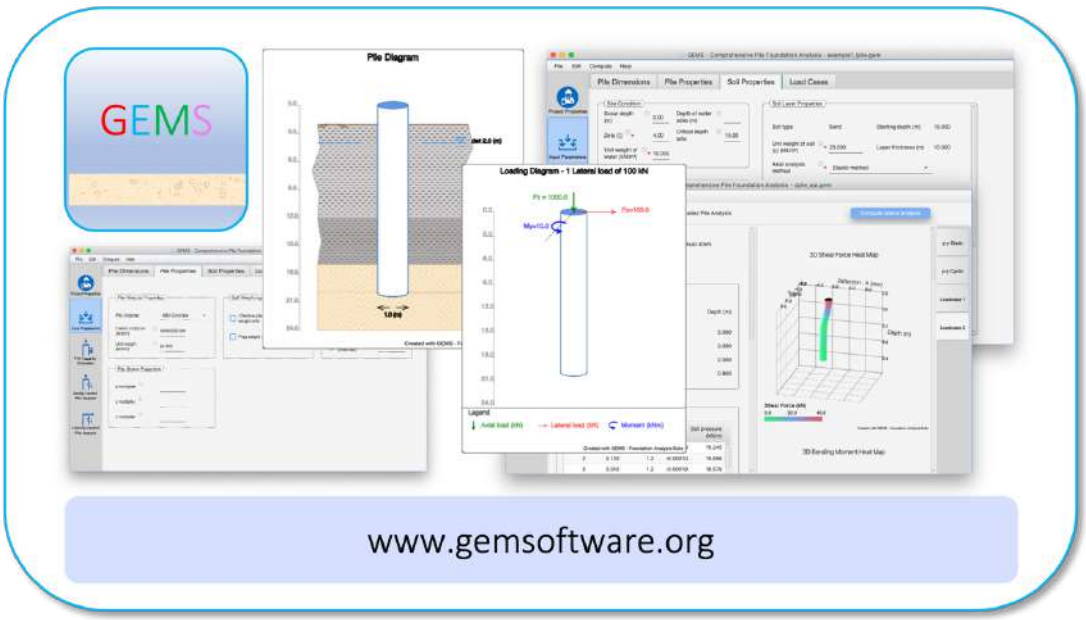
Geotechnical Engineering Modelling Software (GEMS)

Comprehensive Pile Foundation Analysis (Land, Bridge & Waterfront Structures)



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

Comprehensive Pile Foundation Analysis

Our software module is designed to support a wide range of structures, including buildings, bridges, wharves, jetties, and towers. By leveraging advanced analysis techniques, GEMS delivers accuracy and reliability in foundation analysis, empowering you with robust insights and optimal solutions.

Don't settle for guesswork or excel spreadsheets when it comes to pile foundation analysis. Trust GEMS to provide you with robust software that empowers you to make informed decisions based on accurate data and analysis.

Get started today and experience the power of Geotechnical Engineering Modelling Software (GEMS) !

Versatile Application: Our software enables analysis of piles in different environments, including land, bridges, and water-front structures.

Flexible Loading Analysis: With GEMS, you can accurately analyse the loading on piles in both axial (compressive or tensile) and lateral (shear and moment) directions.

Wide Range of Pile Types: Whether you're working with bored piles (cast-in-situ concrete, CFA), driven piles (precast concrete, cast-in-situ concrete, steel), or piles with various cross-sections, our software has you covered.

Consideration of Soil Conditions: GEMS takes into account various soil types such as clay, sand, and rock, as well as critical soil conditions like the groundwater table and scour, ensuring comprehensive and accurate analysis.

Module-based Approach: Our software includes three essential modules for pile foundation analysis:

Pile Capacity Estimation

Determine the maximum load-bearing capacity of your piles efficiently.

Axial Pile Analysis

Analyse the axial load behaviour and performance of your piles.

Lateral Pile Analysis

Assess the response of piles under lateral loading conditions, including shear and moment.

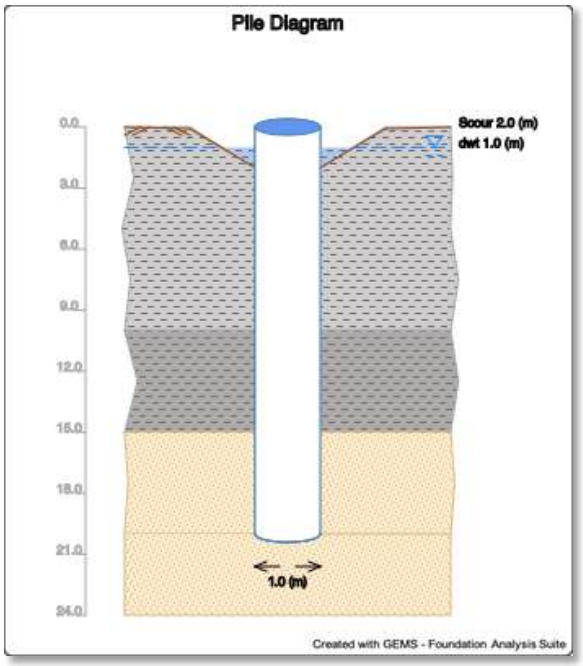
Linear and Non-linear Analysis: GEMS offers both linear and non-linear methods of analysis, giving you the flexibility to choose the most suitable approach for your project requirements.

