AdSec

Pile Alp

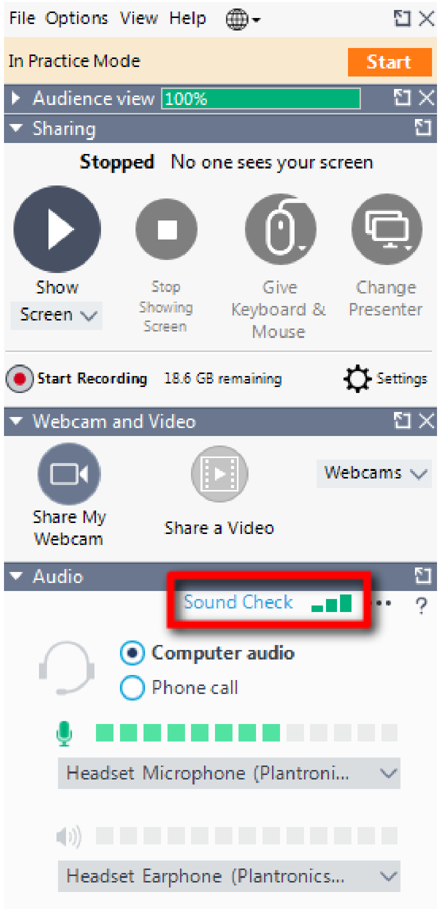
Single Pile Analysis

Zeena Farook

www.oasys-software.com

The webinar has started

Can you hear us? Please type in the questions box if you can.



Who is Oasys?

- Wholly owned by Arup
- Formed in 1976 to develop software for in-house and external use
- Most programming and sales staff are engineers
- In recent years have added marketing and sales staff
- Have expanded the development team worldwide

Oasys Customers

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Webinar Objectives

1. Introduce theory for Pile, Alp and AdSec
2. Set up analysis files and examine results
3. Apply partial factors to results
4. Case Study Example

Previous webinars:

- Tips and Tricks
- Advanced Analysis Options
- Step by step guide

The design of a single pile - Definition

What is a single pile?

- A pile that when loaded does not have any interaction effects with the adjacent pile
- Spacing between the piles will depend on solution modelled and the ground conditions

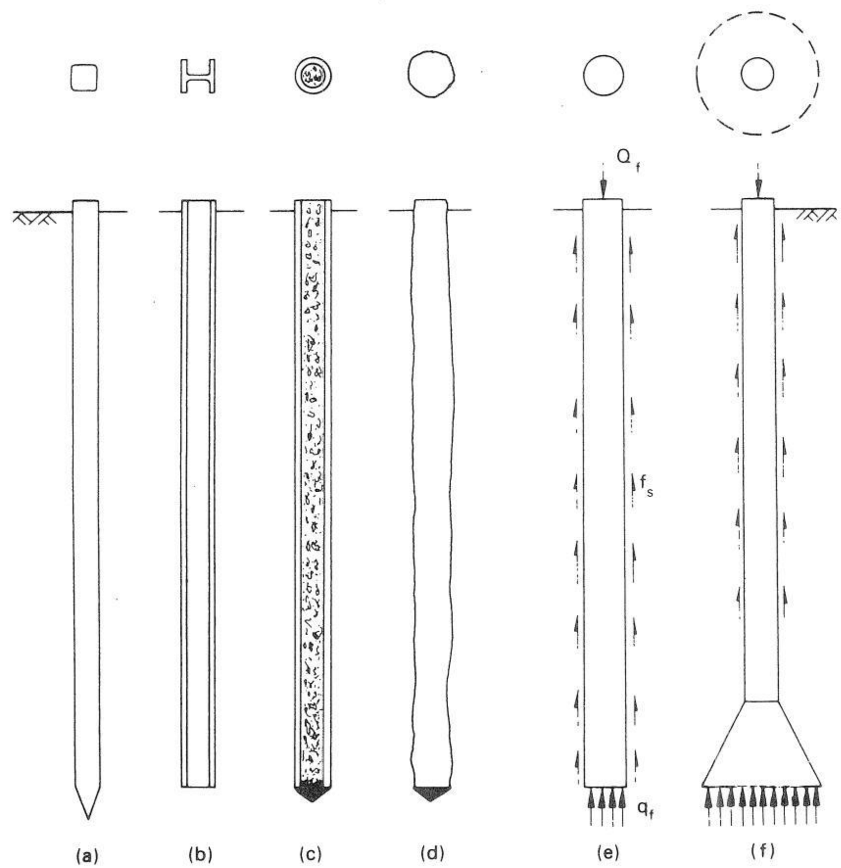


Fig. 8.17 Principal types of pile: (a) precast RC pile, (b) steel H pile, (c) shell pile, (d) concrete pile cast as driven tube withdrawn, (e) bored pile (cast *in-situ*), (f) under-reamed bored pile (cast *in-situ*).

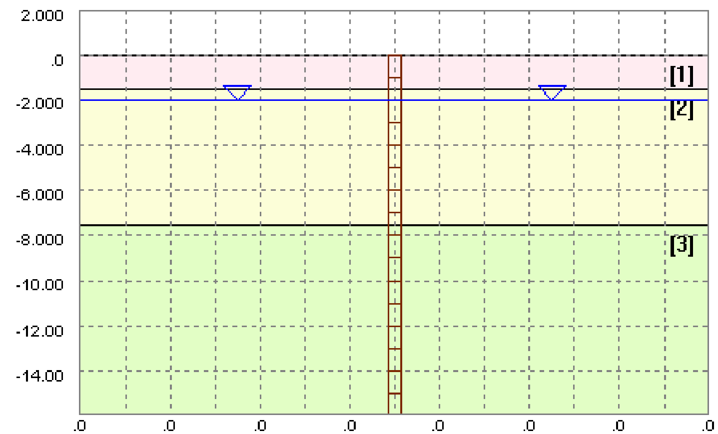
Craig's Soil Mechanics, 7th Edition

The design of a single pile - Analysis

Program	Analysis	Design Outputs
Pile	Pile vertical capacity and settlement analyses	Required length Pile settlement Soil settlement (utilities)
Alp	Pile lateral loads and displacements	Moment Cage length
AdSec	Non-linear concrete and composite section analysis	Stiffness Cracking

but, if you are interested in:

