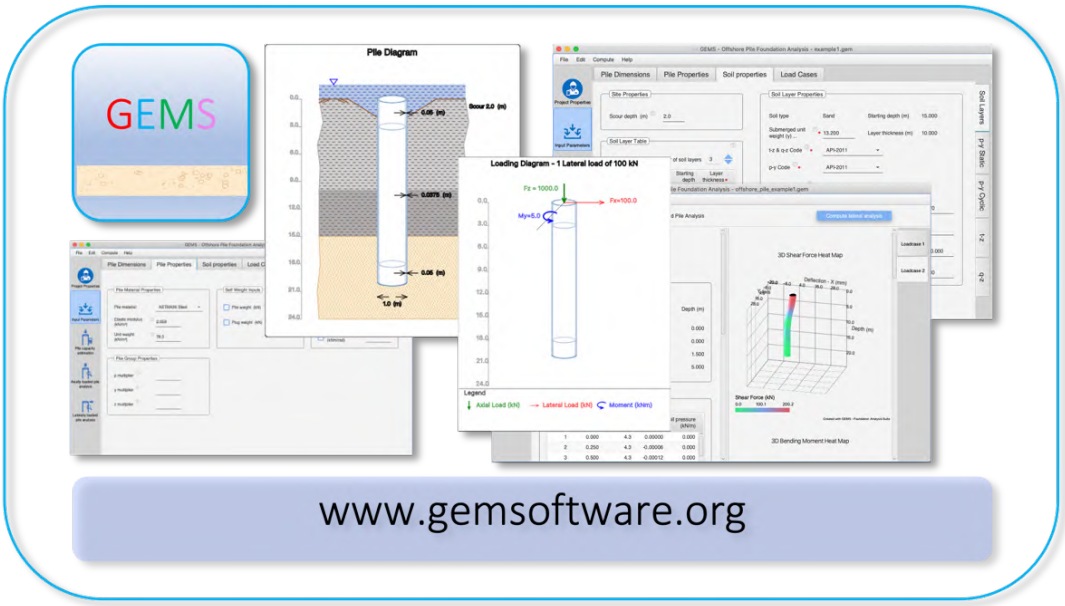
Geotechnical Engineering Modelling Software (GEMS)

Offshore Pile Foundation Analysis



GEMS Overview

Geotechnical Engineering Modelling Software (GEMS) develops advanced and intuitive Computer Aided Design & Engineering (CAD & E) software for foundation analysis & design.

Our software is designed to streamline the complex process of geotechnical engineering, enabling engineers to work more efficiently and effectively. GEMS foundation analysis suite employs modern finite element modelling techniques for analysis & design of shallow and deep foundations. The foundation analysis suite includes modules for

- Beam foundations
- Comprehensive Pile Foundation Analysis (Land, Bridge & Waterfront Structures)
- Offshore pile foundations
- Raft foundations
- Pile Group Settlement Analysis




GEMS foundation analysis suite is available for download on Windows, MacOS based computers. It is also available on the cloud (for use online using a browser).

Windows

Mac

GEMS CLOUD

Offshore Pile Foundations

In the dynamic field of offshore energy exploration, ensuring the stability and safety of pile foundations for offshore platforms is paramount. Offshore structures, from jacket-type oil platforms to complex deep-sea installations, demand robust foundation systems that can endure operational stresses, environmental loads, and severe storm conditions. GEMS Offshore Pile Foundation Analysis software is designed to meet these demands, offering engineers a comprehensive and reliable tool to analyse and optimize offshore pile foundations with accuracy and efficiency.

Our software suite features three specialized modules tailored to address the key aspects of offshore pile design and analysis:

Pile Capacity Estimation: This module provides a precise assessment of the ultimate axial capacity of piles under compressive and tensile loads. Using data from soil layers, it breaks down capacity into contributing factors, viz. shaft friction and base resistance. The module supports industry-standard codes, such as API-2000 RP and API-2011 RP-GEO amongst other codes, ensuring compliance with regulatory guidelines. For engineers, this means confidence in every estimate, backed by tried-and-tested standards.

Axially Loaded Pile Analysis: With a focus on axial load behaviour, this module enables engineers to analyse pile deformation under both compressive and tensile forces. Utilizing advanced finite element modelling, the software generates essential t-z and Q-z curves, either based on soil properties or user-defined data, for accurate analysis. This module allows engineers to assess and optimize structural integrity across varying load conditions, ensuring safe and resilient designs.

