model

Responses of the soil and the structure- determined simultaneously

Numerical methods: Continuum Methods FEM, FDM



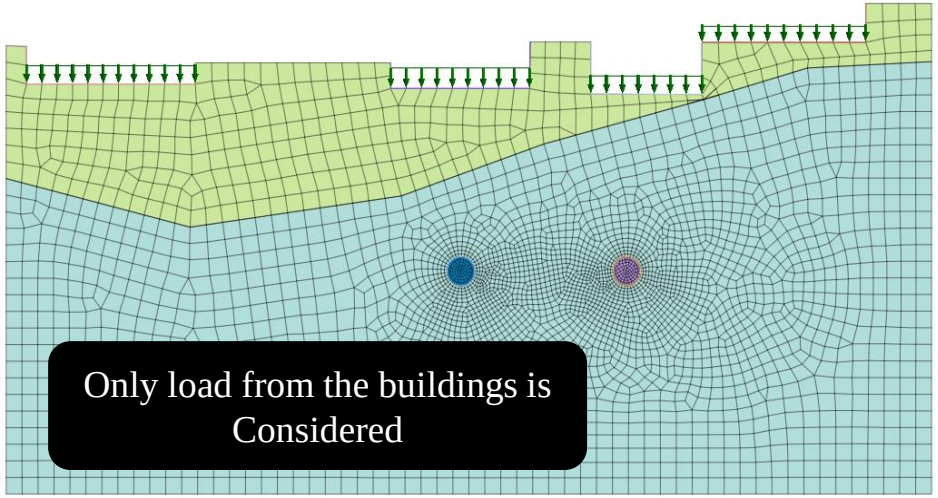


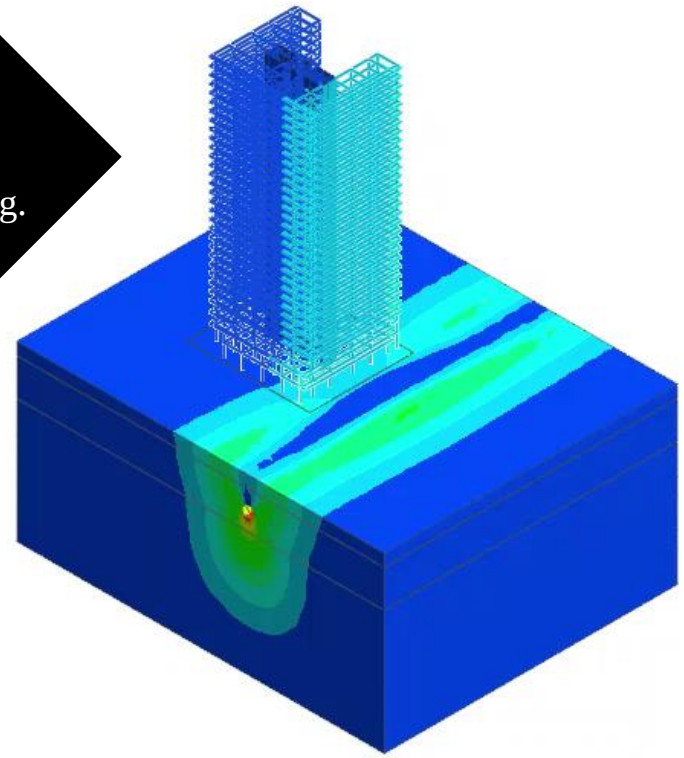
SSI: APPLICATIONS

SSI: Applications

- Considering the WHOLE Super Structure in Continuum modelling

The building along with foundation is considered. Hence Differential Displacement can be easily estimated which in real results in cracks in the building.



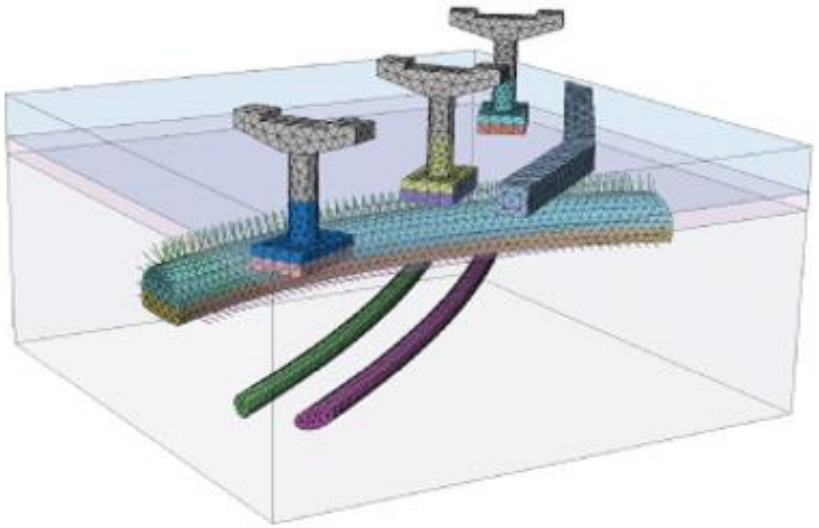


Regular Approach

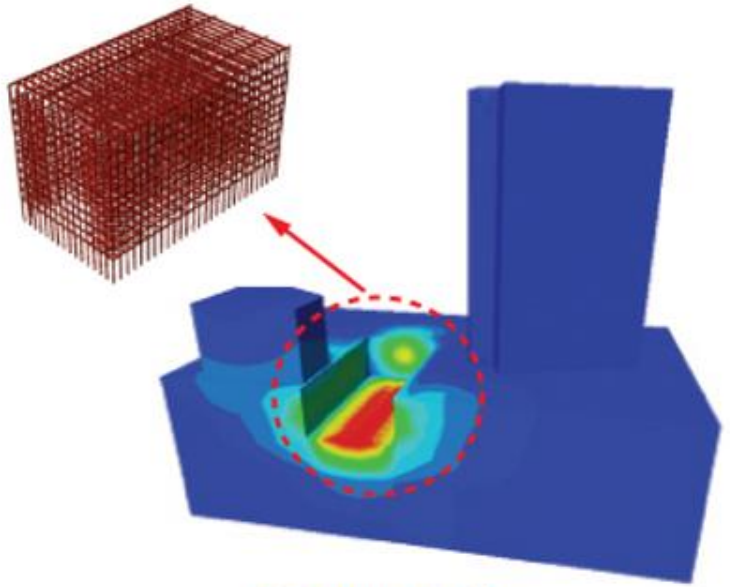
Best Approach

SSI: Applications

- Effect of Tunnelling on Adjacent Structures



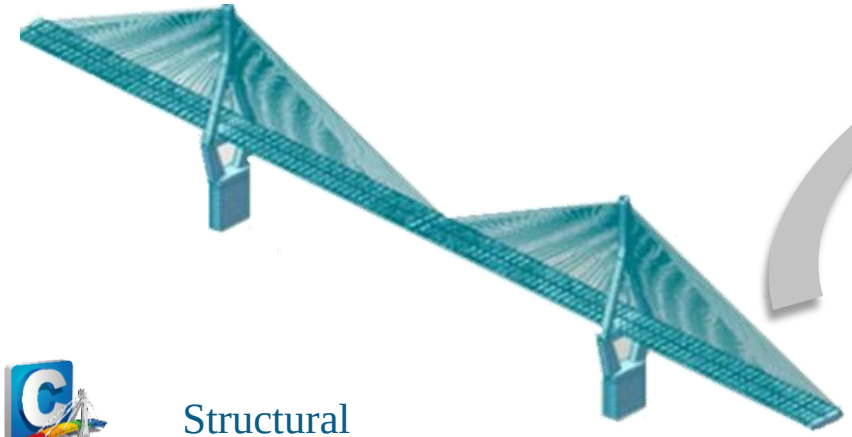
Adjacent Structures



Subway station
(H-Pile+slurry wall)