- Pile Groups – Oasys GSA Raft
- Retaining Walls – Oasys Frew



Pile

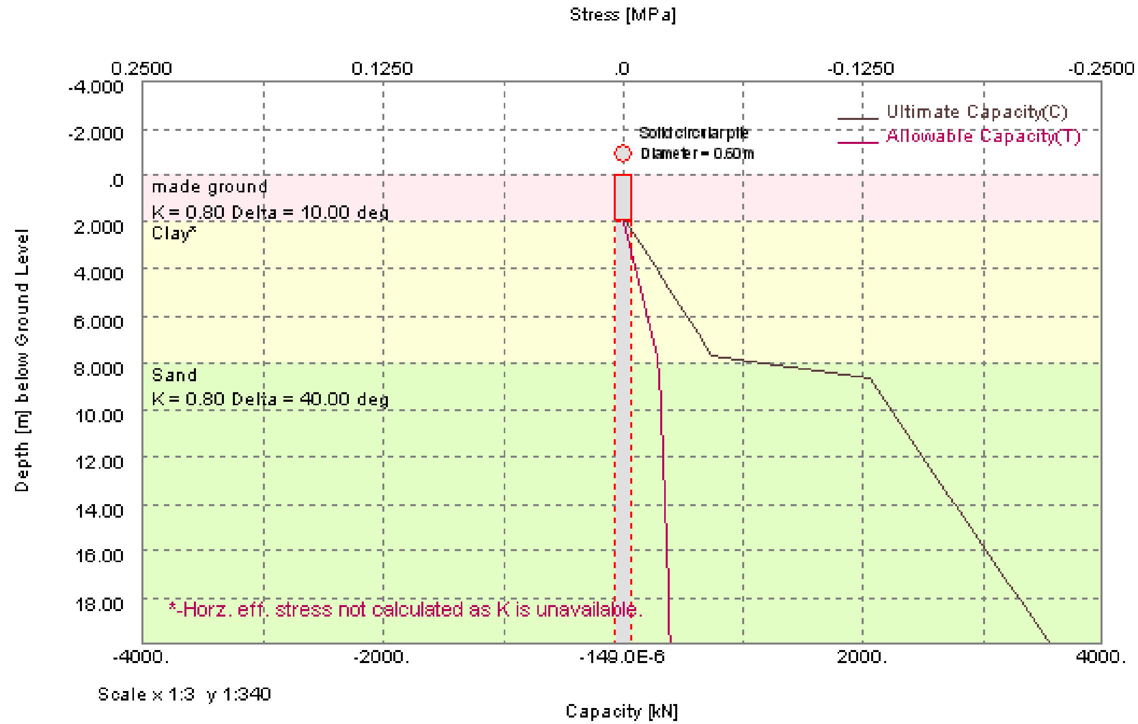
Pile Capacity and Settlement

Pile – Capacity
What does it do?

- Determines the vertical load capacity of a pile for:
  - Different pile types
  - Different pile materials
  - A range of pile lengths
  - Numerous different soil layers
  - Site specific groundwater conditions
  - Different factors of safety or design resistance

Pile - Capacity

- Output
  - Ultimate and allowable capacities
  - Tension and compression capacities
- Input
  - Pile section
  - Under-reams
  - Soil parameters

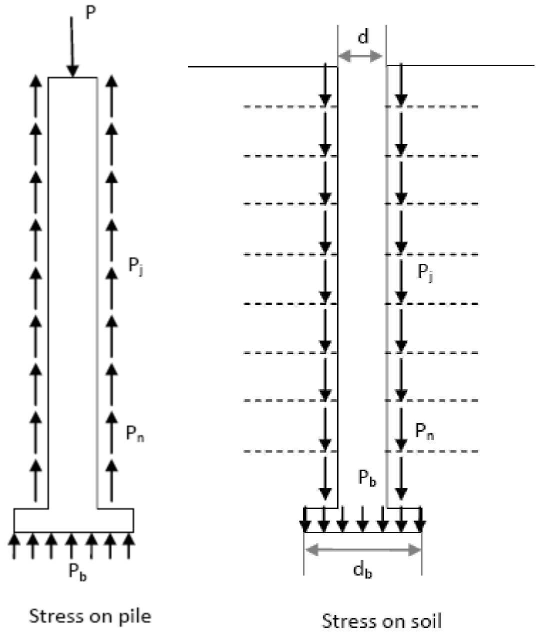


Pile – Capacity
Why use it?

- Replaces the need for spreadsheet calculations and errors that maybe within them!
- Calculates shaft and base capacity for:
  - Total stress (undrained parameters)
  - Effective stress (drained parameters)
  - Combination of both
- Models plugged and unplugged behaviour for tubular and H piles
- Can incorporate negative skin friction *(not used in tension calculations)*

Pile – Settlement Theory

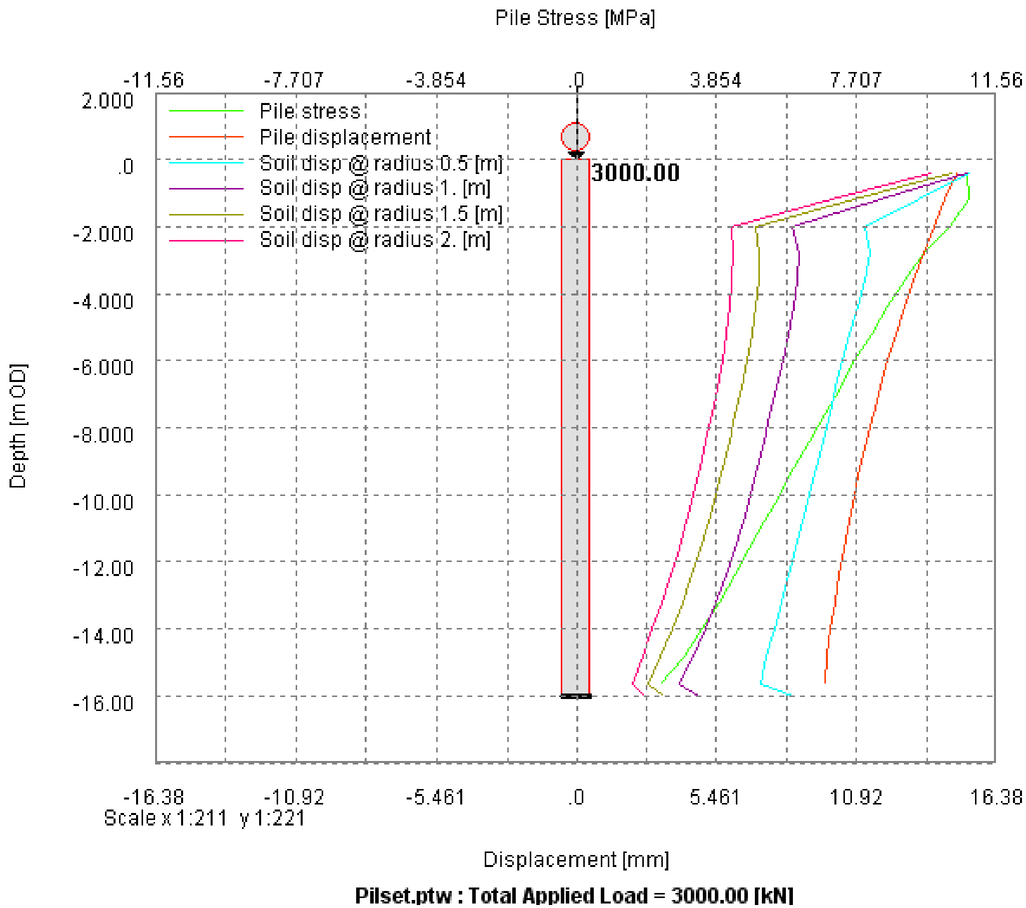
- Purely elastic model
- Young's Modulus of
  - Soil above pile toe
  - Soil below pile toe
  - Pile
- Compressible pile in sections
- Continuum soil
- Based on paper by Mattes and Poulos (1969)