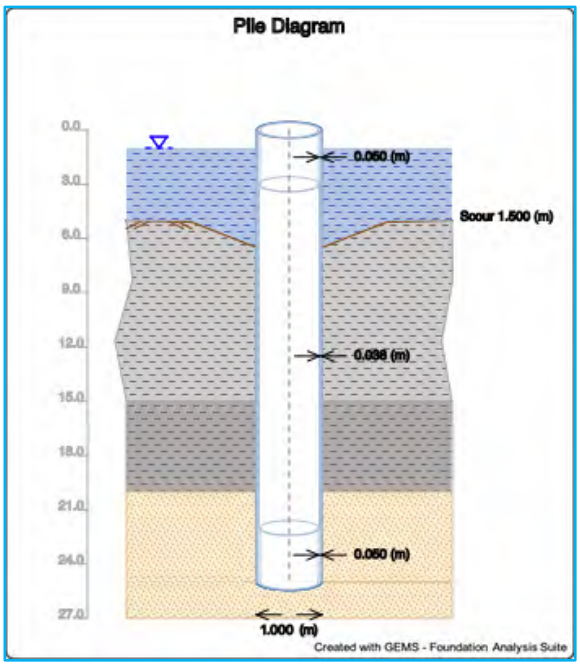
Laterally Loaded Pile Analysis: This module focuses on lateral load and moment analysis, essential for withstanding ocean currents and environmental forces. By generating p-y curves based on soil properties or user input, it accurately models the interaction between the pile and the surrounding soil. Finite element methods and non-linear springs are used to represent soil support, while graded mesh discretization enhances accuracy. Engineers can also incorporate beam-column effects to model real-world conditions.

Each module in the Offshore Pile Foundation Analysis suite is designed with a user-friendly interface, advanced computational methods, and flexibility to adapt to various project requirements. From initial capacity estimation to detailed deformation analysis, GEMS empowers engineers to confidently make data-driven design choices.

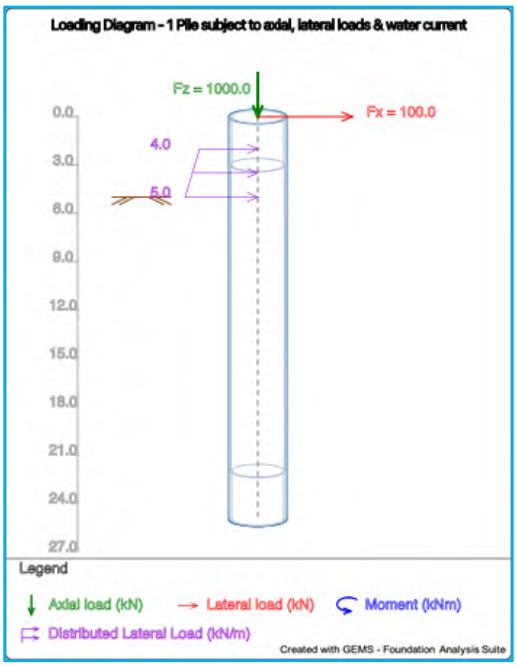
Choose GEMS for your offshore projects—engineered for safety, optimized for performance.

Key Features

- Axial pile capacity estimation
- Analysis of the pile foundation under lateral and axial loads.
- Generation of p-y, t-z and Q-z curves based on soil properties.
- User defined p-y, t-z and Q-z curves.
- Multiple load cases.
- One click computation and analysis for all load cases and modules.
- Pictorial representation of the pile and soil layers.
- Loading diagrams for each load case.
- Export of results to Microsoft Word, Excel and PDF
- Supported on Windows, Mac and Cloud.
- Data can be input in either SI units or 'Commonly used American units' (*kips for force and foot for length*).
- Handy tool for resolving forces
- Multiple axial, lateral loads and lateral moments can be specified along the length of the pile at various depths (up to 20 including pile head) for each load case.
- Distributed lateral load (triangular, uniform, or trapezoidal) can be given.
- Static and cyclic loadings can be incorporated for lateral analysis.
- Self-weight of pile may be included.
- Local scour consideration, water depth.
- Pile thickness can be varied along the length of the pile.
- Pile length above ground can be specified.
- Provision for customizing axial rigidity data
- Facility of prescribing lateral displacement, rotation & rotational spring at the pile head.
- Consideration of group effect by user prescribed p-multiplier, y-multiplier & z-multiplier.
- Graded mesh for lateral pile analysis along the pile length for better accuracy



Pile diagram



Loading Diagram

Pile Capacity Estimation

The Offshore Pile Foundation Analysis software by GEMS includes a robust module for estimating the ultimate axial capacity of pile foundations under compressive and tensile loads. This module provides a detailed breakdown of capacity into key contributing factors, viz. shaft friction and base resistance, at various soil depths.

Our software incorporates different codes and practices for the calculation of pile capacity, including API-2000 RP or API-2011 RP-GEO for clay and sand layers with features to include user prescribed parameters. We use a distance of 3D to develop full base resistance in strong layers and adopt a safe distance of 3D from the pile tip to prevent punch-through of underlying weak layers.

For rock layers, our software adopts an approach based on unconfined strength to estimate pile capacity.

