

# **New Approach of Using Jacked Anchors as Reinforcement in Soil Stabilisation Works for a Cut-and-Cover Tunnel with 17m Deep Excavation**

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# CONTENT

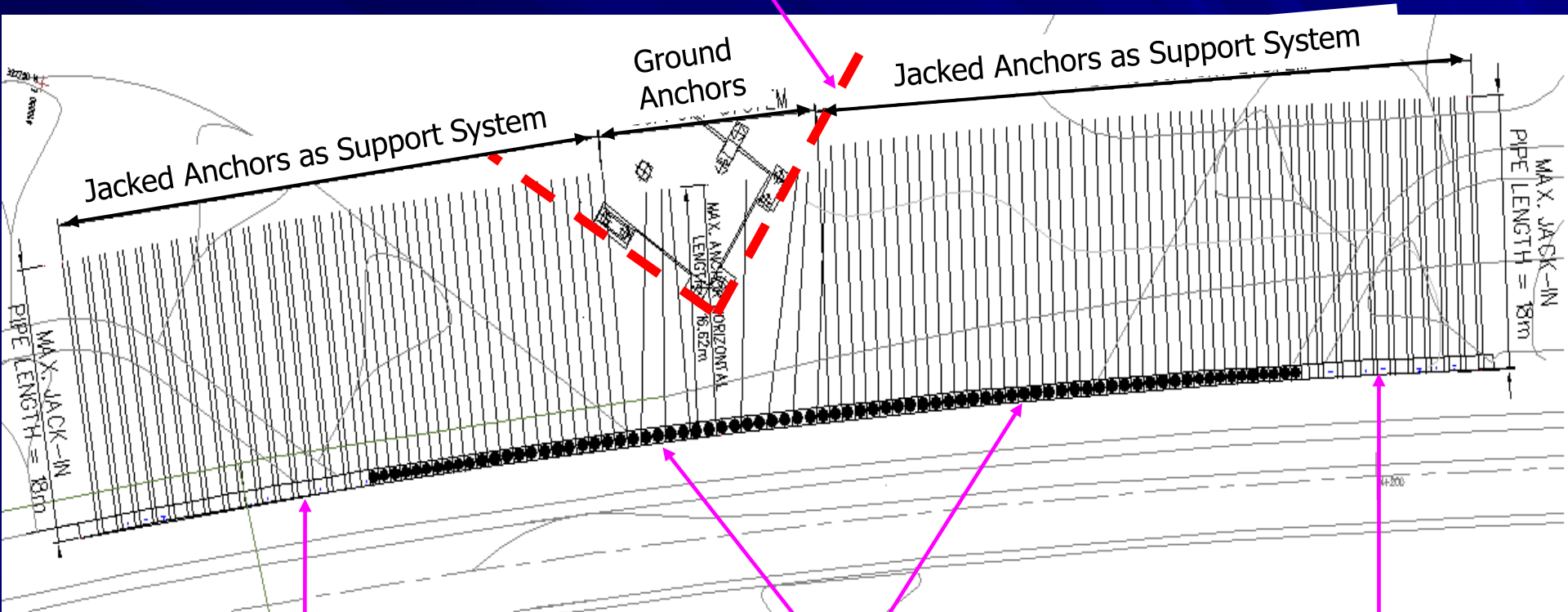
- Project Details
- Geology and Subsoil Conditions
- Test Results and Instrumentation
- Back Analyses with FEM Modelling
- Conclusions & Recommendations

# GENERAL PROJECT DETAILS

- 17m deep excavation for cut-and-cover LRT tunnel on Filled Ground
- Near to existing high-rise building (8m away).
- Temporary walling systems consist of:
  - CBP Wall
  - Soldier Pile Wall
- Compliance Design : 5 rows of Ground Anchors (Slow)
- Alternative Design : 9 rows SGE Jacked Anchors (Rapid Installation)