Pile - Settlement

Settlement of a pile and surrounding soil

- Output
  - Pile settlement
  - Soil settlement away from pile
  - Pile stresses
- Input
  - Pile dimensions
  - Soil stiffness
  - Negative skin friction
  - Heave



Advanced features

- t-z curves
- Thermal piles
- Cyclic loading
- Stages
- Negative skin friction

Pile Set-up

Pile Capacity and Settlement

Oasys
YOUR IDEAS BROUGHT TO LIFE

Alp

Horizontal Loading and Displacements on Pile

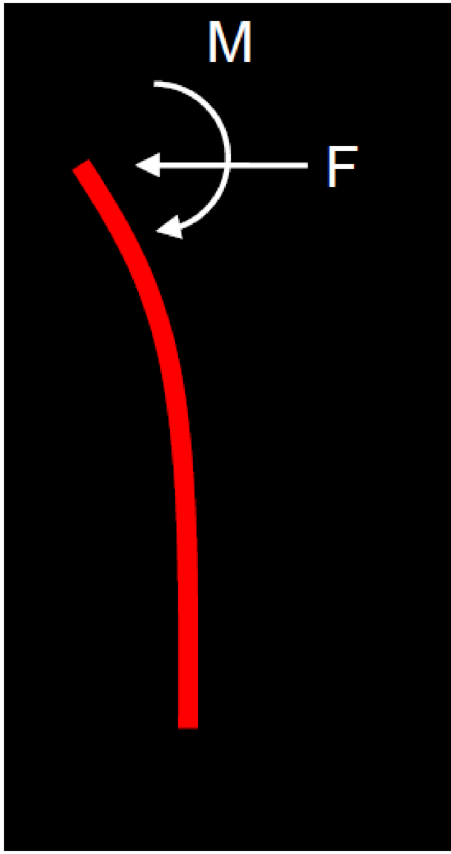
Alp

Alp calculates:

- Earth pressures
- Horizontal movements
- Bending moments
- Shear forces

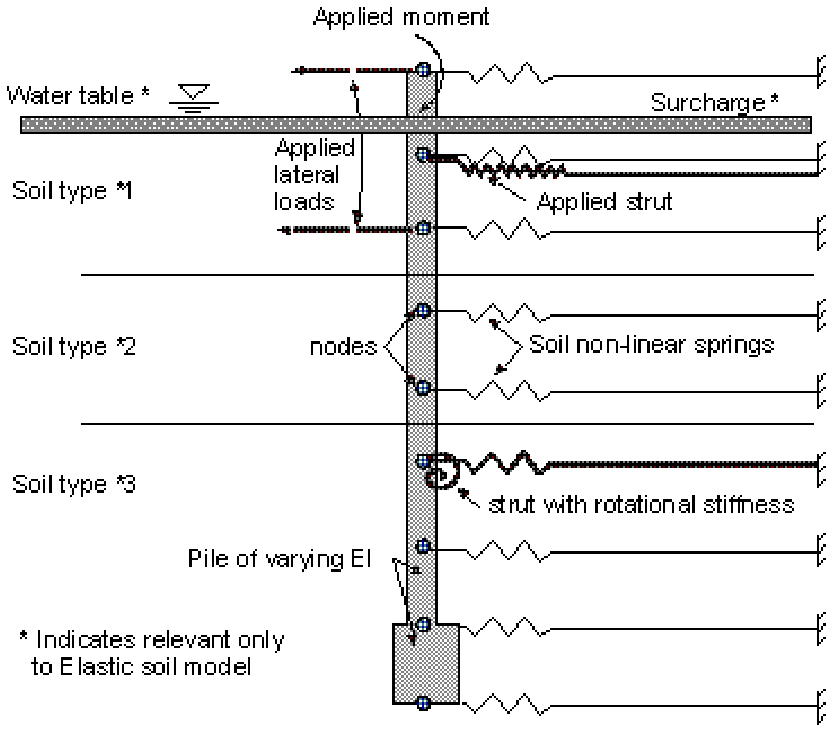
Based on:

- Lateral loads, moments or displacements
- Lateral and rotational restraints
- Soil load deflection behaviour

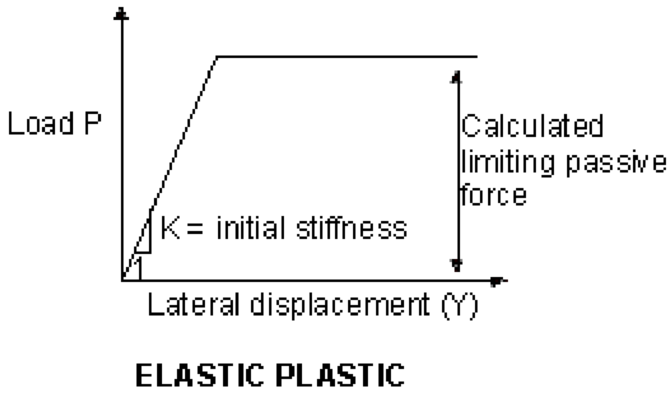


Alp
Theory - Representation

- Models the pile as a series of elastic beam elements
- Models the soil as a series of non-interactive non-linear springs
- Forces, moments and stiffnesses are applied at nodes
- Soil response modelled as Elastic Plastic or P-Y



Alp
Theory – Elastic-Plastic



- Assumes elastic behaviour until a passive limit is reached –simplistic!
- At limit, a constant limiting passive force is used

$K = E\ h\ E_{fact}$

E = Young's modulus of soil
h = distance between mid-point of adjacent nodes

$Fp = (K_q\sigma_v' + cK_c)\ h\ D$

K_q = Passive resistance coefficient for the frictional component of the soil
K_c = Passive resistance coefficient for the cohesive component of the soil

Alp
Theory – P-Y Soil Model

BUT Soils are not Elastic-Plastic

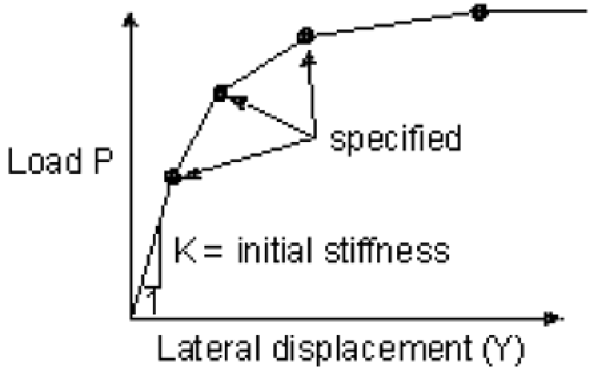
Predefined models for:

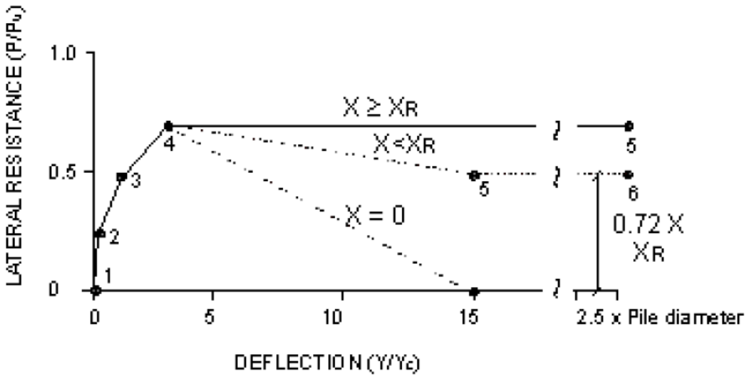
- Soft Clay (Matlock 1970)
- Stiff Clay (API 21)
- Sand (API 18 or 21)
- Weak Rock (Reese 1997)
- Strong Rock (Turner 2006)

User can define P-Y curves for different strata

Cyclic loading can be considered

P-Y Curve:





Alp Set-up

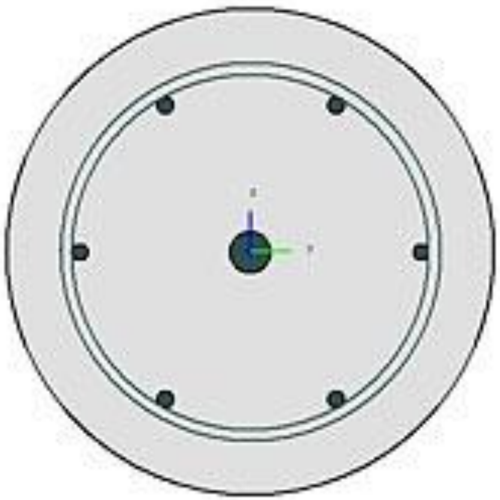
Horizontal Loading and Displacements on Pile

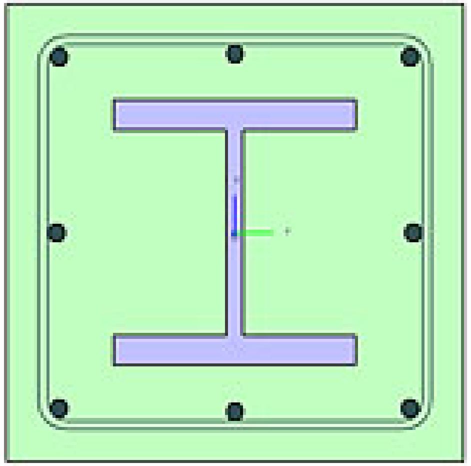
AdSec

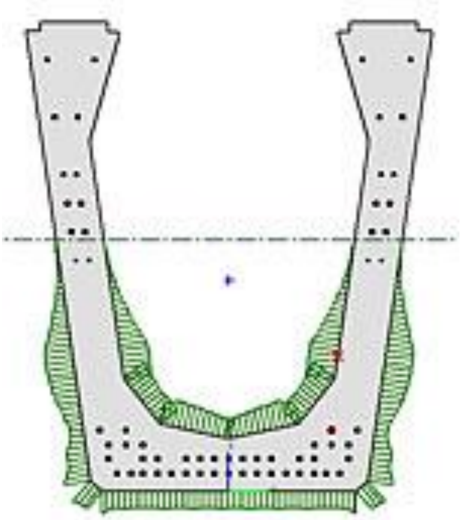
Non-linear Concrete and Composite Section Analysis

AdSec

Non-linear concrete and composite section analysis







AdSec Theory

- Program carries out a strain plane analysis for any given section to solve the following equation:

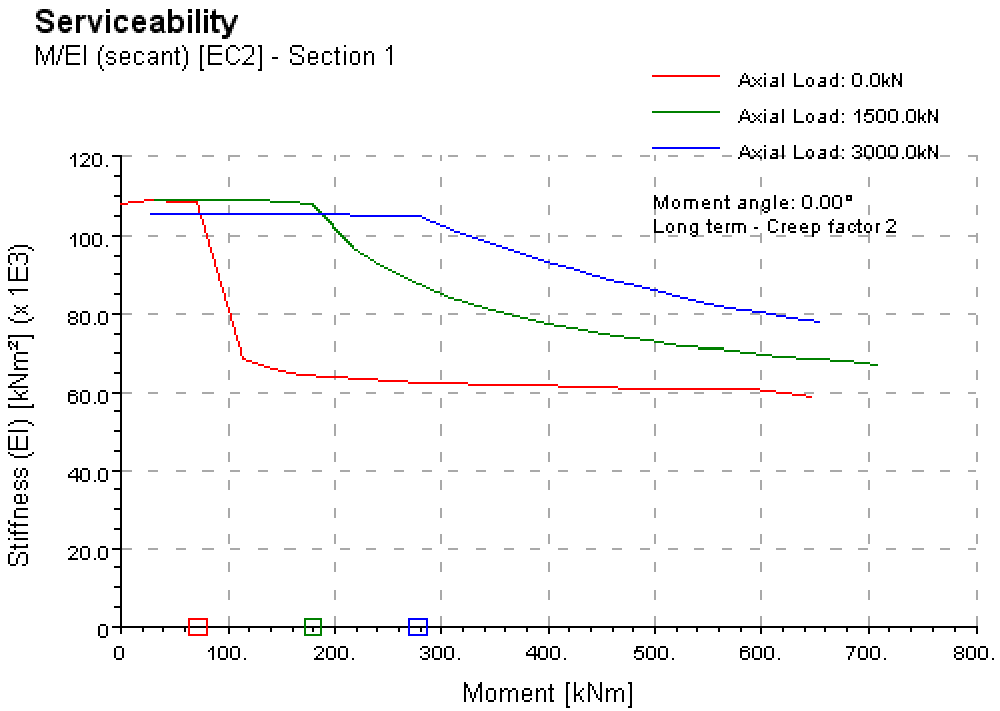
$$\varepsilon = \varepsilon_{ax} + \kappa_{yy}.z' + \kappa_{zz}.y'$$

- ULS Analysis
  - Ultimate strength of section
  - Uses material factors or strength reduction factors
- SLS Analysis
  - looking at the section in its normal working state
  - allow for both long term (creep) and short term loading