With GEMS Pile Capacity Estimation module, you can achieve fast, accurate, and reliable capacity calculations, making it an essential tool for safe and optimized offshore foundation design.

Axially Loaded Pile Analysis

This is a powerful module specifically designed to analyse the behaviour of pile foundations under axial compressive and tensile loads. Our software offers two independent sub-modules to handle this task:

Generation of t-z and Q-z curves

This sub-module is designed to create a comprehensive set of t-z curves along the pile's shaft length and a Q-z curve at the pile base for compressive loading. Multiple t-z curves are generated for each soil layer. The below methods are available for generation of the t-z for each layer and Q-z curves at the pile tip.

Soft Clay	Stiff Clay	Sand	Weak Rock	Hard Rock
• API-2011 • API-2000	• API-2011 • API-2000	• API-2011 • API-2000	• Elastic (continuum) Bi-linear t-z q-z springs	• Elastic (continuum) Bi-linear t-z q-z springs

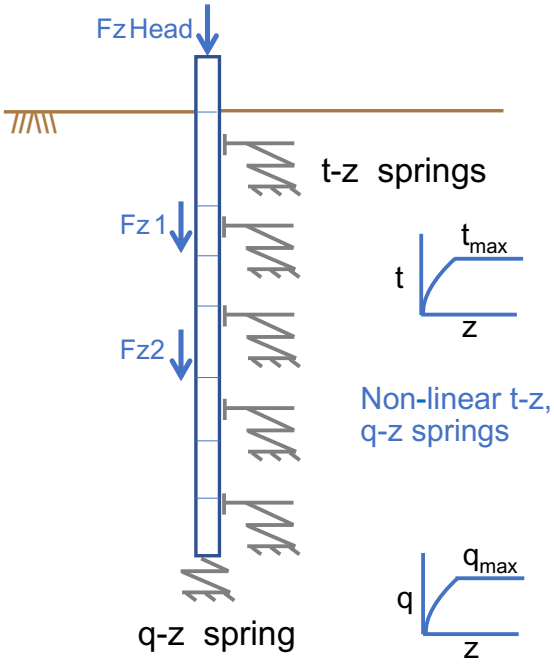
API based methods, also account for reduction in post peak adhesion in clay layers through a factor R.

Axial pile deformation analysis

Interaction between pile and soil is implemented by finite element modelling of pile as an elastic structural member of variable axial rigidity, soil support along pile shaft by a set of t-z springs and the base support by a Q-z spring. Both t-z and Q-z springs represented by curves, model the non-linear nature of soil support. Either user defined t-z, Q-z data or curves generated in module based on soil properties can be used. The analysis uses an Iterative approach to achieve convergence.

The following loading may be given and used for the analysis

a) Axial loads at various depths along the length of the pile (up to 20 including load at pile head).
b) Self-weight of the pile



Modelling of soil support using t-z, q-z springs

The analysis provides settlement of the pile head under a given load on the pile, variation of axial load, axial stresses along the pile length, and the load carried by the pile base. Different loads applied on the pile head and the corresponding head settlements provide the load settlement curve.

With our Axially Loaded Pile Analysis module, you can optimize your pile designs and ensure their structural integrity under axial compressive and tensile loads. Our software's sophisticated finite element modelling methods, coupled with an intuitive interface, make it an excellent choice for engineers at any level of experience.

Laterally Loaded Pile Analysis

Our offshore pile foundation software offers two independent sub-modules for lateral pile analysis:

Generation of p-y curves.

In this module p-y curves are generated for the soil layers based on their properties. Multiple p-y curves are generated for each layer. The below methods are available for generation of p-y curves based on soil type.

Soft Clay	Stiff Clay	Sand	Weak Rock	Hard Rock
• API-2011	• API-2011 • REESE	• API-2011 • Hybrid model for liquified sand (Based on ϕ)	• REESE	• Turner (2006)

Lateral pile deflection analysis.

Analysis of a pile subjected to lateral loads and moments is carried out in this module. Finite element based approach is adopted to model the pile and the soil support. The pile is modelled as an elastic member divided in to a number of bending elements. The soil support stiffness and strength is modelled by a series of non-linear discrete springs distributed continuously along the pile length based on the p-y curves.