# Layout Plan

## Building Boundary



**Soldier Pile Wall  
(Type C & D)**

**CBP Wall  
(Type A, A1 & B)**

**Soldier Pile Wall  
(Type C & D)**

# Jacked Anchors Installation

Ground Anchors

POJ Building

SGE Jacked Anchors



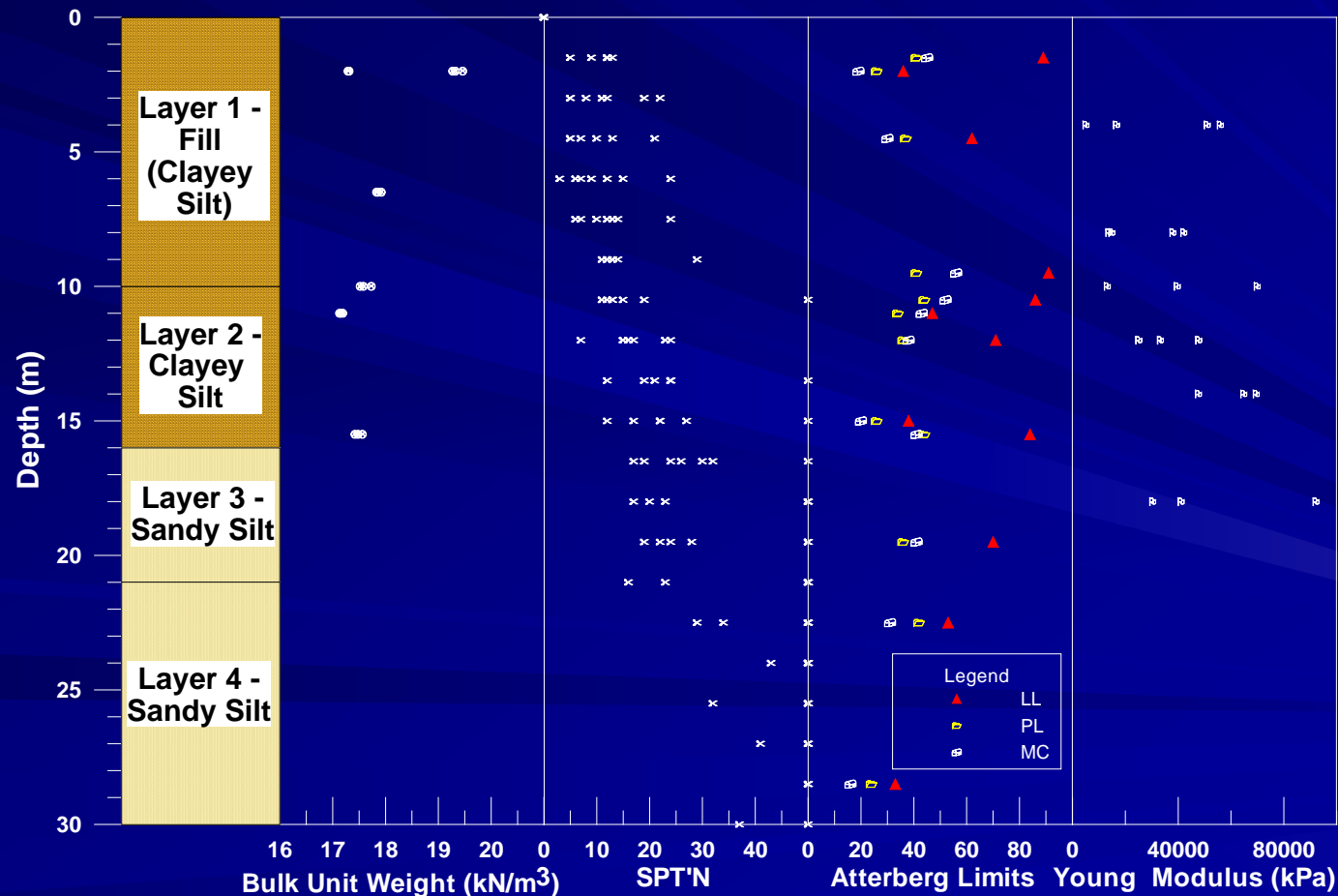
Tunnel Construction in progress

CBP Wall

Tunnel Construction in progress

# GEOLOGY AND SUBSOIL CONDITIONS

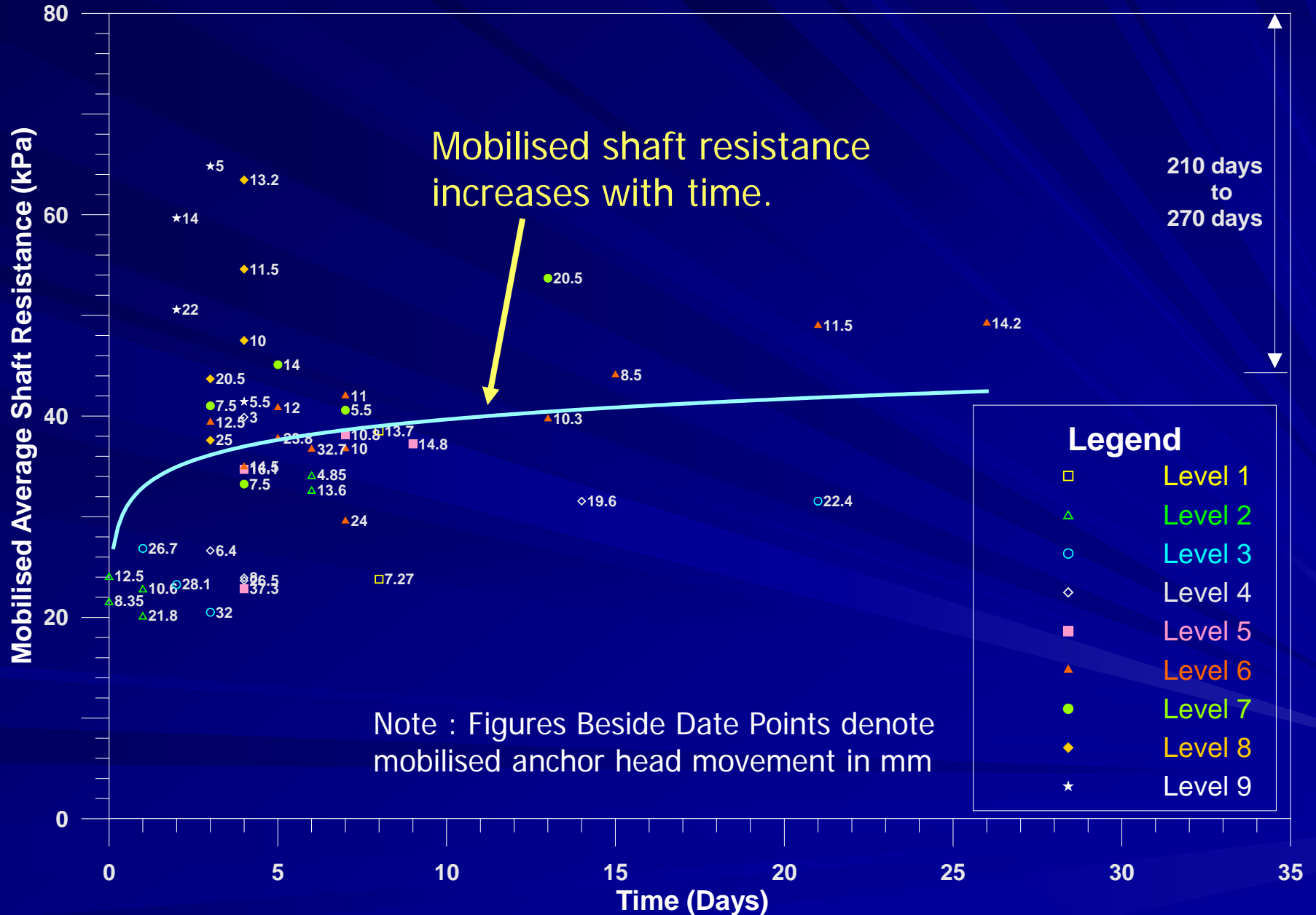
- Meta-sedimentary Kajang formation overlain by some alluvial deposits consisting of sandy clayey silts and fill
- Subsoil Profile