Industry-Standard Procedures: Benefit from our software's inclusion of various common procedures used in practice, ensuring compliance with industry standards and enhancing the reliability of your analysis results.

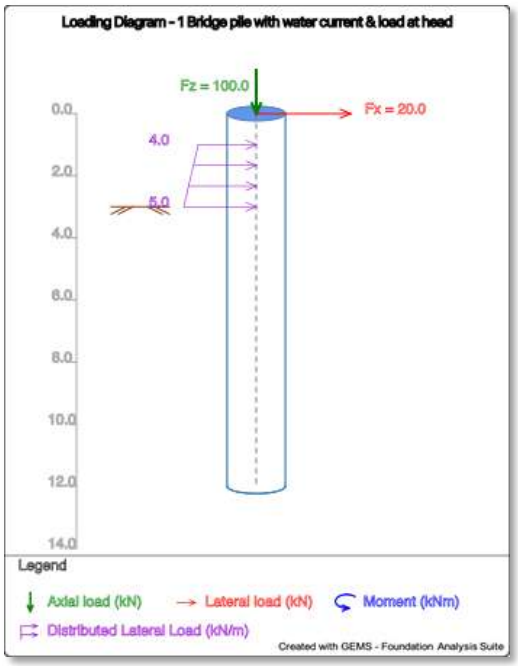
This software offers a single platform consideration of different soil strata, pile sections, pile types, codes of practice as well as other well-known procedures adopted in practice

Key Features

- One click computation and analysis for all load cases and modules.
- Piles of circular, square, rectangular, circular-tubular, and I or H cross sections can be analysed.
- Axial pile capacity estimation
- Analysis of the pile foundation under combined lateral and axial loads.
- Linear & Non-linear analysis models
- Multiple load cases.
- Pictorial representation of the pile and soil layers.
- Loading diagrams for each load case.
- Export of results to Microsoft Word, Excel, & 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*)
- Self-weight of pile may be included if required.
- 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.
- Local scour & ground water table considerations.
- Pile length above ground can be specified.
- Take reinforcement parameters into account.
- Facility of prescribing lateral displacement, rotation & rotational spring at the pile head.
- Generation of p-y, t-z and Q-z curves based on soil properties.
- Handy tool for resolving forces.



Pile diagram



Loading Diagram

Piles are used to provide foundation support to wide ranging structures such as buildings, bridges, wharves, jetties and towers. Piles may be broadly classified into several types as shown below.

Pile types								
Based on soil displaced	Displacement		Part displacement			Non- displacement		
Based on pile material & method of construction	Driven		Driven			Bored		
	Precast concrete	Cast-insitu-concrete	Precast concrete	Steel		Cast-insitu-concrete		
	Square or rectangular	Circular	Hollow cylindrical	Tubular	H-section	Circular	With enlarged base	CFA

The choice of the pile type is governed by sub-soil strata, ground water conditions, its chemical composition, facility of construction, local experience, available technology, and cost.

The loading on piles can be in axial direction (compressive or tensile) and in lateral direction (shear and moment). The loading may be due to self-weight of structures, live loads, wind and earthquake forces. In water front-structures forces due to ship impact, wave, current forces, and mooring forces will require consideration. In bridge piles, scour around piers needs to be taken in to account. Abutment piles will also be subject to lateral earth pressure. In many instances axial and lateral forces will act above the ground level requiring consideration of beam column action. In all cases the piles designed should meet the serviceability and safety requirements under all loading conditions.

The pile analysis software is developed keeping in view all the above requirements

This pile analysis software can be used in several ways towards achieving design requirements:

- Based on sub-soil properties and pile parameters, analyse the pile for different loading scenarios.
- Perform analysis towards optimizing pile length and size.
- Evaluating performance of different types of piles in making a choice.
- It may be used in comparing results of load tests with the results of analysis and in fine tuning pile design parameters.

The Piles of circular, square, rectangular, circular-hollow and I or H cross sections can be analysed. Bored piles (Cast-insitu-concrete), and driven piles (Precast concrete, Cast-insitu-concrete, Steel) can also be analysed

Circular

Square

Rectangular

Hollow circular

I or H Section

Soil scour around the piles and pile lengths projecting above the ground can be specified. These provisions are especially useful in analysing piles used in foundations of bridges and waterfront structures. Depth of ground water table in the subsoil can also be considered.

