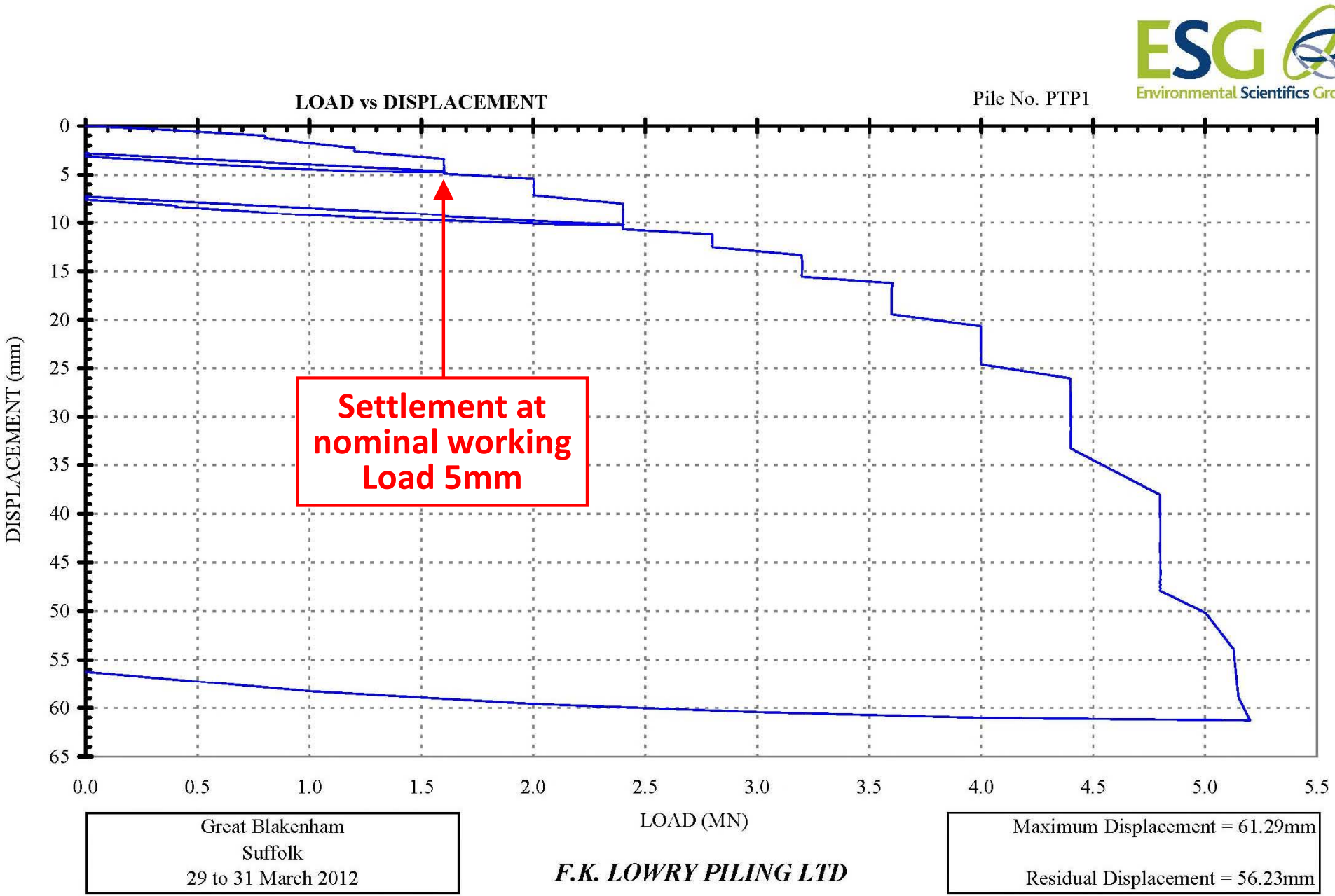
# Pile Settlement

- Options:
  - Pile load test
  - Empirical
  - PIGLET method
  - CEMSET method
  - Poulos Method (incorporated in Oasys PILSET/PILE)
  - Finite Element or Boundary Element methods (REPUTE)
- For calculation, the emphasis is a rigorous and reliable calculation method

