CE 632: GROUND IMPROVEMENT

Case study 2- Ground Improvement using Pre-loading with prefabricated vertical drains and its modelling in Plaxis 3D.

Submitted by:
Bibek Chand (23M0632)

Course Instructor:
Prof. Ashish Juneja

Department of Civil Engineering
Indian Institute of Technology Bombay, Powai, Mumbai 400076

Content :

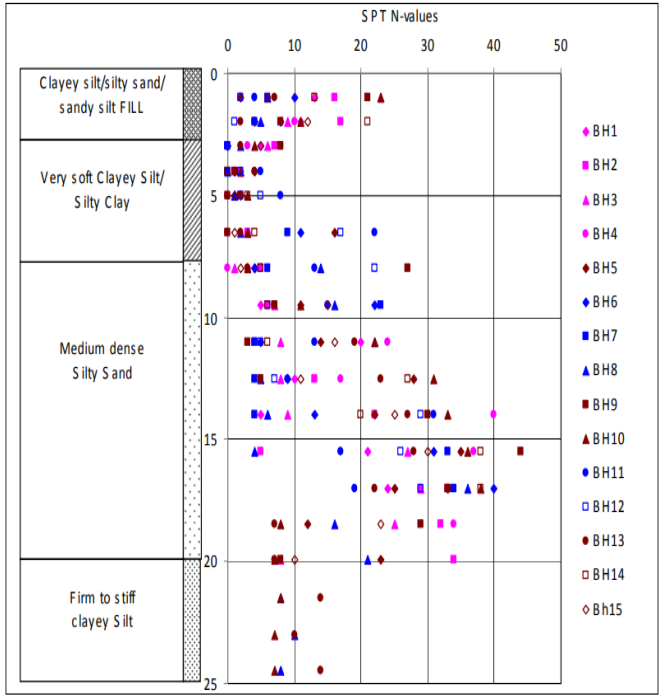
- Introduction
- Subsurface conditions
- Data used ,analysis using Plaxis 3D
- Conclusion
- References

Introduction

- Container yard construction at Chittagong sea port, Bangladesh.
- Area of 60700 m2 over a subsoil of soft clayey silt/silty clay .
- Design load of 56 kPa .
- Layer depth up to 7m.
- Use of prefabricated vertical drains.

Subsurface Conditions :

- Governed by shallow sea water and flood plain activities of river karnafully.
- Very soft to firm CM or MC and fine grained SM.
- 15 boreholes drilled of diameter 125 mm using water flush aided by chiseling up to 14-24.5m .
- Split-spoon sampler and thin-walled Shelby tubes.



Calculated parameters:

Parameters	Value
Water Content	(30 - 50)%
Liquid Limit	(32 - 57)%
Plasticity Index	(9 -25)%
Specific Gravity	(2.71 – 2.77)
Unit Weight	(20 -23) kN/m3
Undrained Shear Strength	
Vane Shear Test	(9-56) kpa
UU test (6 shelby sample)	Nearly 30kpa

Table: Soil properties

Compressibility and Permeability Parameters	
Coefficient of Compression	0.17 - 0.45
Coefficient of recompression	0.05 – 0.07
Initial void ratio	1.04 – 1.62
Pre-consolidation Pressure	(30 - 50) kpa
Coefficient of consolidation(vertical)	(2 – 21)m2/year
Coefficient of horizontal consolidation	(12 - 70)m2/year
Coefficient of vertical permeability	(0.012 – 1.009) m/year
Coefficient of horizontal permeability	(0.047 – 2.302) m/year

Table: Compressibility and permeability properties

Ground Improvement Work

- PVD to allow horizontal drainage.
- Consolidation in short period of time.
- Smear effect taken.

