Invited Talk

International Workshop on Advanced Numerical Modelling in Geotechnical Engineering

IIT Kanpur

8 November 2025

Numerical Modeling of PVD-Supported Railway Embankment on Thick Marshy Deposit

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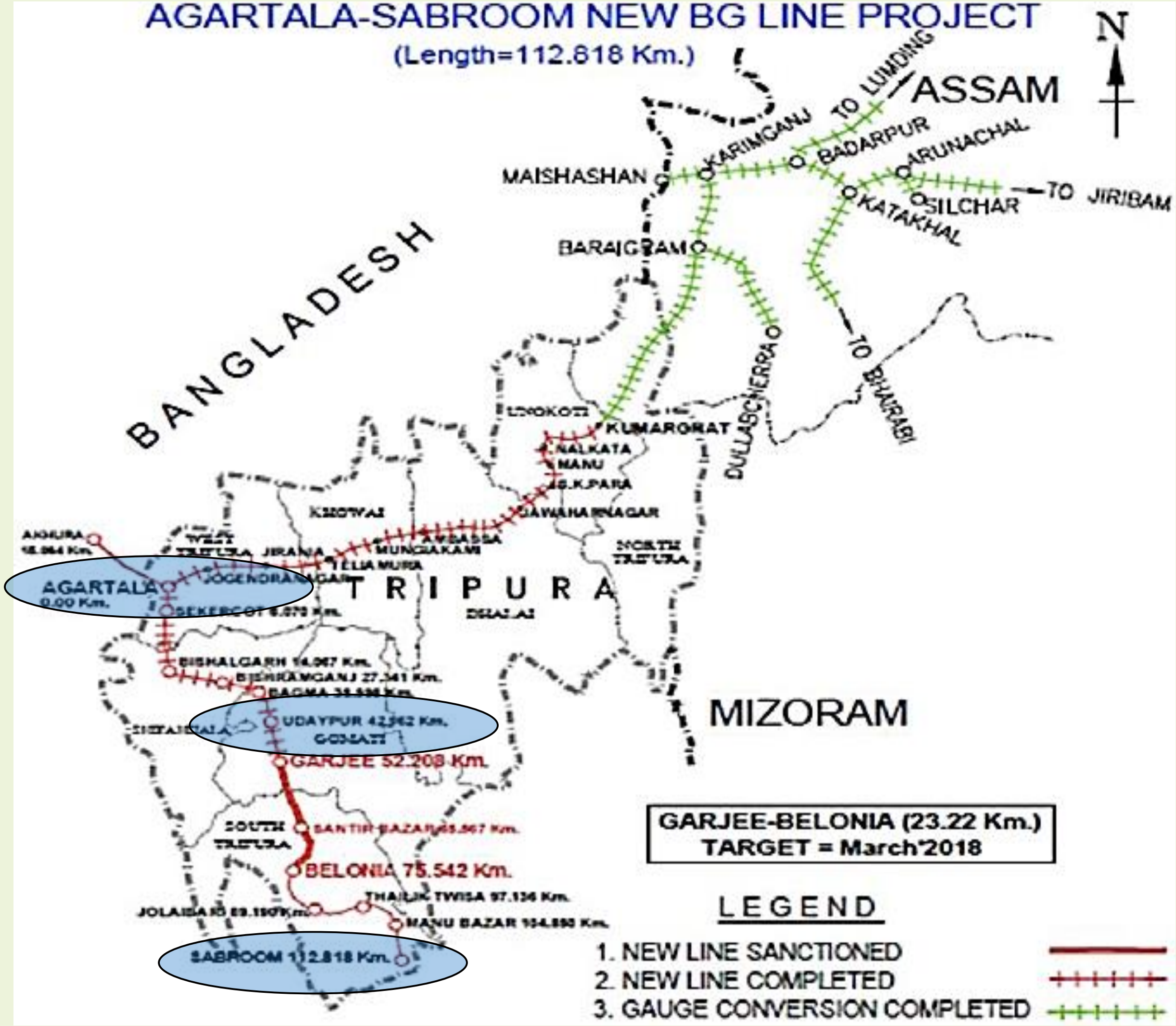
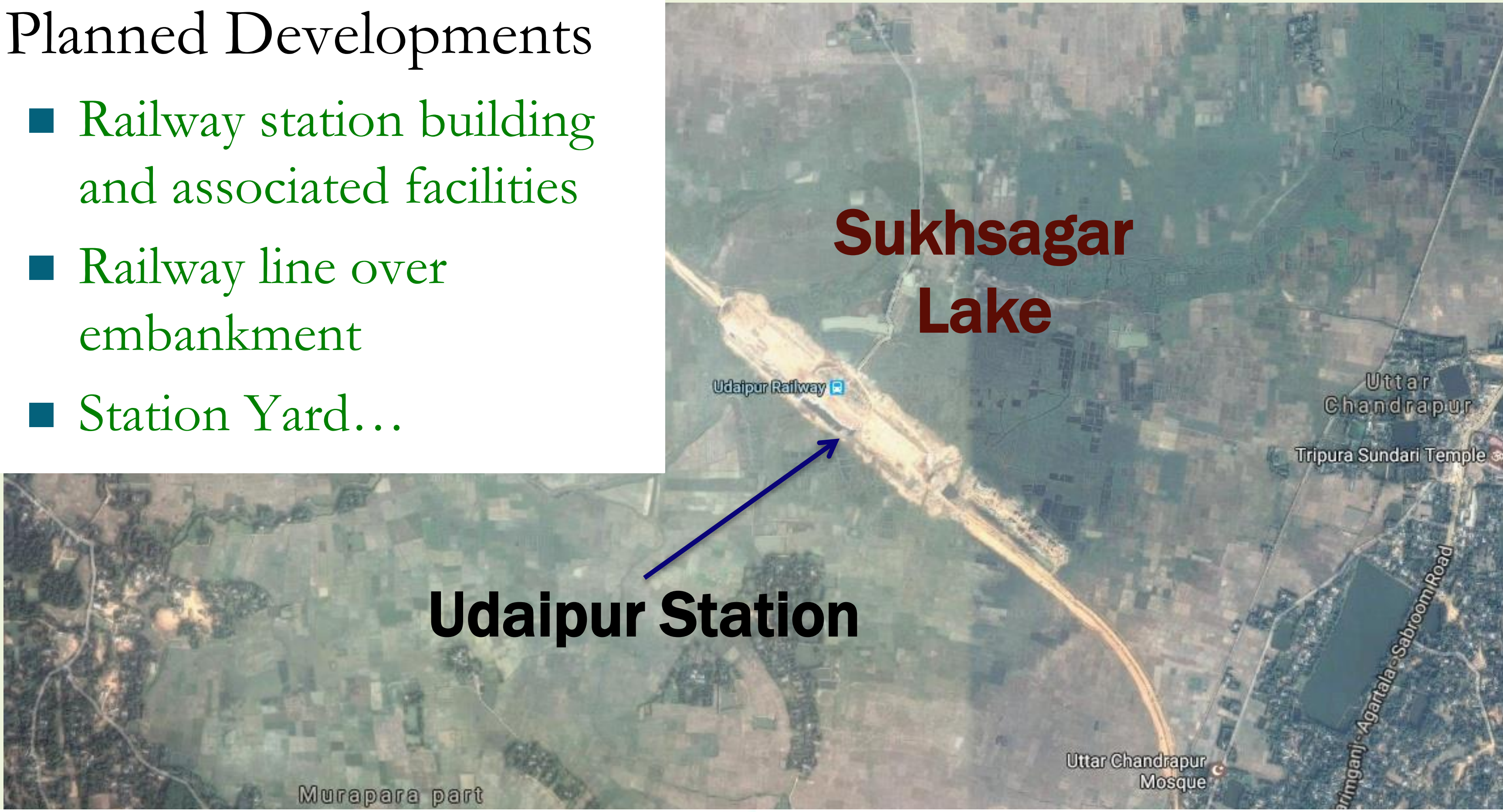
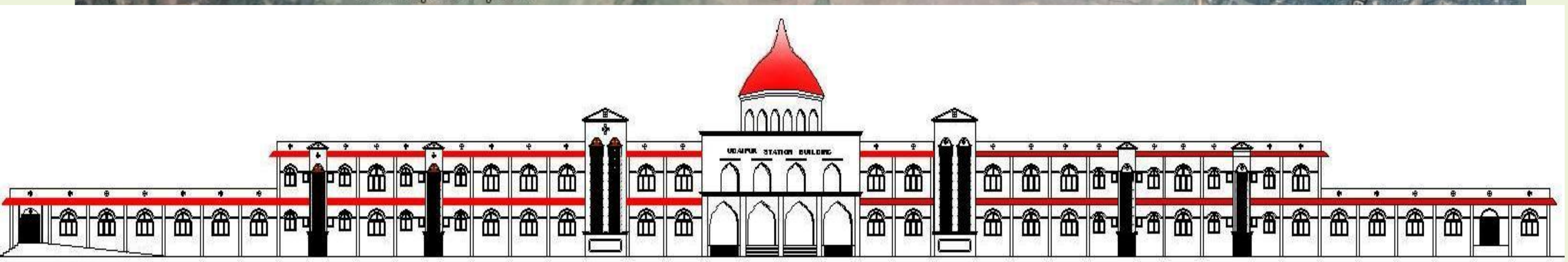
Rail Links of Tripura (the then Proposed and Existing)



- Planned Developments
  - Railway station building and associated facilities
  - Railway line over embankment
  - Station Yard…





Chronology of the Problem

- Formation of station yard construction started in Dec' 2010

Problems Faced during Embankment Construction

- Target height of embankment
  - 6.2 m
- Embankment construction started in stages: Dec’ 2010
  - September 2011
    - First failure noticed at 3.0-3.5 m height
  - March 2012
    - Large settlements as a height of 5-5.2 m is reached
    - Heaving up of ground until 30 m distance from the embankment
- Further construction stopped

Chronology of the Problem

- Station building:
  - Earth filling started in Nov' 2011
  - Pile foundation started in Dec' 2011 and completed by Nov' 2012
  - Differential settlement observed in Pile cap No. 13, 14 and 35 in May 2012
  - Cracks noticed in plinth beam and grade beams connected to pile caps
  - Brickwork for wall done in Jan' 2014 that yielded further differential settlement


JCB
LIFTALL

3-Stage Remedial Measures

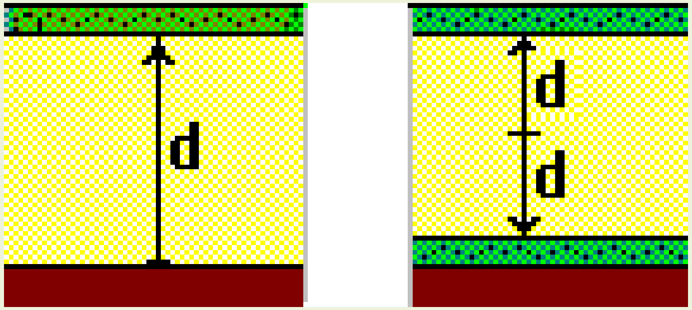
- Ground improvement of the adjoining area by Prefabricated Vertical Drain (PVD) for accelerating consolidation of soft soil
  - ❖ Arresting long-term settlement

- Sheet piling of adequate retaining capacity around the station building before stripping off the existing surrounding embankment for PVD installation
  - ❖ Preventing the movement of embankment soil

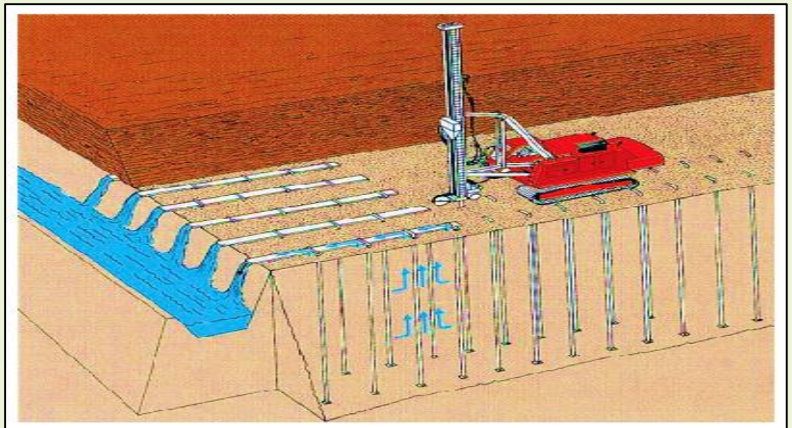
- Retrofitting of the station building by providing additional pile raft system and Carbon Fibre Reinforced Polymer (CFRP)
  - ❖ Distribution of building load and Strengthening the building

Ground Improvement by Consolidation

- Consolidation settlement in soft clay subsoil
  - ❖ Time-rate of long-term primary consolidation
    - Permeability of the soft layer
      - Rate of dissipation of pore-water pressure
    - Number of drainage layers
    - Distance between the drainage layers
    - Lesser prevalence of double drainage in reality

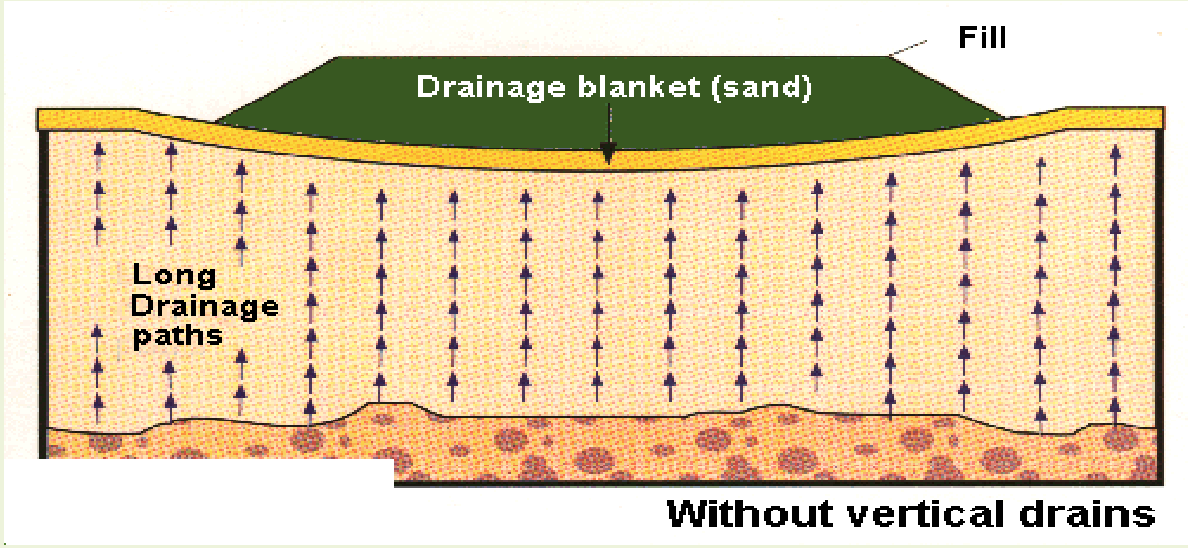


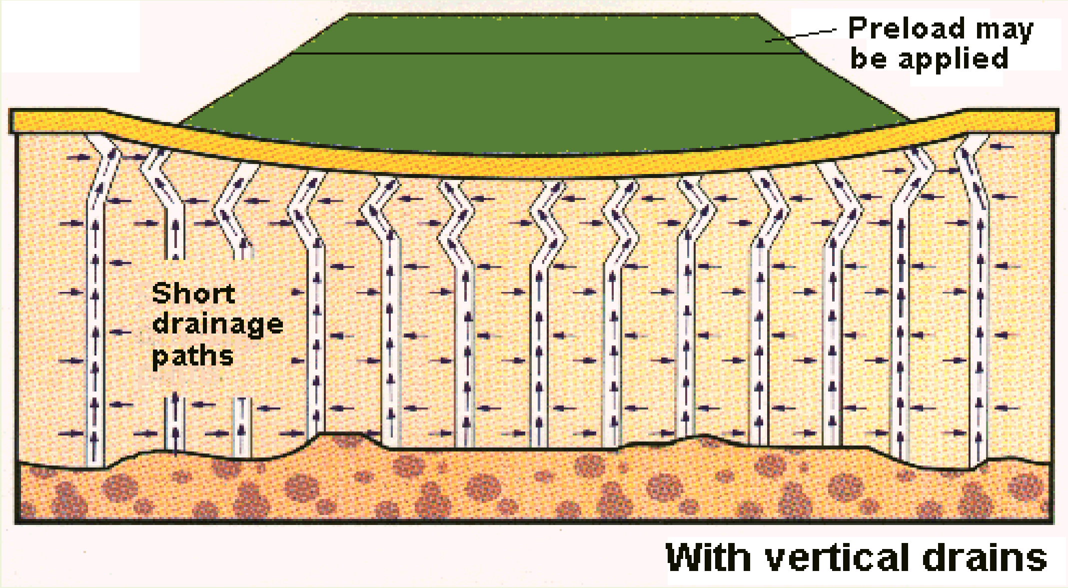
- Decrement in consolidation time
  - ❖ Decrease the distance between the drainage layer
    - Installation of vertical drains aided by surcharge preload embankment

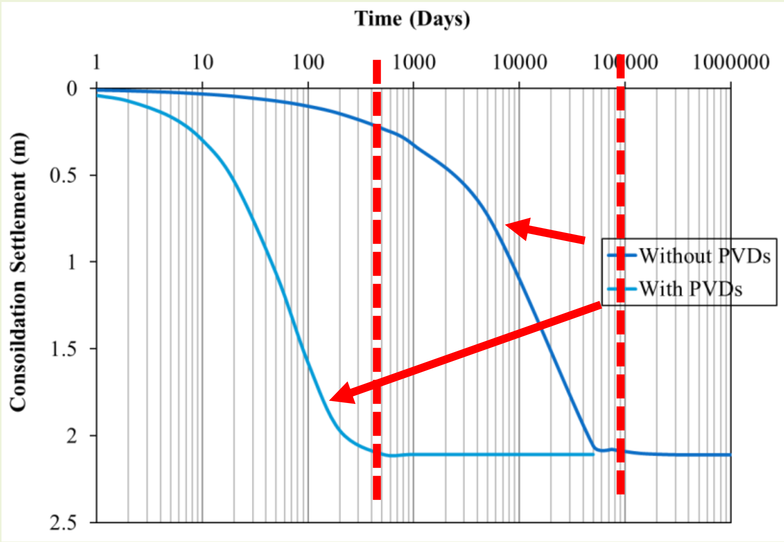


Geo-strata Brochure (2004)

Preloading Embankment with Vertical Drains







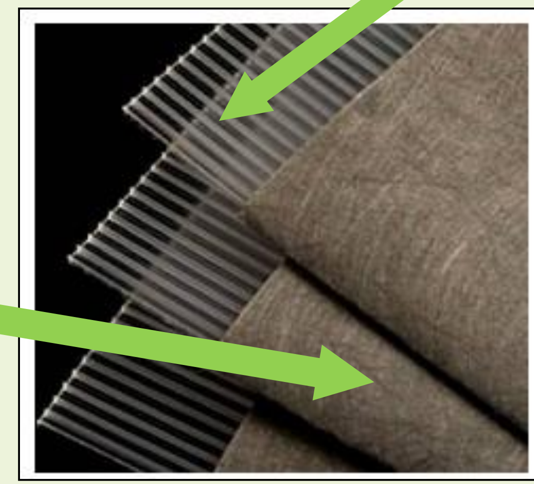
Types of Vertical Drains and Installation Techniques