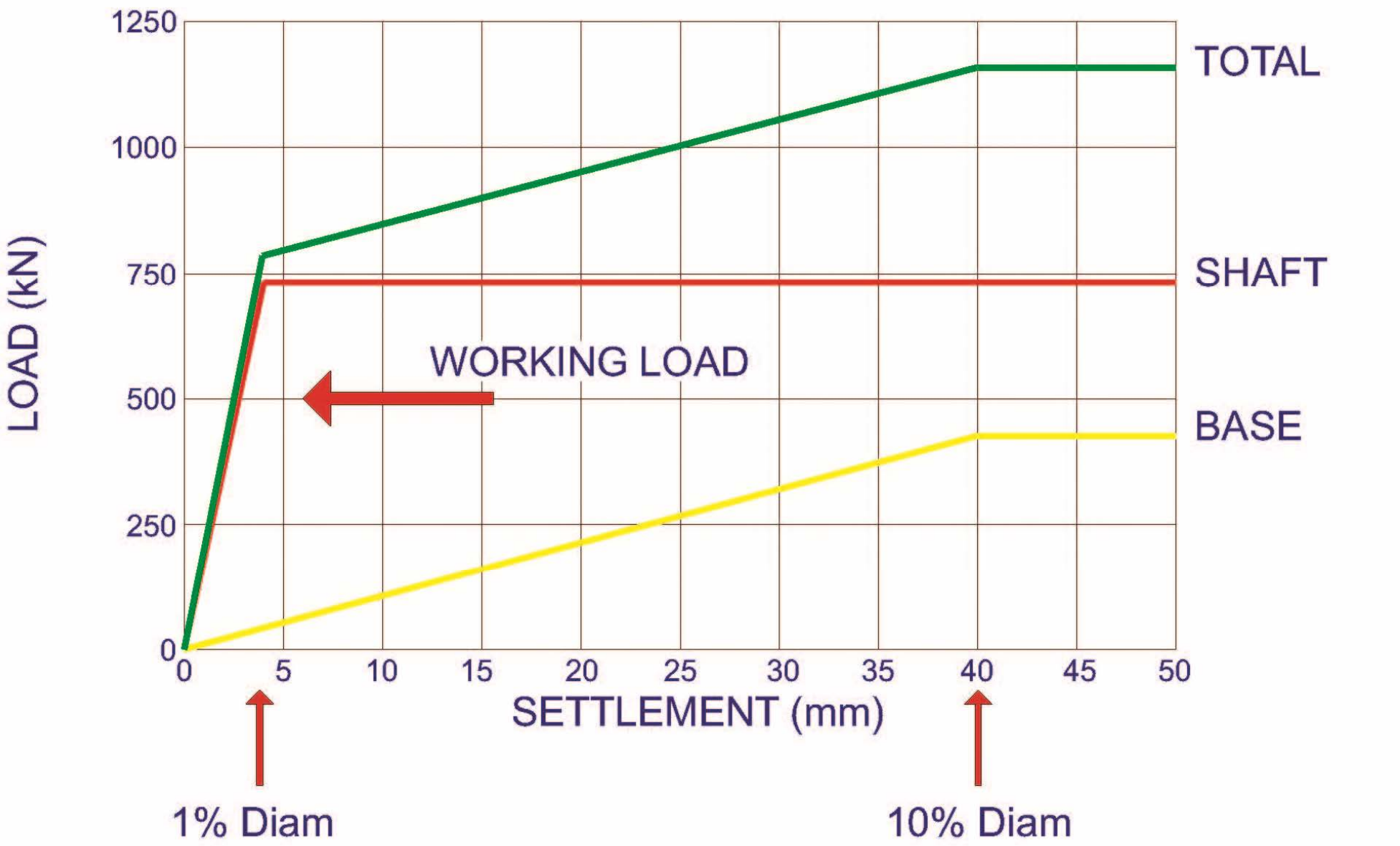
# Pile Load Test Results



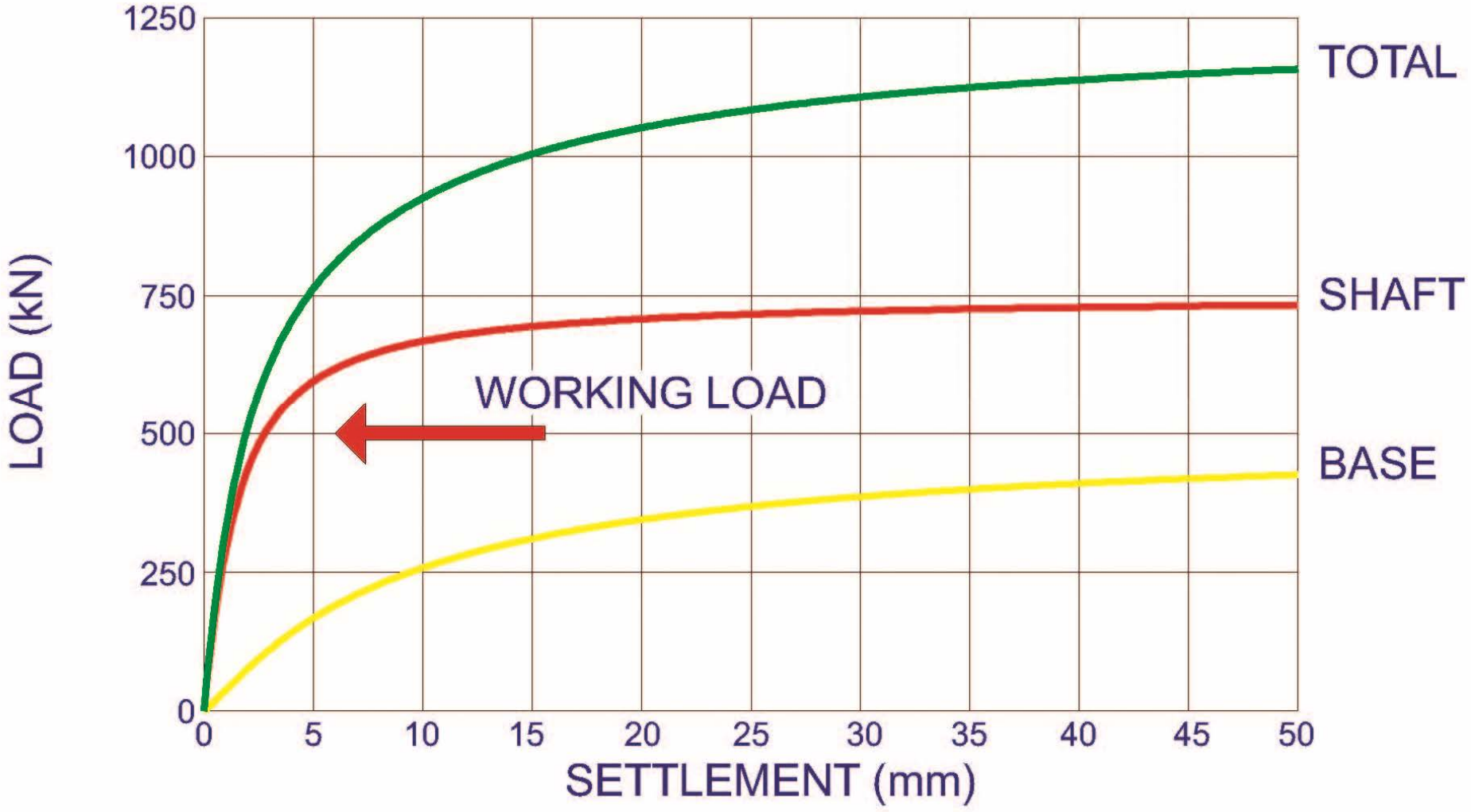
# Pile Settlement

- Empirical method: Pile settlements are dependent on the stiffness properties of the founding soil or rock, the pile geometry, and the mechanism of load transfer to the ground.
- Typically:
  - Shaft friction is mobilised at a movement equal to about 1% of the pile diameter
  - End bearing is mobilised at a movement equal to about 10% of the pile diameter
- Good for understanding behaviour but not rigorous