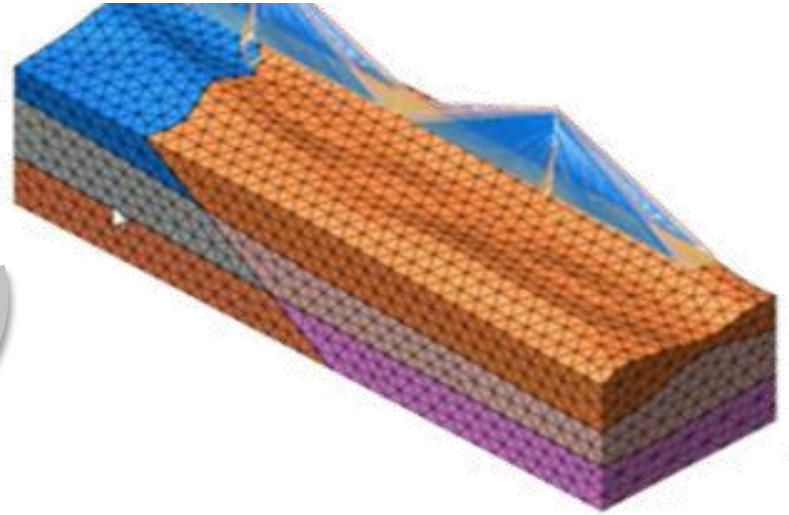
SSI: Applications

- Design Optimization Studies- using Interoperable Midas Programs



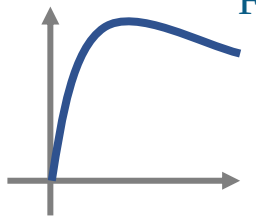
Structural
FEM Model

Reactions



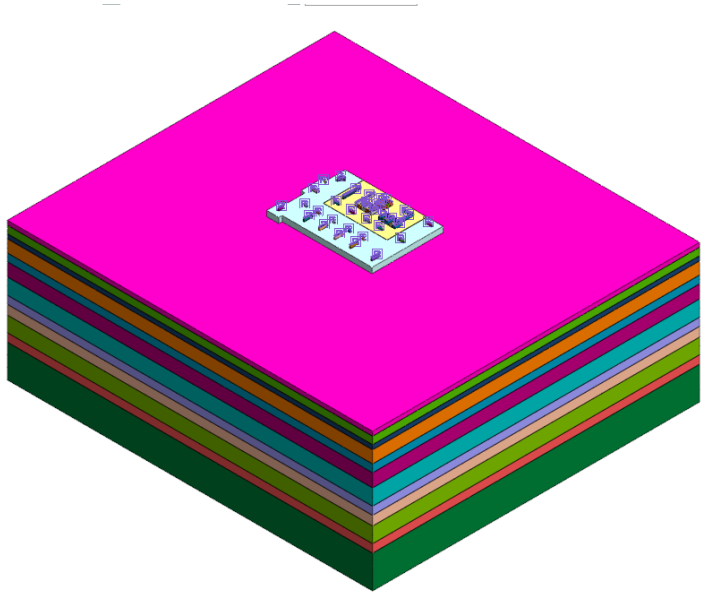
Structure Modeled
along with Soil

Force-Displacement Curves

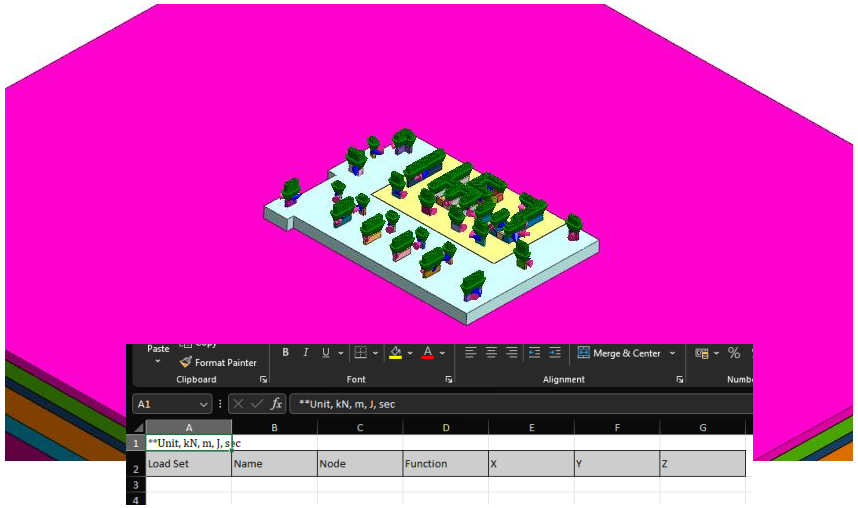


SSI: Applications

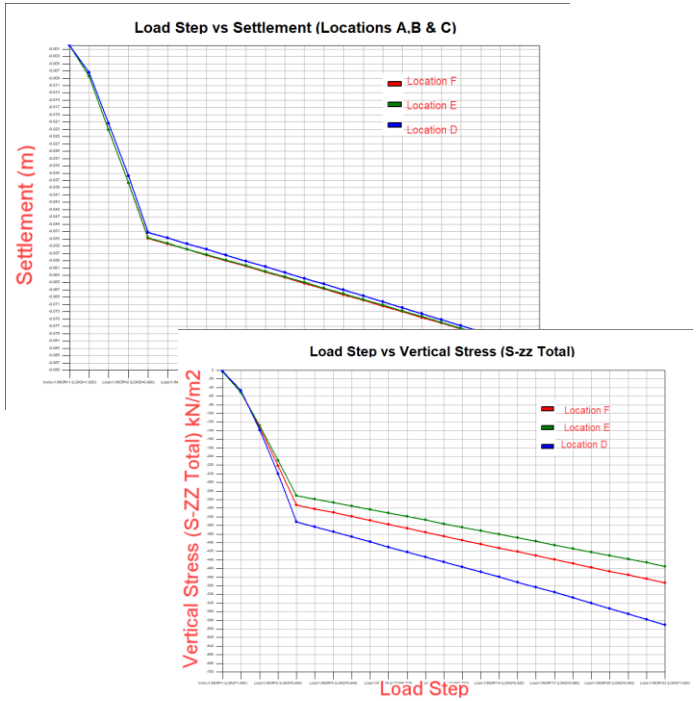
- Design Optimization- Manual



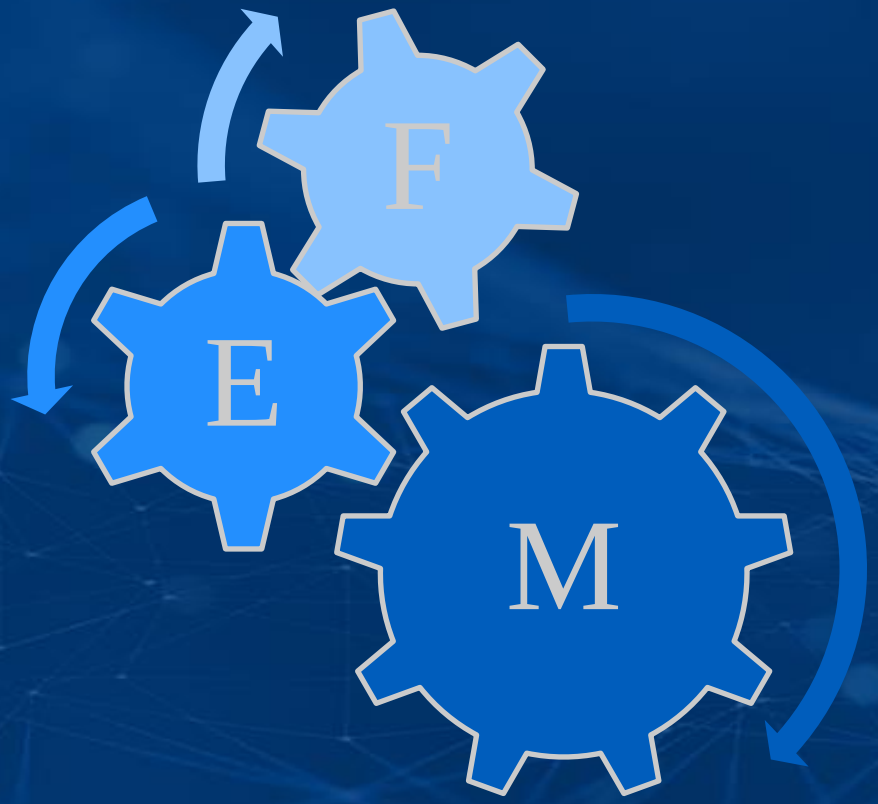
Step-1:
Foundation and Soil Modeling



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



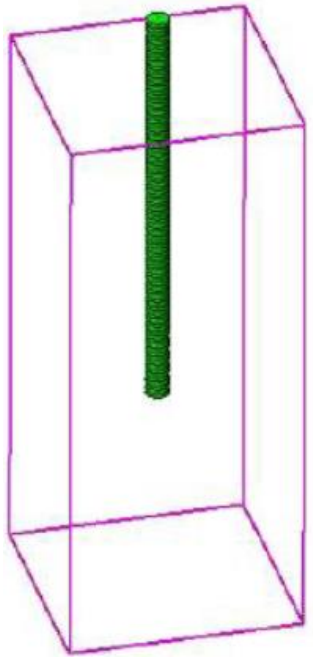
Step-3:
Export the Stiffnesses back to Structural tool