Pile Capacity Estimation

The ultimate axial capacity under compressive or tensile load is computed based on the soil layer properties. The software gives the pile capacity at various depths of soil, and also breaks it down to its contributing factors viz. shaft friction and base capacity. The pile capacity estimation is based on the sub-soil layer properties. Presently the below methods of analysis are available:

Clay	**Sand**		**Rock**
	Side Friction	Base capacity	
• α method (IS-2911) • Semple & Rigden method • Kolk & Van-der-velde method • API-2011	• K-δ-Zc method (IS-2911) • Meyeroff SPT method (IS-2911) • β method (API-2011) • K-δ method (API-2000)	• Nq - Zc method (IS-2911) • Nq-Berezantev-Zc method • Meyeroff SPT method (IS-2911) • Nq-qlim method (API-2011, API-2000)	• Approach based on unconfined strength is adopted

A distance of 3D is used for developing full base resistance in strong layers. A safe distance of 3D from pile tip is adopted to preclude punch through underlying weak layers. For rock layers an approach based on unconfined strength is adopted.

Axially Loaded Pile Analysis

a) Axial pile deformation analysis

Pile is modelled as an elastic structural member having the cross section of the pile and the elastic properties of the pile material. The soil support providing the shaft friction is modelled by a set of side springs based on t-z curves. The tip resistance provided by the pile base the base is modelled by a spring based on Q-z curve.

The following loading may be given and used for the analysis

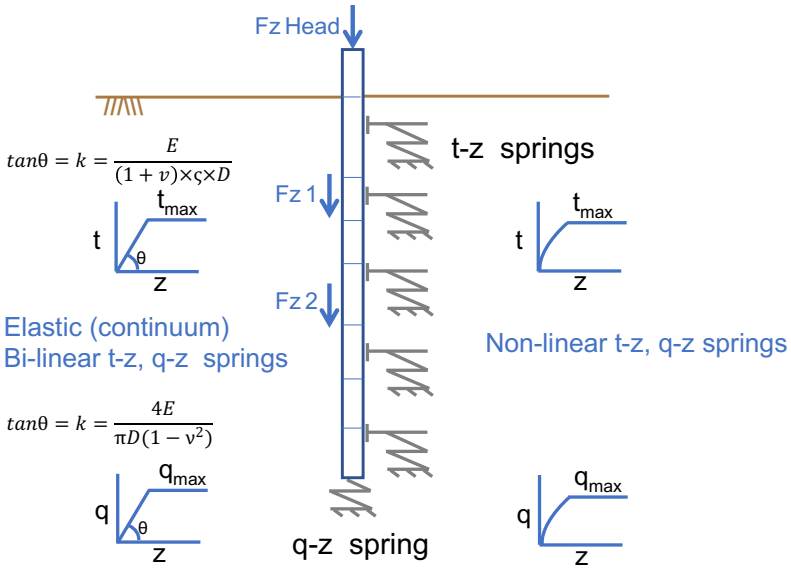
a) Axial loads at various depths along the length of the pile (up to 20 including load at pile head).
b) Self-weight of the pile

The software supports both '*Elastic (continuum) Bi-linear*' and '*Non-Linear*' approaches for modelling and any one of them can be selected for analysis.

In the '*Non-Linear*' approach, for the soil layer, based on the t_{max} and q_{max} values calculated , non-linear t-z curves (interface shear stress- vertical pile movement at that point) and q-z curve (bearing stress and toe displacement) are developed based on API-2011 guidelines. In the case of rock layers, using the t_{max} and q_{max} values, t-z and q-z relationships are modelled by a bilinear elastic – plastic curve based on the elastic modulus and Poisson ratio of the rock layer.

In the '*Elastic (continuum) Bi-linear*' approach, for the soil layer, t-z and q-z relationships are modelled by bilinear elastic – plastic curves based on the elastic modulus, Poisson ratio ,t_{max} and q_{max} for the layer.

The axial pile analysis follows a non-linear finite element model using the axial rigidity of the pile and the nonlinear soil support based on the t-z curves and q-z curve. The analysis uses an iterative approach to achieve convergence.



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

The analysis provides settlement of the pile head, variation of axial load 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.

b) Generation of t-z and Q-z curves

Development of a set of t-z curves along the shaft length and 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 base.

Soft Clay	Stiff Clay	Sand	Weak Rock	Hard Rock
• Elastic Method • API-2011 • API-2000	• Elastic Method • API-2011 • API-2000	• Elastic Method • API-2011 • API-2000	• Elastic Method	• Elastic Method

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

Laterally Loaded Pile Analysis

a) Lateral pile deflection analysis.