# Pile Settlement - Empirical



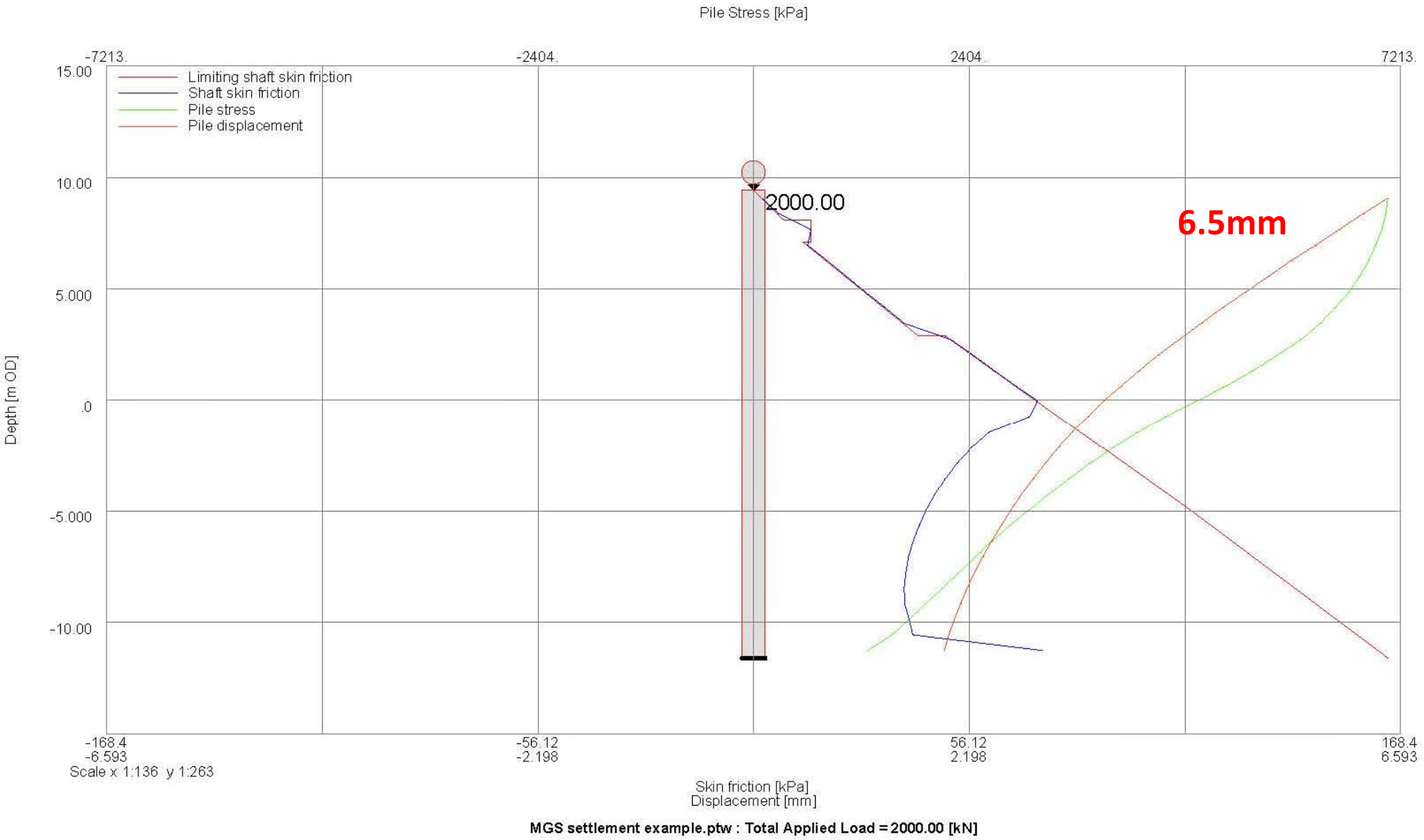
# Pile Settlement – Real Behaviour



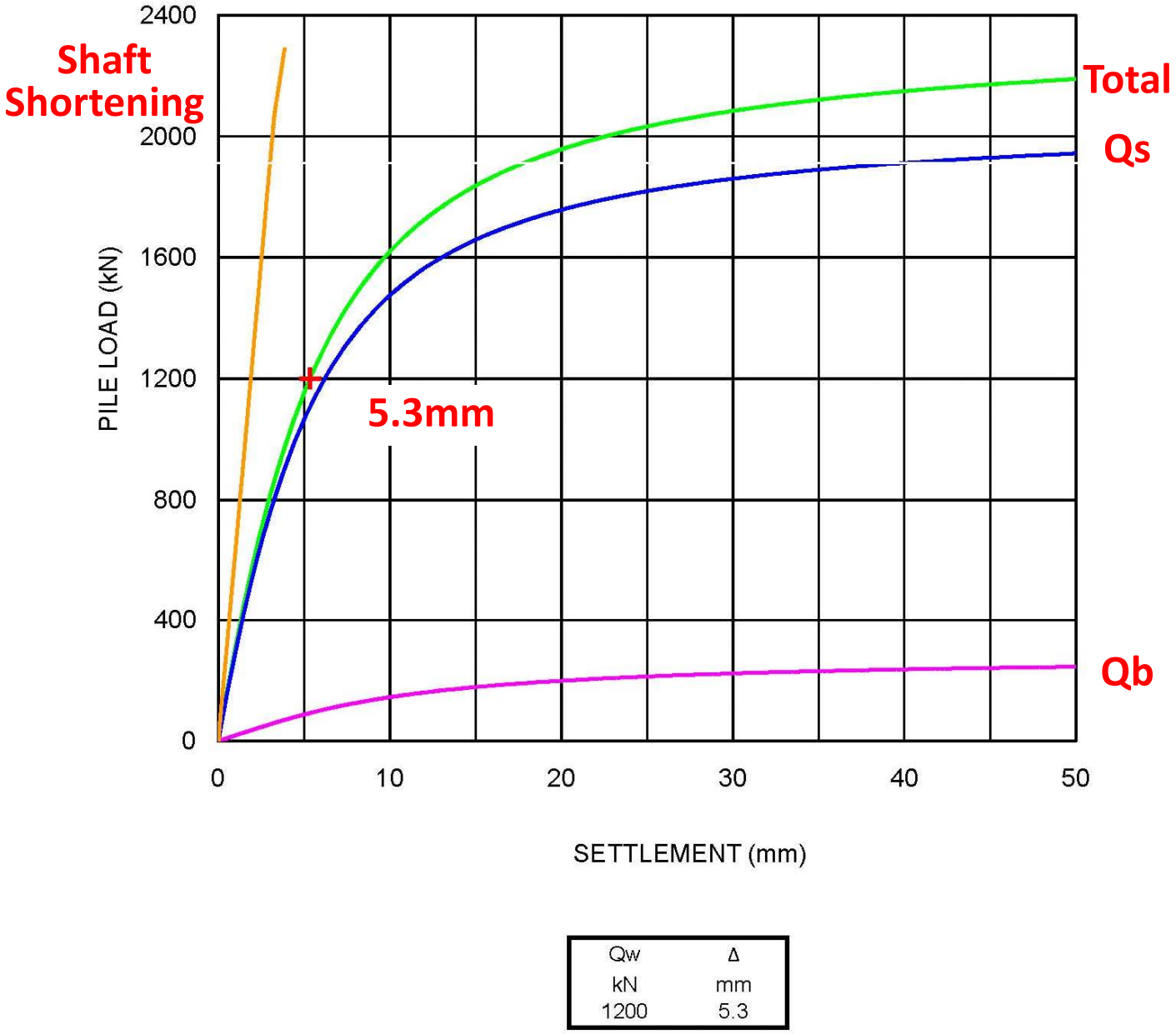
# Pile Settlement

- Computational approaches for assessing pile settlements available as computer programs:
  - PIGLET Closed form elastic continuum equations
    Randolph (1980)
  - CEMSET Simplified hyperbolic functions for the pile base and shaft Fleming (1992)
  - PILSET Iterative approach based on Mindlin equations
    Poulos & Davis (1980) - Oasys Limited
  - REPUTE Based on boundary elements