GTS NX ANALYSIS CAPABILITIES

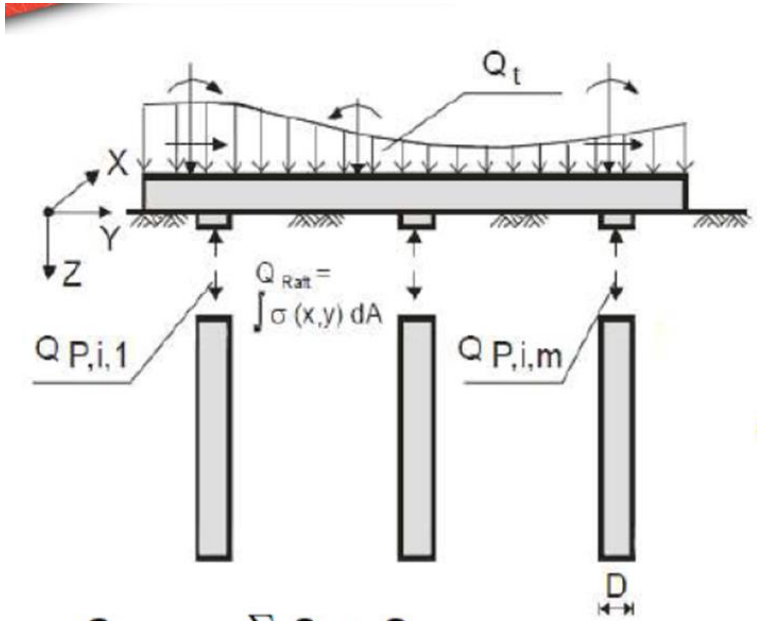
Pile Modelling Techniques

3D Solid + 3D Pile + Plane Interface



3D Solid + 1D Pile (Beam) + Pile Interface

Interactions

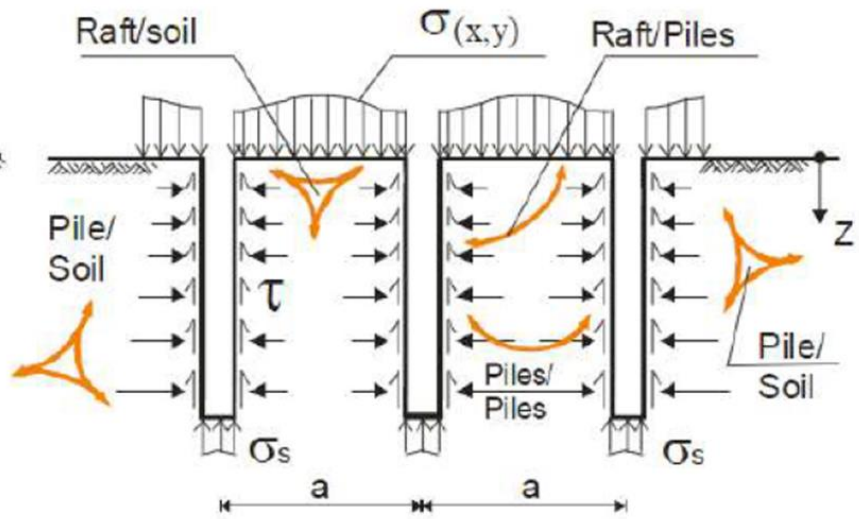


$$Q_{tot} = \Sigma Q_P + Q_R$$

$$Q_P = Q_b + Q_s$$

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

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

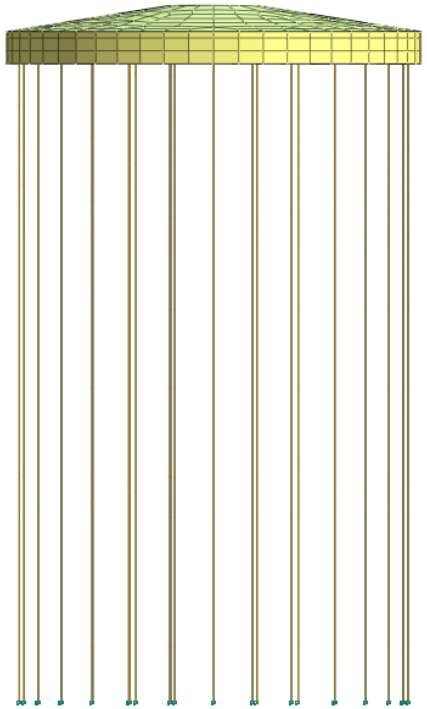


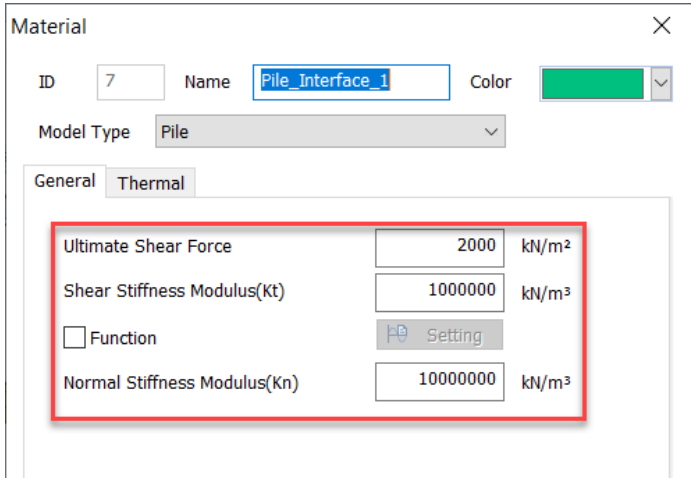
Interaction influences:

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

Pile Interface

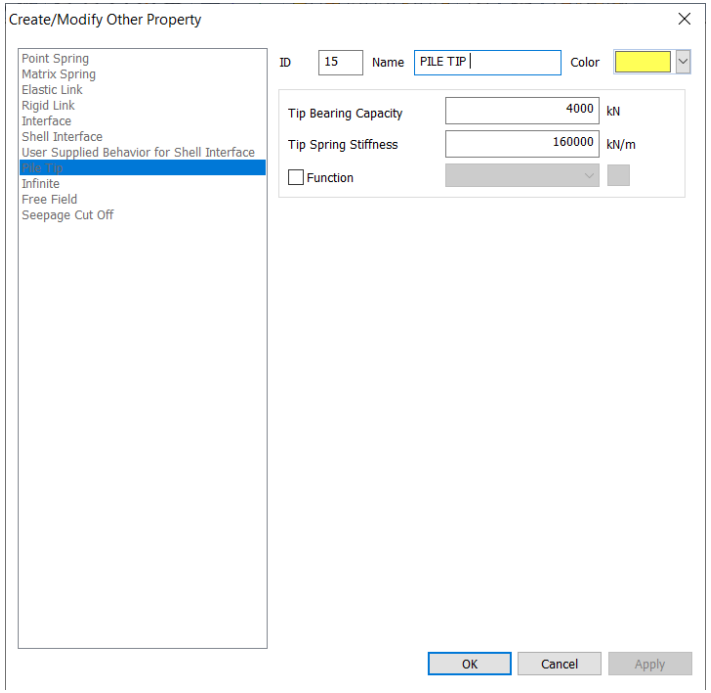
Important To Create a 3D model For These Foundations As Pile Group Effect is Ignored In 2D Models.