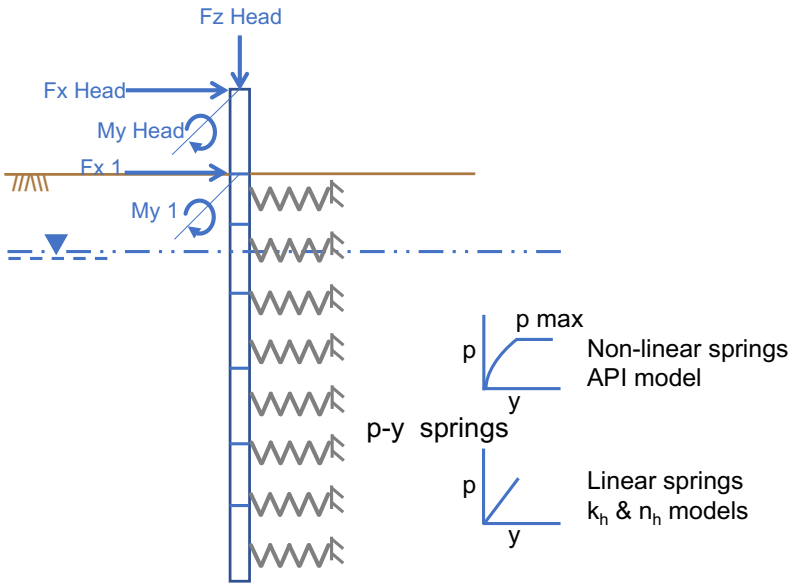
Analysis of a pile subjected to lateral load and moment is carried out in this module. Finite element based approach is adopted to model the pile and the soil support in which the pile is divided in to a number of elastic beam bending elements. The method allows consideration of inhomogeneous and non-linear modelling of soil support. The lateral soil support for the pile is modelled by the well-known p-y springs.

The following loading may be given and used for the analysis

a) For each load case, 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). 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. Distributed lateral 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.



Modelling of soil support using p-y springs

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.

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

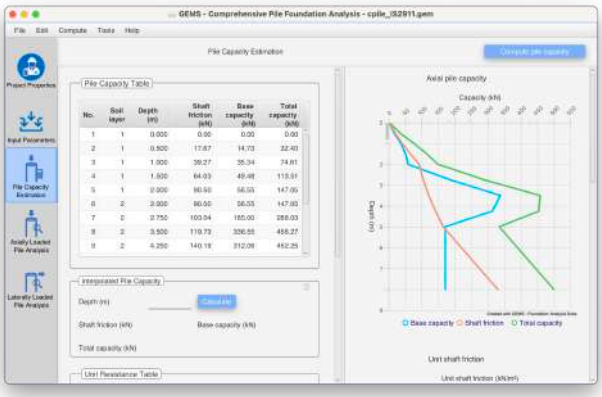
b) Generation of p-y curves.

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
• K_h based horizontal subgrade modulus • N_h based horizontal subgrade modulus • API-2011	• K_h based horizontal subgrade modulus • Reese • API-2011	• N_h based horizontal subgrade modulus • Hybrid model for liquified sand (Based on ϕ) • Hybrid model for liquified sand (Based on SPT) • API-2011	• Reese • K_h based horizontal subgrade modulus	• Turner (2006) • K_h based horizontal subgrade modulus

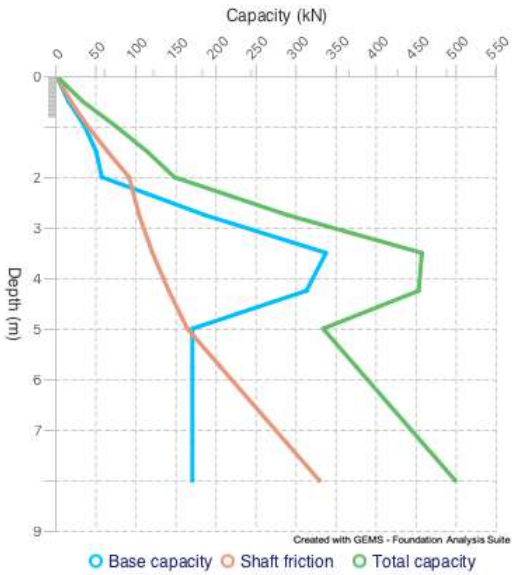
Analysis

Results of pile capacity estimation and analysis for axial loading and lateral loading are shown in three separate panes. The analysis consists of tabular and graphical representation of the results.