Drain Type	Installation Method	Drain Diameter (m)	Typical Spacing (m)	Maximum Length (m)
Sand Drain	Driven or Vibratory closed-end mandrel	0.15 - 0.6	1.0 - 5.0	≤ 30
Sand Drain	Hollow stem continuous-flight auger	0.3 - 0.5	2.0 - 5.0	≤ 35
Sand Drain	Jetted	0.2 - 0.3	2.0 - 5.0	≤ 30
Prefabricated sand drains	Driven or Vibratory closed-end mandrel	0.06 - 0.15	1.2 - 4	≤ 30
Prefabricated band shaped drains	Driven or Vibratory closed-end mandrel	0.05 - 0.1	1.2 - 3.5	≤ 60

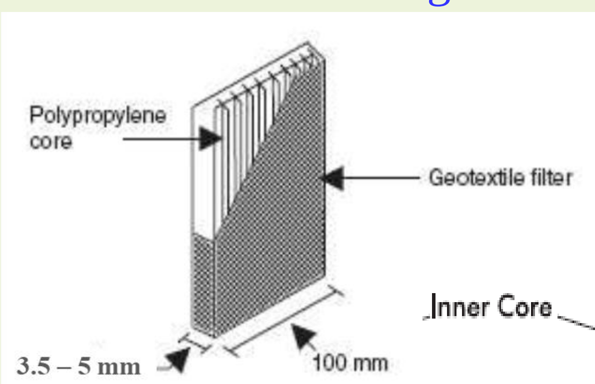
Holtz *et al*. (1991)

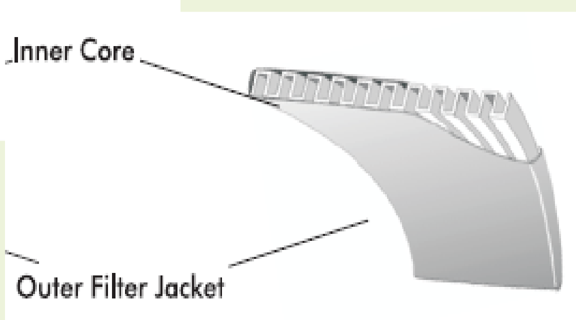
Prefabricated Vertical Drains / Band Drains

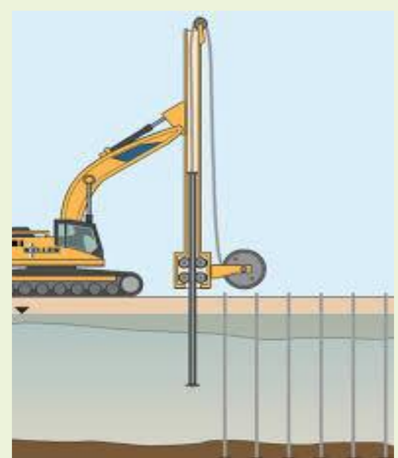
- Getup of a PVD / Band drain
  - ❖ Polymeric core consisting series of drainage channels
    - Allows passage of water
  - ❖ Filter sleeve encasement
    - Non-woven geotextile
    - Prevent migration of fine soil particles into the drain

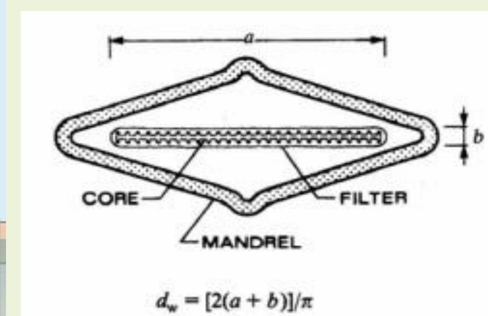


Global Synthetics (2010)



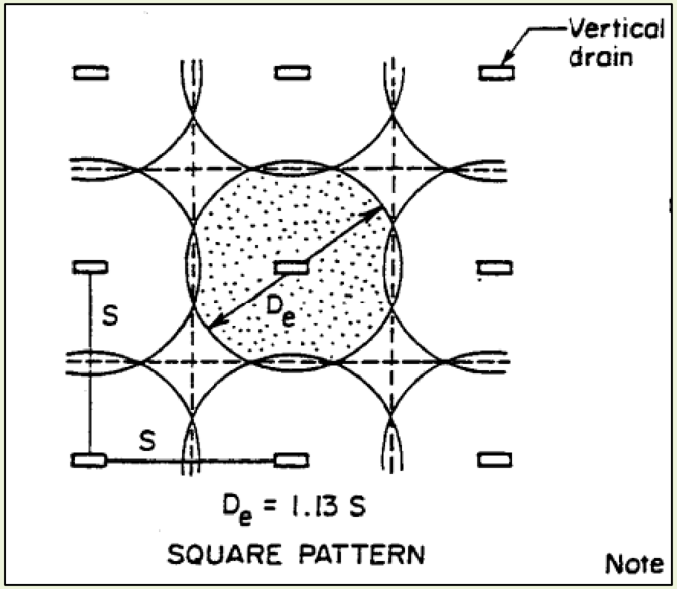


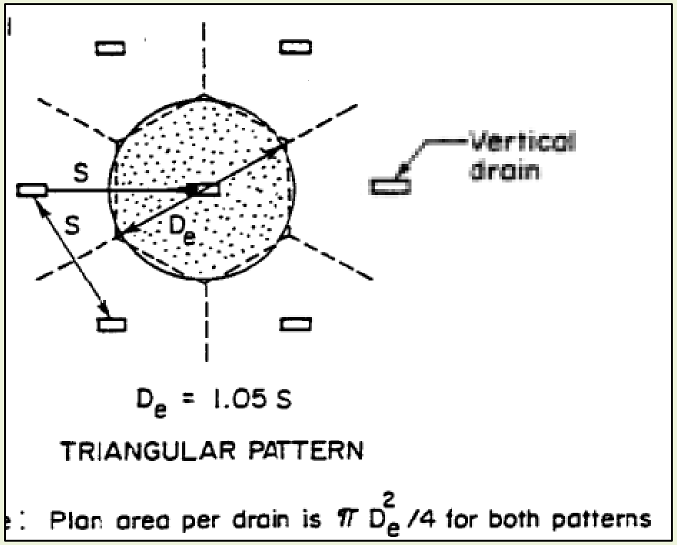




Arrangement of PVD: Influence Zone

- Arrangement of band drains
  - Square or Triangular grid
    - Equivalent diameter (D_e)
  - Equivalent diameter of the influence zone in terms of the drain spacing (S)
    - Drains installed in a square pattern
      - D_e = 1.13 S
    - Drains installed in a triangular pattern.
      - D_e = 1.05 S

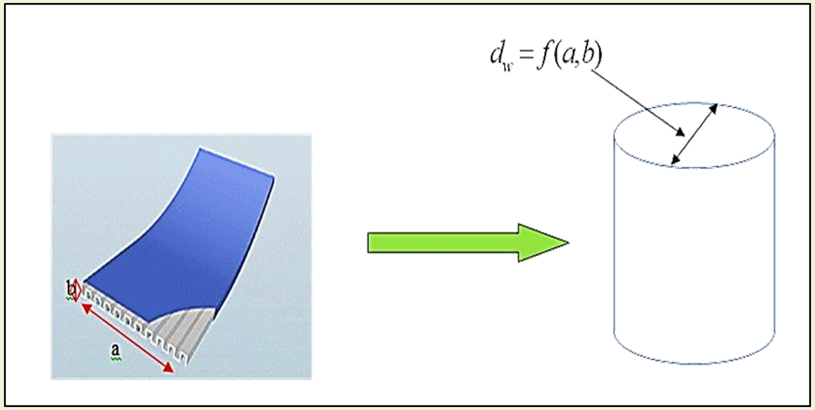




Bergado (1984)

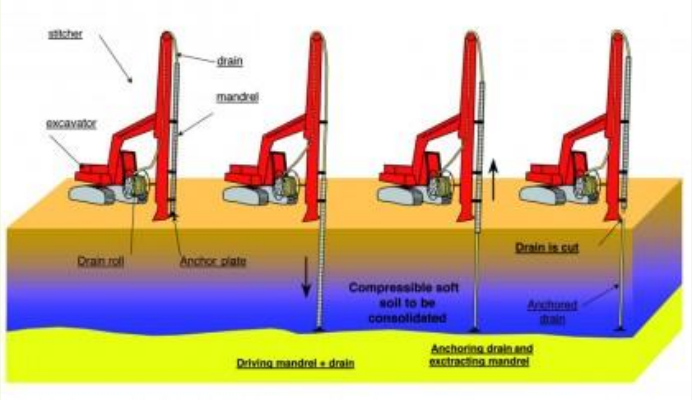
Equivalent Diameter of Band-PVDs

- Equivalent cylindrical drain (for ease of analysis)
  - ❖ Equivalent drain diameter for band shaped drain
  - ❖ Diameter of circular drain which has the same theoretical radial drainage performance as the band shaped drain (Naga *et al*., 2012)

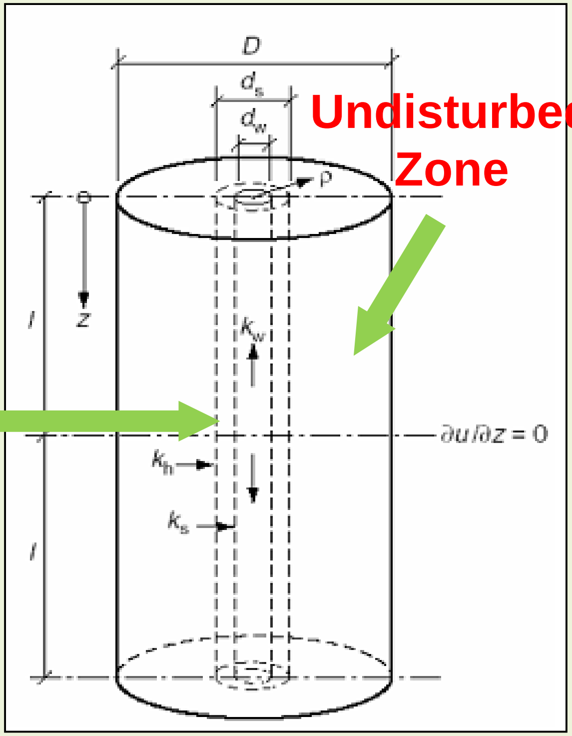


Reference	Expression
Hansbo (1979)	$d_w = 2(a+b)/\pi$
Atkinson and Eldred (1981)	$d_w = (a+b)/2$
Fellenius and Castonguay (1985)	$d_w = [4(ab)/\pi]^{0.5}$
Long and Covo (1994)	$d_w = 0.5a + 0.7b$
Abuel-Naga and Bouazza	$d_w = 0.45a$

Smear Effect from Installation



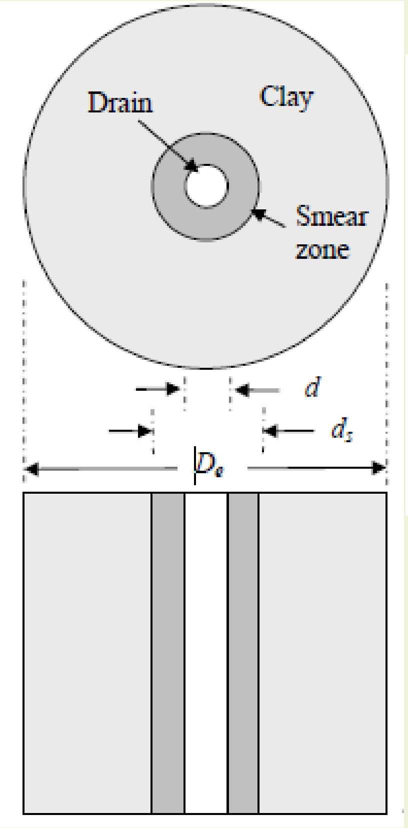
- Formation of smear zone ***(Barron, 1948)***
  - ❖ Varieties of installation equipments
  - ❖ Mandrel is pushed into the ground statically or dynamically
    - ▪ Mandrel protects the drain during installation
  - ❖ Surrounding soil gets displaced and pushed during installation
    - ▪ Development of shear strains
    - ▪ Increase in total stress and pore-pressure
- Smear zone
  - ❖ Zone of reduced permeability in the soil adjacent to drain periphery
  - ❖ Installation in varved soils
    - ▪ Dragging of more finer impervious layers over the pervious layers



Hansbo (1981), Wood (1982)

Smear Zone

- Smear zone
  - ❖ Smear zone is the zone of reduced permeability in the immediate vicinity of the drain



Reference	Equation
Akagi (1977)	$d_s = 2d$
Hansbo (1980)	$d_s = (1.5 - 3.0)d$
Jamiolkowski et al., (1981)	$d_s = (5 - 6)d/2$

Smear zone (Settle3D theory manual, 2007)

Extent and Permeability of Smear Zone: Summary

Source	Extent	Permeability	Remarks
Barron (1948)	$r_s = 1.6 r_w$	$k_h / k_s = 3$	Assumed
Hansbo (1979)	$r_s = (1.5 \sim 2) r_w$	Not mentioned	Based on available literature at that time
Hansbo (1981)	$r_s = 1.5 r_w$	$k_h / k_s = 3$	Assumed in case study
Bergado *et al.* (1991)	$r_s = 2 r_w$	$k_h / k_v = 1$	Laboratory investigation and back analyses for Bangkok Soft clay
Onoue (1991)	$r_s = 1.6 r_w$	$k_h / k_s = 3$	From test interpretation
Almeida *et al.* (1998)	$r_s = (1.5 \sim 3) r_w$	$k_h / k_s = 3 \sim 6$	Based on experiences
Indraratna *et al.* (1998)	$r_s = (4 \sim 5) r_w$	$k_h / k_s = 1.15$	Laboratory investigation (For Sydney clay)
Chai and Miura (1999)	$r_s = (2 \sim 3) r_w$	$k_h / k_s = C_f (k_h / k_s)$	The ratio between lab and field values
Hird *et al.* (2000)	$r_s = 1.6 r_w$	$k_h / k_s = 3$	Recommend for design
Xiao (2000)	$r_s = 4 r_w$	$k_h / k_s = 1.3$	Laboratory investigation (For Kaolin clay)

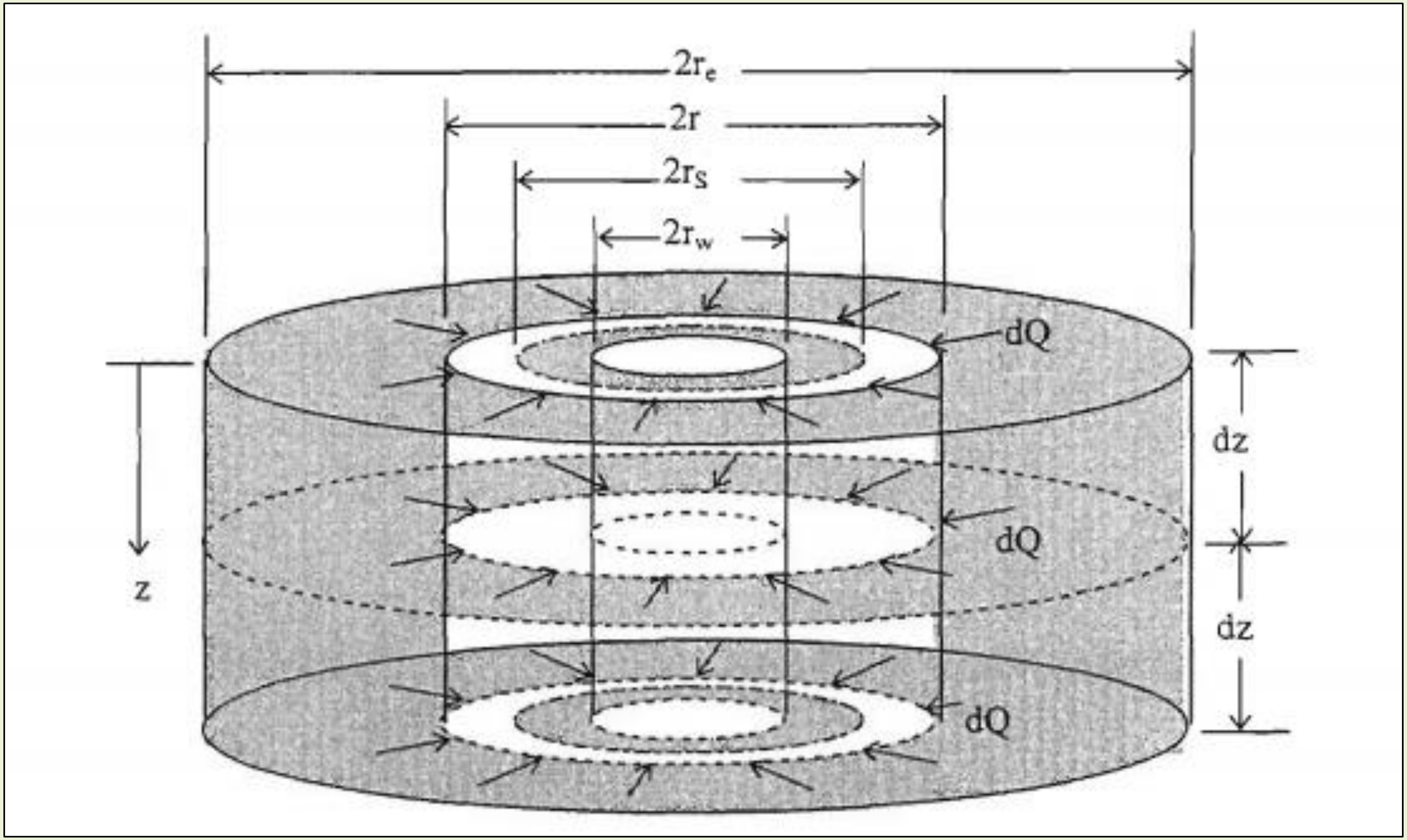
(Sathananthan, 2005)

Well Resistance

- Retardation of radial consolidation process
  - Resistance to water flow into the vertical drains
- Governing factors
  - Maximum drain discharge capacity (q_w)
  - Radial permeability of the soil (k_h)
  - Effective discharge length of the drain (l_m)
  - Probable geometric defects on the drain
    - Deterioration of drain filter, Clogging, Siltation
    - Drain folding during installation
- Well resistance factor $R = q_w / k_h l_m^2$
  - **Mesri and Lo (1981), Sathananthan (2005)**
    - $R < 5$ → Negligible well resistance

Unit Cell PVDs: Radial Consolidation Theories

- Notations used **Cheng *et al.* (1995)**

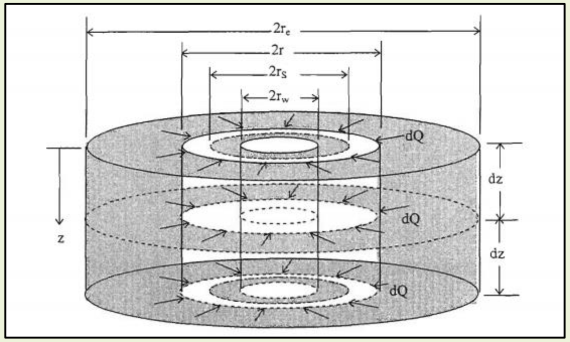


PVDs: Radial Consolidation Theories

- Consolidation theory in Cartesian radial co-ordinates ***(Terzaghi, 1943)***

$$\frac{k_h}{\gamma_w}\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)+\frac{k_v}{\gamma_w}\left(\frac{\partial^2 u}{\partial z^2}\right)=\frac{a_v}{1+e}\left(\frac{\partial u}{\partial t}\right) \qquad c_h\left(\frac{1}{r}\frac{\partial u}{\partial r}+\frac{\partial^2 u}{\partial r^2}\right)+c_v\left(\frac{\partial^2 u}{\partial z^2}\right)=\left(\frac{\partial u}{\partial t}\right)$$