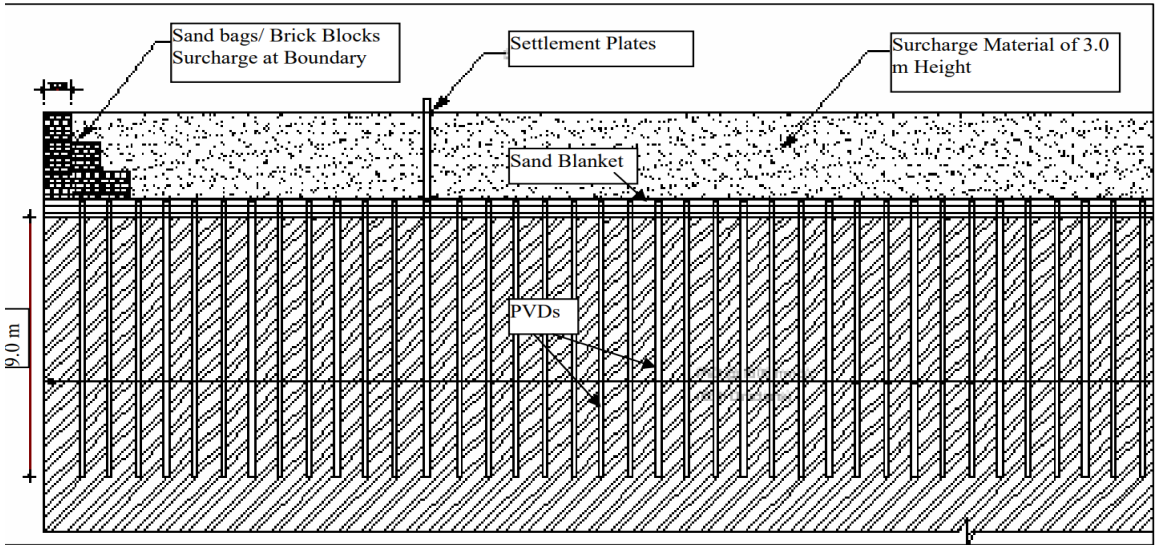


Figure: PVD application in the port

Properties	Burst strength
Drains	
Weight per unit length	70 gm/m
Width	100 mm
Thickness	4 mm
Water discharge capacity	2840 m3 /year
Core	
Tensile strength	750 N
Filter Jacket	
Apparent opening size (AOS)	90 µm
Grab tensile strength	400 N
Elongation at break	50 %
Puncture resistance	130 N
Burst strength	800 kPa
Burst strength	6310 m/year

Table: PVD dimension and properties

Modelling using Plaxis 3D:

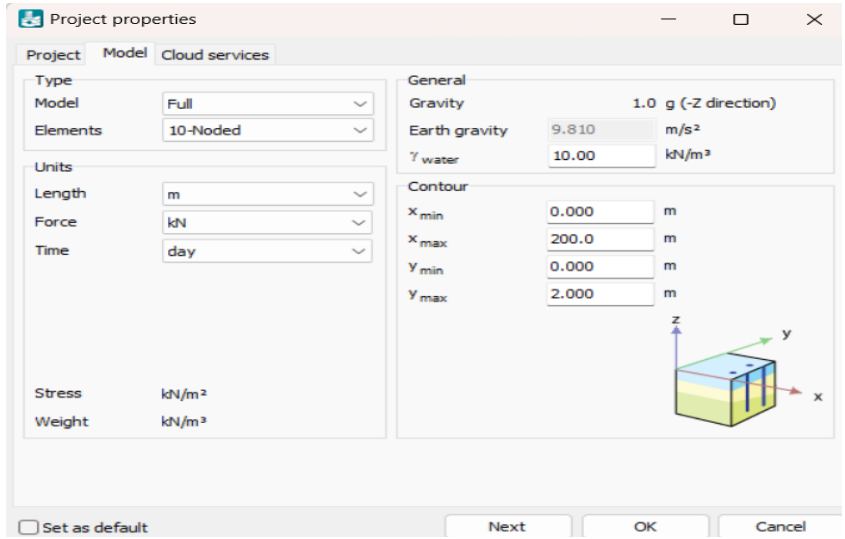


Table: Project properties

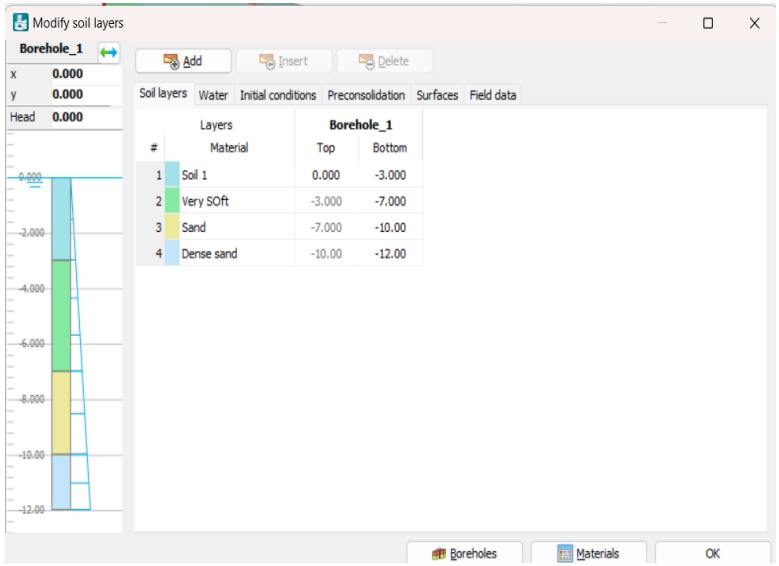


Table: Project properties

Layer	Depth (m)	Soil Model
1	0-3 (Soil 1)	Hardening (Drained)
2	3-7 (Very soft)	Soft Soil (Undrained A)
3	7-10 (Sand)	Hardening (Drained)
4	10-12 (Dense sand)	Hardening (Drained)

Table: Layers and soil model

Analysis Using Plaxis 3D :

Staged construction consists of phases :

- **Initial phase**: In-situ profile of soil according to depth before excavation.
- **Construction phase**: Pvd were placed to a depth of 9 m at 1m spacing in square grid.
- **Consolidation I**: Allowing compression before surcharge application.
- **Surcharge application I**: 1st stage of pre-loading done.
- **Consolidation II**: Allowing the compression to happen for some time (10days).
- **Surcharge application II**: 2nd stage of pre-loading up to to the design load of 56 kPa.
- **Consolidation Analysis**: Minimum excess pore pressure calculation.