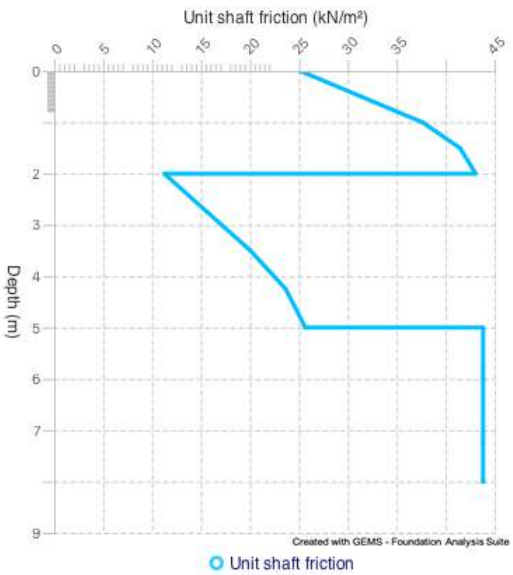


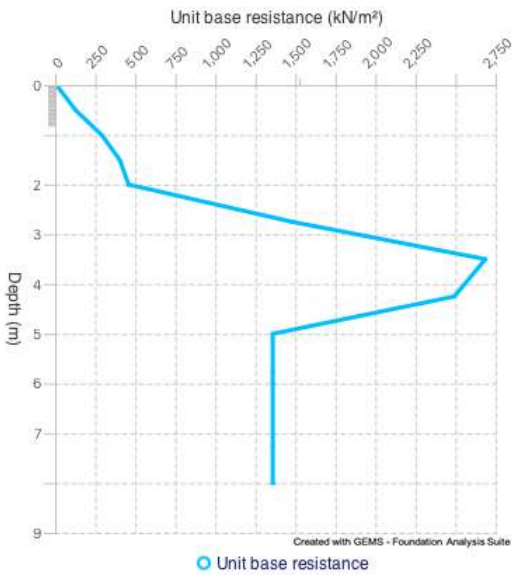
Pile capacity estimation

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.



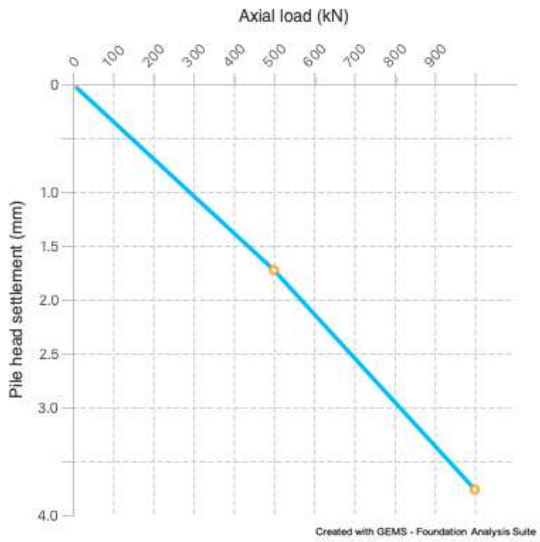
Tabulated values unit shaft friction and unit base resistance along the length of the pile and the graphical representation of the same.

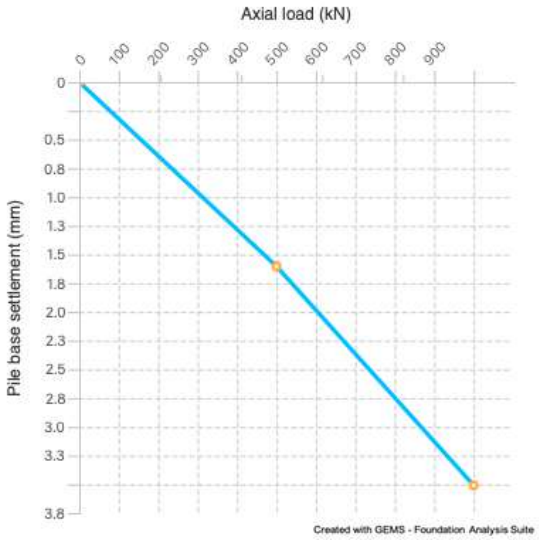




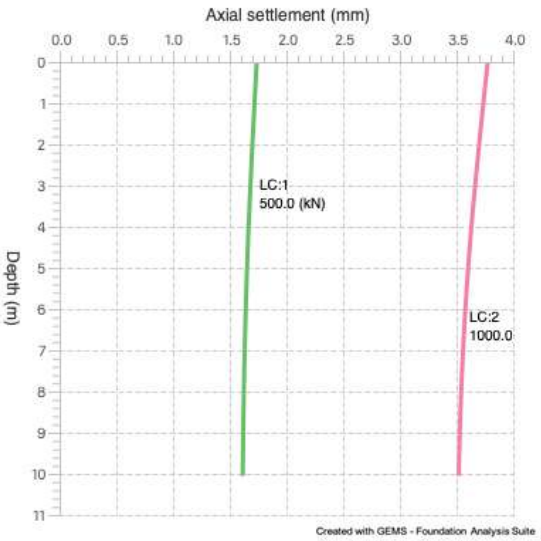
Axial Analysis - Axial pile deformation analysis