The following loading may be given and used for the analysis

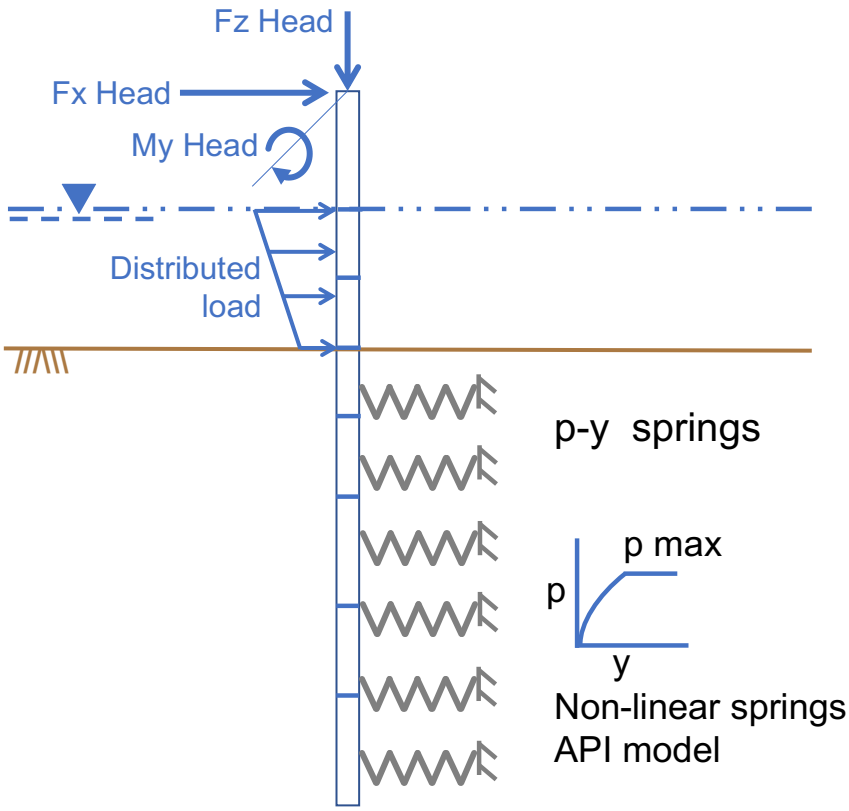
a) Lateral loads, lateral moments, and axial loads can be specified along the length of the pile at various depths (up to 20 including pile head) for each load case. The axial load applied at the pile head will be considered for taking the beam-column effect into account.
b) Distributed lateral load for a section along the pile length. Loading can be triangular, uniform, or trapezoidal.

The following boundary conditions may be given at the pile head

a) Prescribed lateral displacement
b) Prescribed rotation
c) Prescribed rotational stiffness.

The method can consider the effect of axial loading at the pile head due to beam column action in lateral pile analysis. The pile head can project above the ground.

Data on the p-y curves may be specified by the user or data generated in the module based on the soil properties could be used.

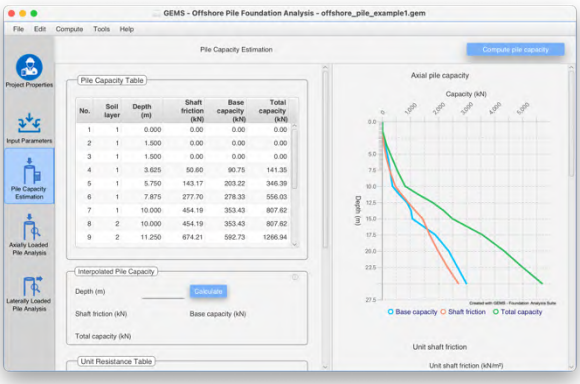


Modelling of soil support using p-y springs

The finite element discretization not only takes in to account the specified pile make-up but is also optimized for better accuracy by adopting a graded mesh along the pile length. An iterative procedure based on secant modulus approach is used for convergence.

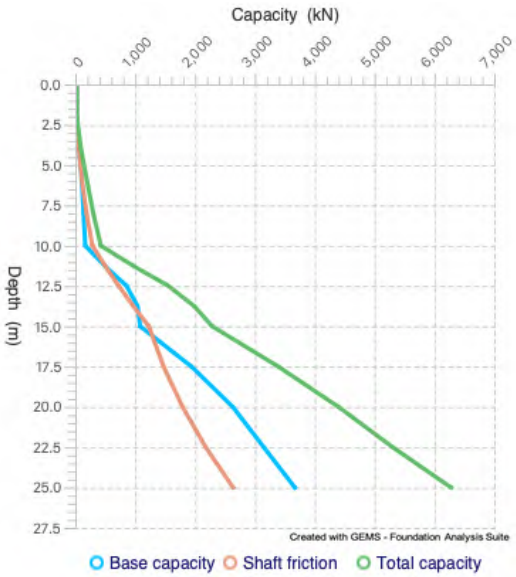
Analysis

Results of pile capacity estimation and analysis for axial loading and lateral loading are shown in three separate panes.