# TEST RESULTS AND INSTRUMENTATION

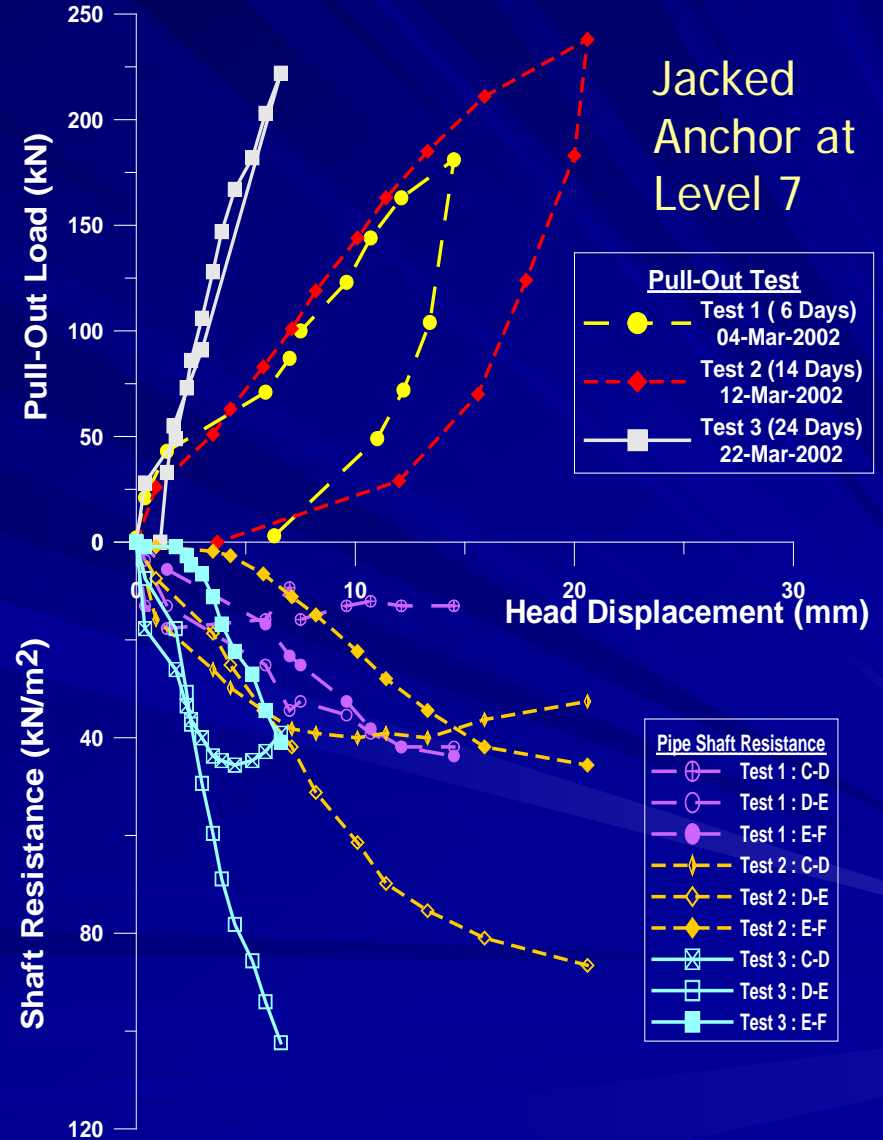
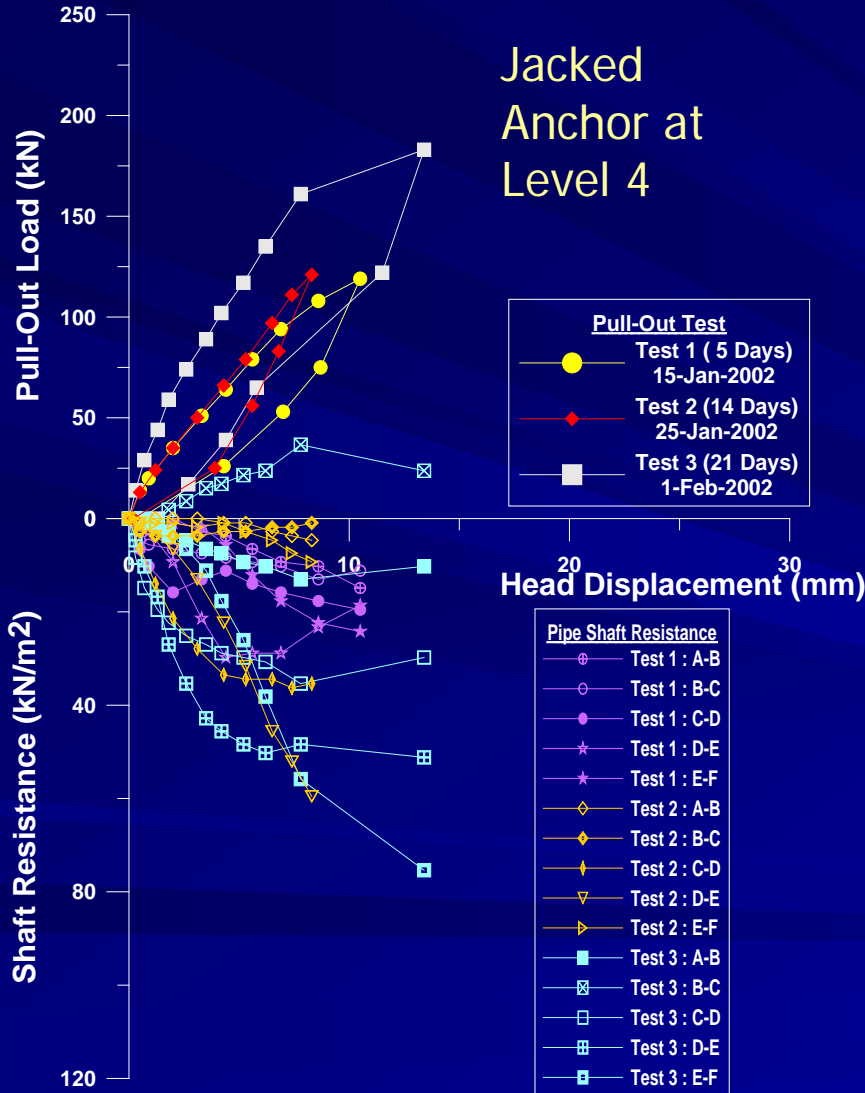
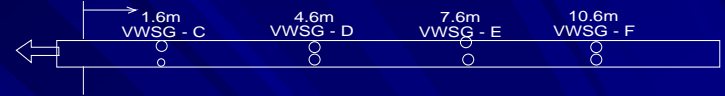
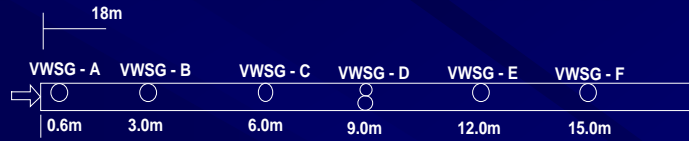
- Pull out tests on jacked anchors to verify the development of shaft resistance with time.
- Inclinator, load cell, strain gauges and settlement marker were installed to verify the design performance of support system.