Friction Piles

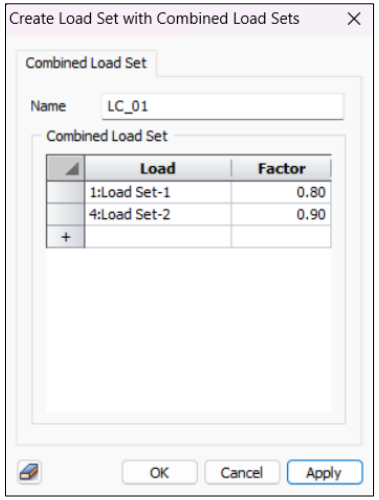
Easy Inputs For Modelling Pile Behaviour Based On Design Needs

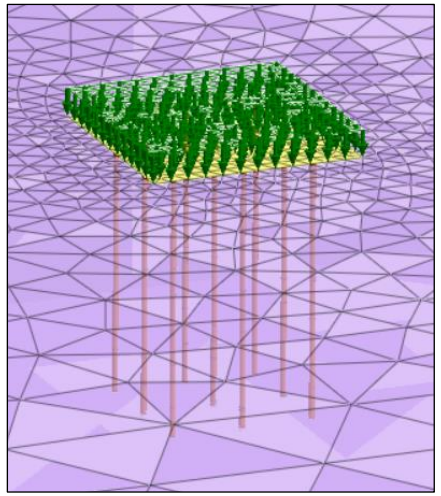


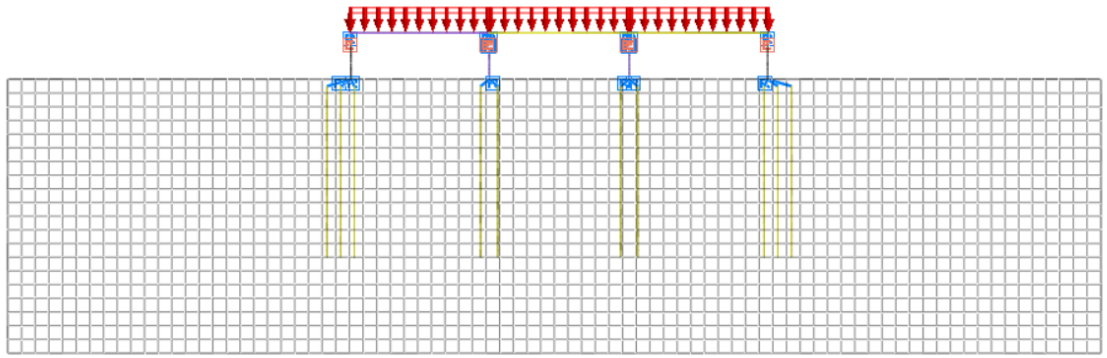
End Bearing Piles

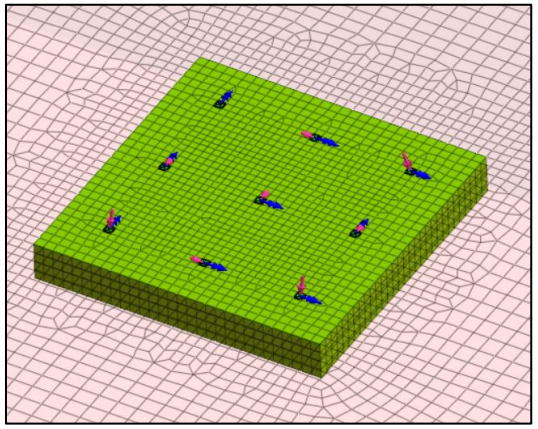
Advanced Loading Features

- Directly add point loads, moments, surface loads etc. to the model
- Create Load Combinations
- Import Load Data from Excel





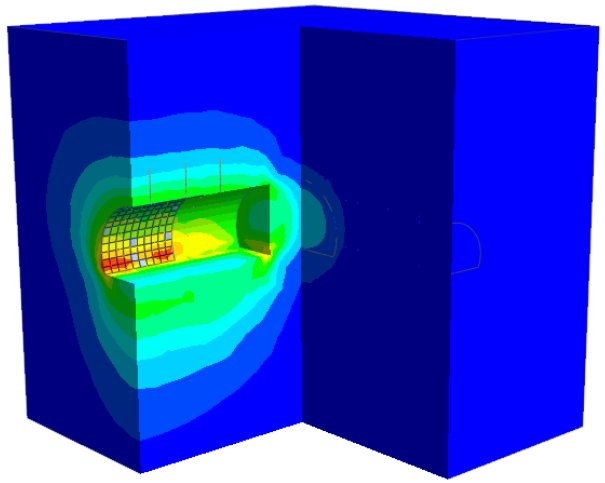


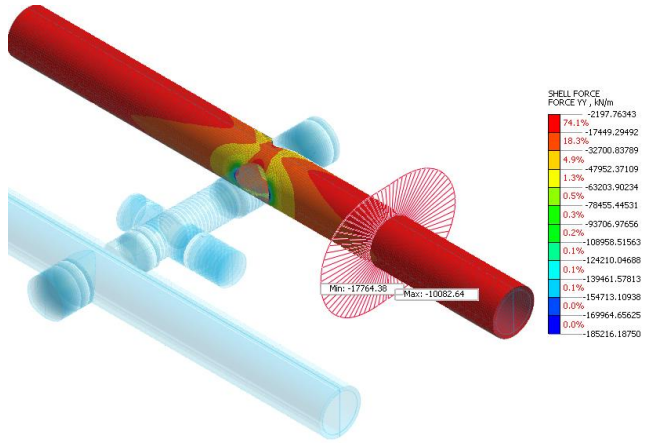


Loads acting at column locations on Raft

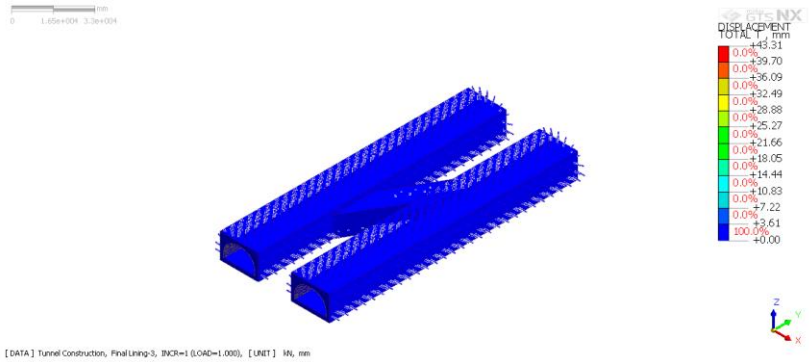
Post Processing Features

- Contours
- Graphs
- Animations
- Tables
- Cutting Plane
- Sections Diagrams
- Reports
- Result Tag/Probing