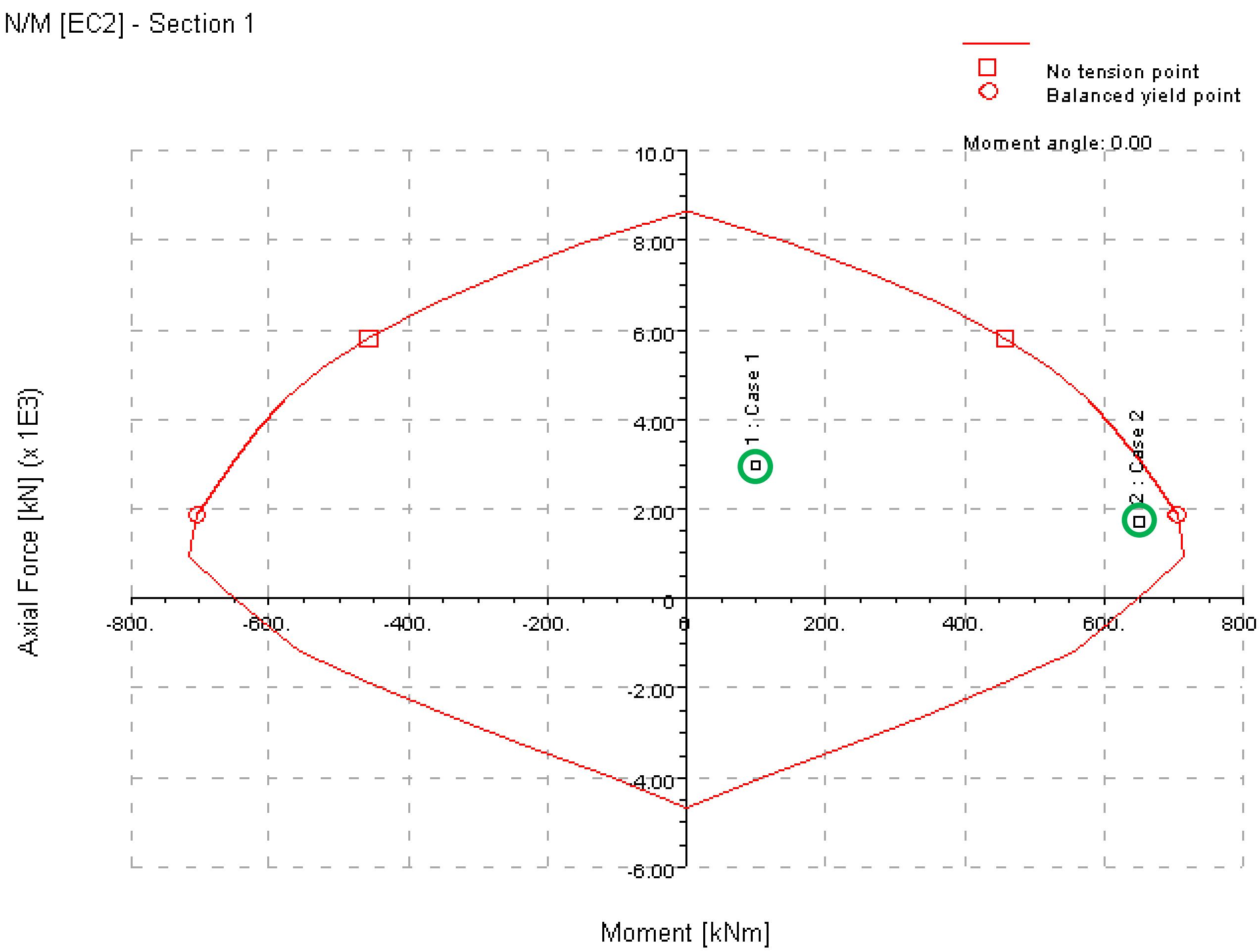
AdSec

Non-linear concrete and composite section analysis

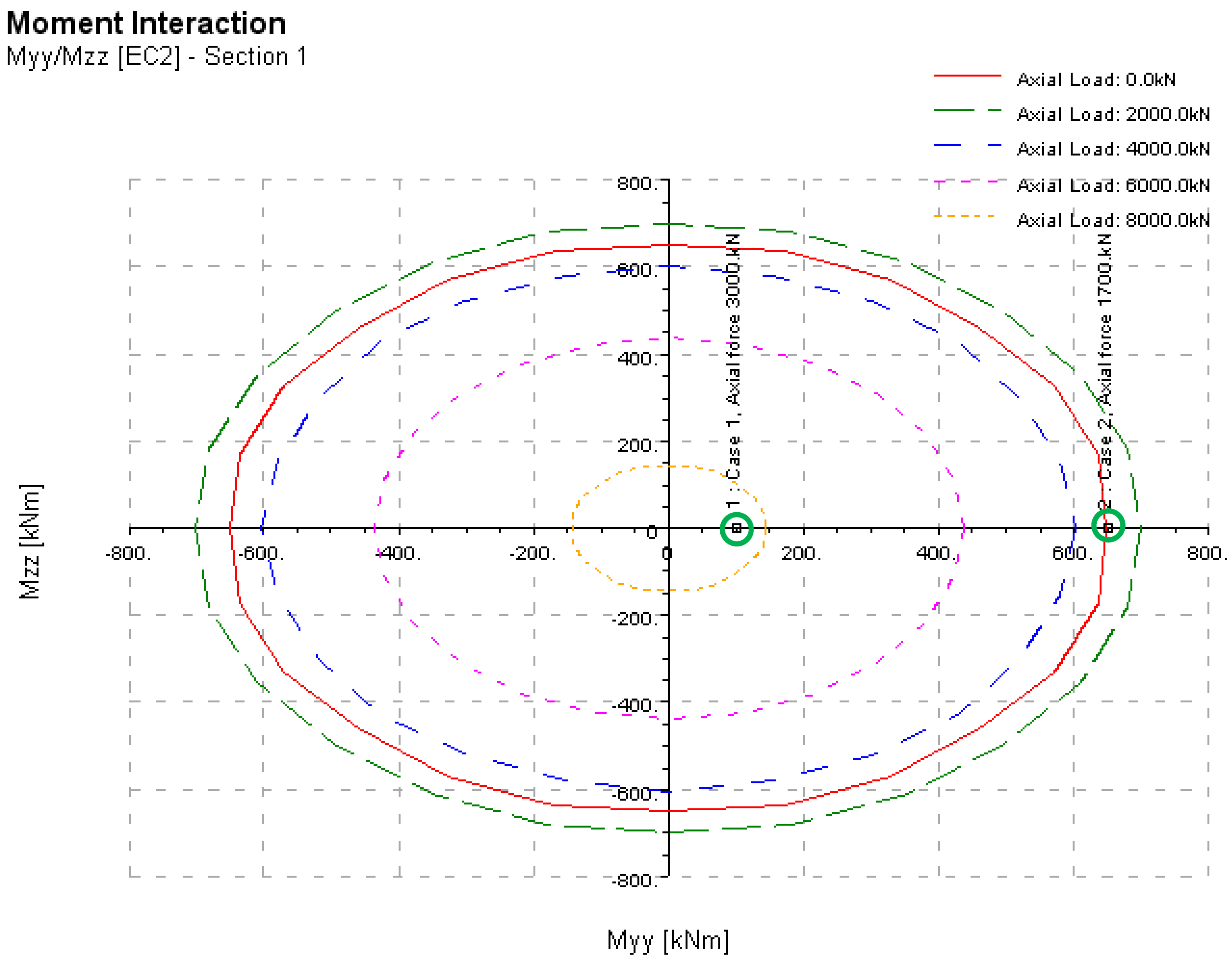
- Output
  - Section capacities
  - Section stiffnesses
  - Cracking
- Input
  - Section
  - Reinforcement
  - Loads