Prospective showing model

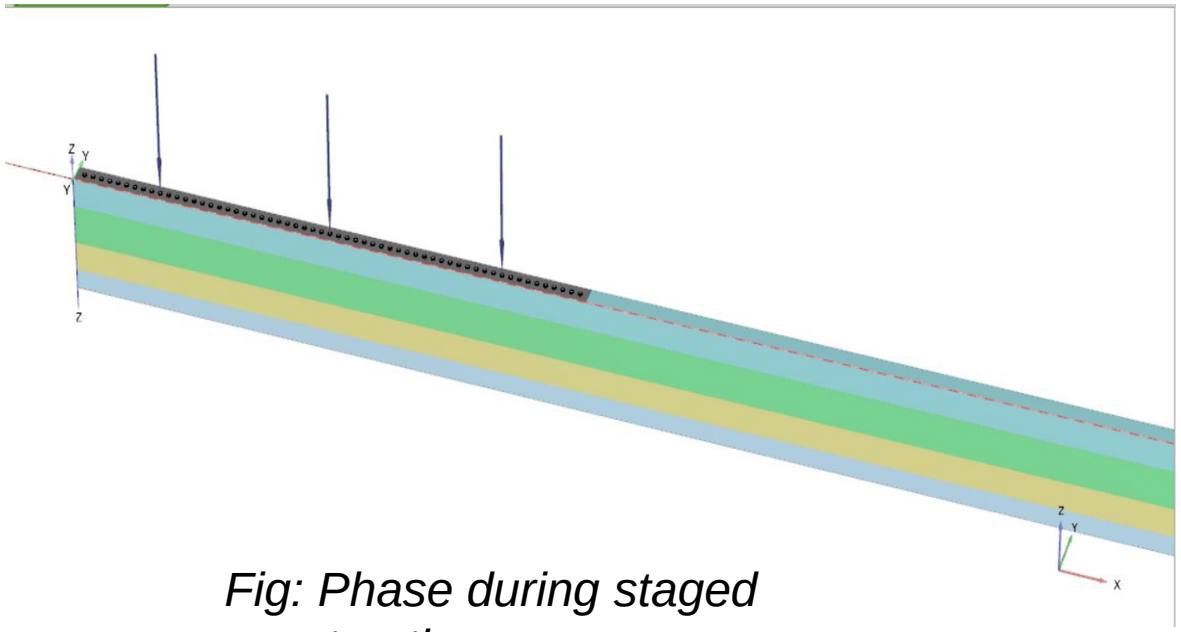


Fig: Phase during staged construction

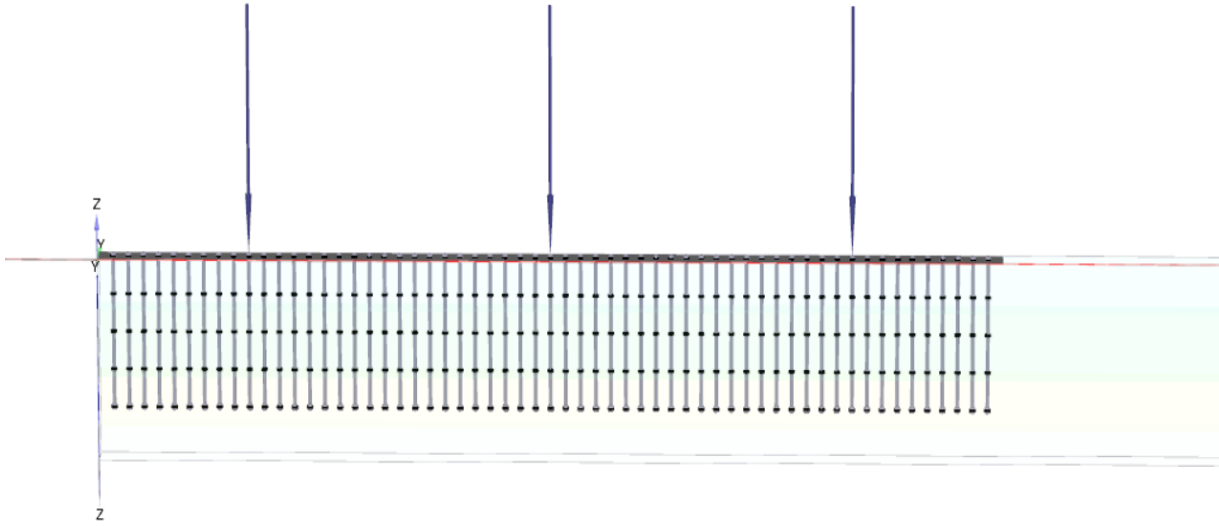