  - ❖ c_v, c_h → Coefficient of vertical and horizontal consolidation
  - ❖ r → Radial distance from the centre of the well
  - ❖ u → Pore-pressure ratio



- Generalized degree of consolidation
  - ❖ Carillo (1948) $$U=1-(1-U_h)(1-U_r)$$

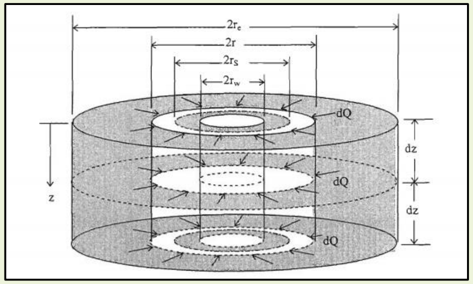
- Solution for pore-pressure ratio and radial consolidation ***(Barron, 1948)***

$$U_r=1-\exp\left(\frac{-8T_h}{F(n)}\right), \quad T_h=\frac{c_h t}{D_e^2} \qquad F(n)=\frac{n^2}{n^2-1}\ln(n)-\frac{3n^2-1}{4n^2}$$

  - ❖ n→ Spacing ratio $$n=D_e/d_w$$

PVDs: Radial Consolidation Theories

- Consideration of smear effect and well resistance in the radial consolidation theories ***(Hird, 1981)***



- ❖ For perfect drain condition

$$F(n) = \ln(n) - \frac{3}{4}$$

- ❖ Considering only smear effect

$$F = F(n) + F_s = \ln\left(\frac{n}{s}\right) + \left(\frac{k_h}{k_s}\right)\ln(s) - \frac{3}{4}$$

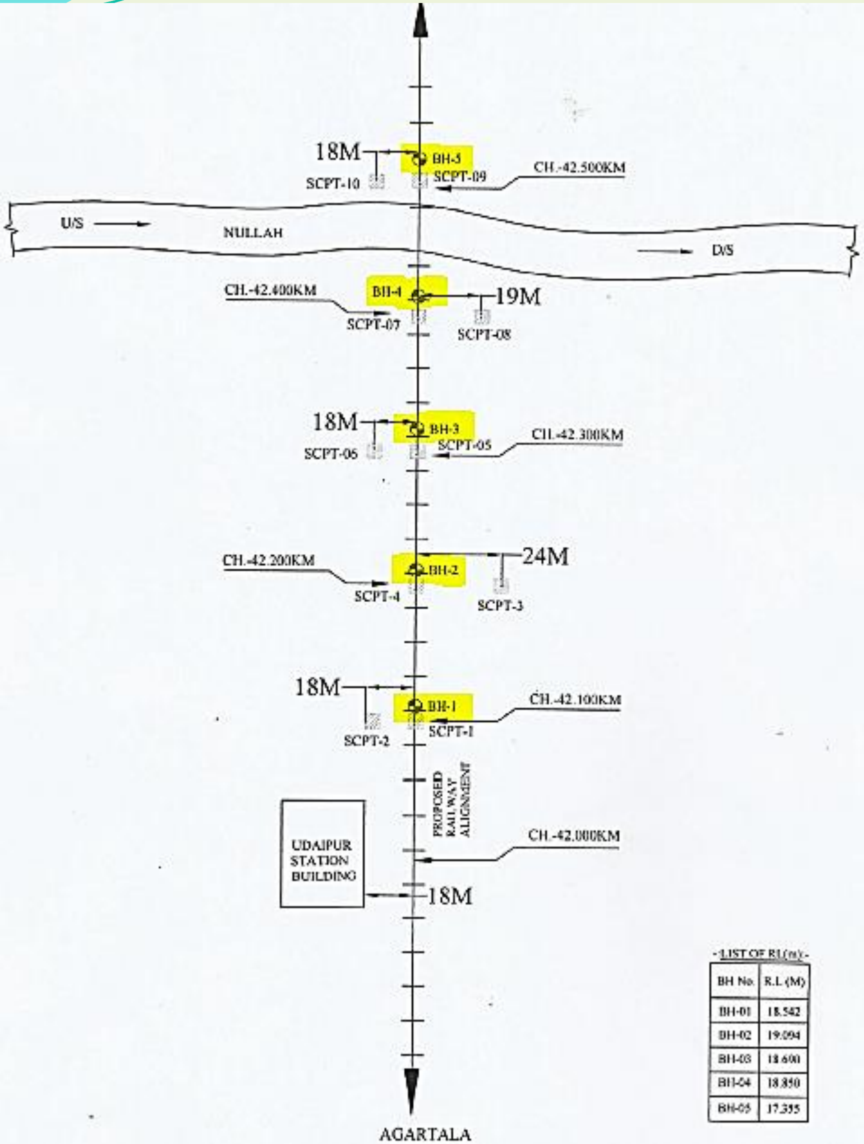
- ❖ Considering both smear effects and well resistance

$$F = F(n) + F_s + F_r = \ln\left(\frac{n}{s}\right) + \left(\frac{k_h}{k_s}\right)\ln(s) - \frac{3}{4} + \pi z(2l_m - z^2)\frac{k_h}{q_w}$$

$$s = \frac{r_e}{r_w}$$

- $F(n)$ → Drain spacing factor, F_s → Smear effect factor, F_r → Well resistance factor, k_h → Horizontal permeability, k_s → Reduced permeability in the smear zone, l_m → length of drainage, z→ distance to the point of flow

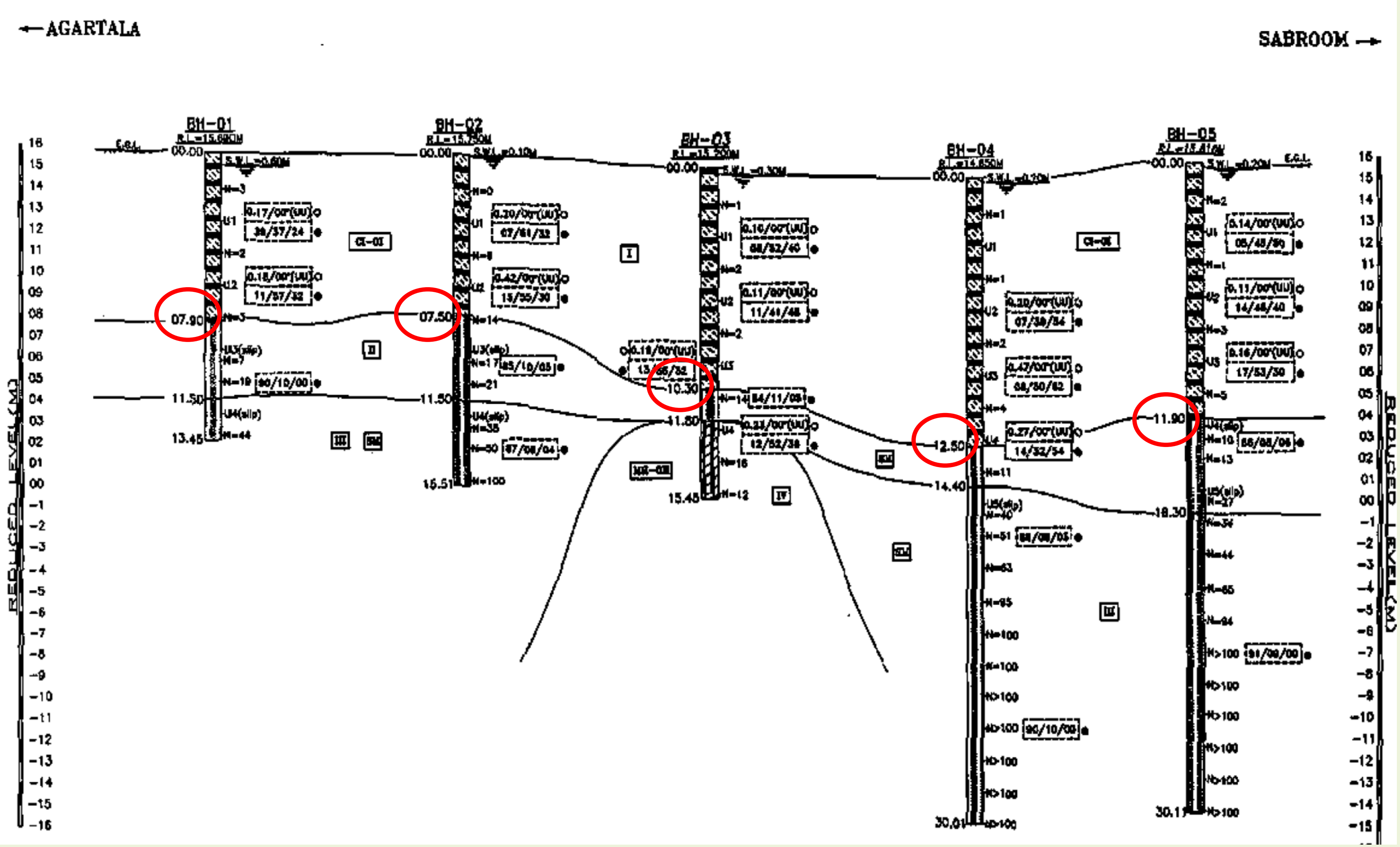
Field Investigation



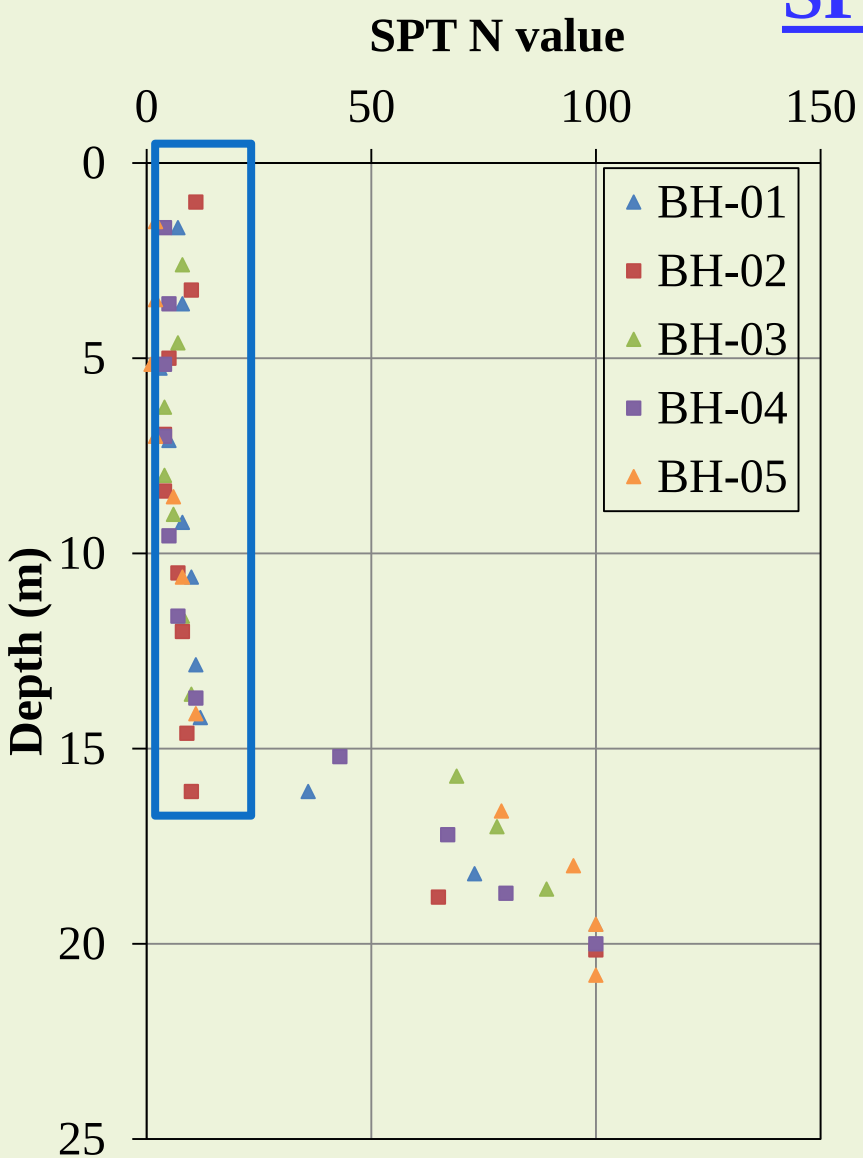
Bore Hole No.	Chainage (km)	G.L. (m)	Terminating Depth (m)	Standing Water Level (m)
BH-01	42.100	18.542	21.37	0.8
BH-02	42.200	19.094	21.87	2.5
BH-03	42.300	18.69	22.18	2.7
BH-04	42.400	18.85	21.48	2.8
BH-05	42.500	17.355	21.15	0.6

Locations of boreholes (CE Testing report, 2013)

Boreholes along the Railway Line



SPT and Subsurface Stratification

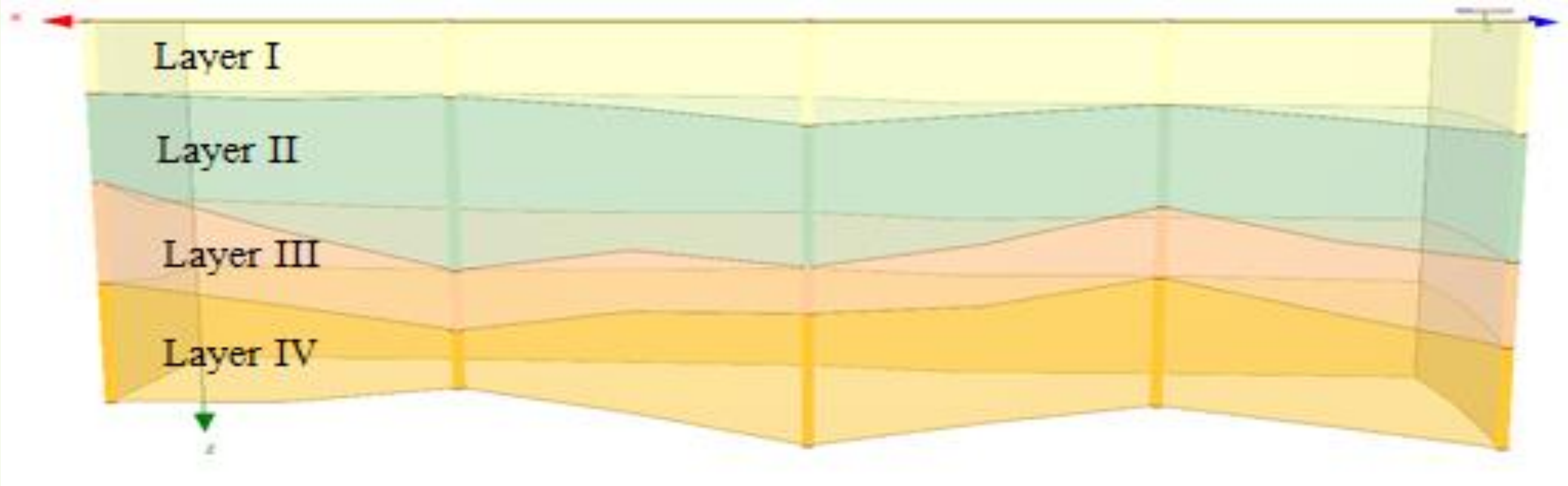


- Stratification of the subsoil

Stratum	SPT N-values	Depth (m)
Layer I	3 - 5	4
Layer II	5 - 10	5
Layer III	10 - 15	4
Layer IV	> 70	5

Tentative Subsurface Profiling

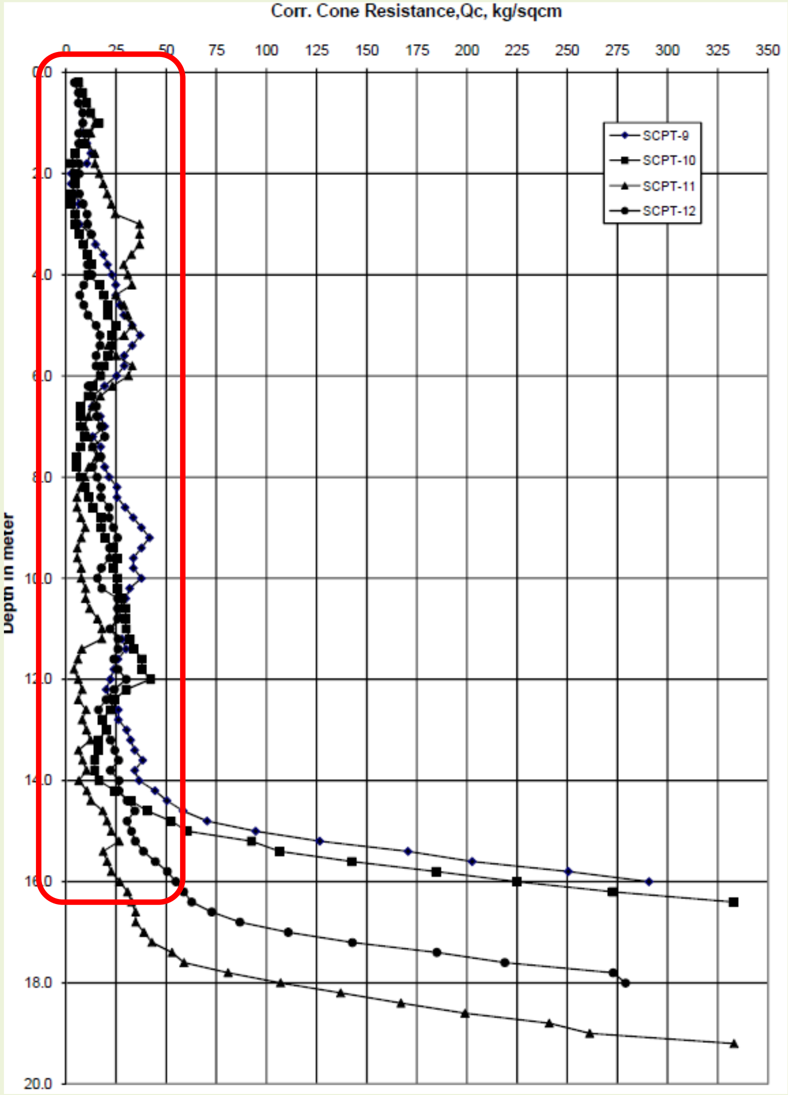
- 4 layers are tentatively identified from available 5 borelogs
  - SPT N-values and physical appearance of the soil