# Mobilised Average Shaft Resistance with Time

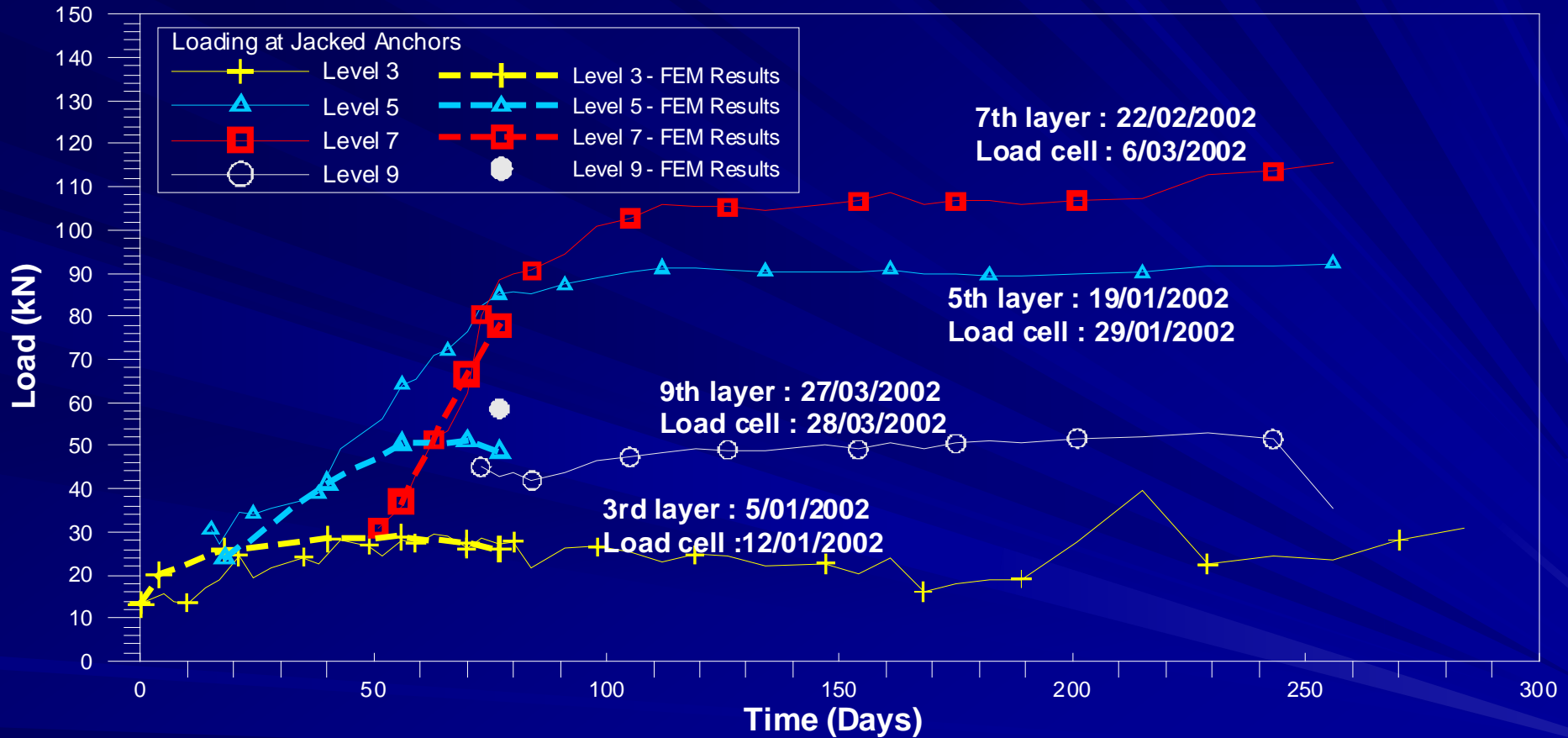




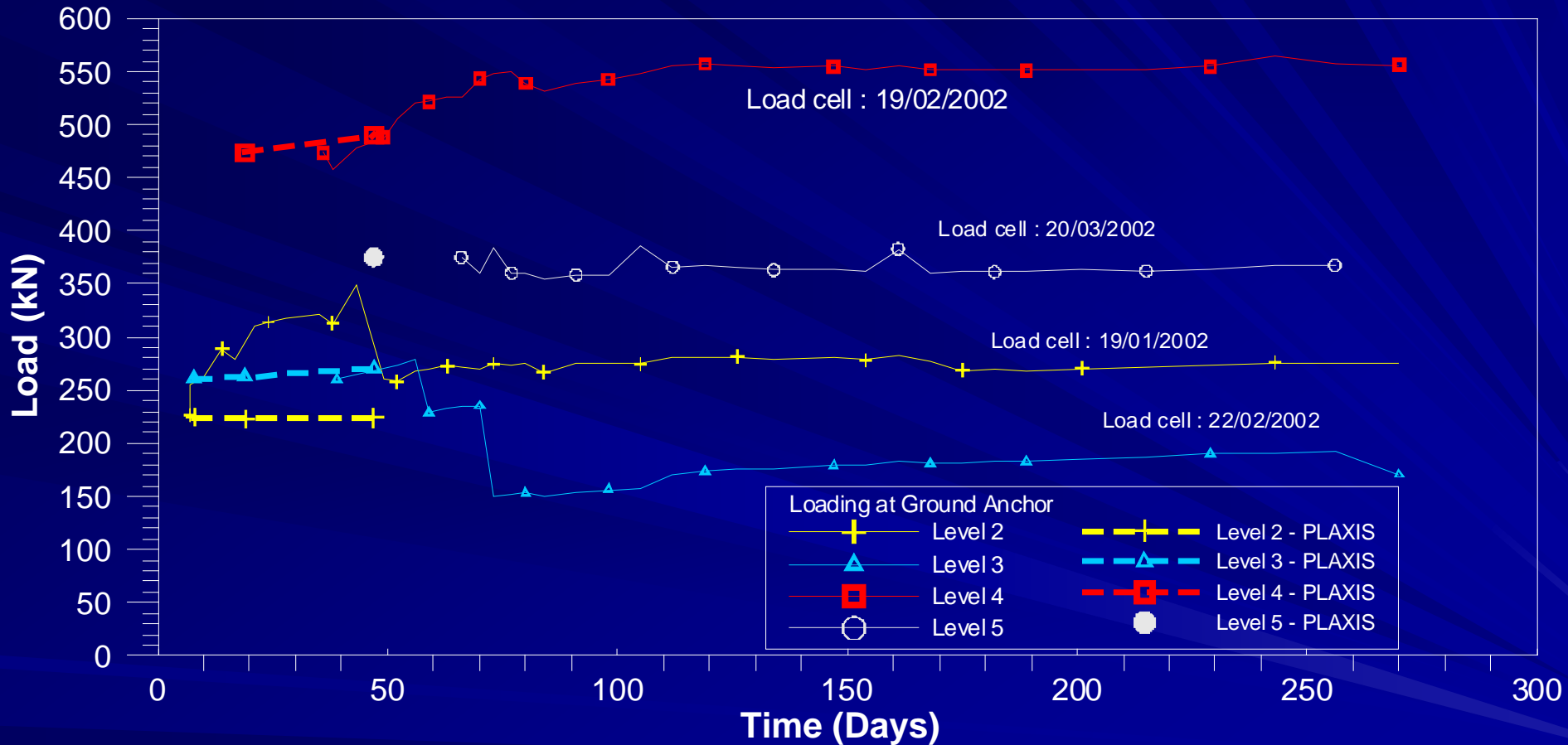
# Pull Out Test Results for Instrumented Jacked Anchor