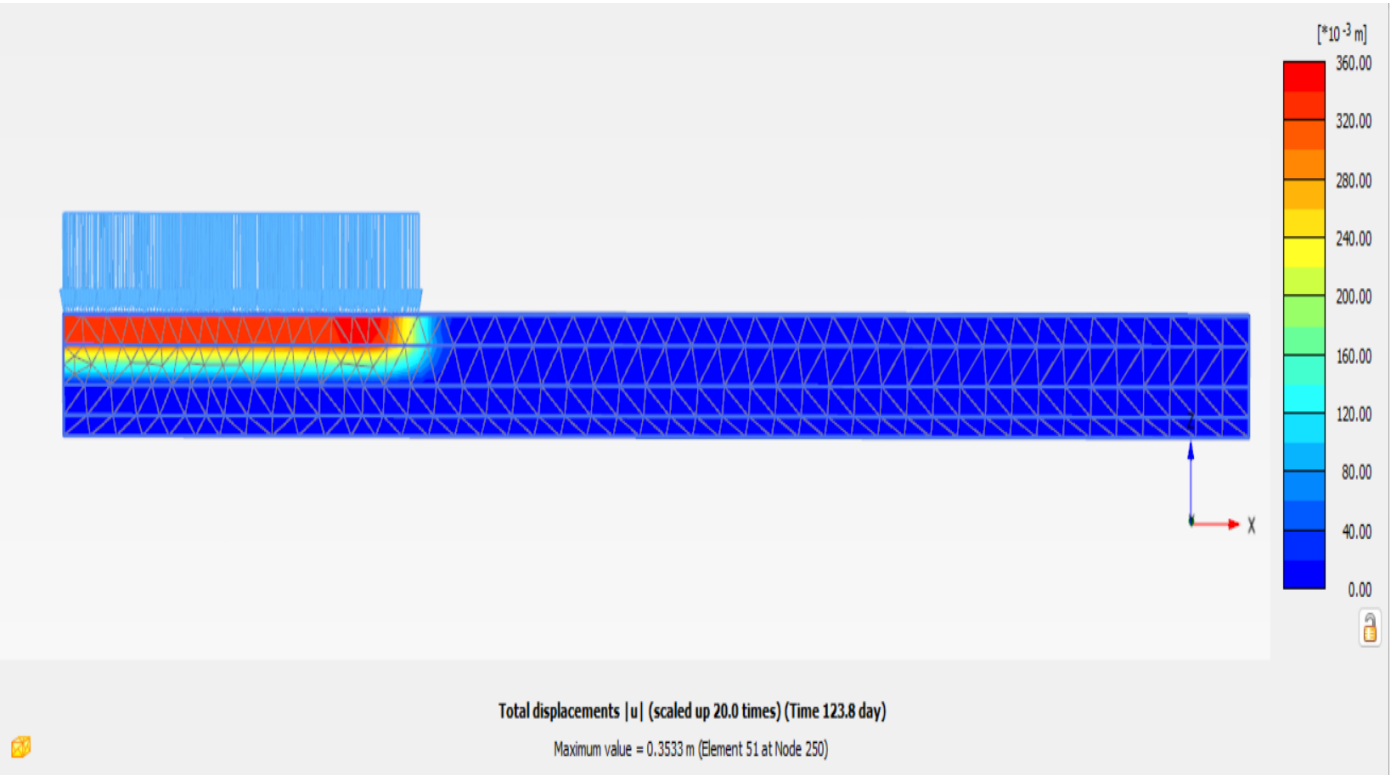
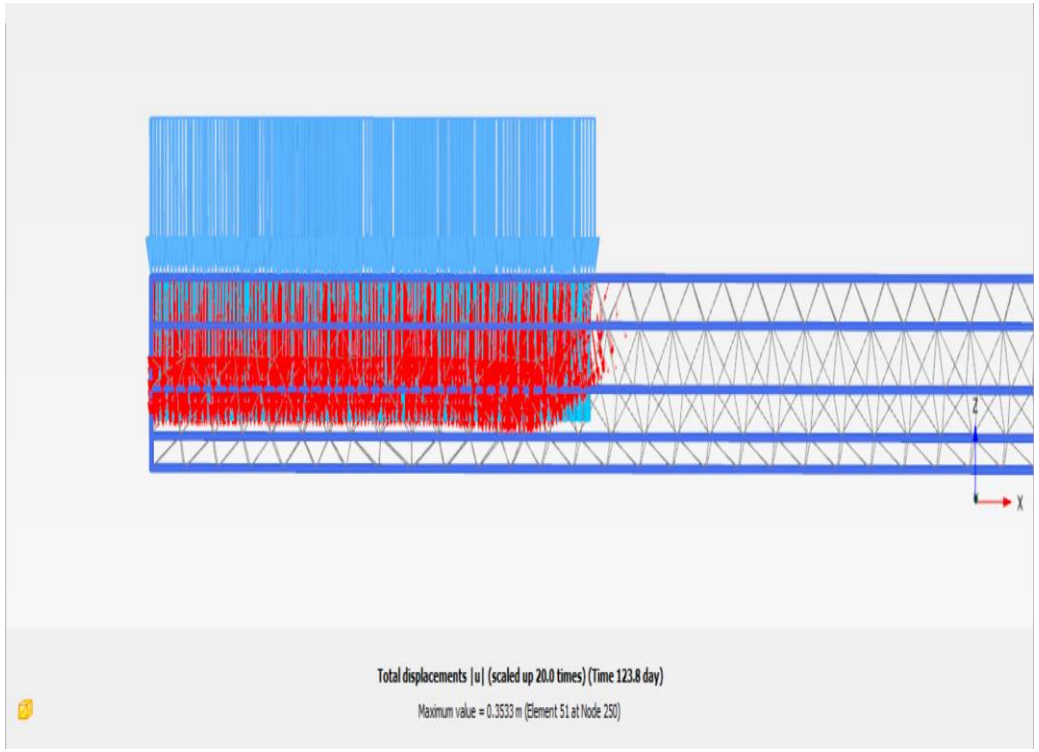


Fig: Section of Pvd drains in the structure mode

Plaxis 3D output showing different views :