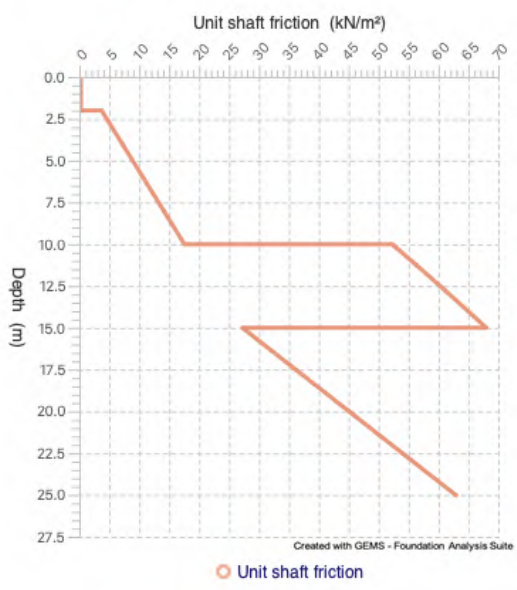


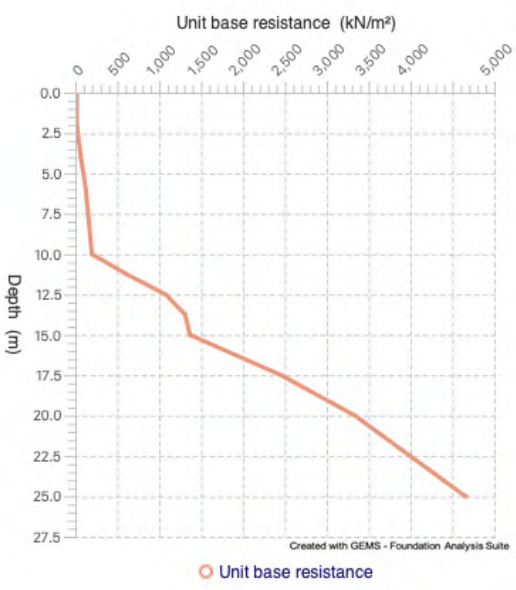
Pile Capacity Estimation

Tabulated values of total pile capacity and its components – shaft friction and base capacity values along the length of the pile and their graphical representation.



Tabulated values unit shaft friction and unit base resistance along the length of the pile and the graphical representation of the same.

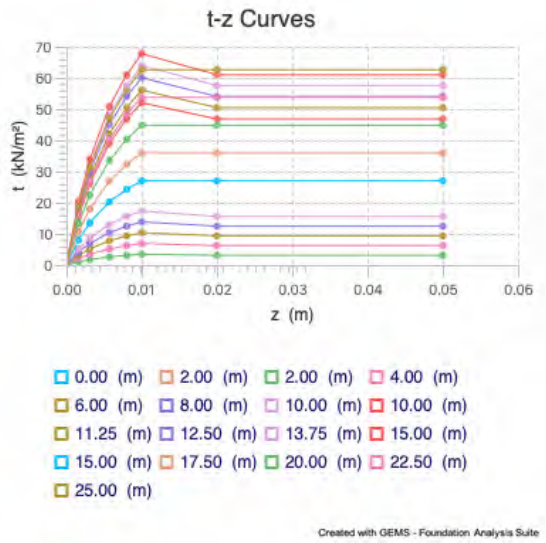


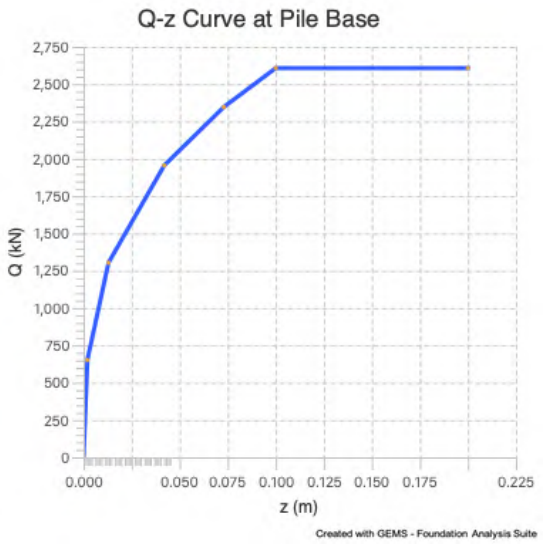


Axial Analysis

Generation of t-z and Q-z curves

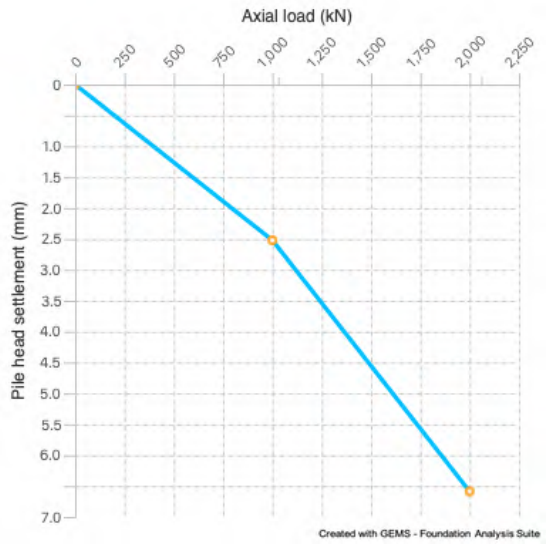
t-z curves are generated for the soil layers based on their soil properties at various depths. Q-z curves are generated at the base of the pile. These are tabulated and represented graphically. The t-z and Q-z curves generated can feed into the axial pile deformation analysis