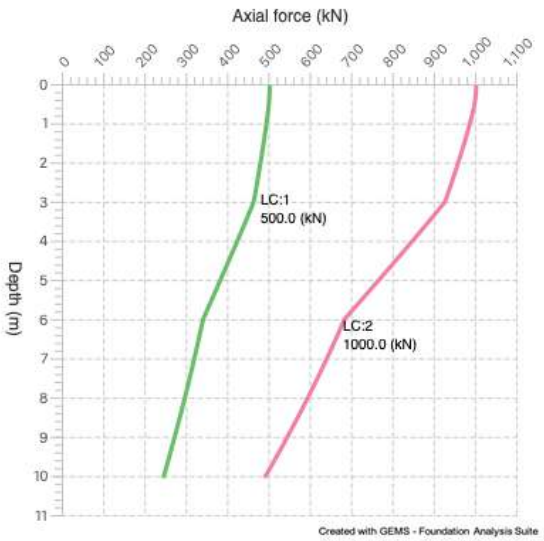
Tabulated values of pile head settlement and pile base settlement and their graphical representation.

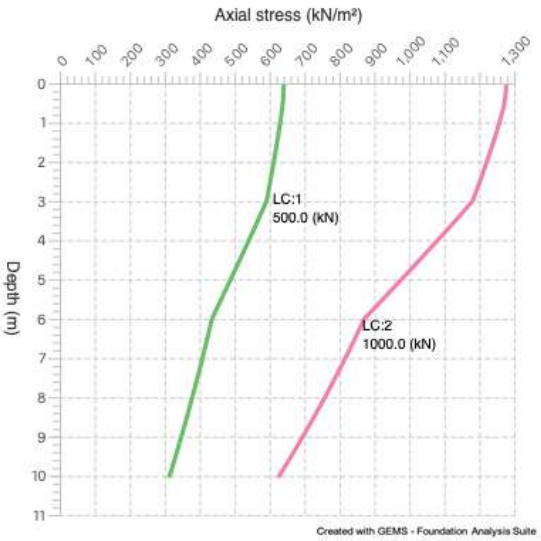




Tabulated values of Axial settlement, axial force, and compressive stress along the length of the pile and the graphical representation of the same.

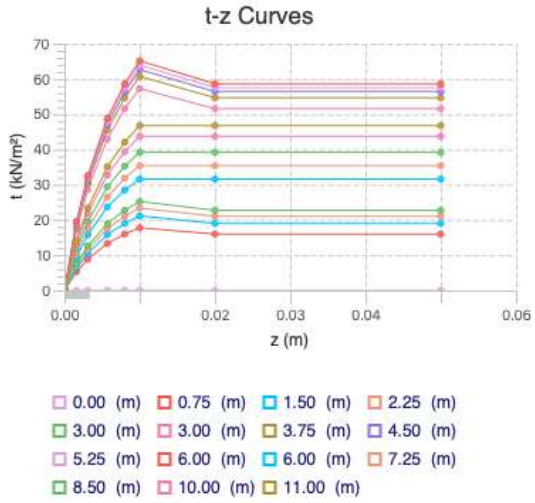


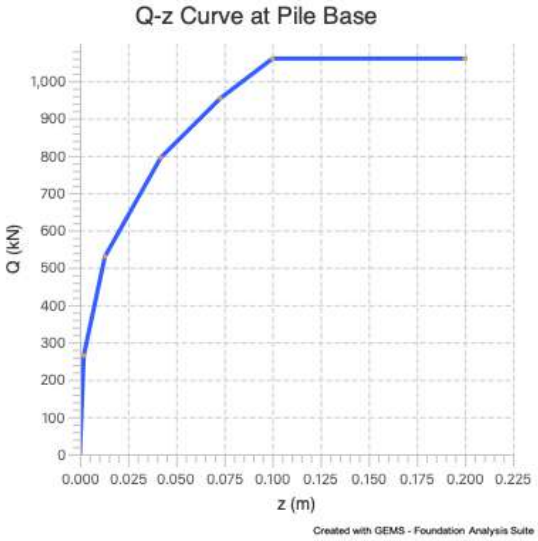




Axial Analysis - Generation of t-z and Q-z curves

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 are fed into the axial pile deformation analysis