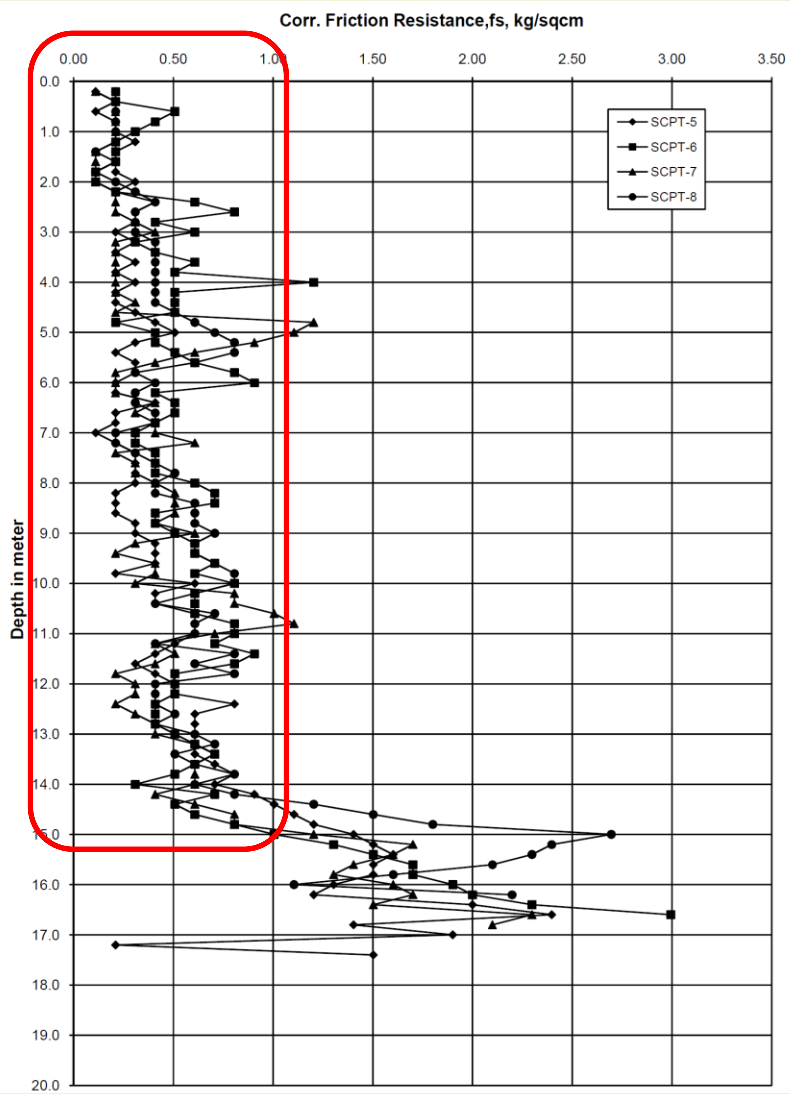


Investigations for Geotechnical Parameters

- SPT
- SCPT
- UDS collection and Laboratory tests

Typical SCPT results





Laboratory tests on Undisturbed Soil

- Proper identification and classification of the sub-soil deposits
- Undisturbed samples of 100 mm diameter were collected by means of pushing Shelby tubes
- Index and Engineering properties of the soil were estimated

Wax Coat

Undisturbed sample cores obtained from the site location

Bore hole details

Index Tests

(a) Dry Sieve analysis (b) Hydrometer Analysis (c) Liquid Limit
(d) Specific gravity by gravity bottles and (e) Plastic Limit

Index Properties

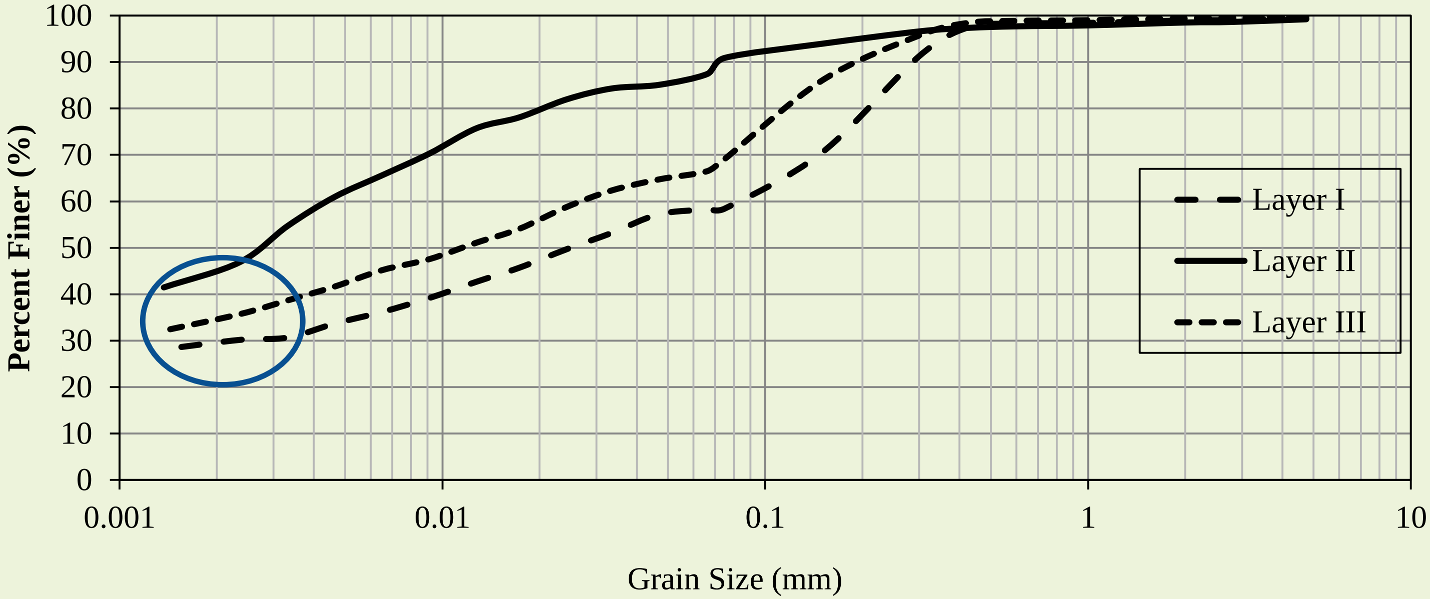
- Summary of index properties

Bore Hole	Sample Number	Depth (m)	Natural Moisture content, %	Specific Gravity	Liquid Limit	Plastic Limit
BH 01	UDS-02	1.65-2.10	28.57	2.511	42.6	-
BH 03	UDS-01	2.00-2.45	26.58	2.601	-	20
BH 01	UDS-04	5.25-5.70	82.52	1.398	55.2	19.04
BH 04	UDS-06	9.55-10.00	23.54	2.335	42.4	20.8
BH 03	UDS-04	6.25-6.70	40.29	2.725	47.6	-
BH 05	UDS-04	5.15-5.60	80	2.257	48.8	-

Particle size Distribution

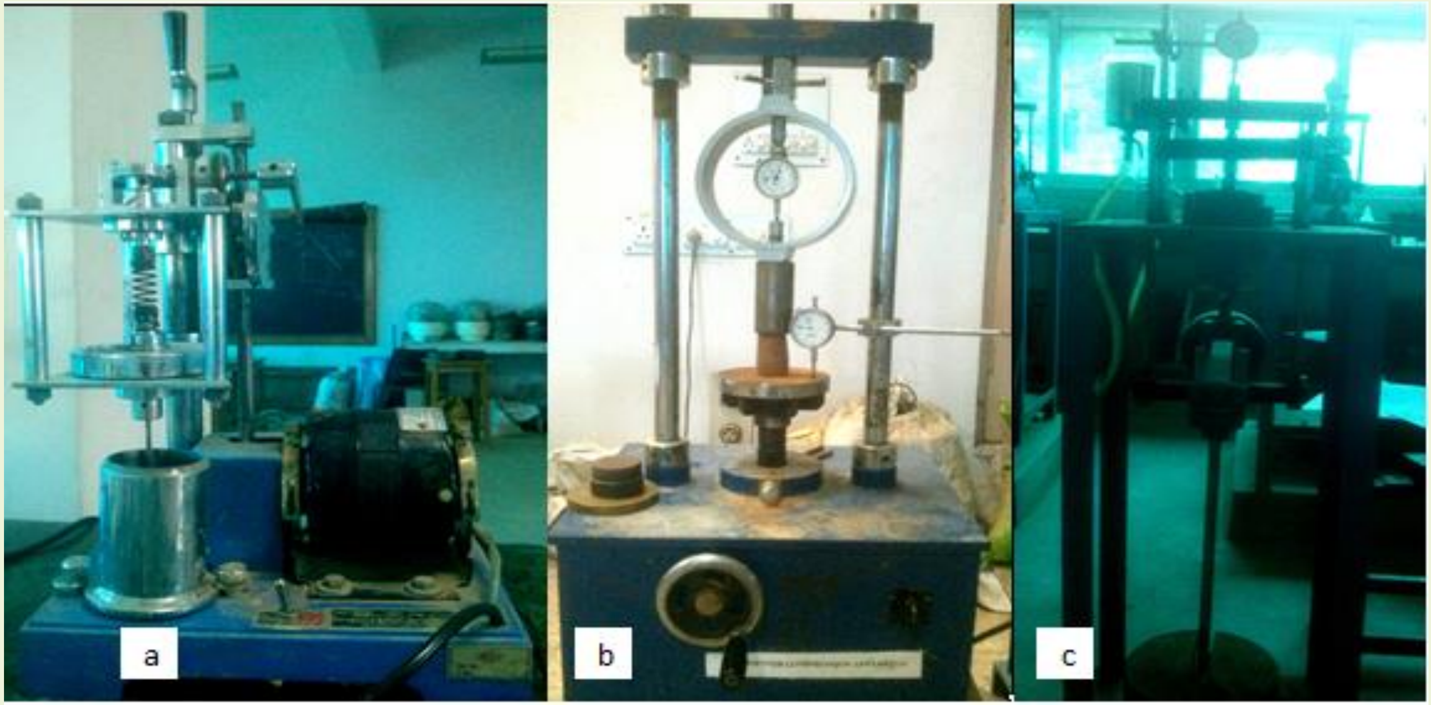
Particle size	Layer I (%)	Layer II (%)	Layer III (%)
Coarse sand (4.75 mm-2 mm)	0.5	2	0
Medium sand (2 mm-0.425 mm)	1.5	0	2
Fine sand (0.425 mm-0.075 mm)	40	7	30
Silt (0. 075 mm-0.002 mm)	28	47	34
Clay (<0.002 mm)	30	44	34

Both wet sieve and hydrometer analysis are conducted to complete particle size distribution of the sub-soil



Engineering Properties of soil

- Undrained shear strength from Unconfined Compression test (UCS) and laboratory Vane shear tests
- Compressibility and Permeability Parameters from Oedometer test



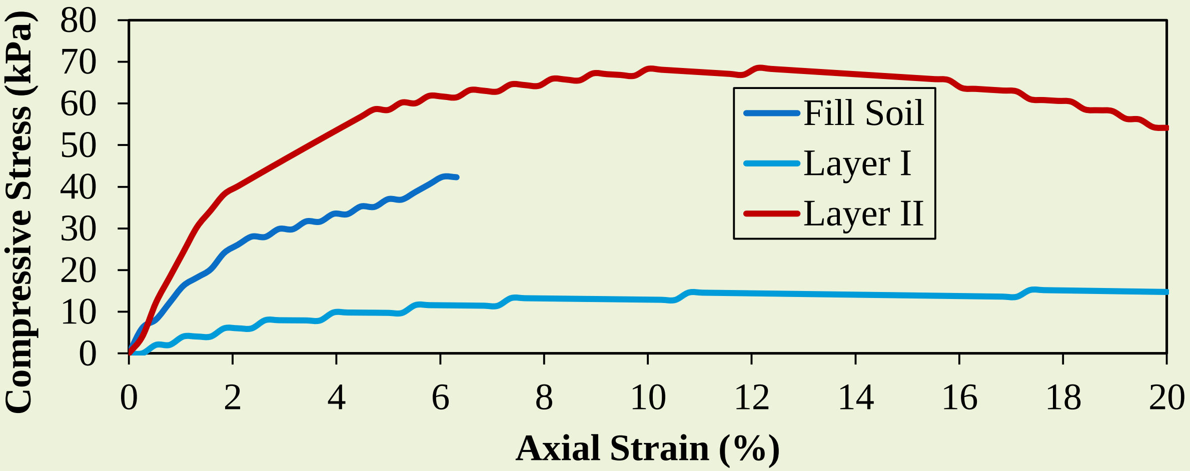
(a) Vane Shear test (b) Uniaxial compression test (c) Oedometer Test

Undrained Shear Strength

Bore Hole	Sample Number	Depth (m)	UCS		Vane Shear		Consistency
			Moisture Content, %	s_u (kPa)	Moisture Content, %	s_u (kPa)	
BH 01	UDS-02	1.65-2.10	28.57	26.48	30.21	34.3	Soft
BH 01	UDS-04	5.25-5.70	75.23	12.17	82.52	7.775	Very Soft
BH 01	UDS-10	16.10-16.55	-	7.03	-	-	Very Soft
BH 03	UDS-01	2.00-2.45	26.58	55.69		16.01	Stiff
BH 03	UDS-04	6.25-6.70	30.92	28.61	40.29	44.36	Medium
BH 04	UDS-04	5.15-5.60	-	-	21.58	105.2	Stiff
BH 04	UDS-06	9.55-10.00	27.67	41.87	23.54	53.97	Medium
BH 05	UDS-02	1.50-1.95	15.16	54.11	20.36	25.61	Stiff
BH 05	UDS-04	5.15-5.60	-	-	80	14.17	Soft
BH 05	UDS-08	12.5-12.6	34.54	22.5	24.4	54.88	Soft

Distribution of undrained shear strength is very erratic (mostly soft) – conducive of large differential settlements

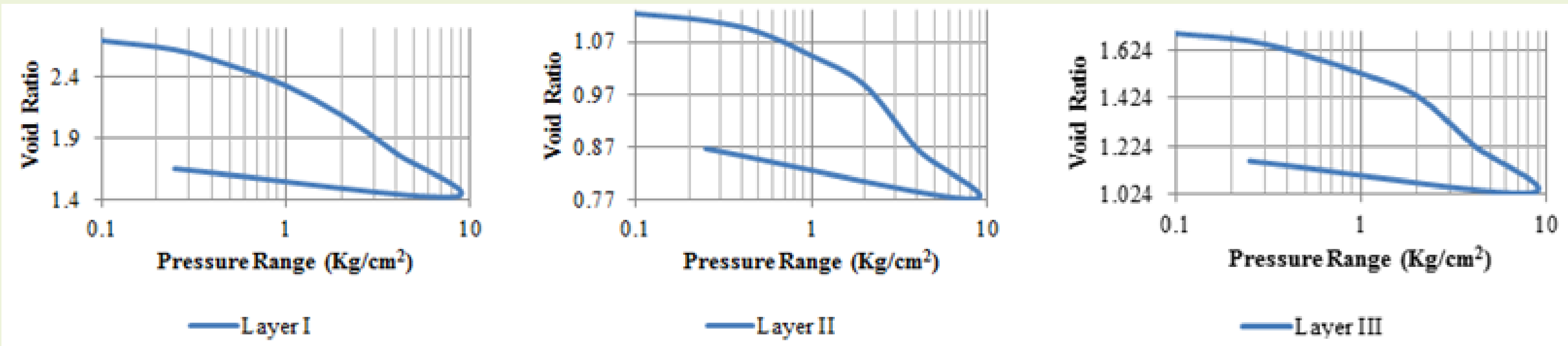
Modes of failure



Stress strain response of different layers under unconfined compression

Consolidation Tests

- Typical *e-p*' for different layers of the soil



- C_c and C_v calculated from the plots

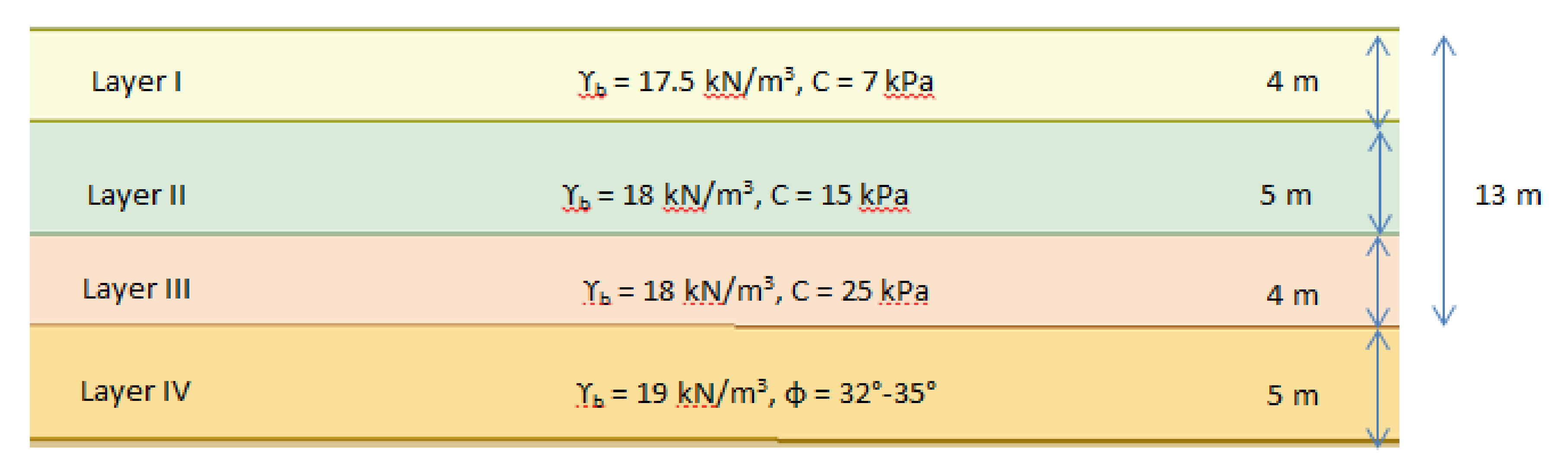
Borehole	Depth (m)	Moisture Content, *w* %	Initial Void Ratio, e_0	C_c	C_v (cm²/sec)	k_v (cm/sec)
UDS-04	10.7-11.1	40.8	1.126	0.365	0.000576	1.57×10^{-08}
UDS-03	9.0-9.45	61	1.702	0.664	0.001369	5.05×10^{-08}
UDS-03	10.0-10.45	87.9	2.719	1.079	0.000838	6.04×10^{-08}