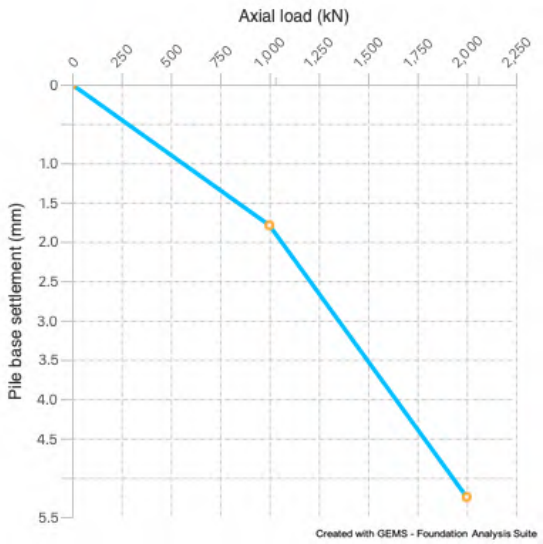




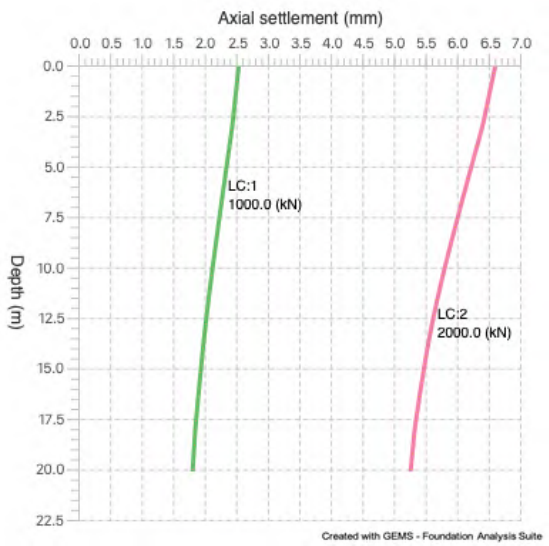
Axial pile deformation analysis

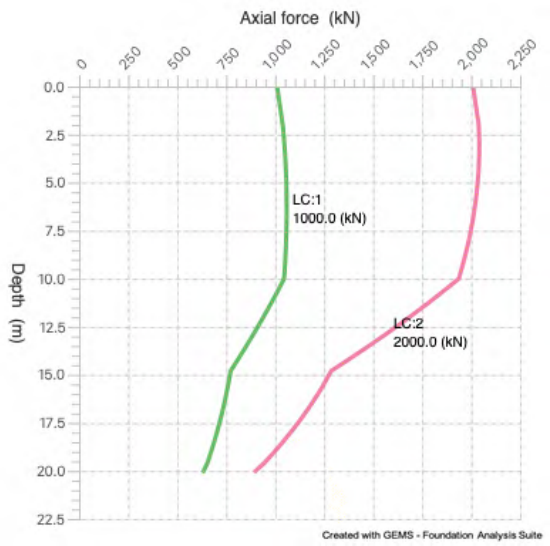
Tabulated values of pile head settlement and pile base settlement and their graphical representation.

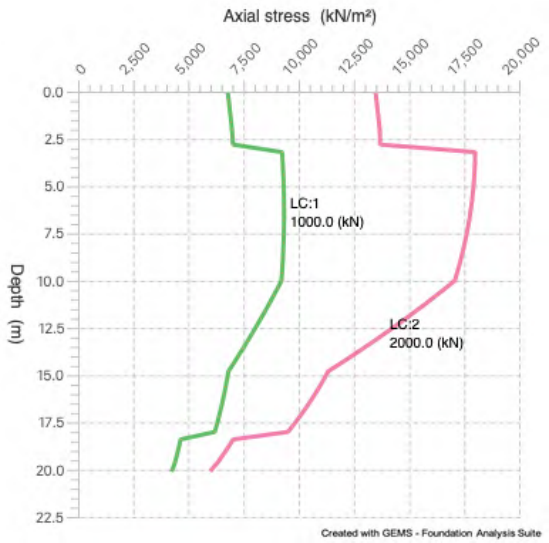




Tabulated values of Axial settlement, axial force, and compressive stress along the length of the pile and the graphical representation of the same.