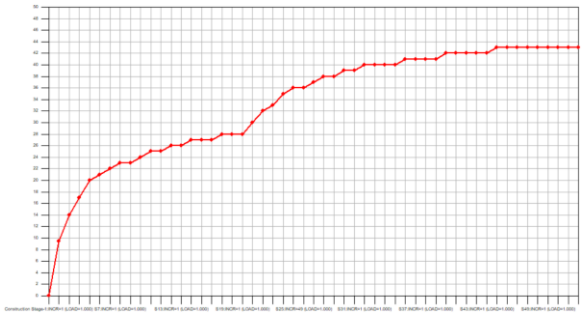




Sectional View: Clipping Line/Plane



Result Extraction as Image, Animation, Video Excel, pdf, Word formats

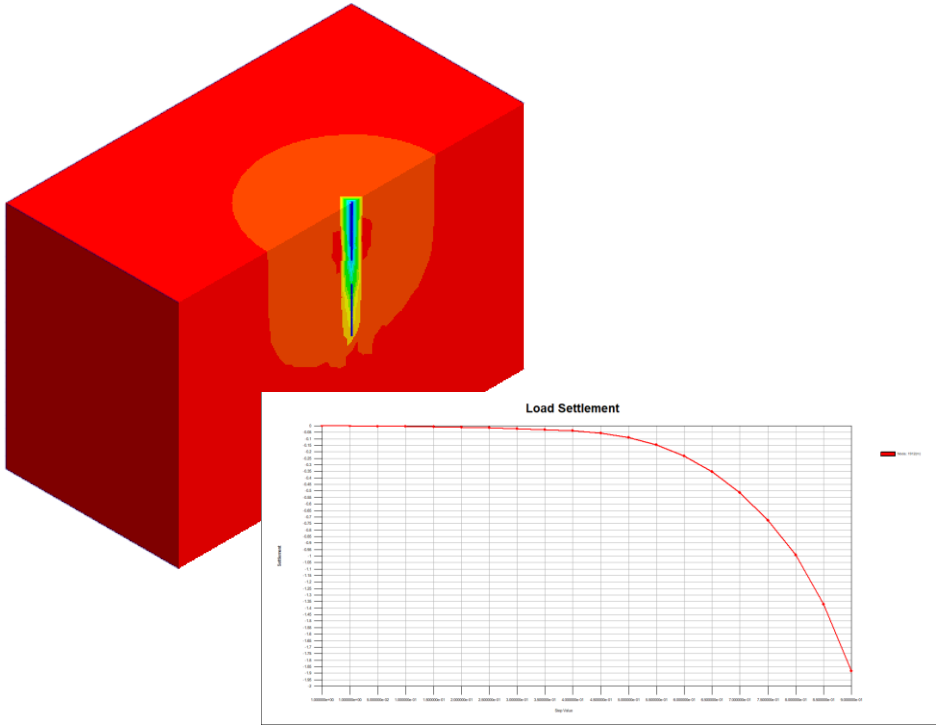


	No	Step	Step Value	Node: 6960 TZ TRANSLATION (V) (m)
▶	1	Initial:INCR=1 (LOAD=1.000)	1.000000e+000	0.000000e+000
	2	Bottom foundation:INCR=1 (LOAD=	1.000000e+000	0.000000e+000
	3	Top construction:INCR=1 (LOAD=1.	1.000000e+000	0.000000e+000
	4	Loading:INCR=1 (LOAD=0.033)	3.333330e-002	-1.812772e-004
	5	Loading:INCR=2 (LOAD=0.067)	6.666670e-002	-3.625544e-004
	6	Loading:INCR=3 (LOAD=0.100)	1.000000e-001	-5.438315e-004
	7	Loading:INCR=4 (LOAD=0.133)	1.333330e-001	-7.251087e-004
	8	Loading:INCR=5 (LOAD=0.167)	1.666670e-001	-9.063859e-004
	9	Loading:INCR=6 (LOAD=0.200)	2.000000e-001	-1.087663e-003
	10	Loading:INCR=7 (LOAD=0.233)	2.333330e-001	-1.268940e-003
	11	Loading:INCR=8 (LOAD=0.267)	2.666670e-001	-1.450217e
	12	Loading:INCR=9 (LOAD=0.300)	3.000000e-001	-1.631495e
	13	Loading:INCR=10 (LOAD=0.333)	3.333330e-001	-1.812772e
	14	Loading:INCR=11 (LOAD=0.367)	3.666670e-001	-1.994049e
	15	Loading:INCR=12 (LOAD=0.400)	4.000000e-001	-2.175326e
	16	Loading:INCR=13 (LOAD=0.433)	4.333330e-001	-2.356603e
	17	Loading:INCR=14 (LOAD=0.467)	4.666670e-001	-2.537881e
	18	Loading:INCR=15 (LOAD=0.500)	5.000000e-001	-2.719162e-003

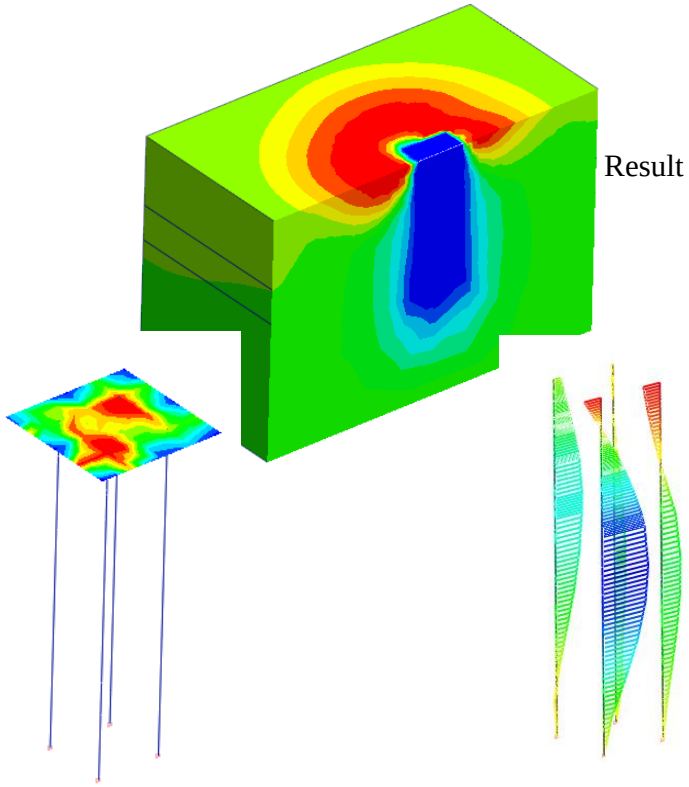
Sorting Dialog...
Style Dialog...
Show Graph...
Export to Excel

Results extracted as Tables and Graphs
Extracted results/graphs directly exported to excel