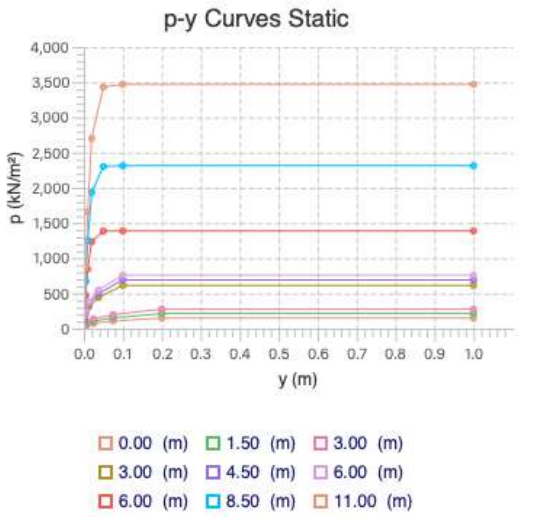




Lateral Analysis

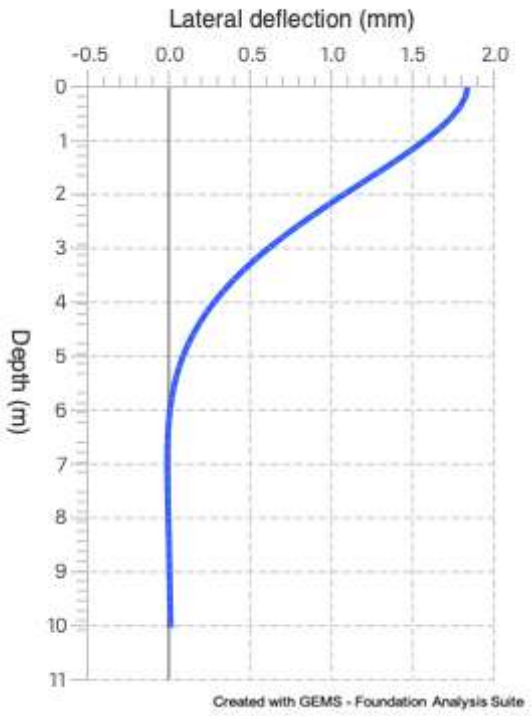
Generation of p-y curves

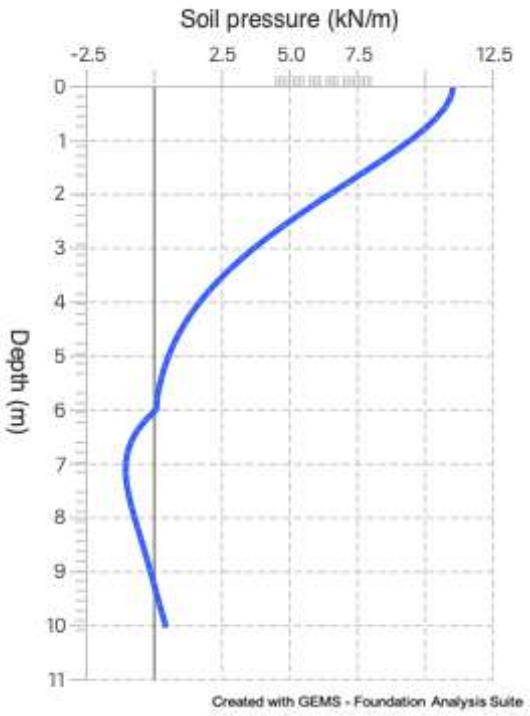
p-y curves are generated for the soil layers based on their soil properties for various depths. These are tabulated and represented graphically. p-y curves are generated for both static and cyclic loading scenarios. The p-y curves generated are feed into the lateral pile deflection analysis



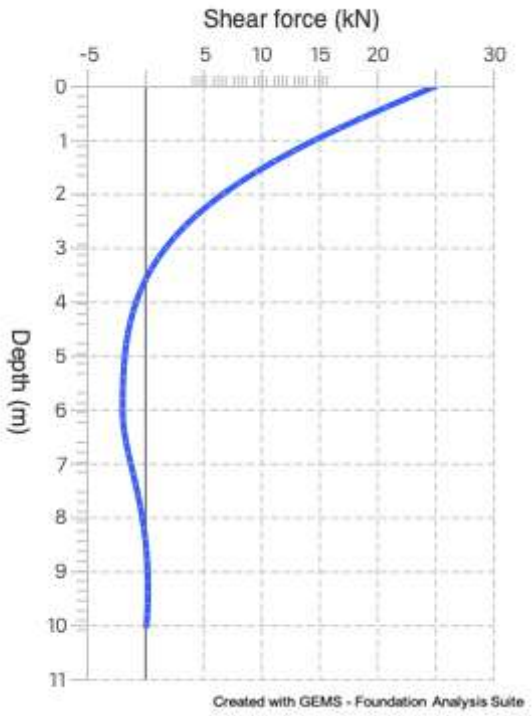
Lateral Analysis – Pile deflection analysis