Subsoil Parameters

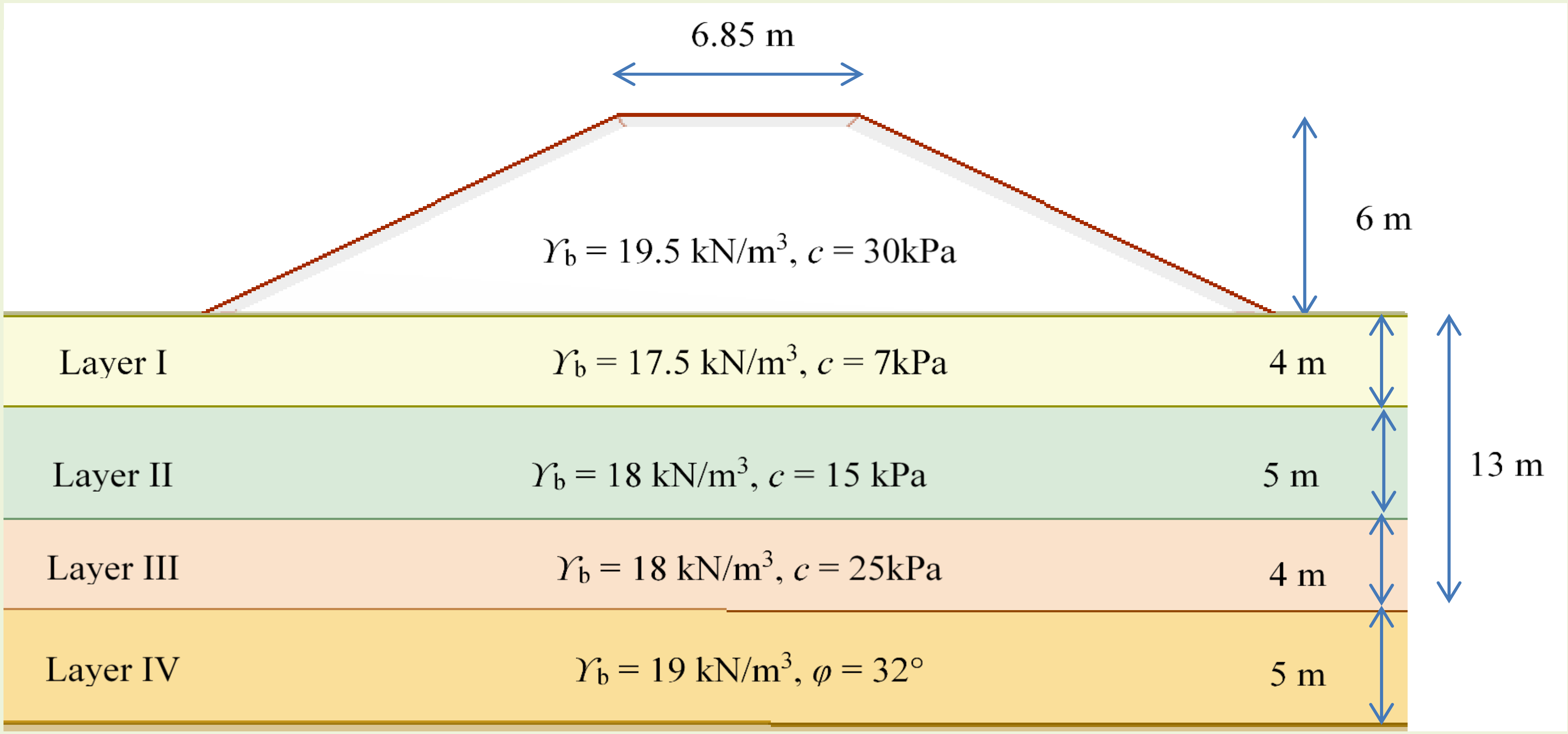
Stratum	Fill	Layer I	Layer II	Layer III	Layer IV
Unit Weight (kN/m^3)	19.5	17.5	18	18	19
Specific Gravity	2.45	2.2	2.34	-	-
Cohesion (kPa)	30	7	15	25	0
Angle of Internal Friction, φ °	-	-	-	-	32-35
Natural Moisture content	24%	48%	23.54%	34.54%	-
Liquid Limit	42%	50%	42.40%	-	-
Plastic Limit	20%	19%	20.80%	-	-
Plasticity Index	22%	31%	21.60%	-	-
Compression Index, C_c	-	1.079	0.365	0.664	-
Coefficient of Consolidation, C_v (cm^2/sec)		0.000838	0.000576	0.001369	
Permeability (cm/sec), k_v	-	8.76×10^{-9}	1.57×10^{-8}	5.05×10^{-8}	-
Initial void ratio, e_0	-	2.719	1.126	1.702	-

Tentative Cross-sEctional Profile with Properties

- The tentative soil profile with parameters found out from the laboratory tests are used for stratification

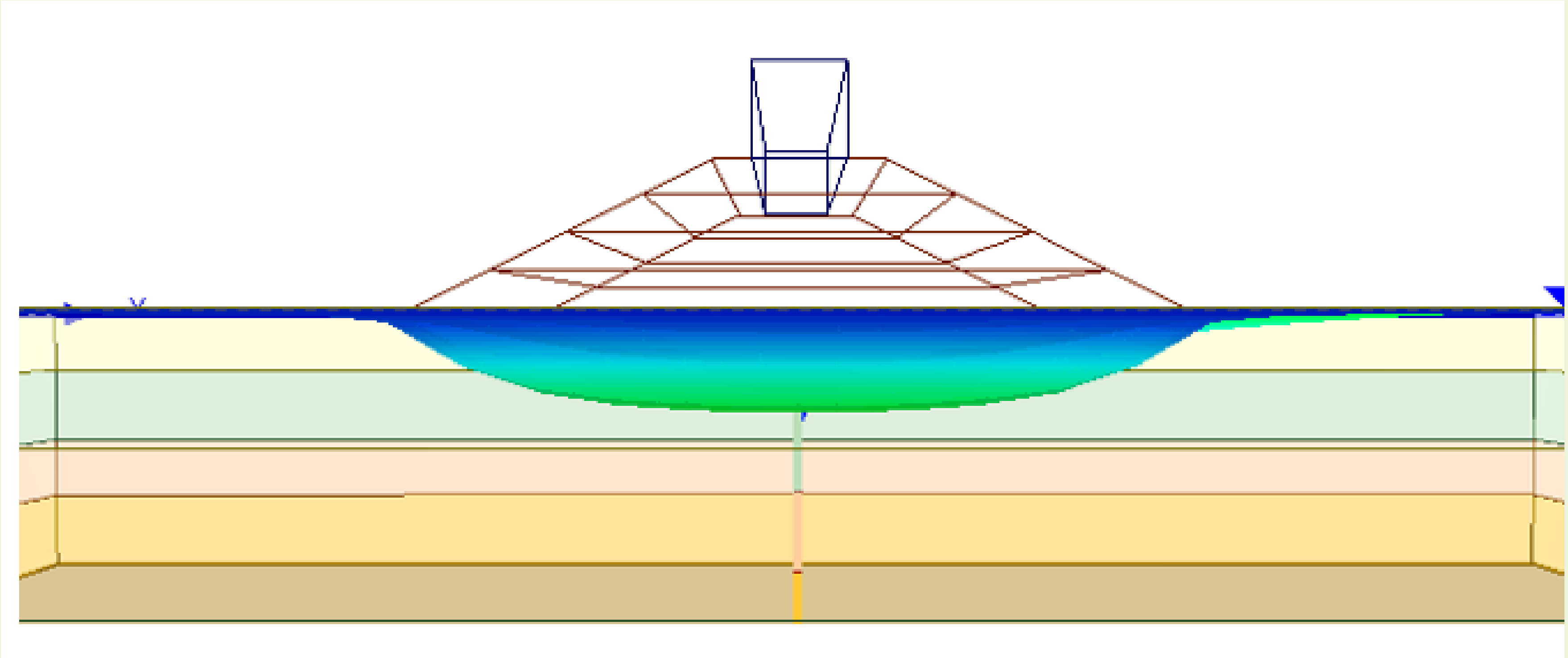


Cross-sectional Analysis (BH-03)

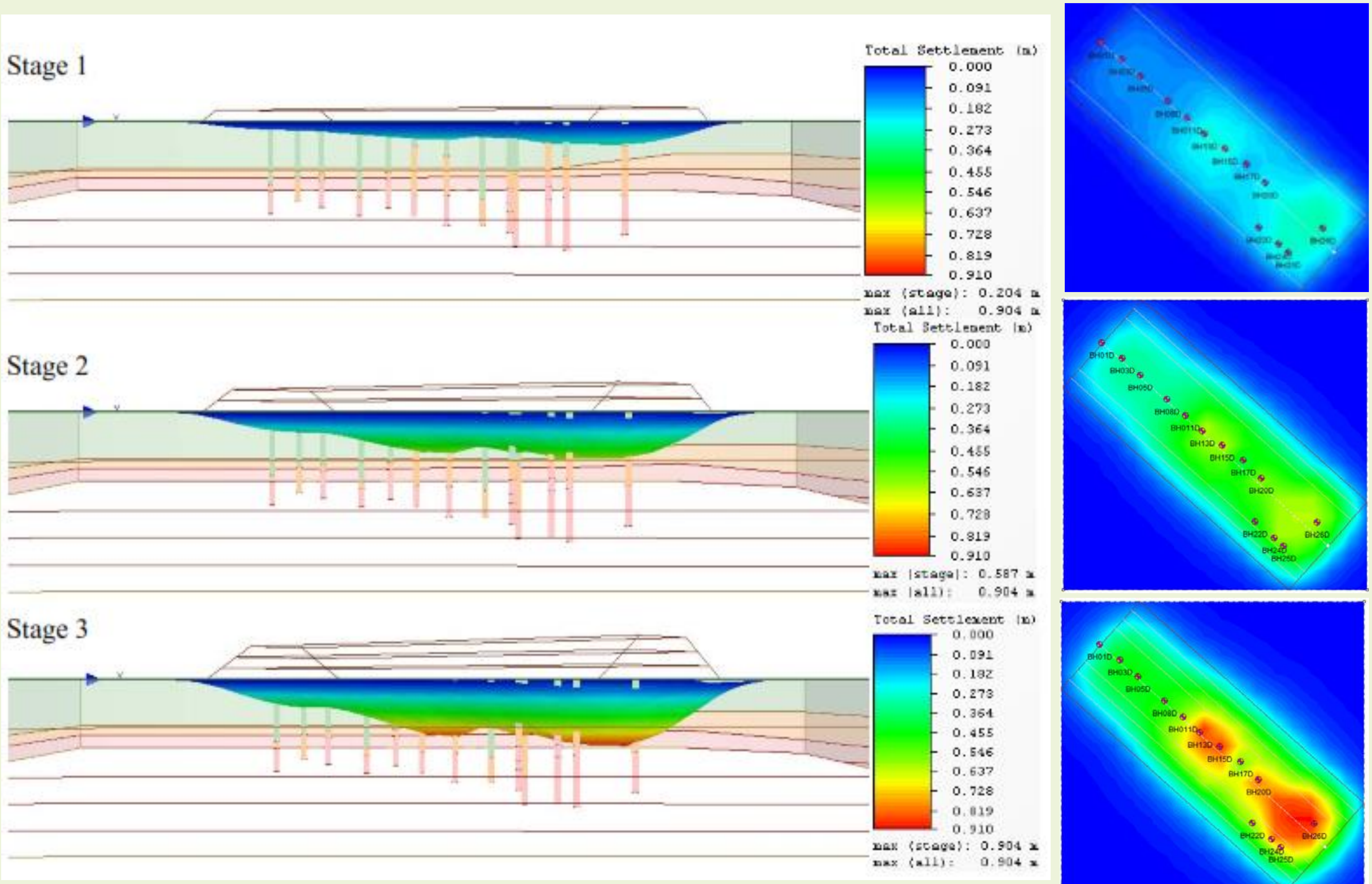


Analysis of Embankment stability

- Using SETTLE3D software (Rocscience 2014)
  - ❖ The primary consolidation settlement of 0.505 m, 0.755 m, and 0.951 m after 3.14 m, 4.64 m, and 6 m embankment heights were observed.
    - Large deformations observed in the field
    - Warrants for ground improvement



Large Differential Settlements along the Embankment



Construction Plan for Embankment at Udaipur Yard

Height of embankment, m	P_0, kPa[H/2*6.53]	δP, kPa [(Δh*19)+24]	No of Days	Settlement due to load with time, mm	Cumulative Settlement, mm	Time* period, days	Uh	Cumulative settlement, m (achievable)	U
0	43.26	0.00	0	0.00	0.00	0	0.00	0.00	0
0.5	43.26	33.50	20	0.488	0.488	20	0.45	0.22	17.75
1	43.26	43.00	20	0.099	0.587	40	0.70	0.42	33.71
1.5	43.26	52.50	20	0.089	0.676	60	0.84	0.56	45.37
2	43.26	62.00	20	0.081	0.756	80	0.91	0.69	55.67
2.5	43.26	71.50	20	0.074	0.831	100	0.95	0.79	63.76
6.2	43.26	141.80		0.407	1.238	**			

Considering 20 days of time period after execution of each stage of 0.5 m

Height of embankment (m)	No of Days	Corresponding degree of consolidation	Initial Cohesion (kPa)	Increased pressure δP [due to DL (kPa)	Gain in Cohesion value	Final Cohesion, kPa	Bearing Capacity of soil, in kN/m²
0	0	0	4	0	0	4	20.6
0.5	20	45	4	9.5	0.75	4.75	24.4
1	20	71	4	19	2.38	6.38	32.8
1.5	20	83	4	28.5	4.18	8.18	42
2	20	91	4	38	6.11	10.11	51.9
2.5	20	95	4	47.5	7.97	11.97	61.5

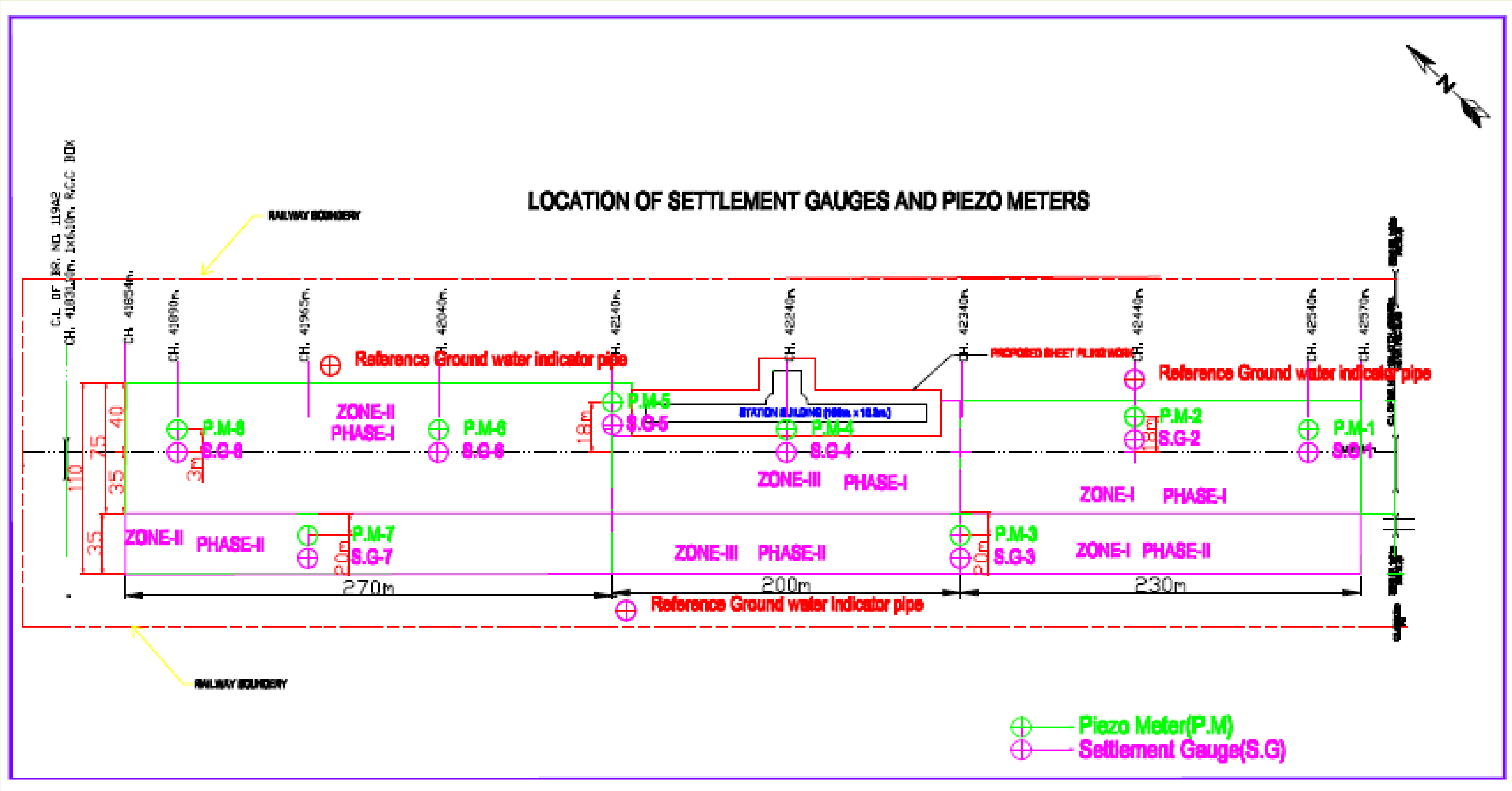
Suzuki and Yasuhara, Soils and Foundations, 2007


L&T-KOMATSU

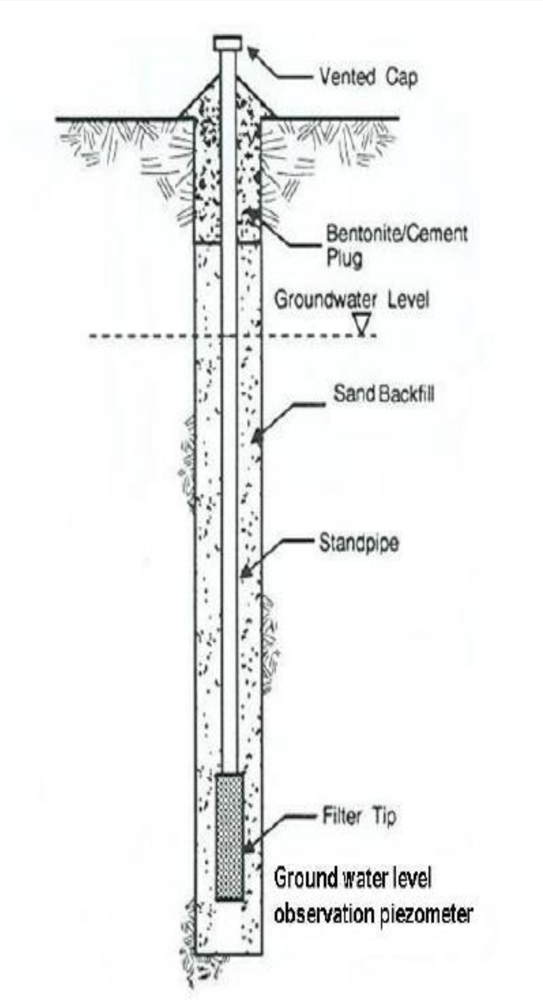
a) Laying of Coarse sand, b) Laying of Non-Woven Geo-textile, c) Laying of Granular Blanket.

d) Laying of Woven Geo-textile, e & f) Stage construction of embankment.