Post Processing Features



Load-Settlement Curves Extraction

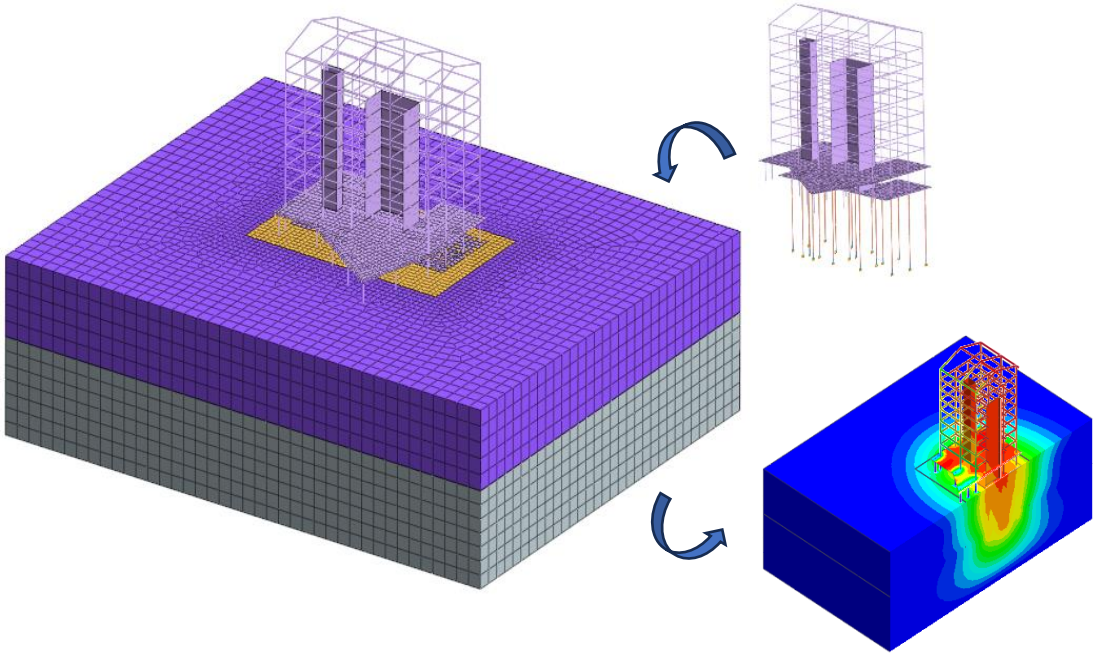


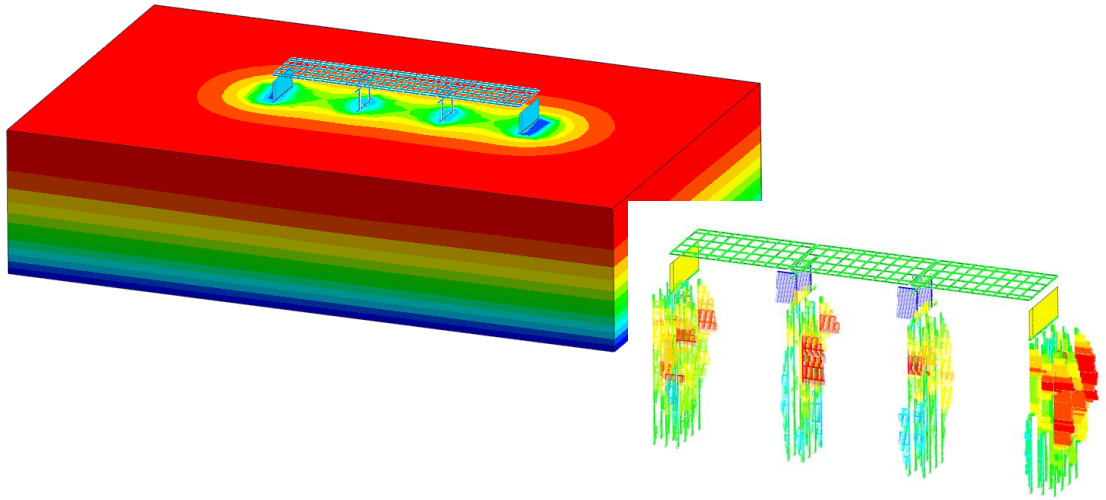
Result Contours in Sectional View

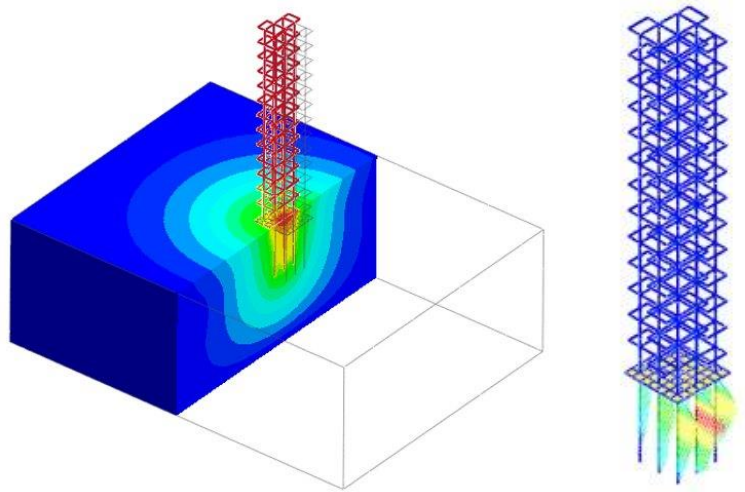
Pile: Axial Force, Shear Force and Bending Moment Results

Structural Forces Results for Piles and Raft

Post Processing Features







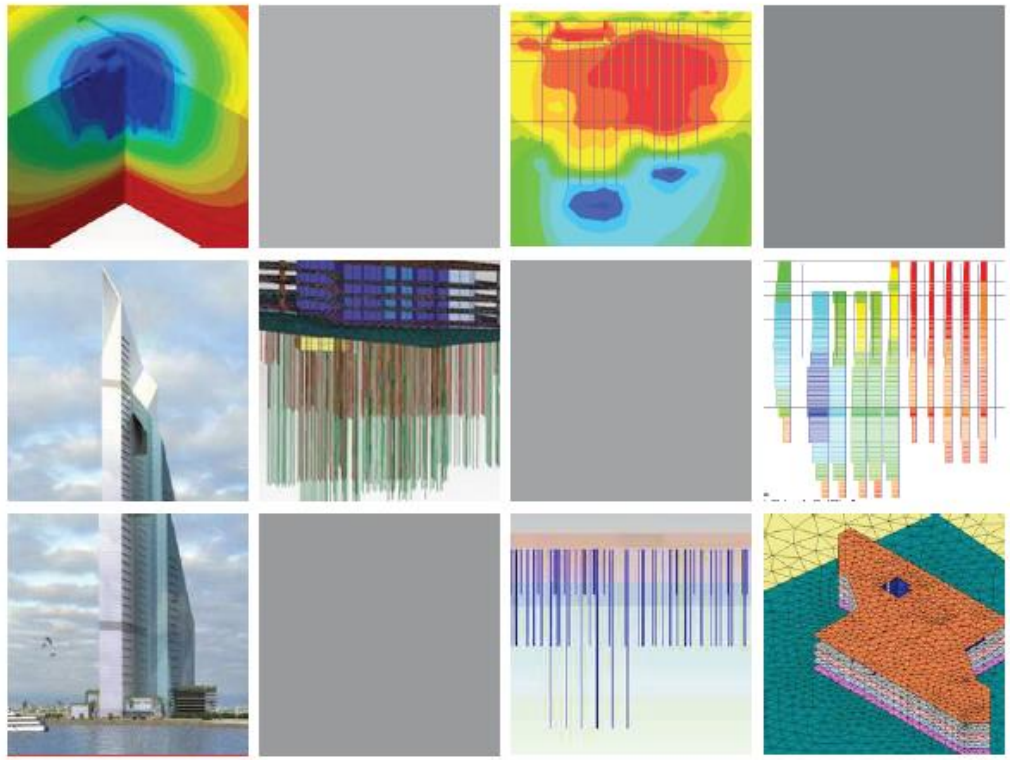
Pile Raft Foundation Modelling with imported Superstructure

PROJECT ACCOMPLISHMENTS

Dubai Tower in Qatar

Doha, Qatar

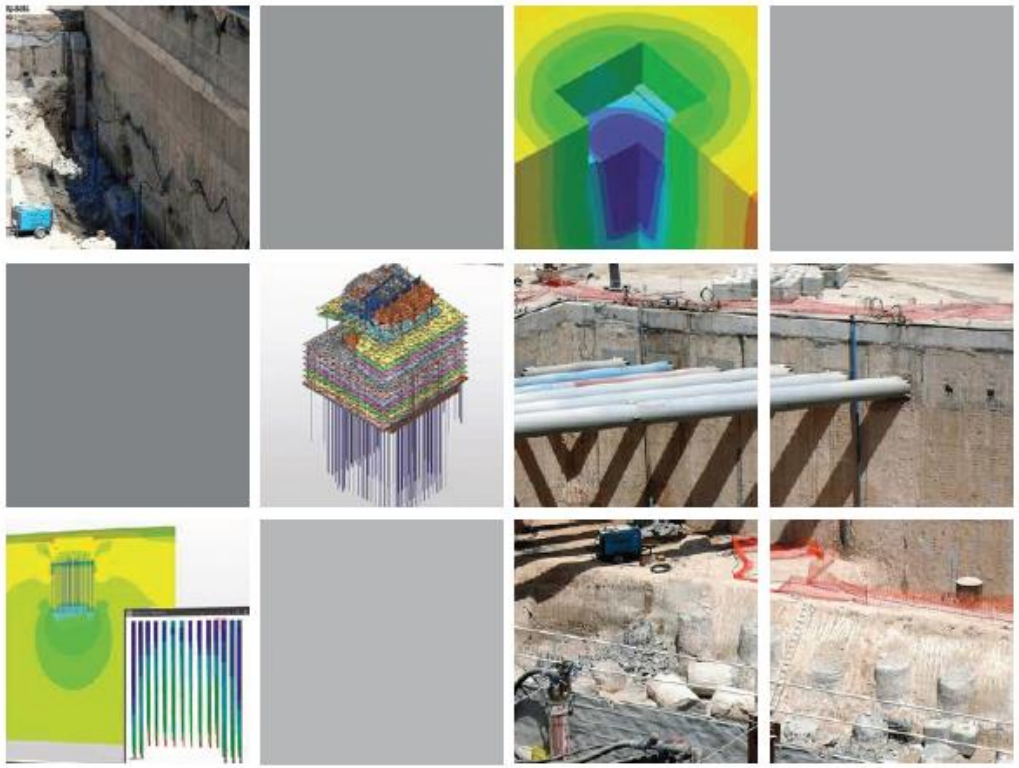
Owner	Sama Dubai (Dubai International Properties)
Engineering Consultant	Hyder Consulting
General Contractor	Al Habtoor - Al Jaber Joint Venture
Architecture	RMJM
Project Type	Mixed-Use Building
Size of the Structure	439m Height (88-Story)
Main features in modelling	- Piled - raft foundation for high - rise building - Analysis results for design (Settlements, Raft forces and bending moments, Pile forces and bending moments)
Description on this project	The proposed development for the Dubai Tower project comprises the construction of an approximately 80 floor high-rise tower with a mezzanine, ground floor and five basement levels. It will be the tallest structure in Qatar when it is complete. The tower was founded on soft sand and required the design of a piled raft in a 3D finite element model to fully understand the behavior.