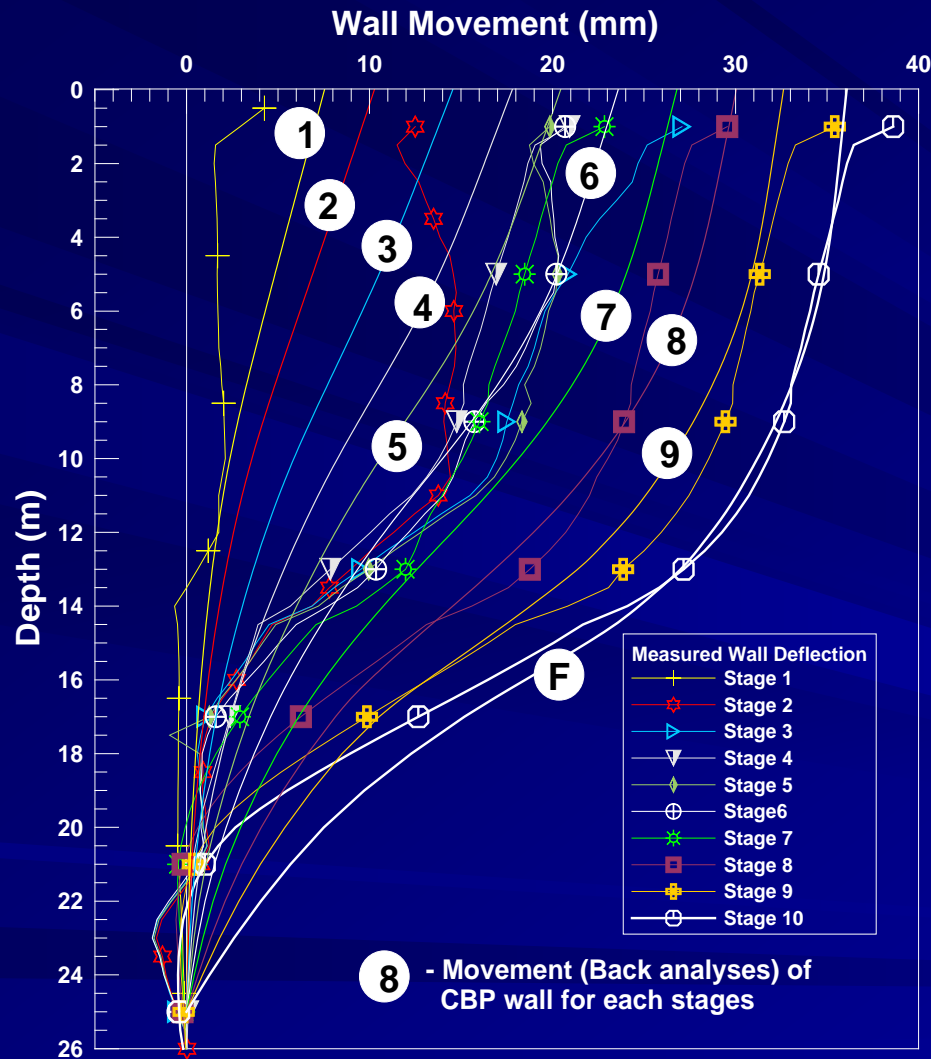
# Jacked Anchor Load with Time



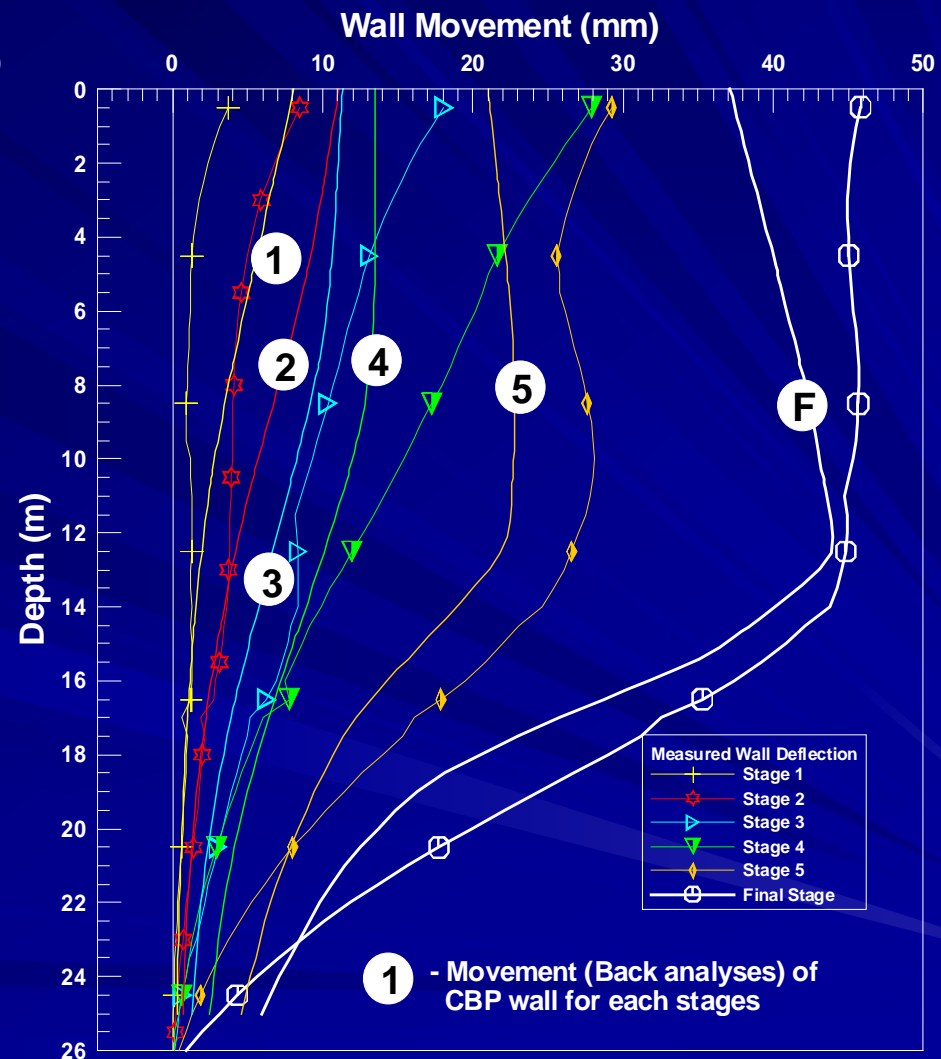
# Prestressed Ground Anchor Load with Time