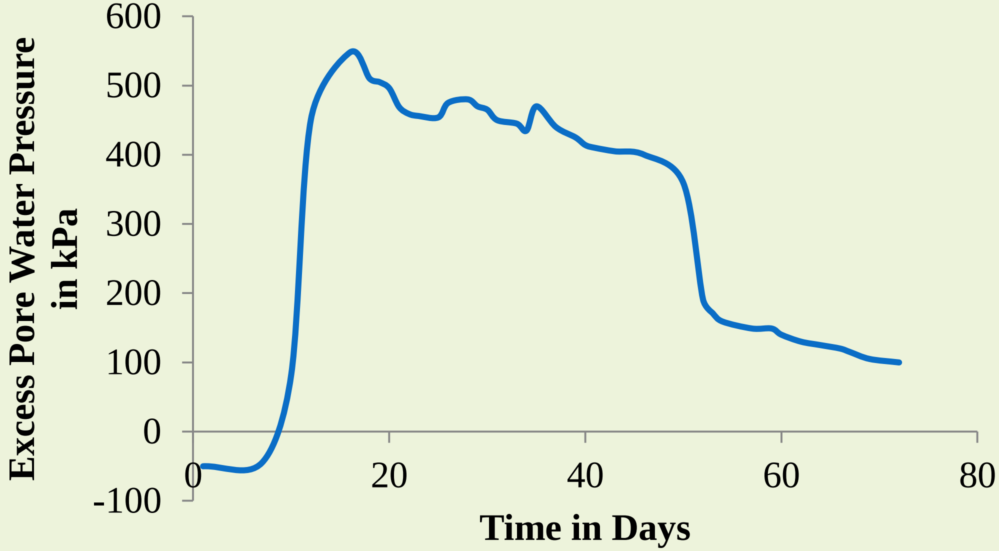
Instrumentation

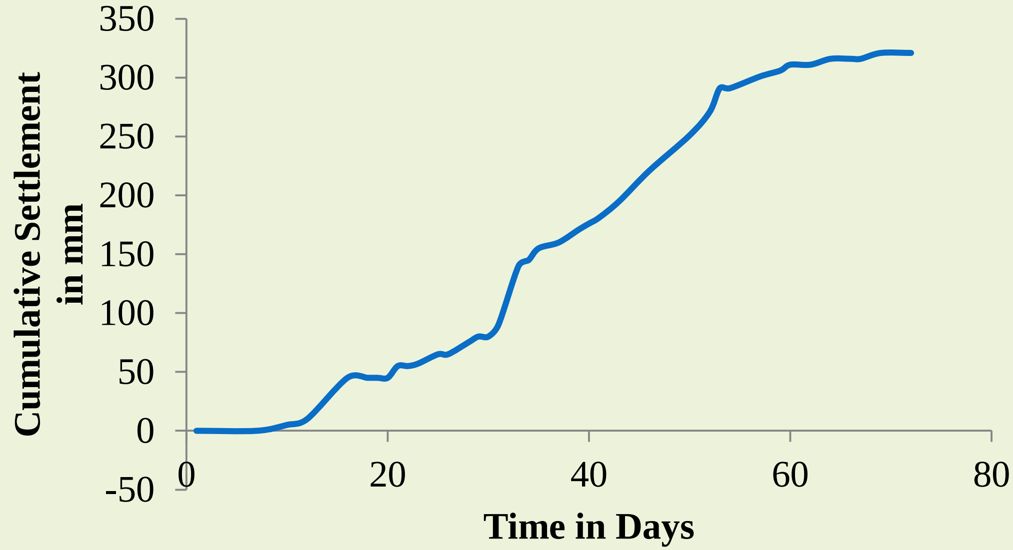


Piezometers & Settlement Gauges

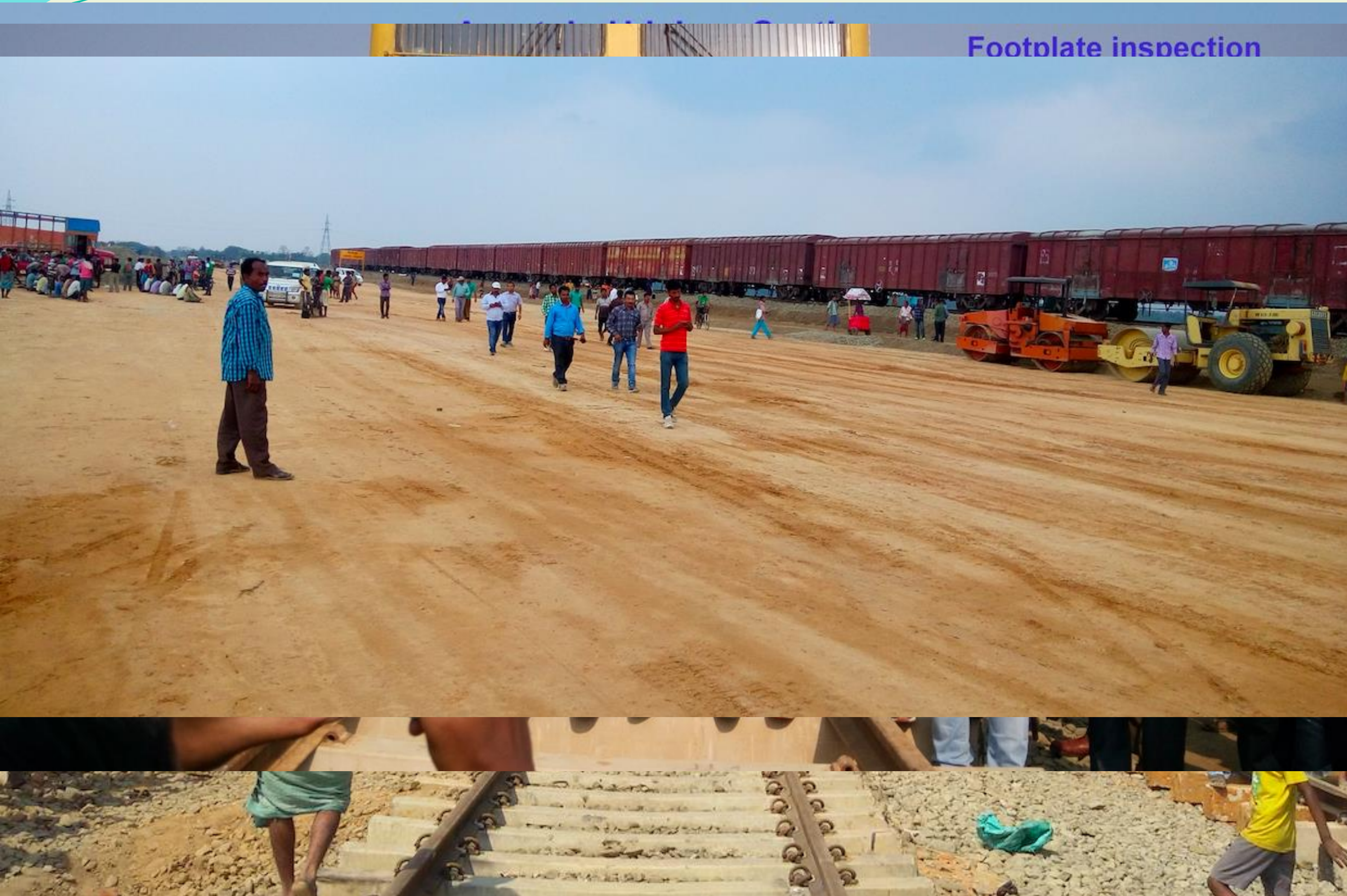


Record of Pore Water Pressure, Settlement & N-Value



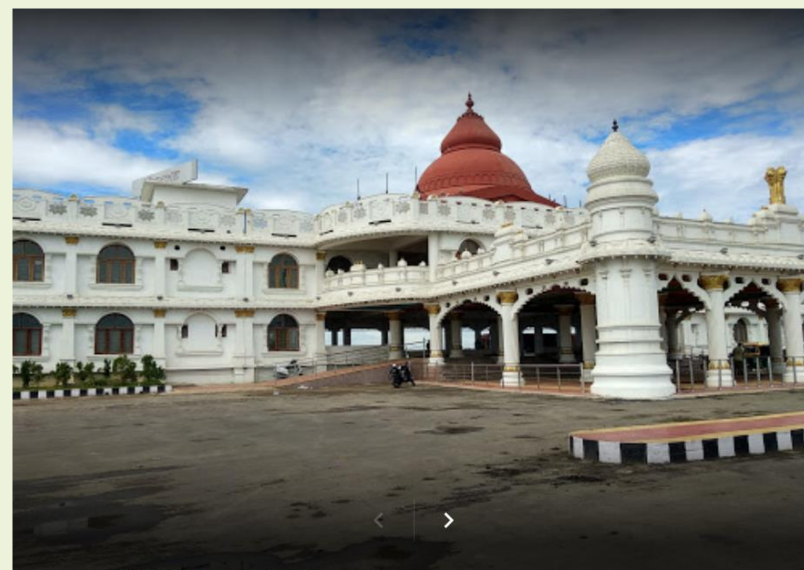


N-Value Before & After Installation of PVDs (Ch: 42.44)			
Depth from OGL	Description of the Soil	Old Bank (May 2014)	New Bank (11 Jan 2016)
2	Soft , deep, grey clayey soil	4	9
3		4	15
4.5	Medium, deep, grey clayey silty soil		16
6		4	11
7	Medium, deep, grey clay silty sand soil	7	16
9		6	25
11	Medium dense silty sand	4	28
12.5		3	29
14.5	Medium to dense sandy soil	6	36
16		66	72
17.5	Very dense sandy soil	100	100
N-Value After 51 days of PVD installation			


Footplate inspection

Heritage Railway Station, Udaipur, Agartala

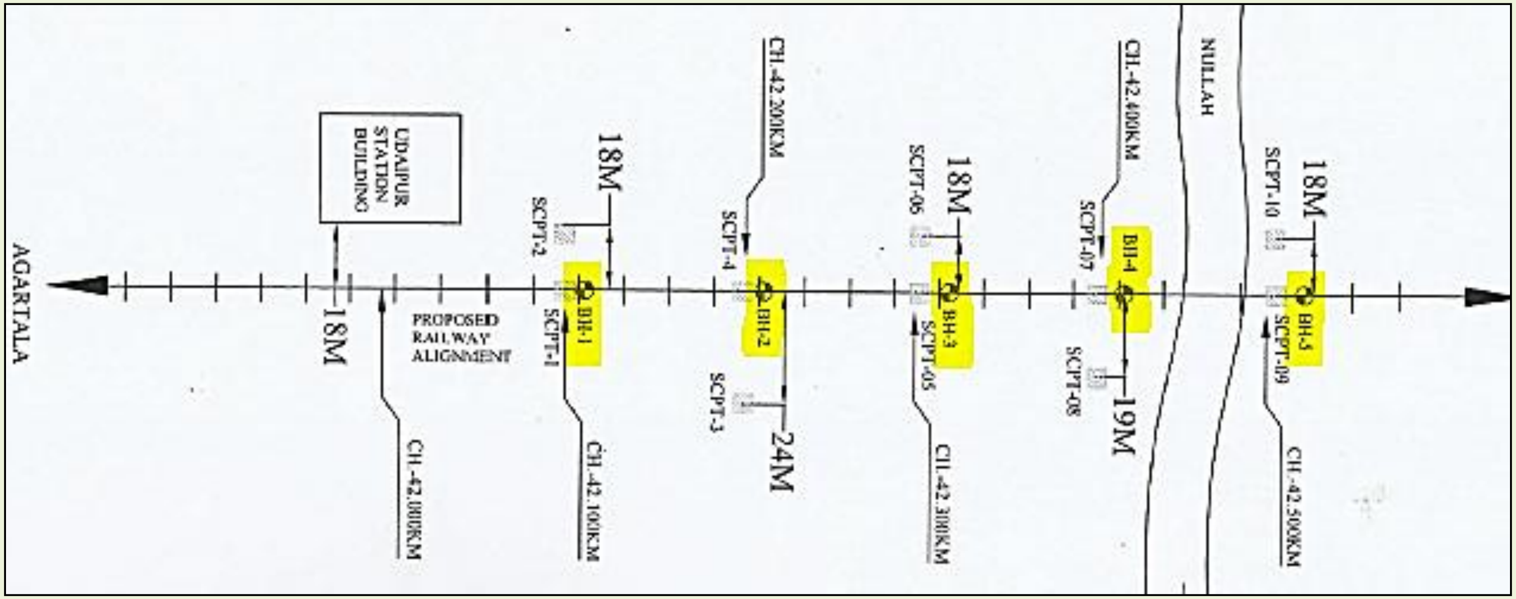
- Application of preloading and PVD for developing of railway yard in a ditch marshland

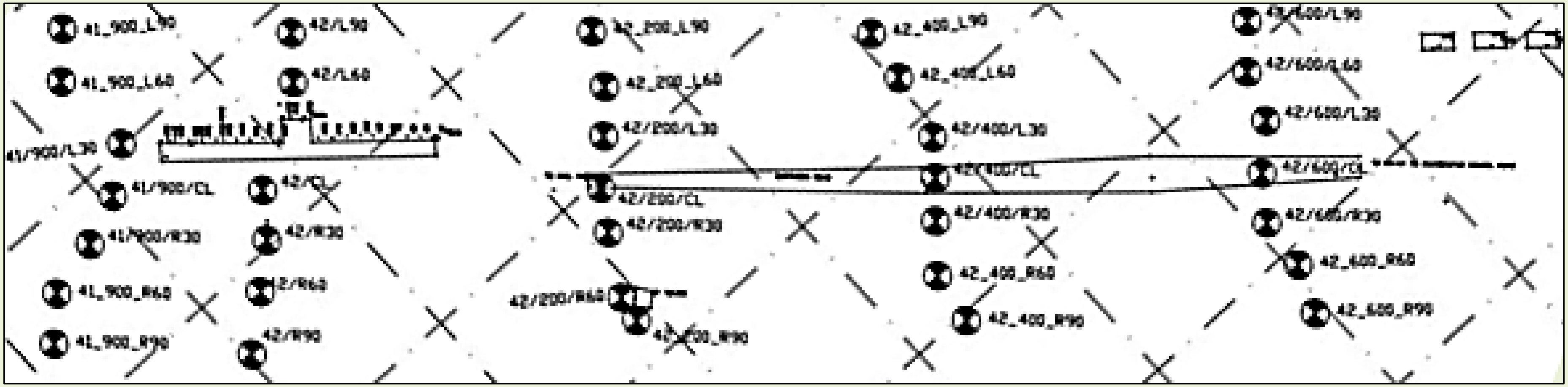



উদয়পুর
उदयपुर
UDAIPUR

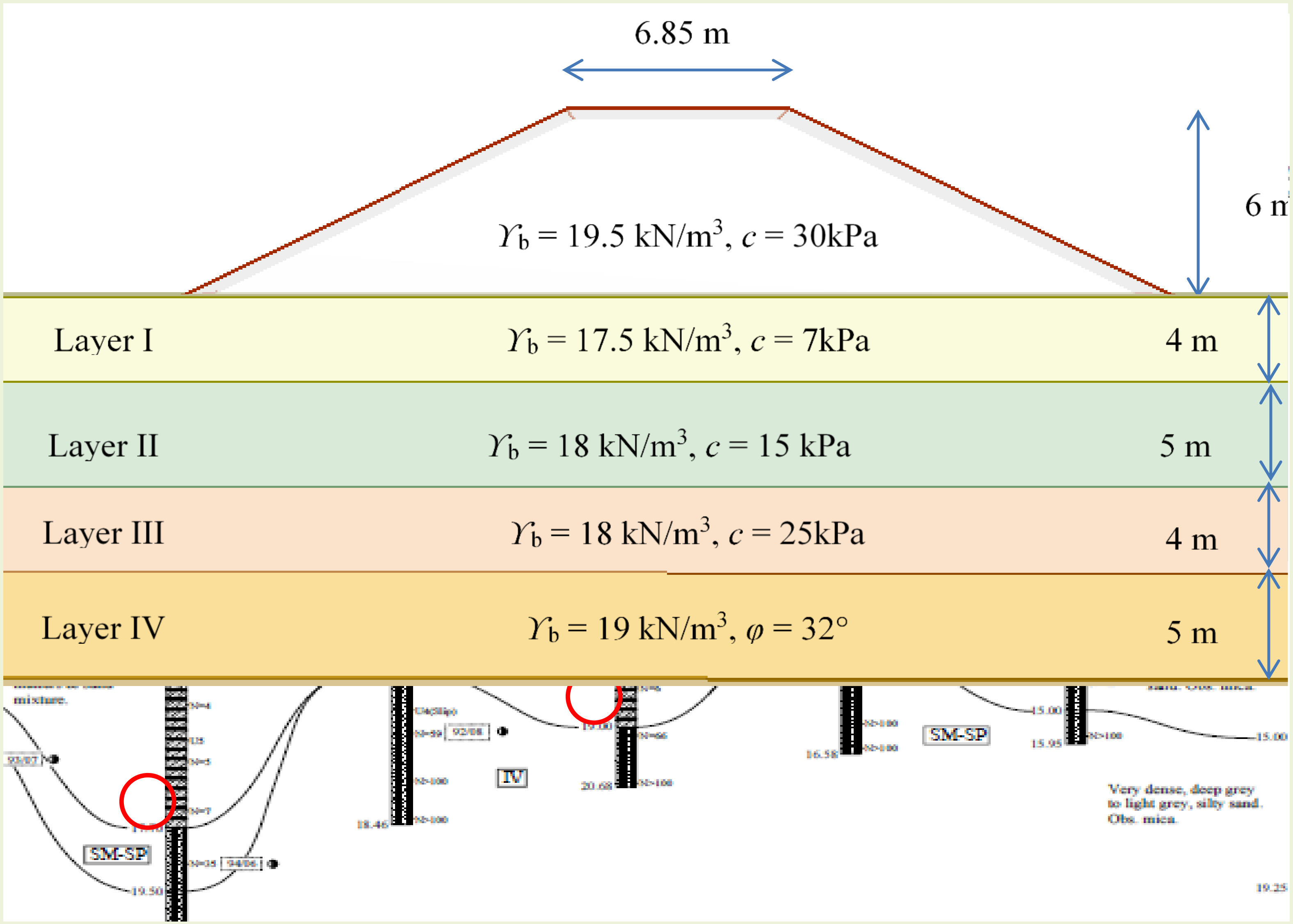
Could we have done little better ??