Pentominium Residential Development in UAE

Dubai, United Arab Emirates

Owner	Trident International Holdings
General Contractor	Arabian Construction Company - Hitachi Plant Technologies
Engineering Consultant	Hyder Consulting
Construction Period	Under Construction
Project Type	Residential Building
Size of the Structure	516m Height (122-Story)
Main features in modelling	- Piled - raft foundation for high - rise building - Analysis results for design (Settlements, raft forces and bending moments, pile forces and bending moments)
Description on this project	The Pentominium Residential Development is located on the west side of the creek in Dubai. The development comprises the construction of an approximately 120 story high-rise tower inter-linked by low level podium structure housing up to 7 basement levels. The Pentominium Tower will be founded on a piled raft and required a 3D finite element model to fully understand the behavior of the foundation interaction with surrounding soil.

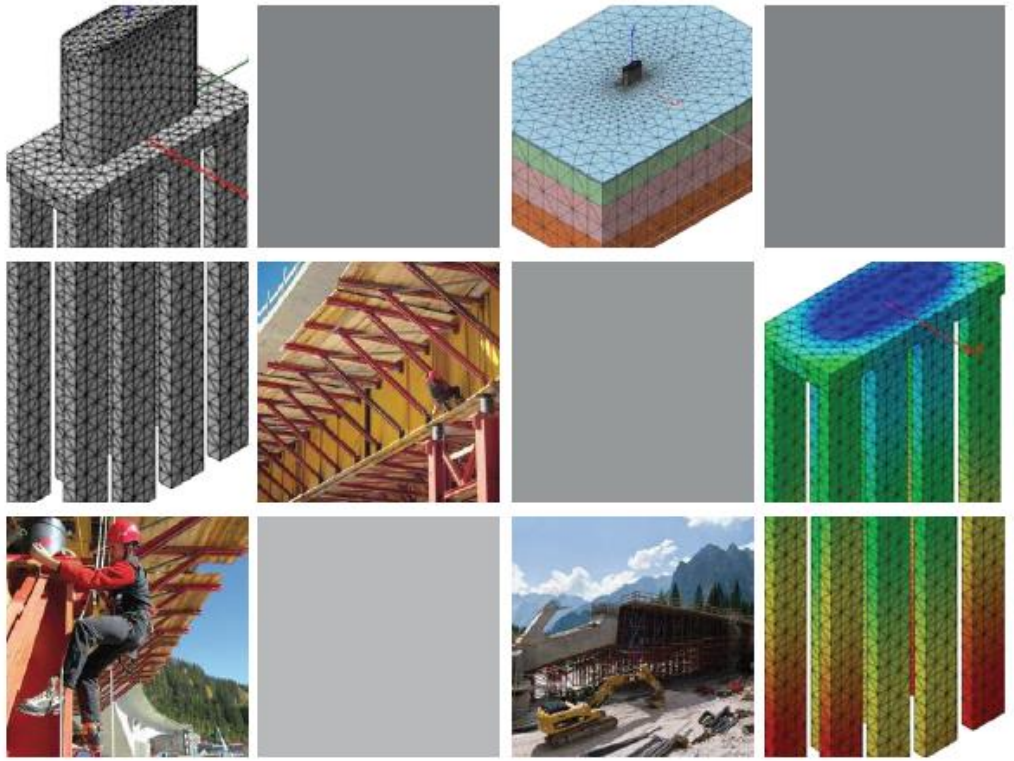


Bridge on the River Rudavoi
- Cortina d'Ampezzo

Belluno, Italy

ULMA

Engineering Consultant	ULMA Construction
Size of the Structure	180m Total Length
Main features in modelling	- Construction stage analysis - Stability analysis for the pier foundation of bridge
Description on this project	After the pier construction, the bridge was completed in three stages. The 70m long stretch between the abutment and the pier was built with horizontal beam - based formwork and full shoring. After concrete hardening and falsework removal, the same material was used in a symmetrical manner between the abutment and the pier on the other side of the bridge. A high capacity shoring tower on a temporary footing supports the central part of the bridge (40m).



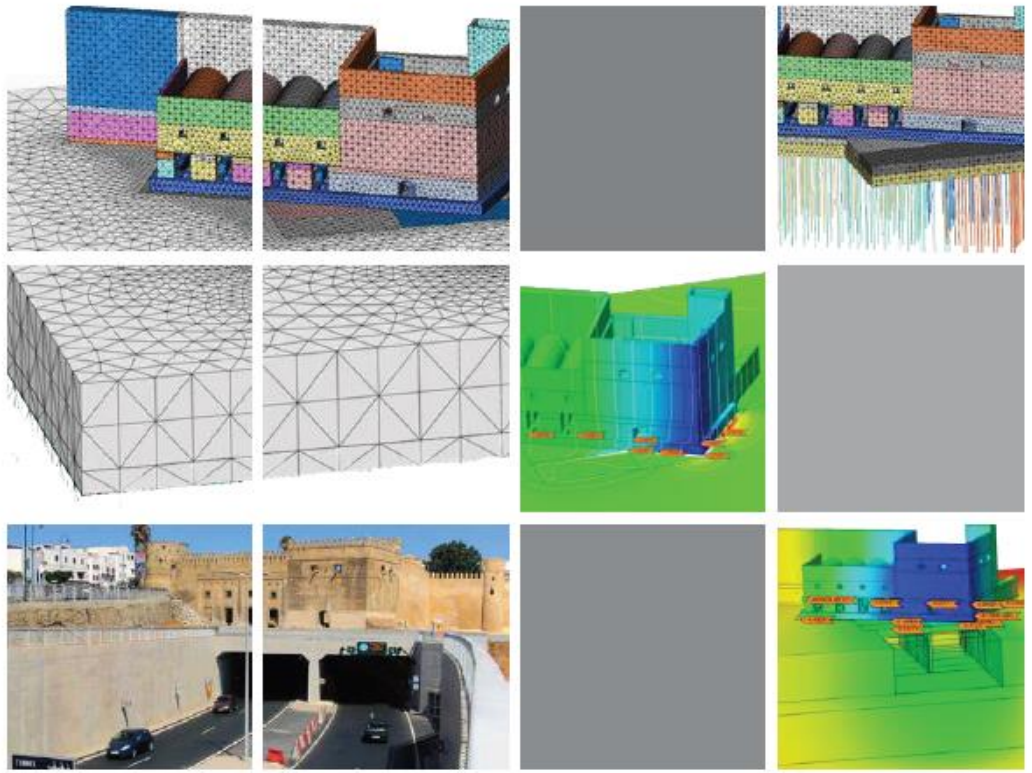
Oudayas Tunnel

- Royal Palace

Rabat, Morocco

Alpina

Owner	Royaume du Maroc – Agence pour l'Am nagement de la Vall e du Bouregreg
General Contractor	Pizzarotti
Engineering Consultant	Alpina
Construction Period	2007 - 2011
Project Type	Road Infrastructure
Main features in modelling	- Tunnel construction under the complex historical landmark - Modeling of micropiles, berlin wall and slab
Description on this project	The new roadway project is characterized by an extension of tunnel entrance that lies underneath the Des Oudayas monument complex. The complex consists of two historic buildings, the fortress, the library, the walls of the Kasbah, and an Andalusian garden. The design of the Des Oudayas Tunnel was necessary to ensure the stability, integrity, and safety throughout all the excavation and construction phases given the excavation's location under the historic structure. The design had to additionally consider the interaction between two parallel 300 m tunnels with on-going traffic.