# Wall Movement

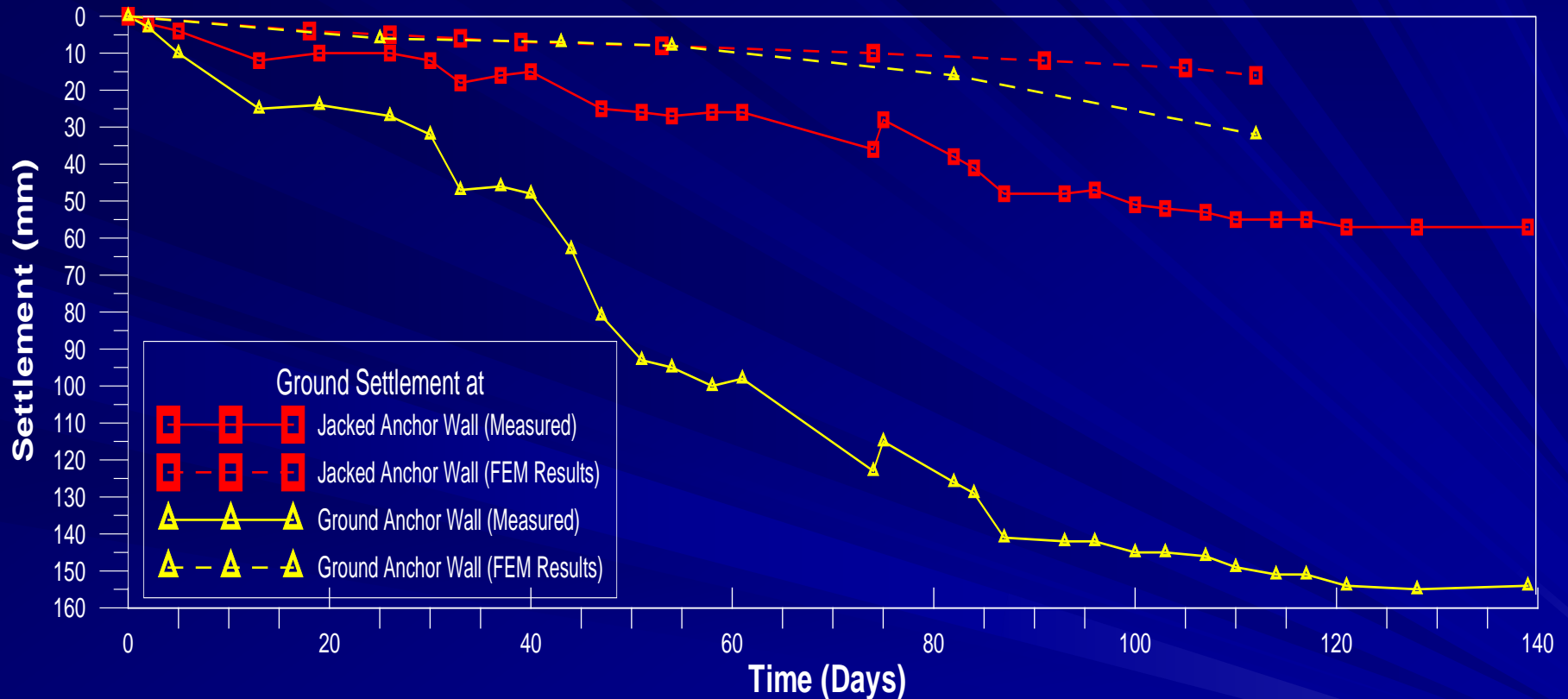


Jacked Anchor Wall



Ground Anchor Wall

# Ground Settlement behind CBP Wall



**Jacked Anchors Wall :  $dV / dH(\text{wall}) = 1.57$**

**Ground Anchor wall :  $dV / dH(\text{wall}) = 3.37$**

**dV : Ground Settlement Behind the Wall**

**dH : Horizontal Wall Deflection**

# BACK ANALYSES WITH FEM MODELLING

- FEM Plane Strain Analysis with 6-Node Elements
- Hardening Soil Model
- Interface Element : To model the Soil Interaction with Wall & Anchorage Elements
- Temporary Wall and Jacked Anchors : Beam Element (Axial & Bending Stiffness)
- Consolidate for 6 months after final excavation to model Drained Condition

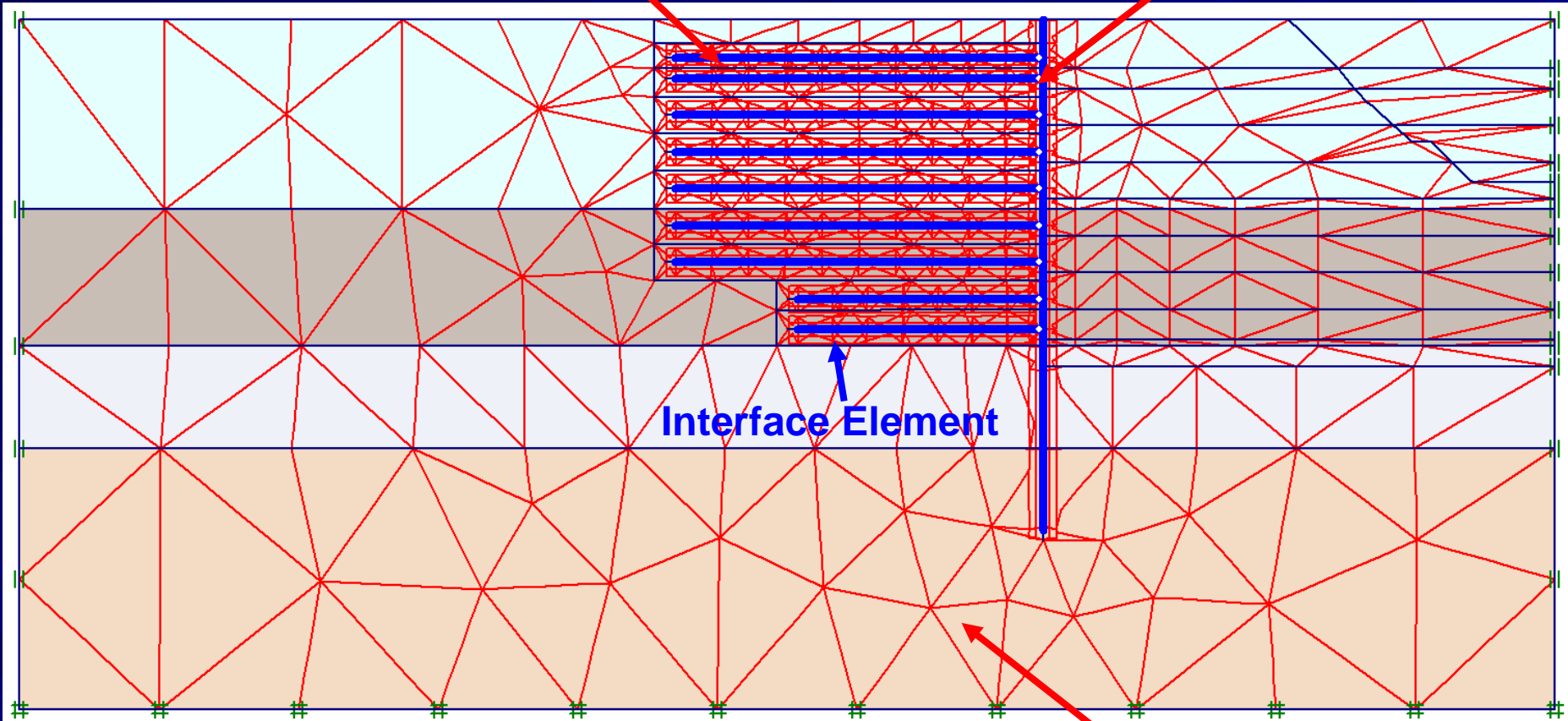
# Typical FEM Model

Beam Element (Jacked Anchors)

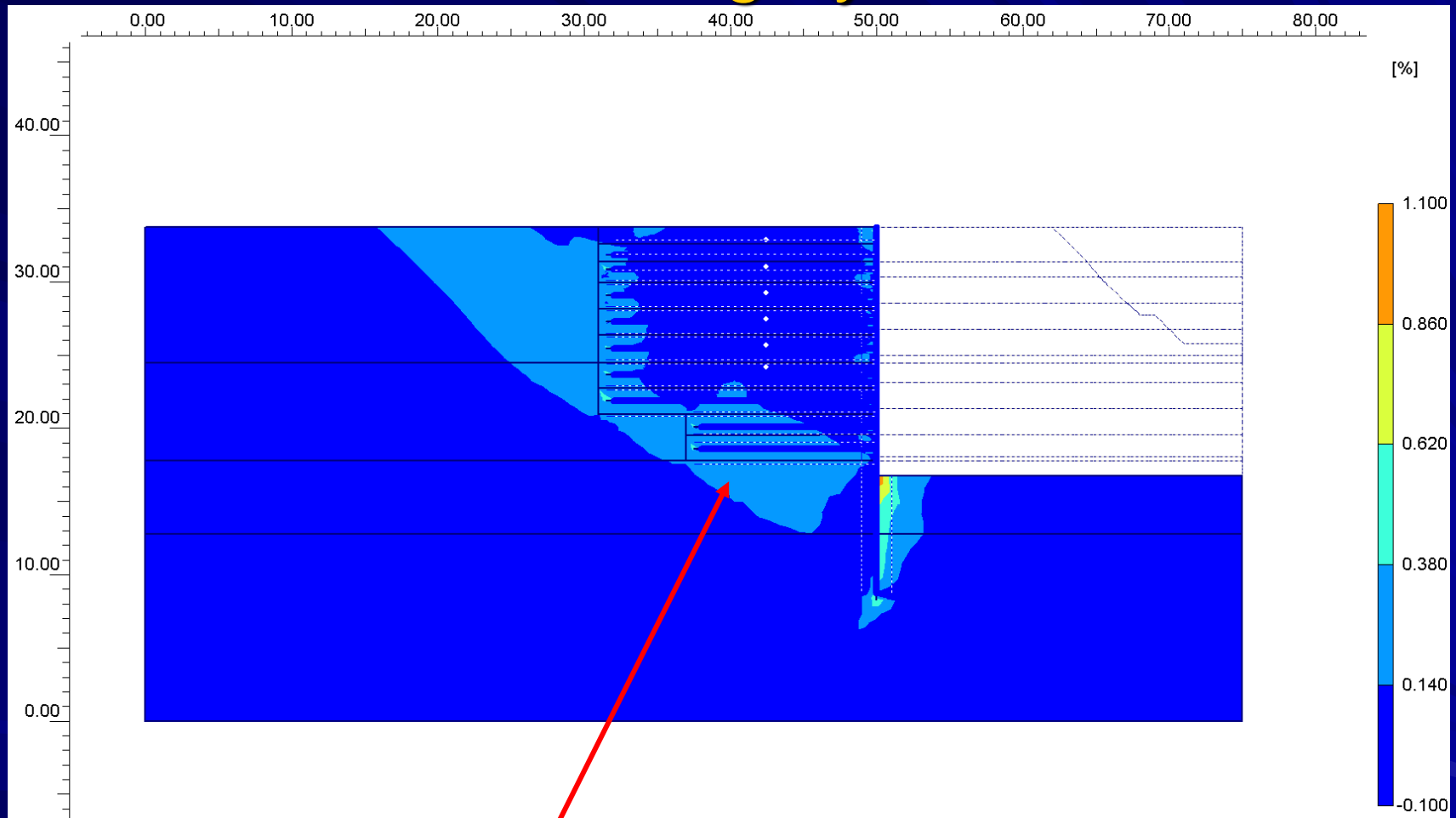
Beam Element  
(CBP Wall and Soldier Piled Wall)