# Example PILE/PILSET Settlement Calculation



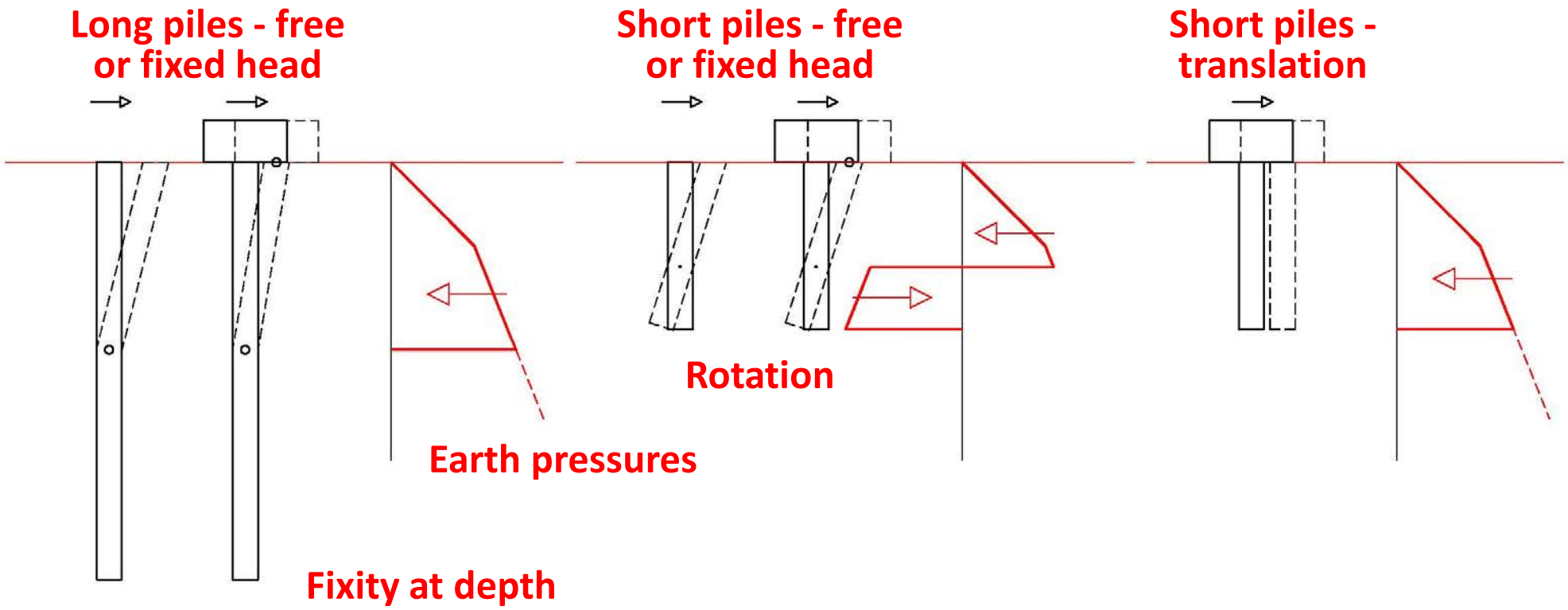
# Example CEMSET Settlement Calculation




| Qw | Δ |
|---|---|
| kN | mm |
| 1200 | 5.3 |

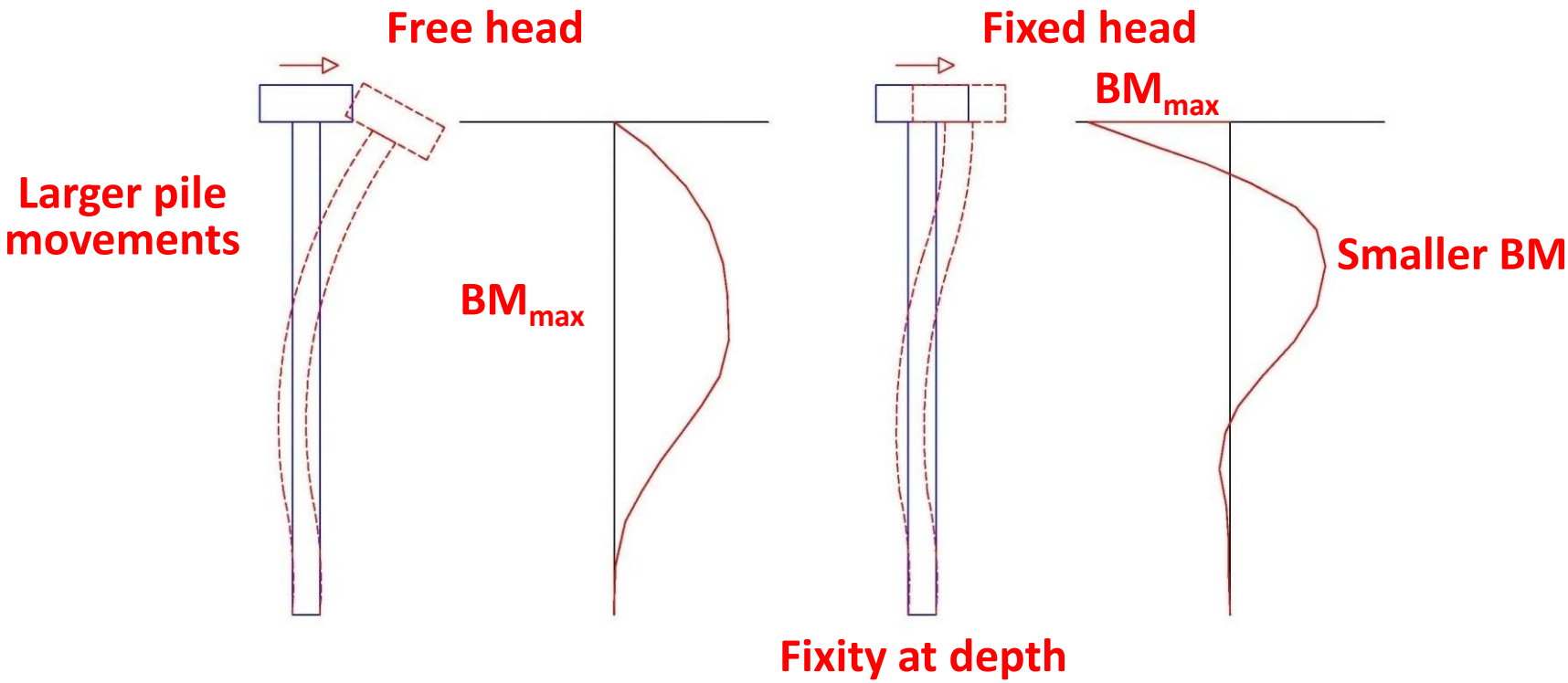
# Horizontal Loading

- It is possible to carry