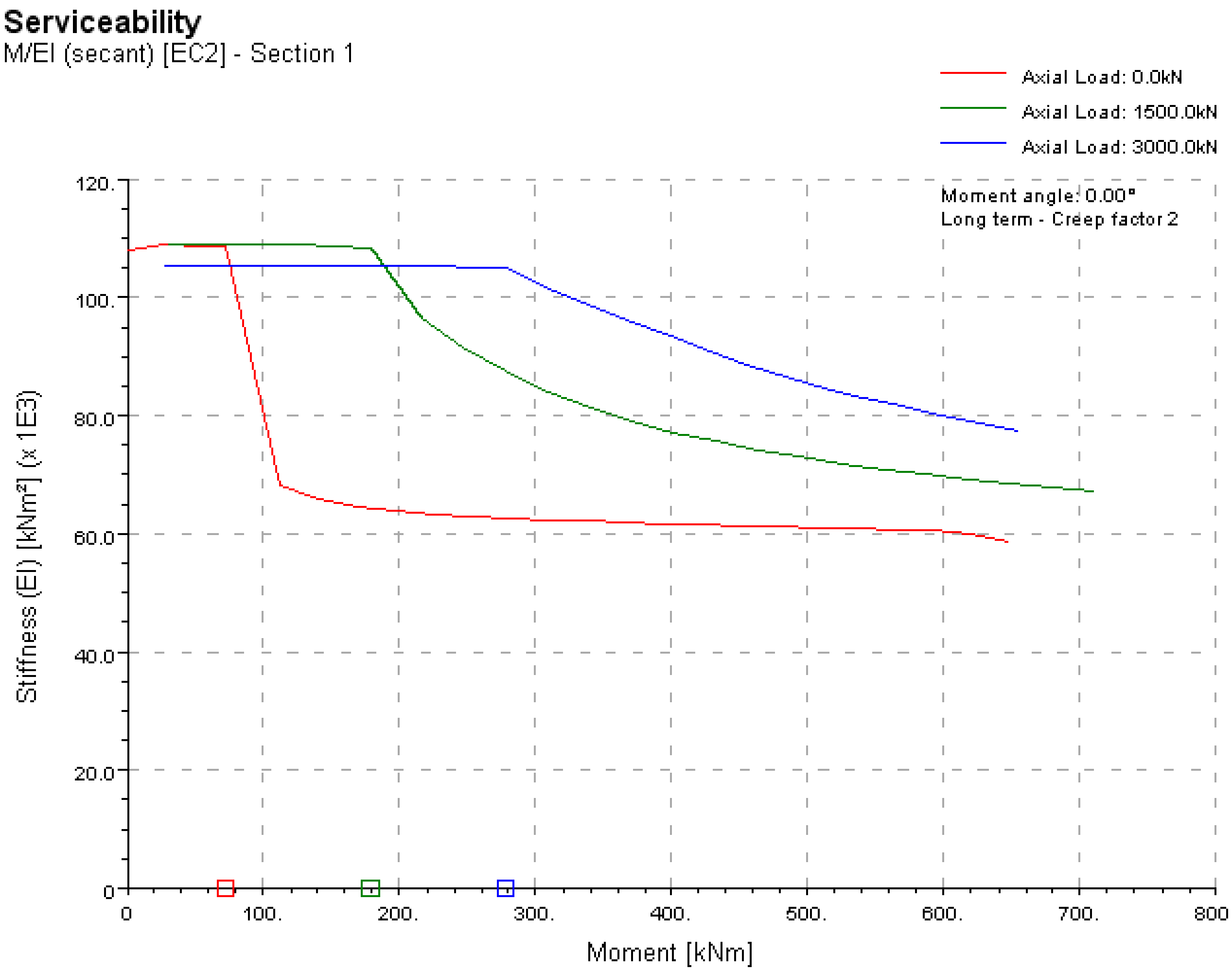
AdSec – Section capacities – N/M



AdSec – Section capacities – M/M



AdSec – Section capacities – Stiffness



AdSec

- Ultimate and Serviceability condition checks
- Regular and irregular concrete and composite sections
- Non-linear cracked section stiffness and capacities
- Crack widths

AdSec Set-up

Non-linear Concrete and Composite Section Analysis

Case Studies

Designing Piles for Transverse Loads

McCarthy's level crossing near Kilmallock

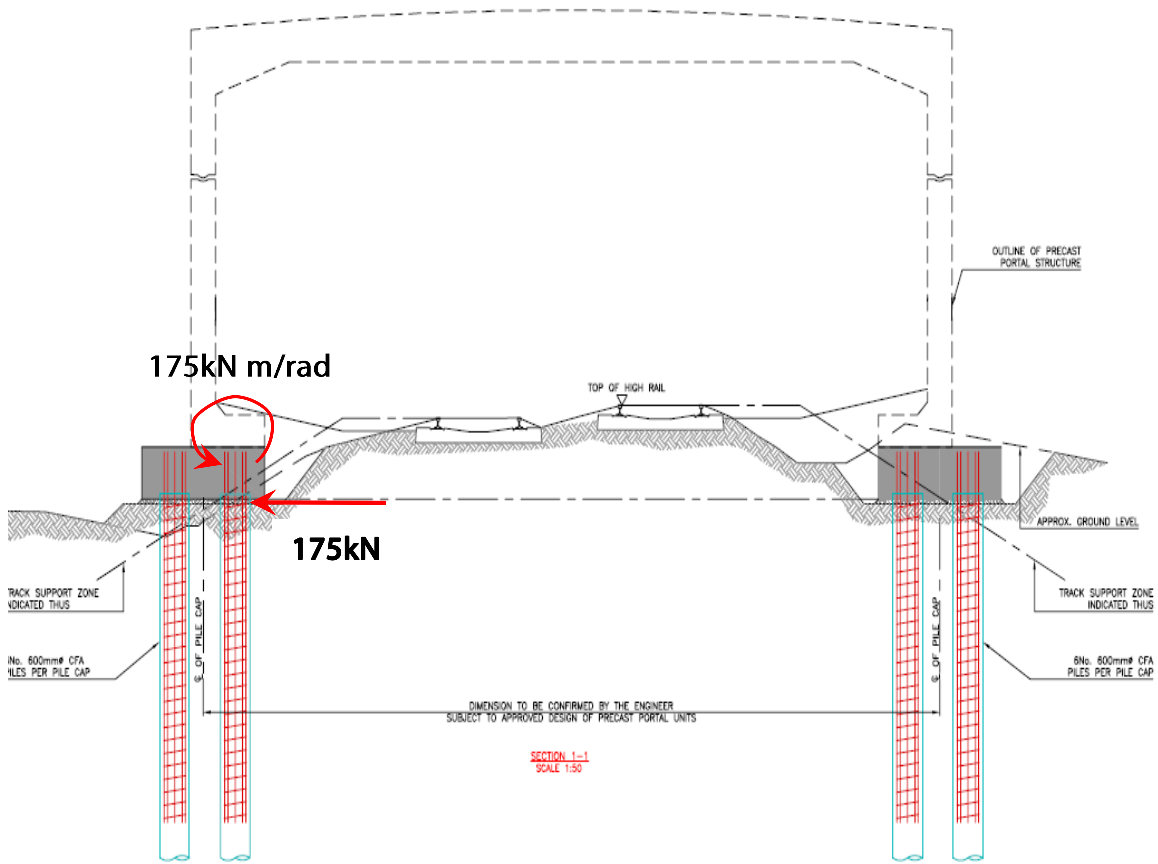
BYRNE LOOBY

Project Brief

BYRNE LOOBY

- BLP were asked to design the piled foundations for the proposed replacement of McCarthy's level crossing near Kilmallock, Co. Limerick.