Interface Element

6-node Element



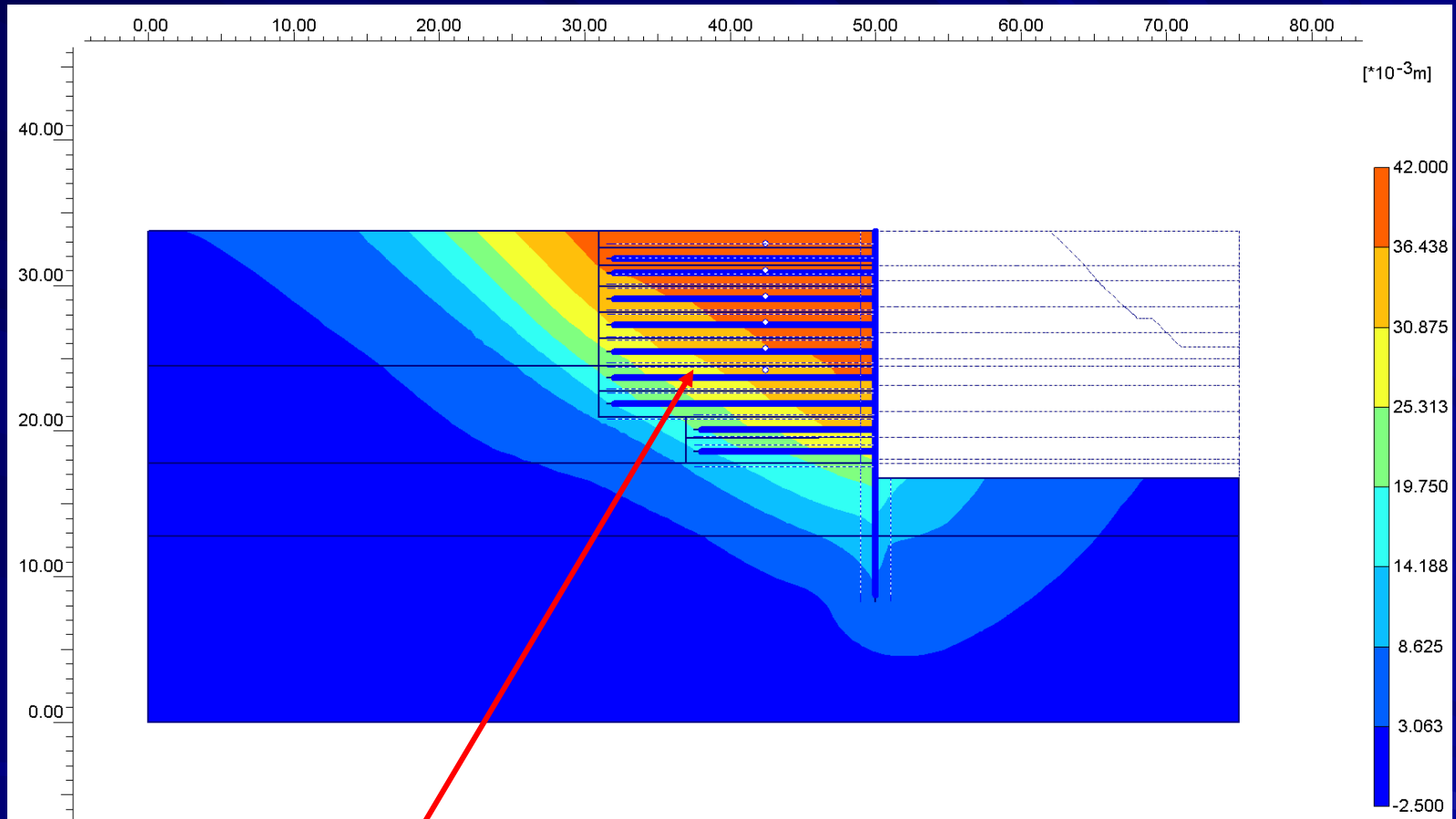
# Soil Shear Strain within Jacked Anchor Retaining System