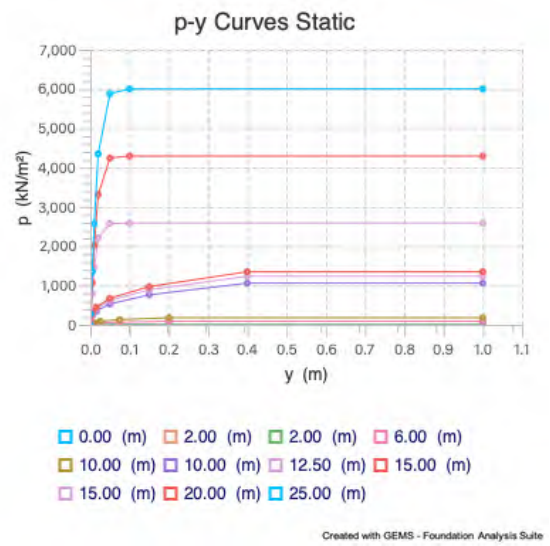




Lateral Analysis

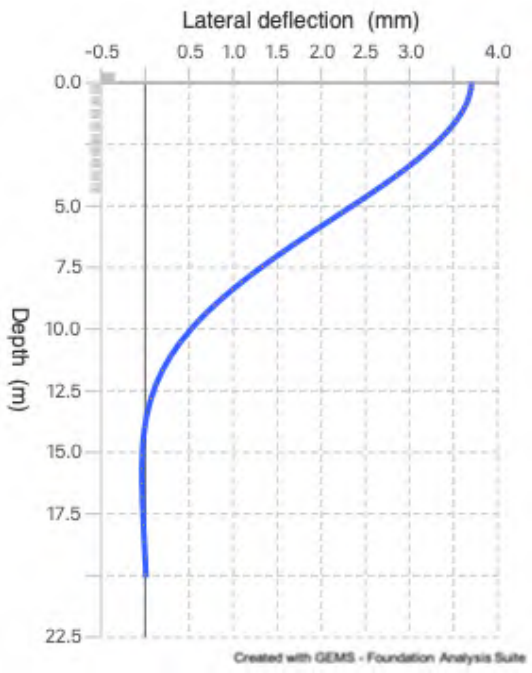
Generation of p-y curves

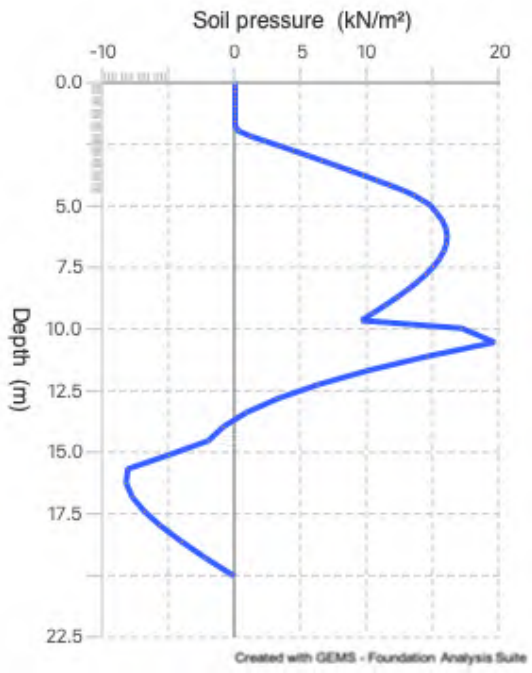
p-y curves are generated for the soil layers based on their soil properties for various depths. These are tabulated and represented graphically. p-y curves are generated for both static and cyclic loading scenarios. The p-y curves generated can feed into the lateral pile deflection analysis



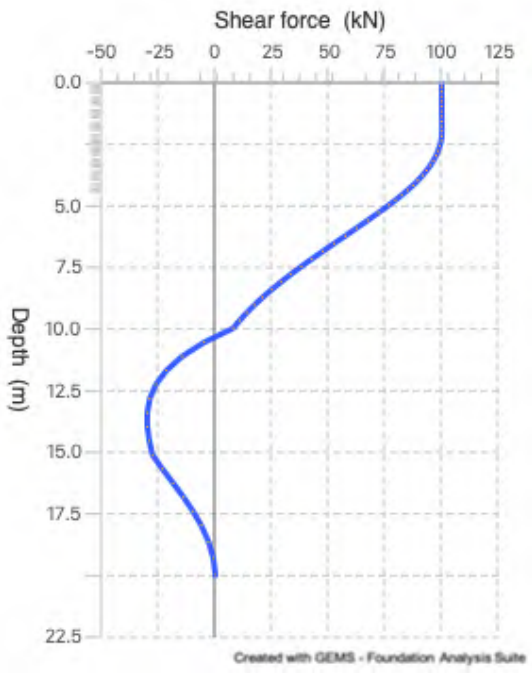
Lateral Analysis – Pile deflection analysis