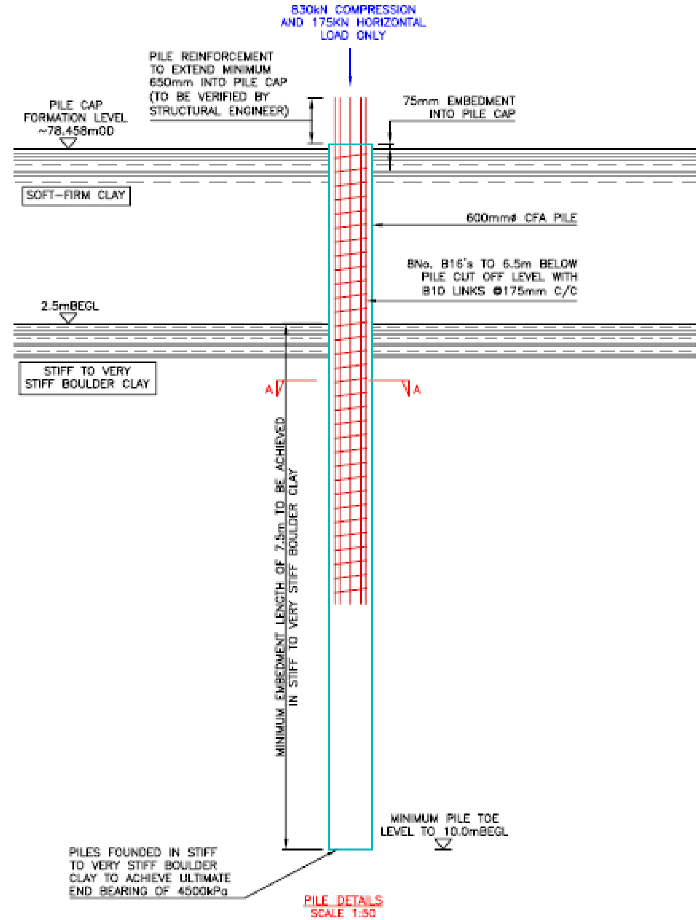
- **The piles had to resist 830kN maximum uniaxial compressive loads**
- **No tension or moment loads were to be transferred to the piles**
- **The piles were subjected to 175kN horizontal load per pile from the superstructure**



Proposed Solution

BYRNE LOOBY

- All piles are designed to be bearing in the stiff to very stiff boulder clay, conservatively ignoring the upper 2.5m of overburden.
- The Consulting Engineers specified the piles to be minimum 600mm diameter



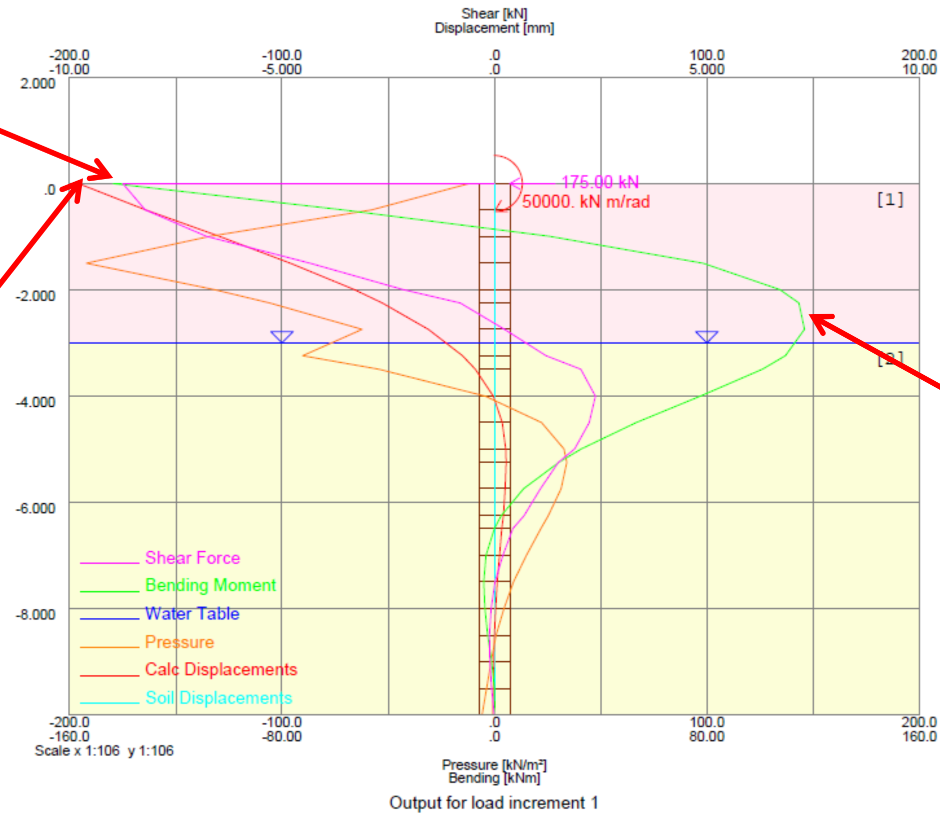
Analysis – Transverse Load

BYRNE LOOBY

- For the ALP analysis a rotational stiffness has been taken for the pile cap. All piles are to be fully tied into this pile cap.