**Relatively larger shear strains ranging between 0.26% and 0.38% developed along the potential slip surface**

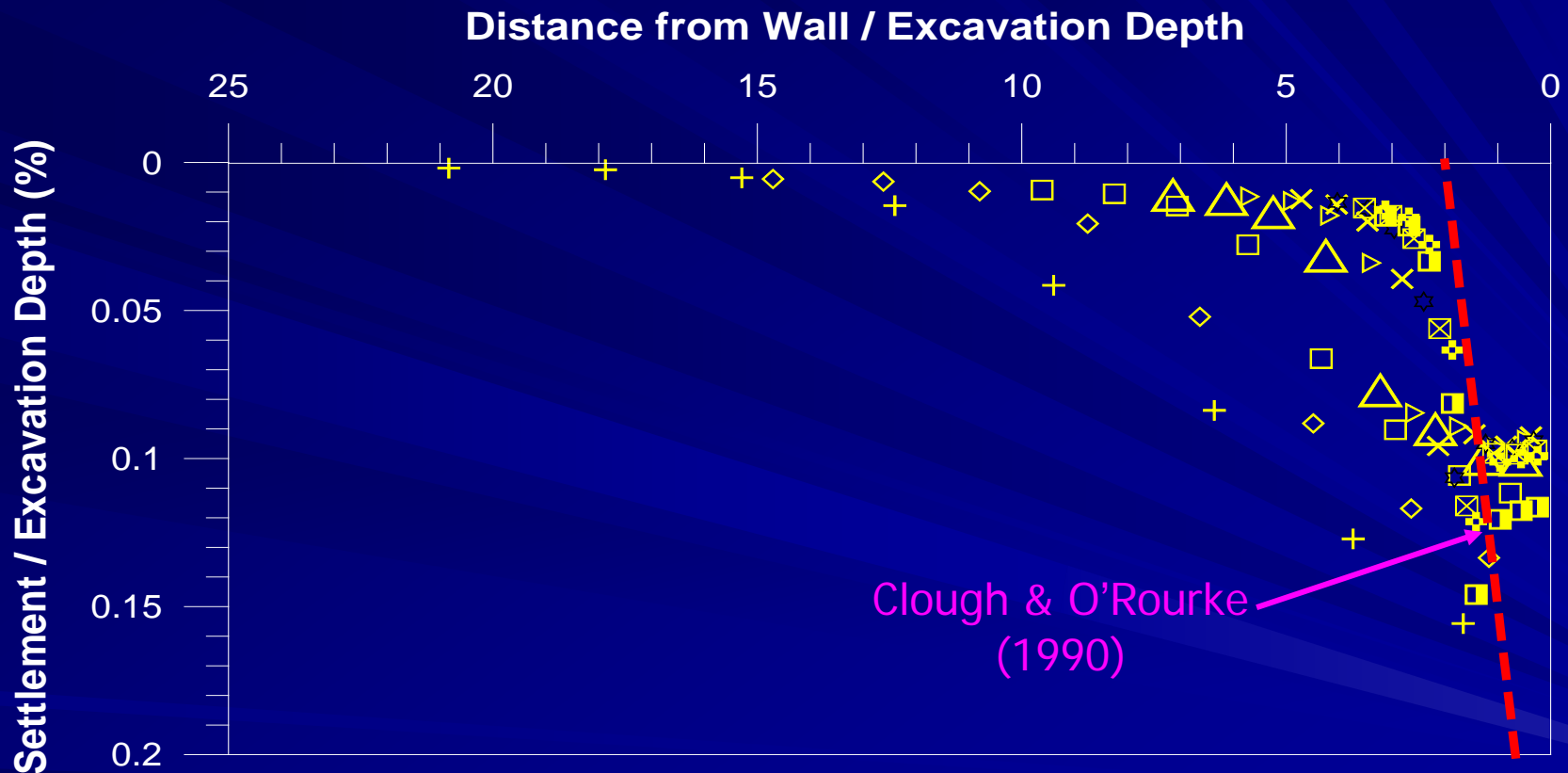


# Total Ground Displacement of Jacked Anchor Retaining System



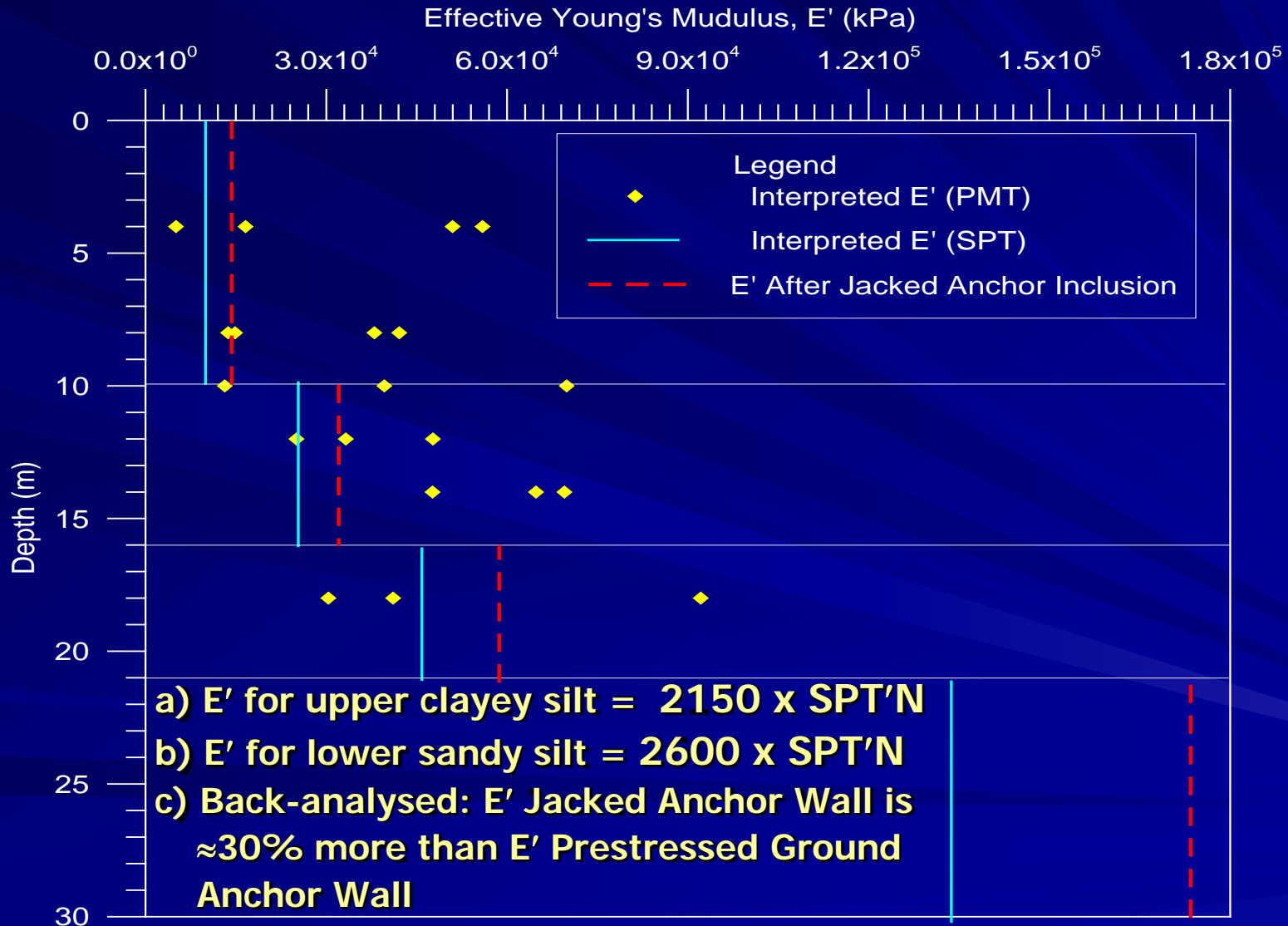
**The reinforced soil mass has more displacement at the upper portion with gradually reduced trend towards the lower portion**

# Dimensionless Ground Surface Settlement



Maximum wall movement of CBP wall at final excavation is about 0.002H

# Interpreted E' from SPT'N and Pressuremeter Test (PMT)



# CONCLUSIONS

- The jacked anchor wall behaves as a semi reinforced soil wall.
- The mobilised shaft resistance of jacked anchor ranges from 20kPa to 30kPa.
- Increase in stiffness shall take into consideration in the design.
- FEM can analyze complicated interaction of the entire soil-structure system

# RECOMMENDATIONS

- Strain gauges shall be installed in pairs at jacked anchor section to avoid flexural effect in the interpretation.
- Monitoring of Settlement and Wall Movement is necessary
- Generation of excess pore water pressure and its dissipation around and along the jacked anchor shall be carried out.

# THANK YOU !



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