- Longitudinal Cross-section with maximum displacement :





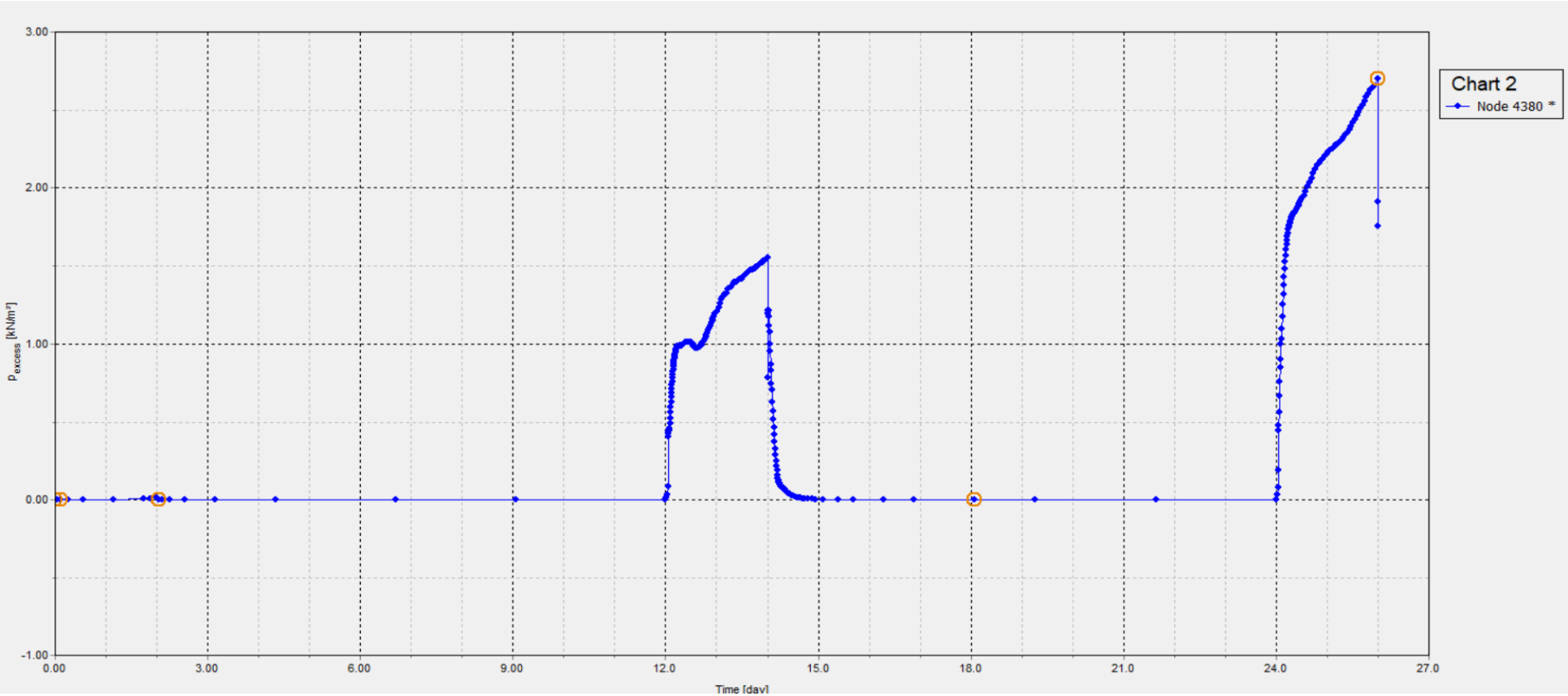


Fig: Excess pore water variation with time

Conclusion:

- Time for consolidation using preloading is about 1-5.5 years for drainage boundary of 3m-7m.
- Use of PVDs along with preloading reduces the time to about 120 days.
- Smear effect is considered and the permeability is reduced near the insertion zone of the drains.
- Classical theory of consolidation is used to find compressibility and permeability properties.

References :

- Dhar, Ashutosh Sutra, Abu Siddique, and Syed Fakrul Ameen. "Ground improvement using preloading with prefabricated vertical drains." ISSMGE International Journal of Geoengineering Case Histories 2.2 (2011): 86-104.
- Plaxis 3D-Tutorial Manual V20.02