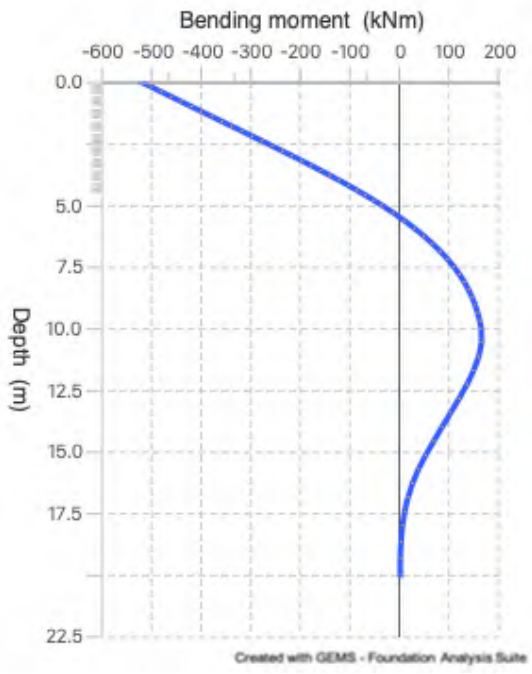
Tabulated values of lateral deflection and soil pressure along the length of the pile and graphical representations of them.



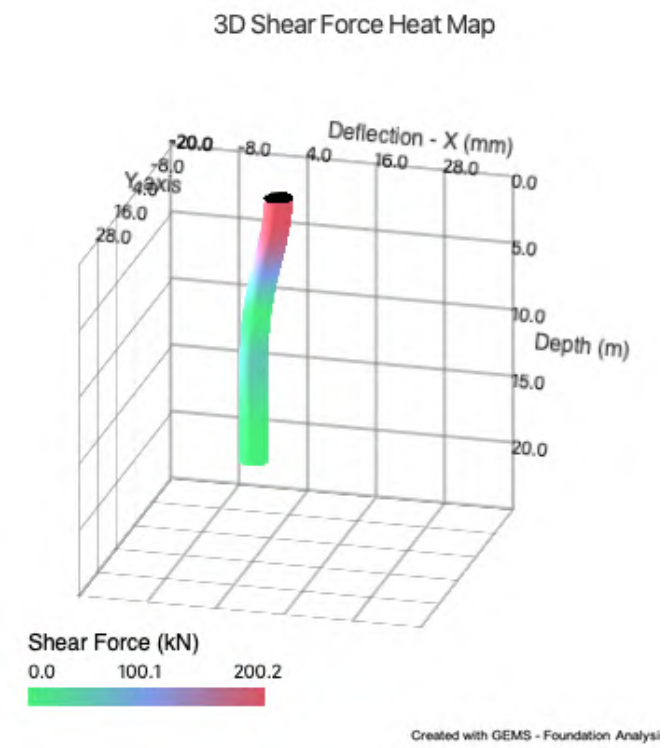


The Bending moment and shear force diagrams.

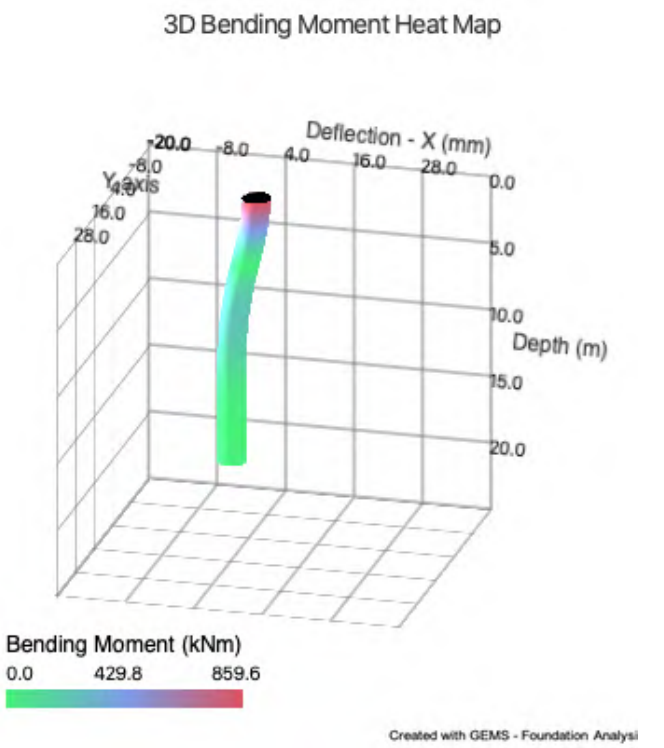




3D Shear Force Heat Map: Shear forces along the length of the pile in conjunction with 3D pile deflection diagram.



3D Bending Moment Heat Map: Bending moment experienced by the pile at various depths in conjunction with 3D pile deflection diagram.



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