out ULS horizontal load analyses but these depend on the assumed mechanism of behaviour



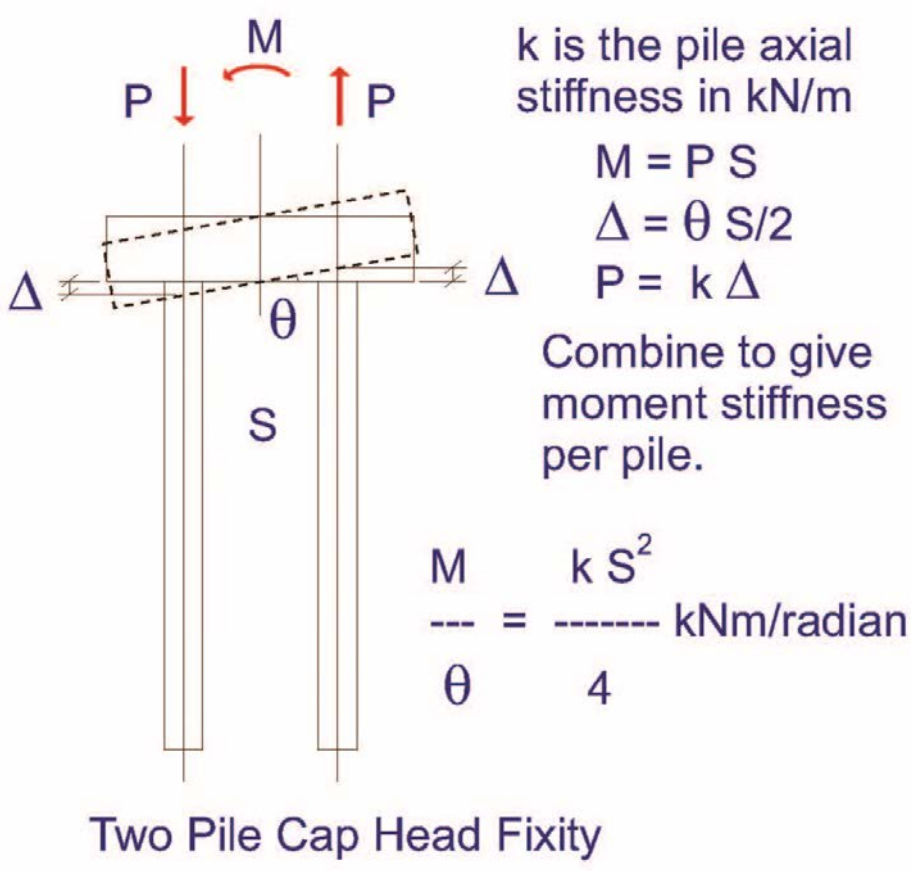
# Horizontal Loading

- Note that real piles have flexural stiffness (EI)
- Horizontal behaviour is controlled by head fixity at the cap