Max Pile SF = 175kNm

Predicted Pile Head Movement <10mm



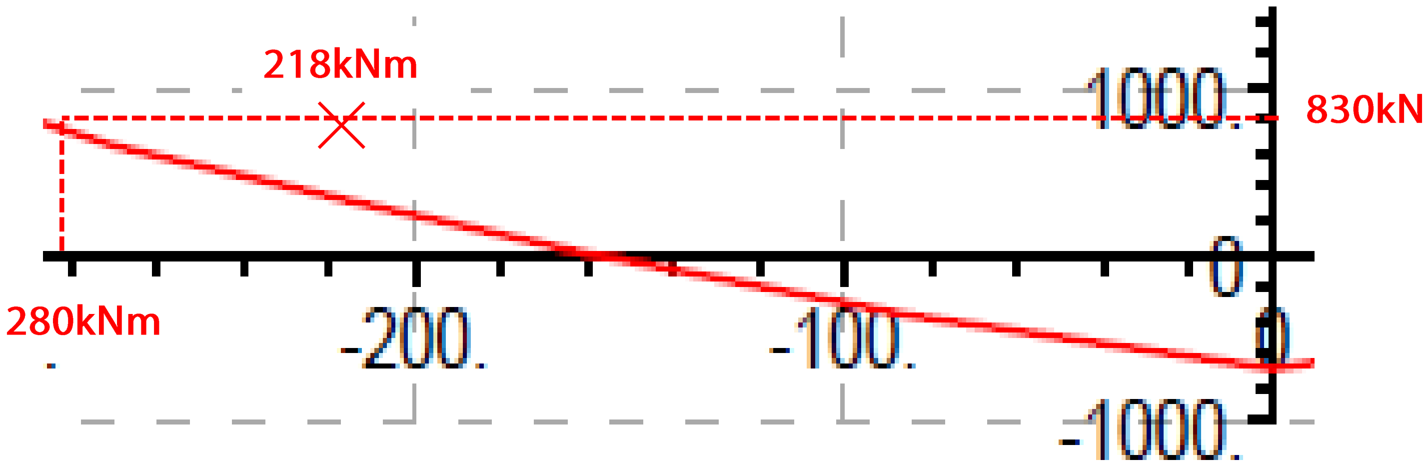
Max Pile BM = 145kNm

- **The pile reinforcement should be installed to a minimum depth of 6.5m below pile cut off level, as per the ALP output.**

Analysis – Structural Capacity of Pile

- The pile reinforcement capacity has been checked using Oasys AdSec software package
- From Adsec $BM_{allowable}$ > 280kNm for a compressive load of 830kN
- $BM_{design} = BM_{generated} \times F.o.S$ Take F.o.S = 1.5
- $BM_{design} = 145 \times 1.5$ => 218kNm < $BM_{allowable}$ = OK

AdSec



COM Interface

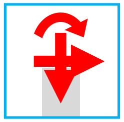
Iterative Pile Design for a Large Site

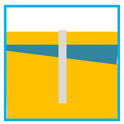
ARUP

Automated Design

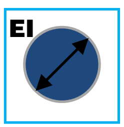
ARUP

Inputs

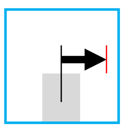

Loads


Ground model

Base models



Pile properties

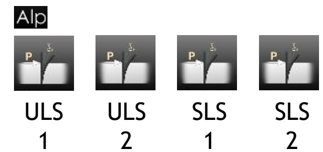

Displacement limit

Automated calculations

Calculation spreadsheet runs iterative design calculations:

1) Lateral calculations

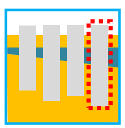

Four alp models per load case. Length iterated to iteration limits.



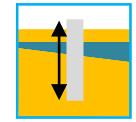
2) Axial calculations

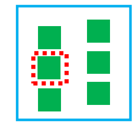

Axial (compression and tension) capacity calculations completed, for ULS1, ULS2 and SLS.
Pile length iterated until FoS = 1 in each case.

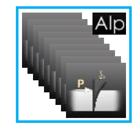
3) Determination of design length


… is the longest of any case (lateral or axial).

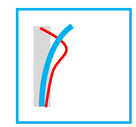
Outputs

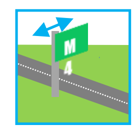

Pile length


Critical case



Iterated models and log file

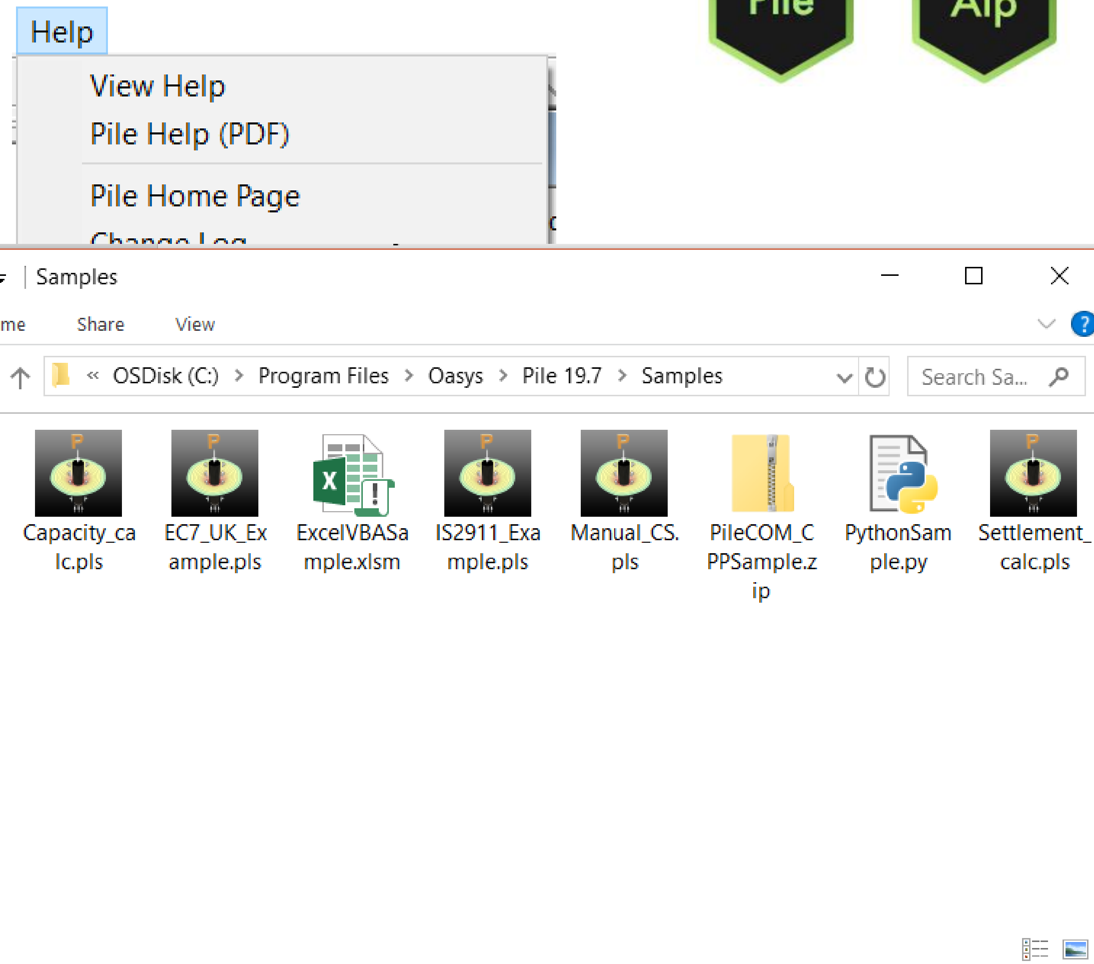

Extracted BM and displacement


Displacement interpretation

Case study from Mark Skinner, Arup

Where do I go for help?

- Program
- Sample Files
- Manual
- Website:
  - Tutorials
  - Webinars
  - FAQ
  - User Voice
- Email



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AdSec	Non-linear concrete and composite section analysis	Stiffness Cracking

Find out more?

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AdSec

Pile

Alp

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