Actual Borehole Investigation Exercise





Cross-sectional Subsoil Profile at 42/200 Chainage



Cross-sectional Subsoil Profile at 42/600 Chainage

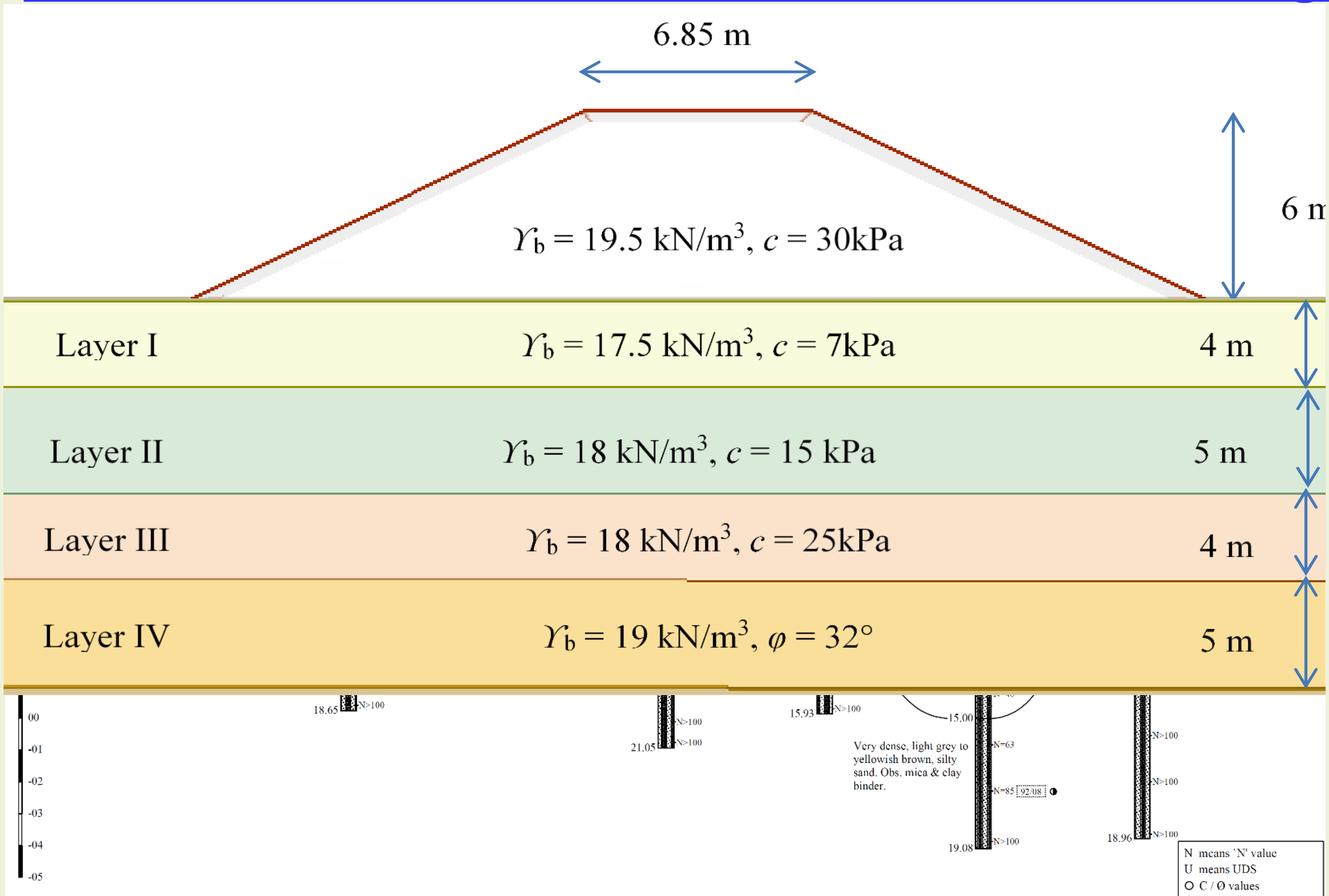
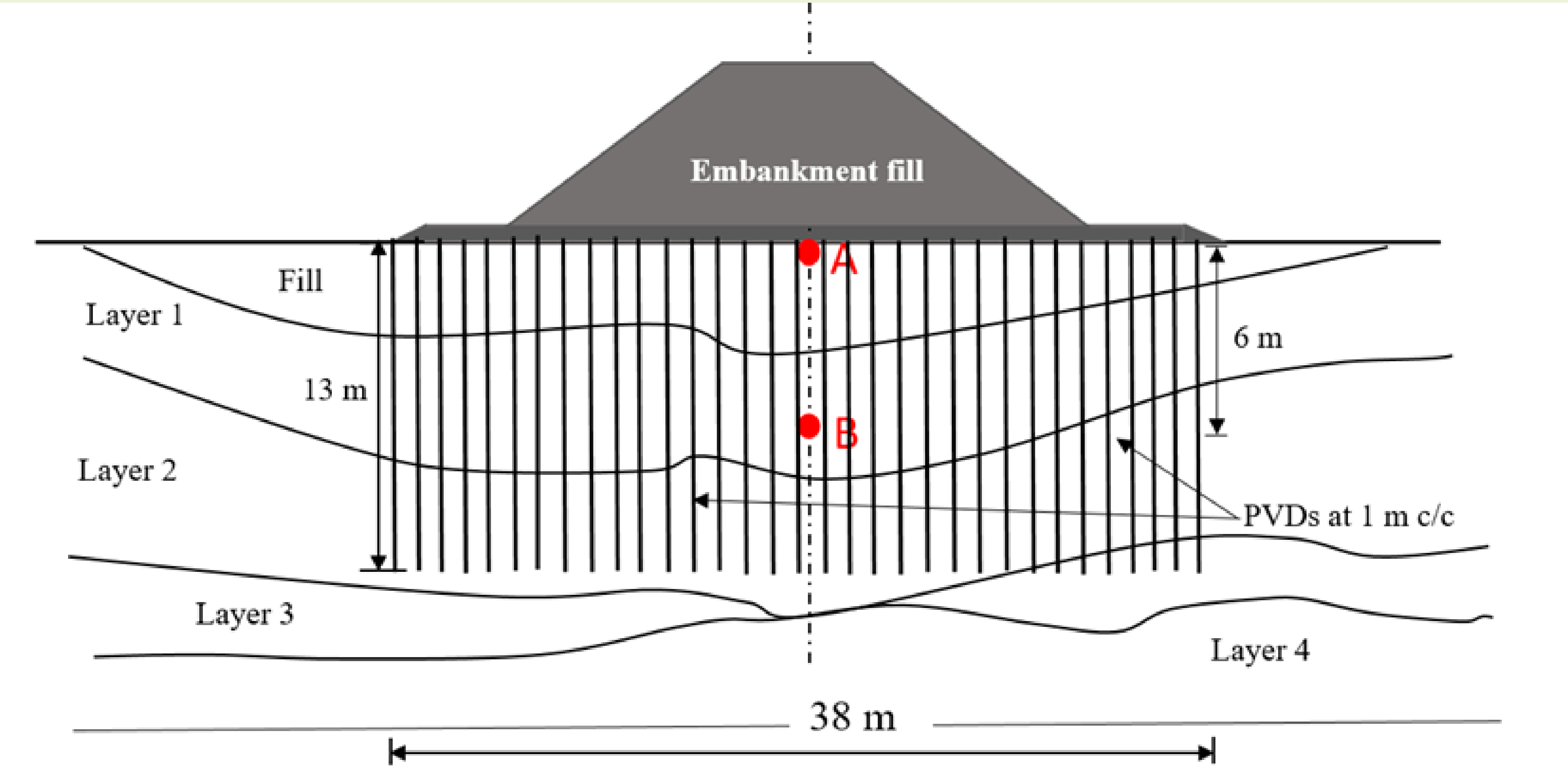
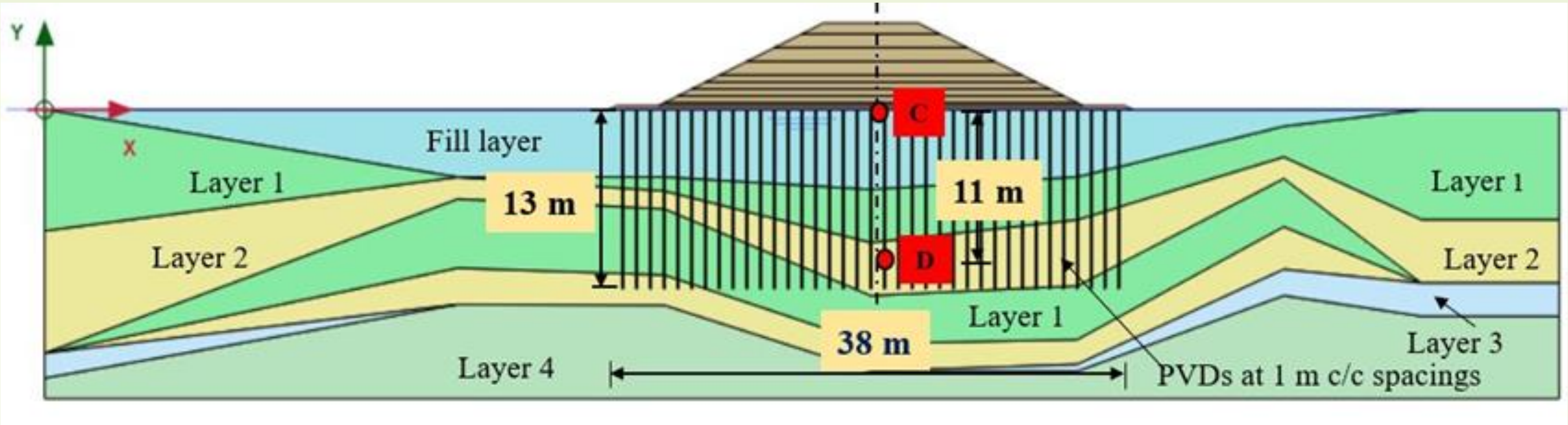


FIG. 2.05 : GENERALISED SOIL PROFILE

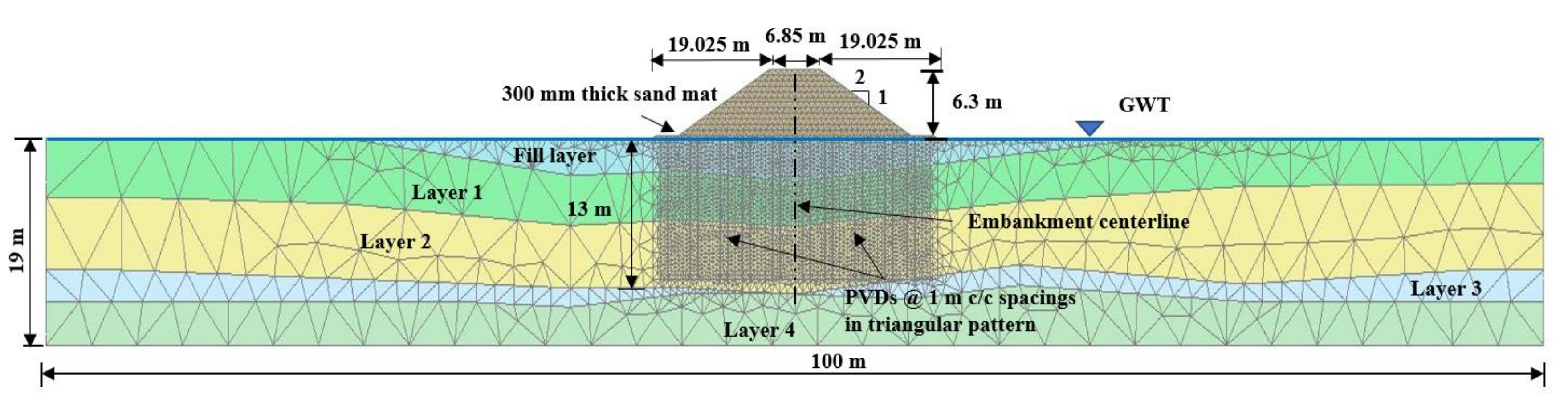
Why Not We Do a More Realistic Numerical Model ??



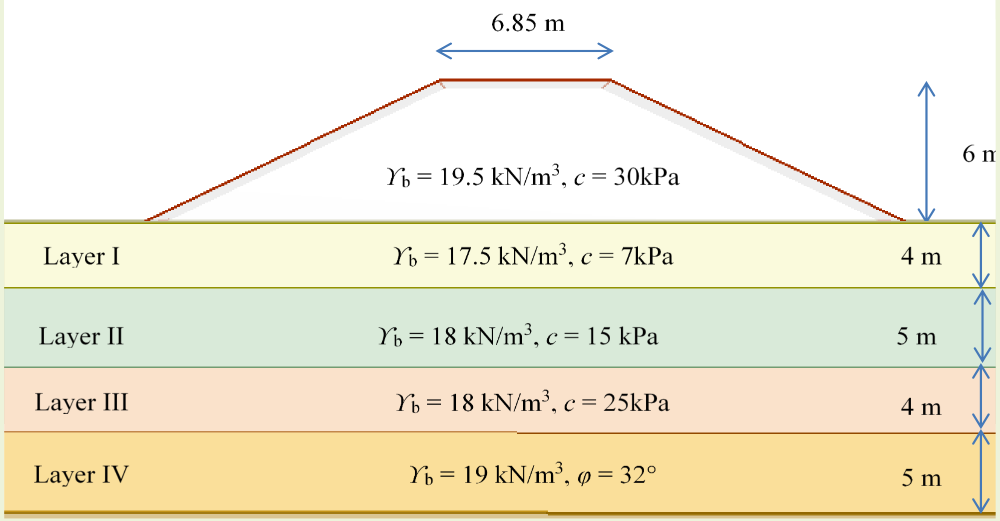
Why Not We Do a More Realistic Numerical Model ??



Typical modeling of cross-sections at various chainages



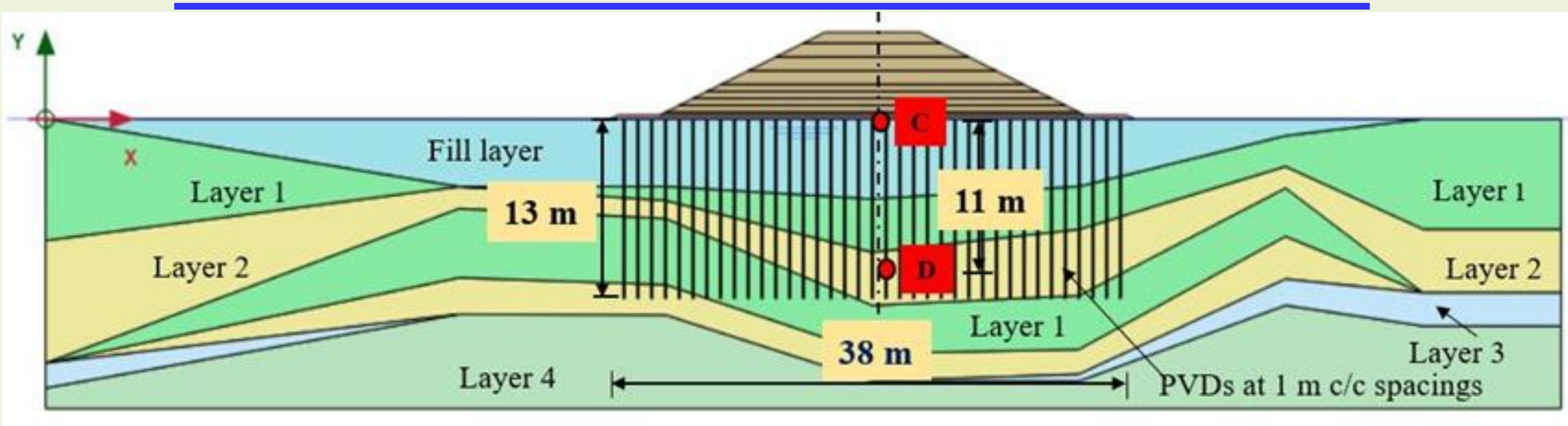
Constitutive Models and Parameters ??



Parameters	Embankment	Fill layer	Layer I	Layer II	Layer III	Layer IV
Material model	MC	MC	SS	SS	MC	MC
Drainage Type	Drained	Undrained	Undrained	Undrained	Undrained	Undrained
E' (kPa)	30×10^3	3450	-	-	0.265×10^5	43×10^3
ν'	0.3	0.3	-	-	0.3	0.3
c' (kPa)	30	52.95	21.57	27.45	25	10
φ' (°)	35	10	10	3	30	35
λ^*	-	-	0.072	0.06	-	-
κ^*	-	-	0.013	0.010	-	-
e_0	0.5	1.6	2.72	1.13	1.7	1.0
k_h (m/day)	0.01673	4.752×10^{-3}	4.324×10^{-4}	4.324×10^{-4}	0.1296	0.864
k_v (m/day)	0.01673	3.168×10^{-3}	2.883×10^{-4}	2.883×10^{-4}	0.0864	0.864
c_k	10^{15}	10^{15}	1.36	0.57	10^{15}	10^{15}

MC represents Mohr-Coulomb model; SS represents Soft Soil model; E' is the Young's modulus; ν' is the Poisson's ratio; Modified compression index, $\lambda^*=C_c/[2.303(1+e_0)]$; Modified swelling index, $\kappa^*=2C_r/[2.303(1+e_0)]$; e_0 = initial void ratio; k_h is the horizontal permeability; k_v is the vertical permeability; c_k is the change in permeability coefficient; C_c and C_r are the are coefficients of compression and recompression obtained from Oedometer tests.

Constitutive Models and Parameters ??



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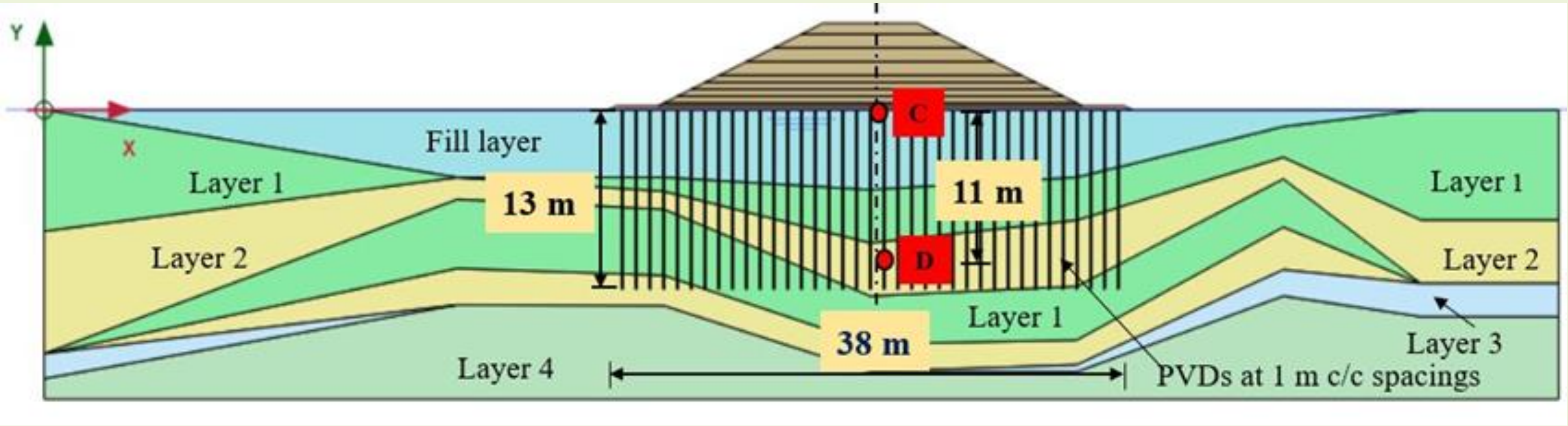
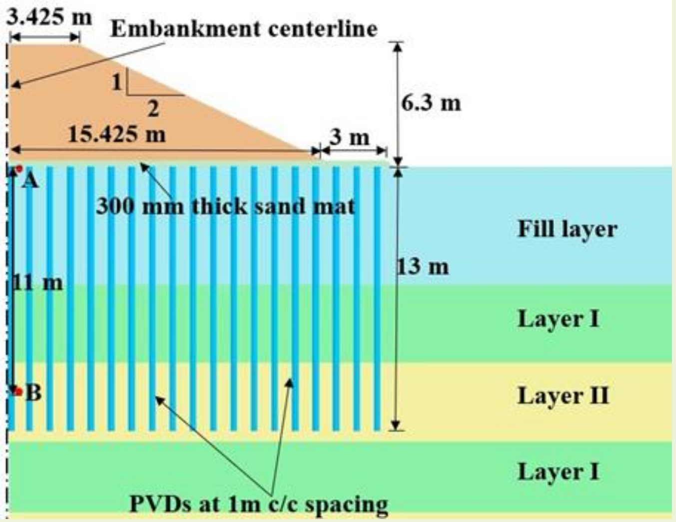
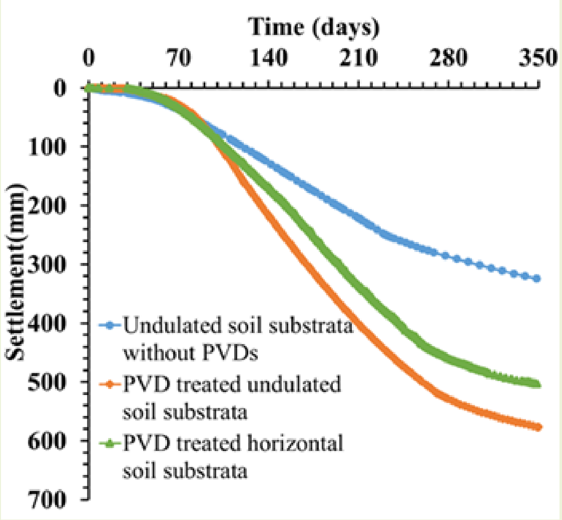
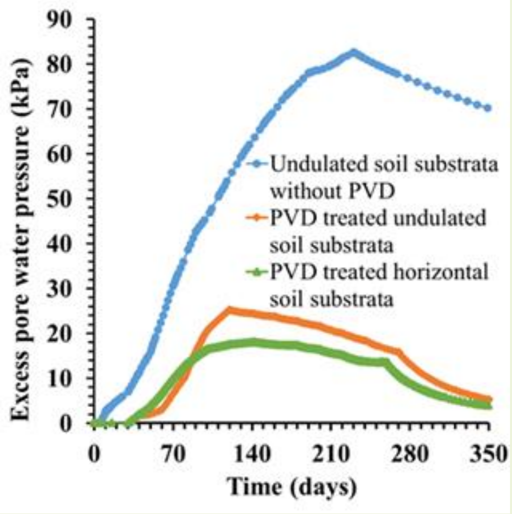
Influence of Realistic Undulating Strata