# Horizontal Loading – Head Fixity

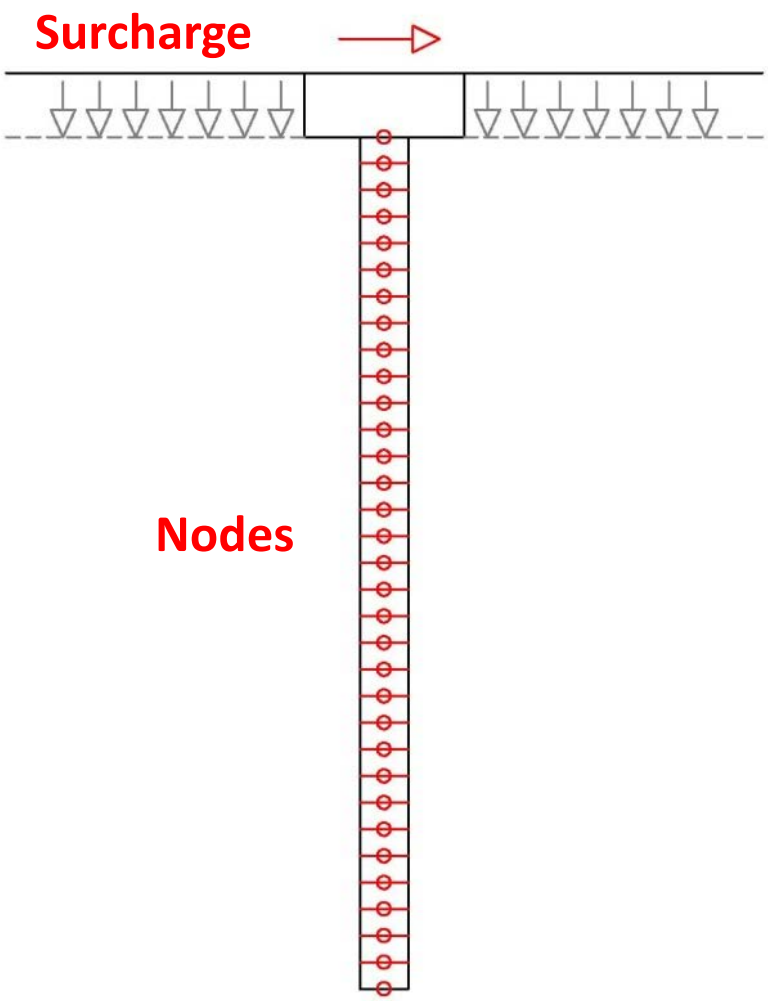
- Head fixity can be modelled as shown
- Larger pile groups have much larger fixity
- Bending moment is Usually maximum at the connection to the pile cap




Two Pile Cap Head Fixity

# Horizontal Loading

- EC7 allows soil-structure interaction software to be used:
  - Options in UK are ALP or WALLAP
  - Pile is modelled as beam elements
  - Ground is modelled as springs
  - Analysis can be based on factored horizontal actions or factored soil strength (and stiffness)
  - Best to analyses without factors
  - Apply partial factors to BM & SF



# Horizontal Loading

- ALP uses Brinch Hansen $k_q$ and $k_c$ coefficients

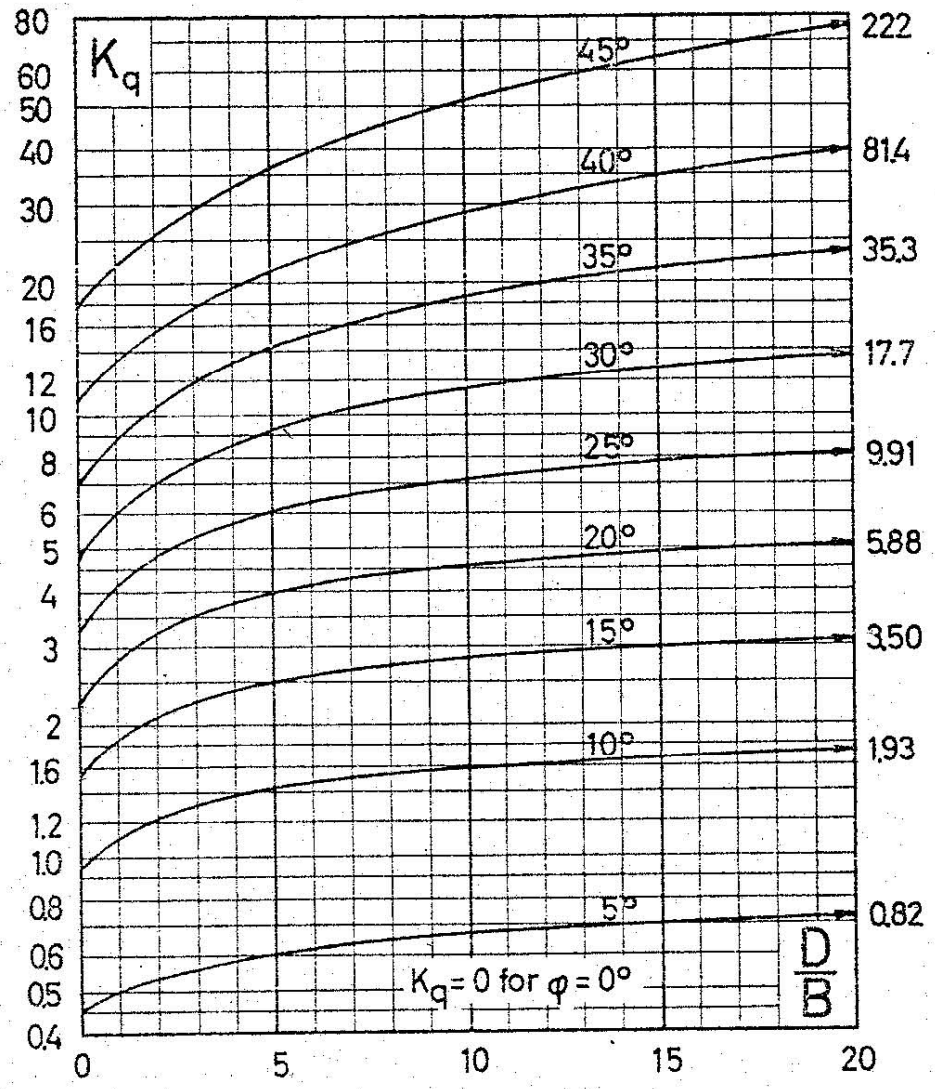



Fig. 5. Earth pressure coefficient for overburden pressure.