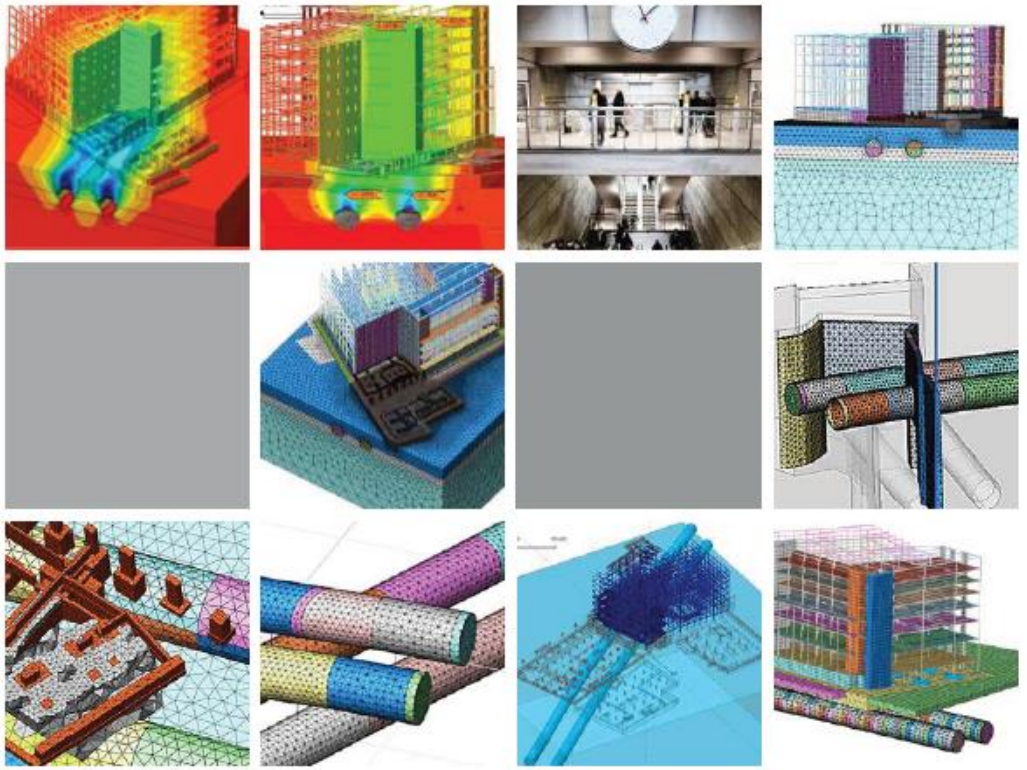


Cityringen
Copenhagen Metro

Copenhagen, Denmark

Lombardi

Owner	Metroselskabet
Engineering Consultant	Lombardi
Construction Period	2011 - 2017
Project Type	Subway Station
Size of the Structure	15.5 km long twin single - track metro tunnels,
Main features in modelling	- Interaction between MIDAS family programs (Gen & GTS NX) - Construction stage analysis for TBM
Description on this project	The Cityringen is a city circle metro - line, approximately 15.5 km long and will serve major areas of the city of Copenhagen including the Danish Parliament, the Central Station, the City Hall, existing major S - train and metro stations and national monuments. The line will have driverless communication - based train control system, with stewards on board. A round trip is expected to take 23 minutes. The headway interval is expected to be 200 sec., with 28 trains of 3 carriages running at 90 km/h.



PROBLEM STATEMENT

Pile Dimensions:

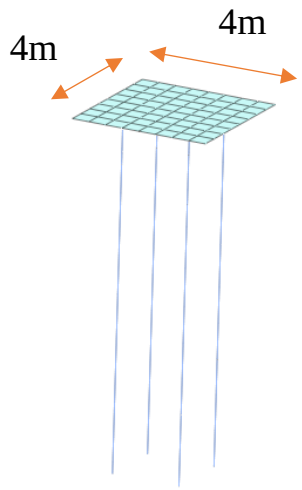
Diameter 0.5m
Length 10m
c/c Spacing 2m

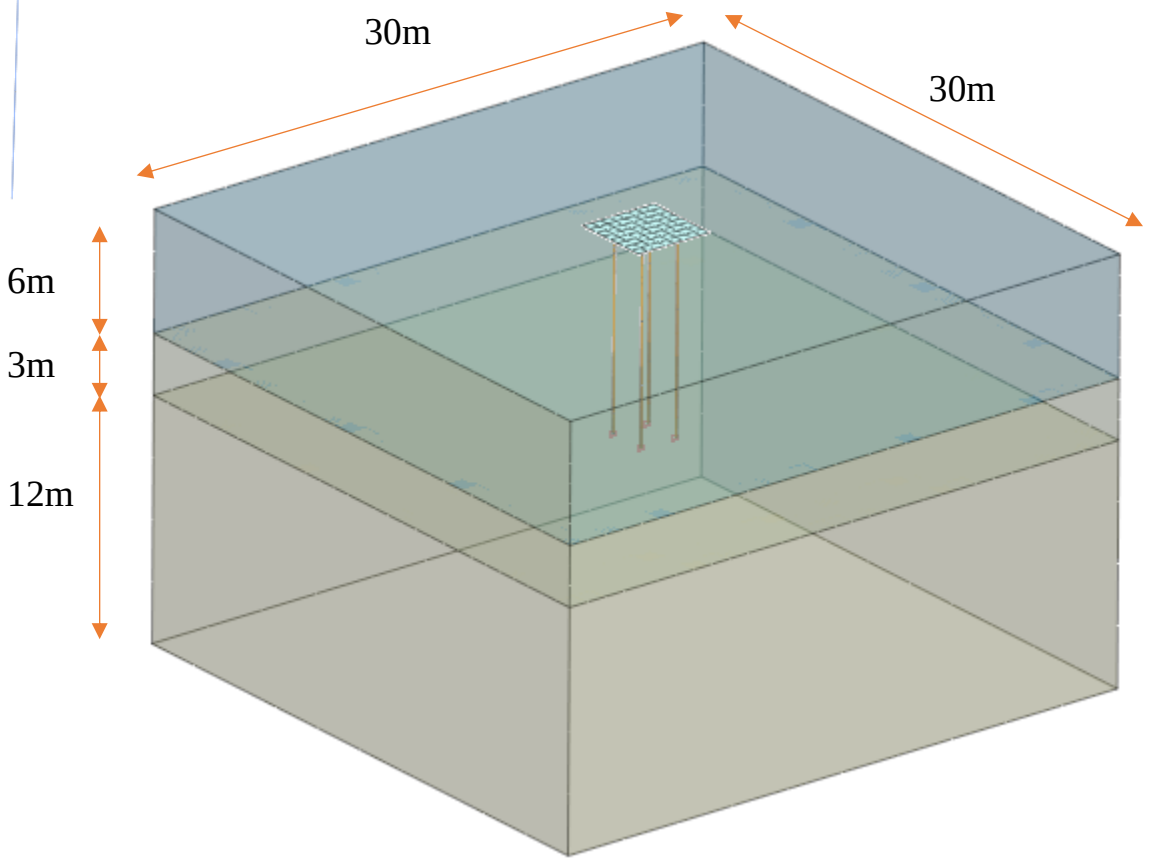
Raft Dimensions:

Section 4mx4m
Thickness 0.75m

Superstructure Loading on the Raft

Non-Linear Static Construction Stage Analysis





LET’S START MODELLING