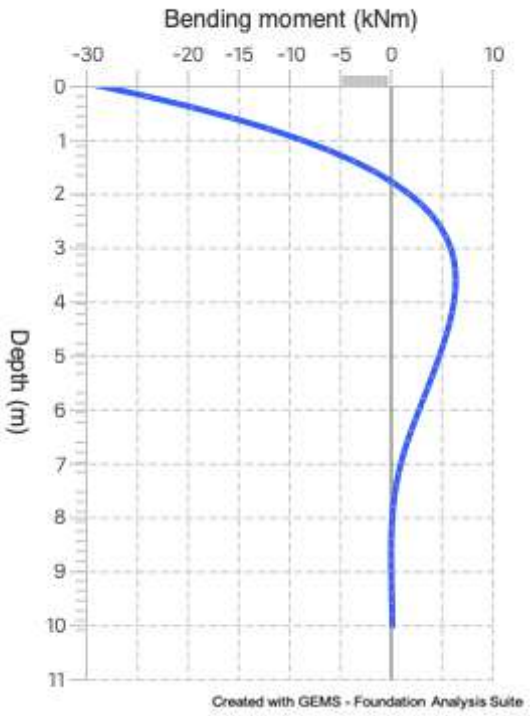
Tabulated values of lateral deflection and pressure along the length of the pile and graphical representations of them.





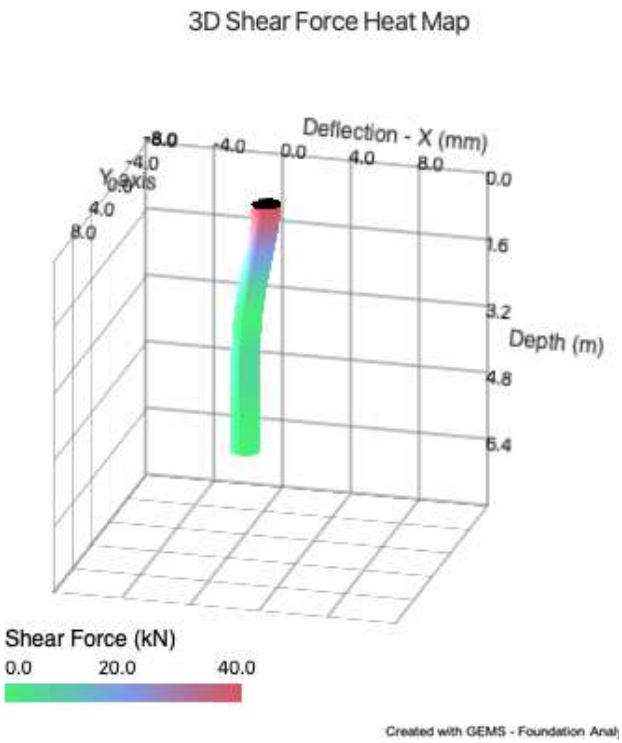
The Bending moment and shear force diagrams.

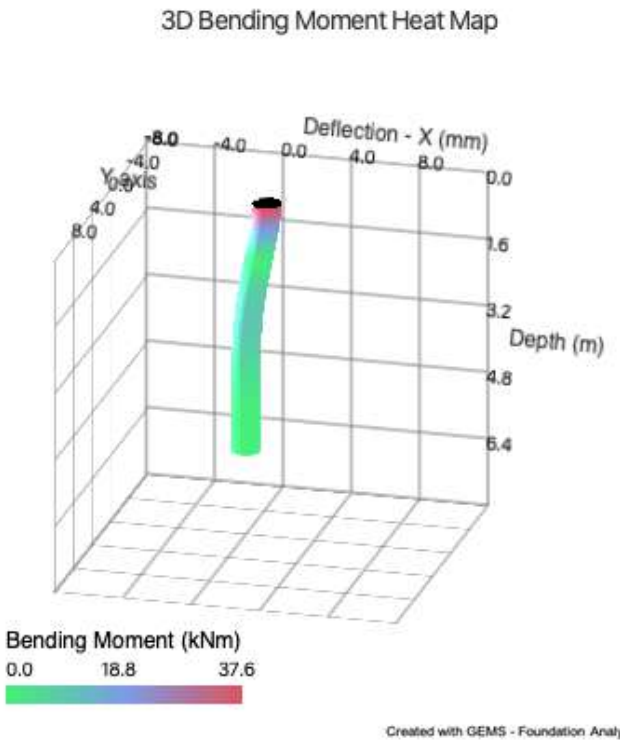




3D Shear Force Heat Map: Shear forces along the length of the pile in conjunction with 3D pile deflection diagram.

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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