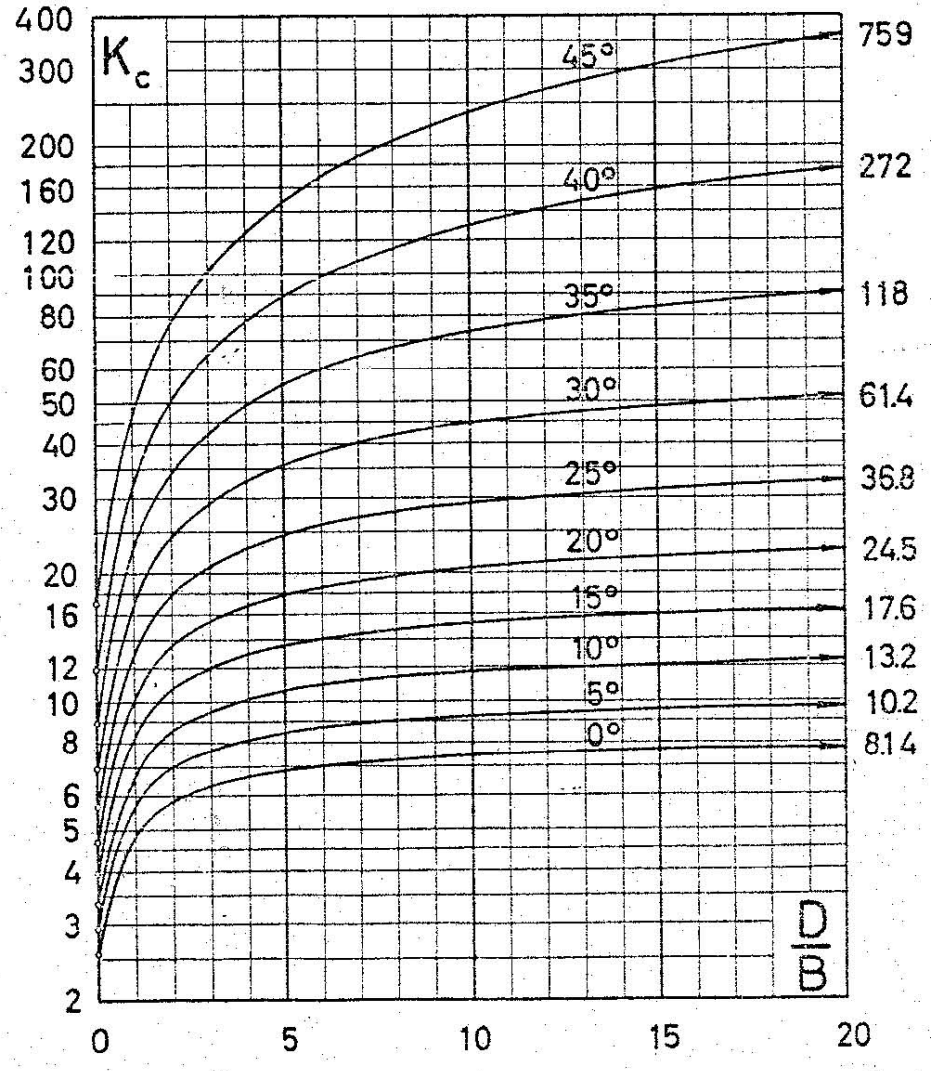
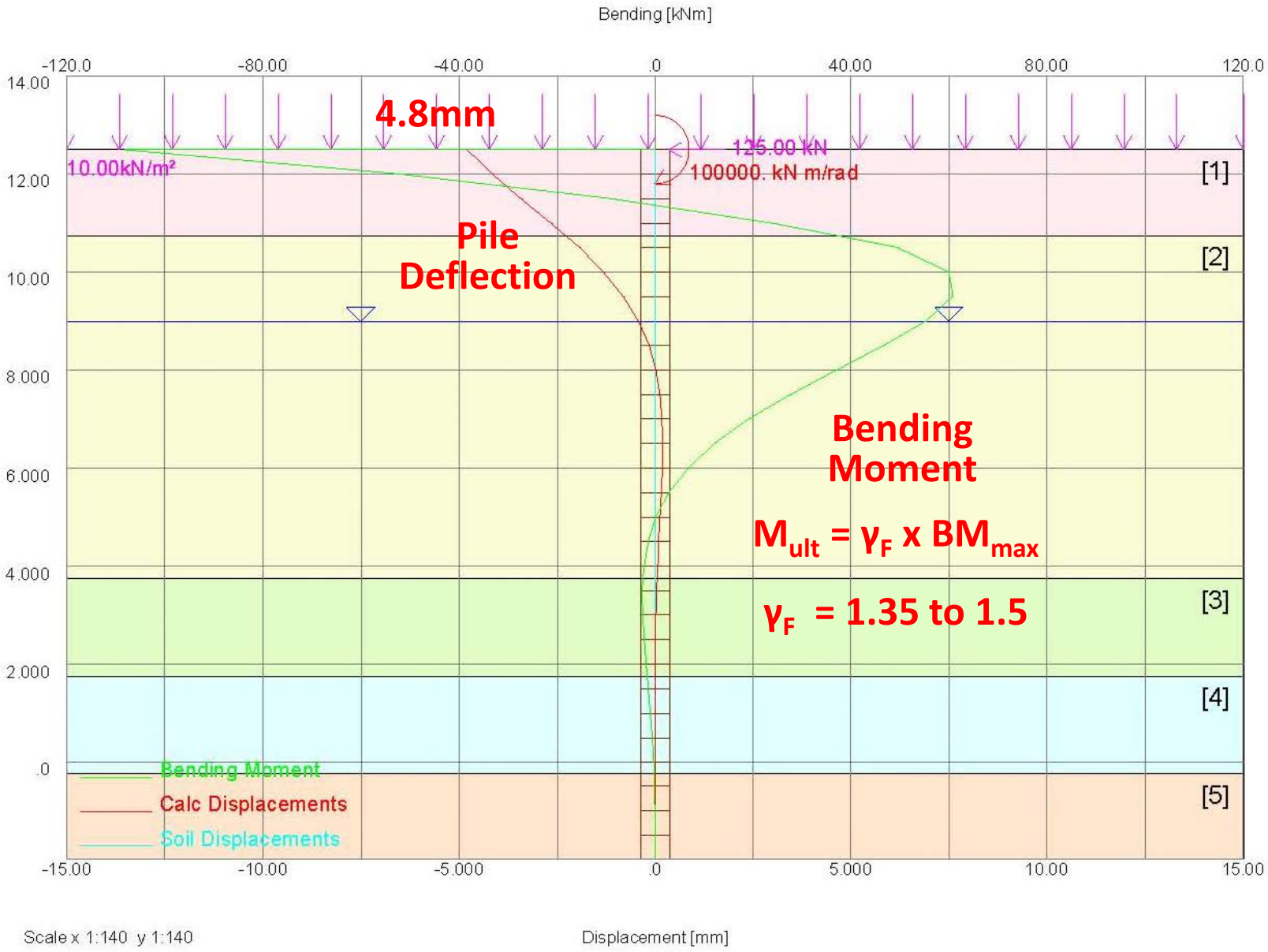


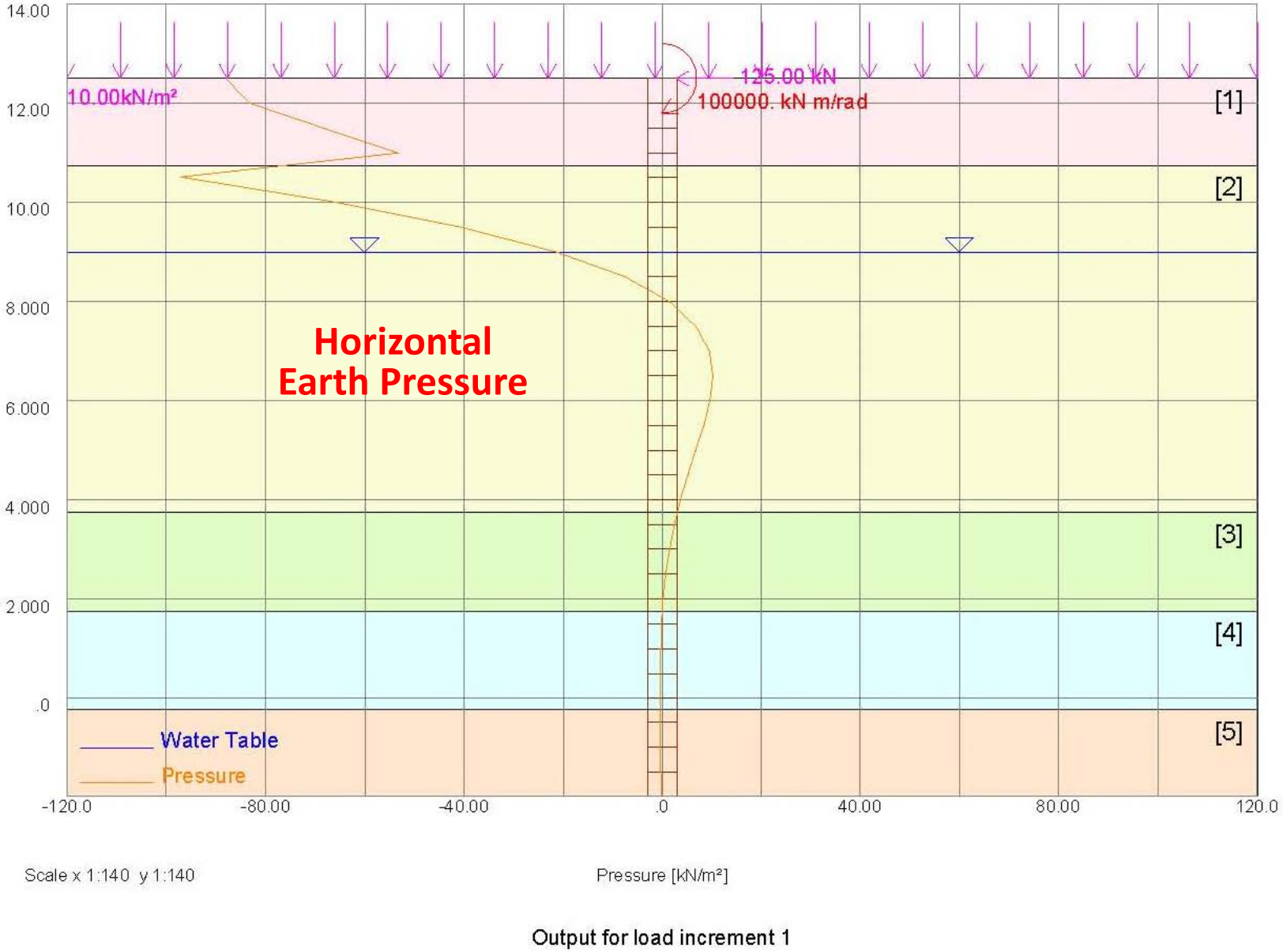

Fig. 6. Earth pressure coefficient for cohesion.

# Example ALP Horizontal Load Analysis




Output for load increment 1

# Example ALP Horizontal Load Analysis




Output for load increment 1