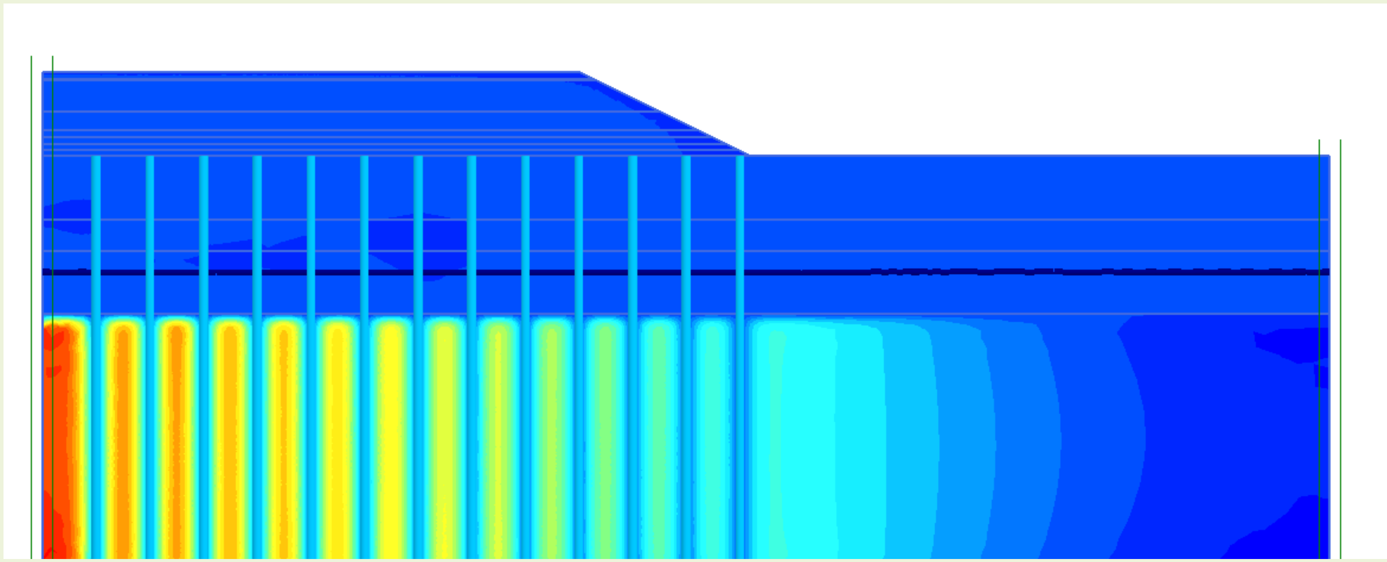


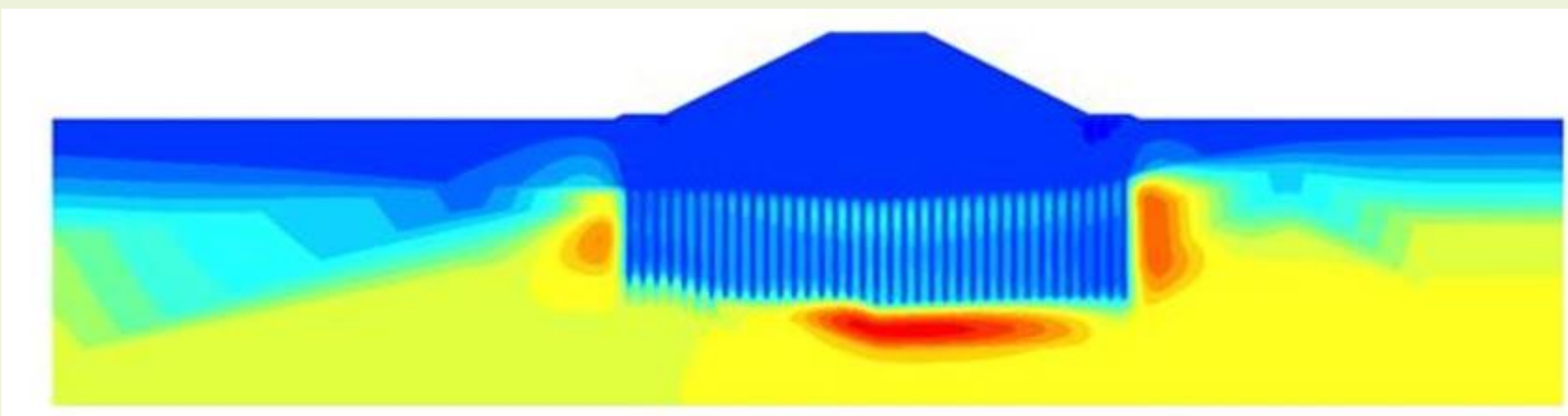




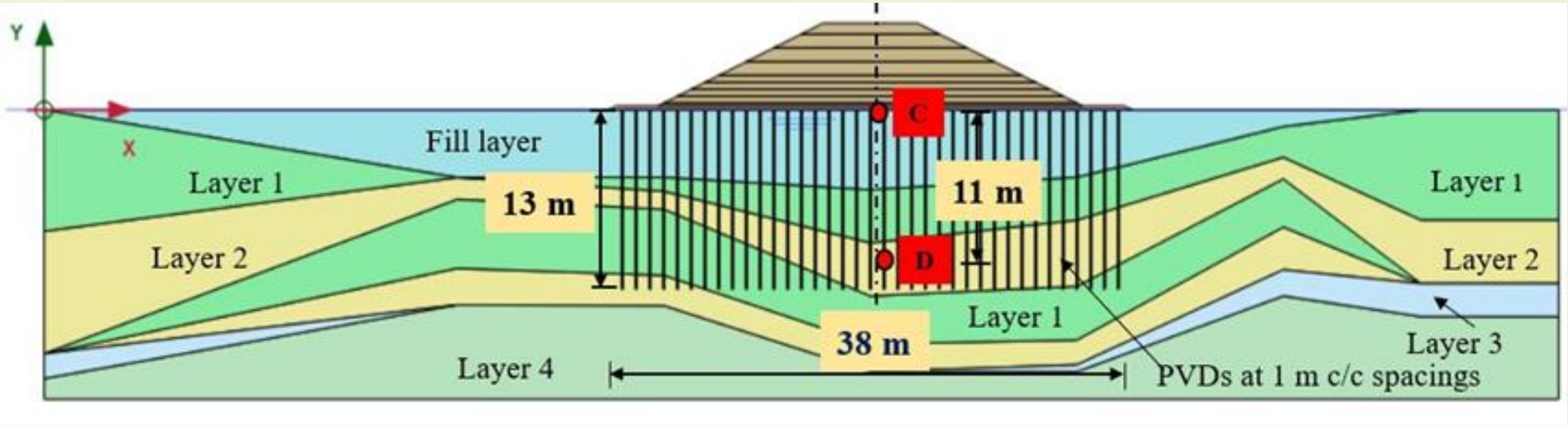


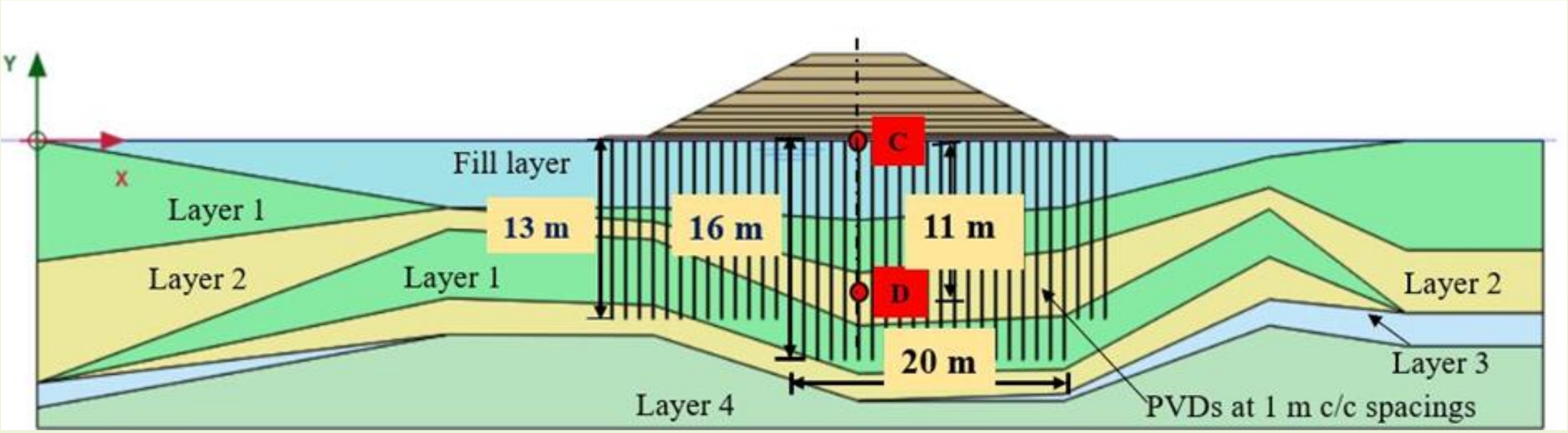
Influence of Realistic Undulating Strata on PWP



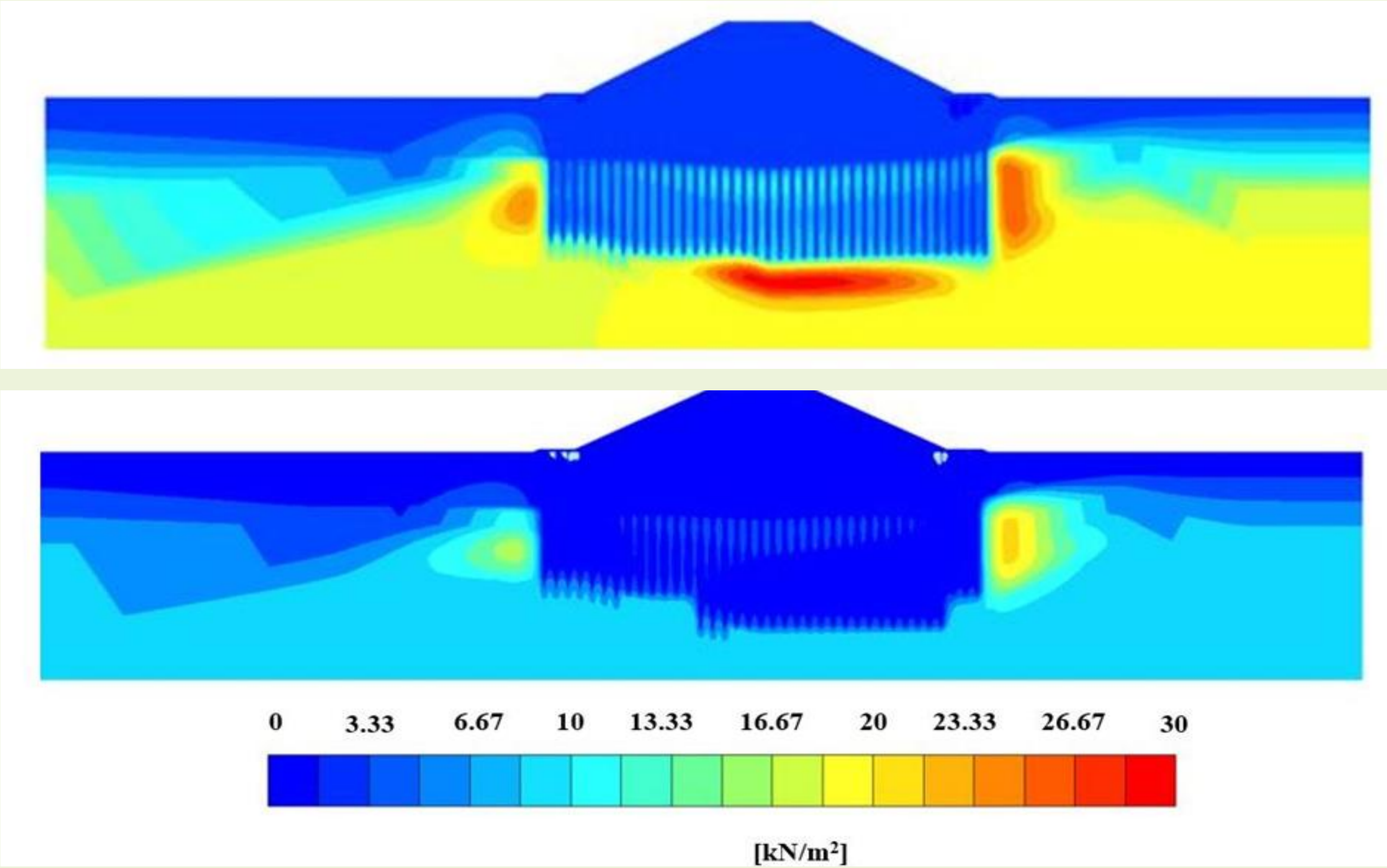


Influence of Realistic Undulating Strata

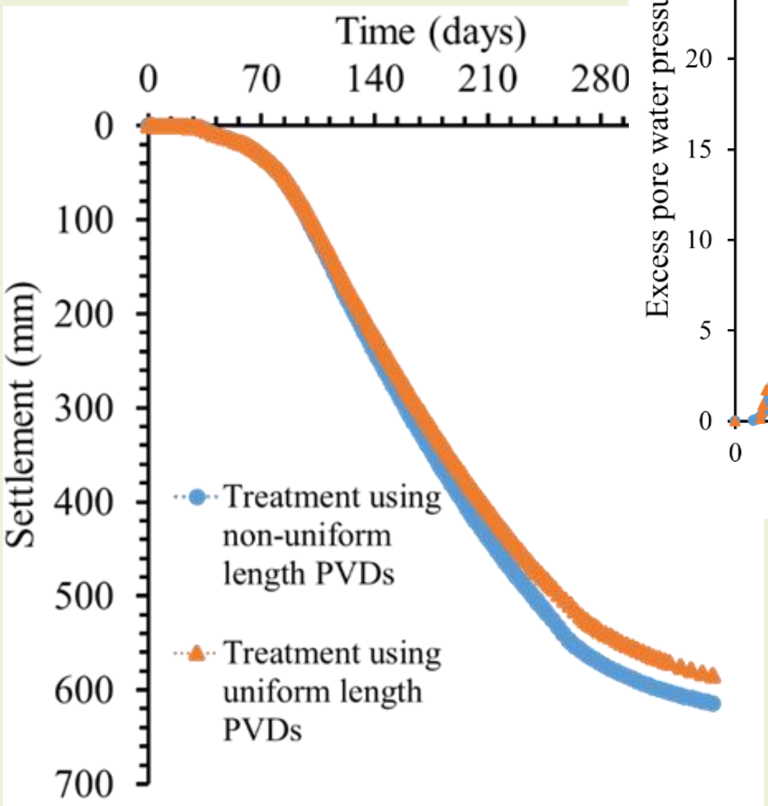


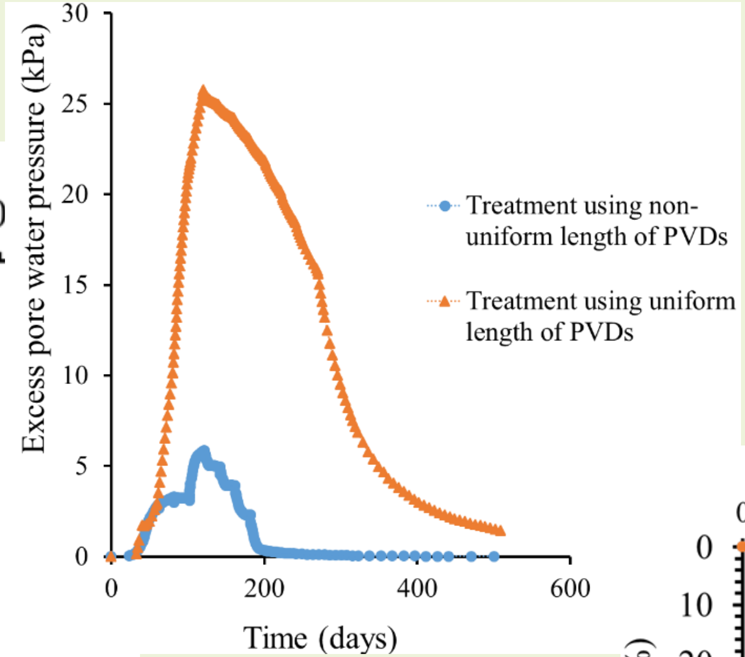


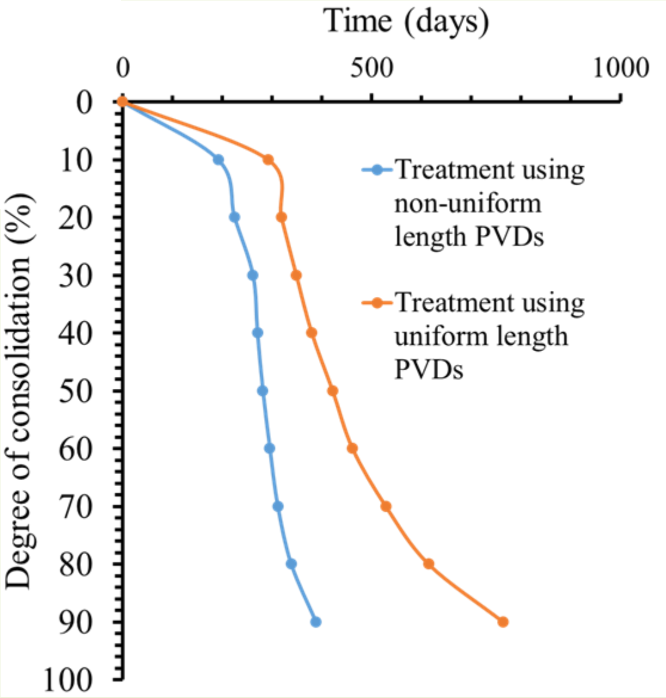
Influence of Realistic Undulating Strata on PWP



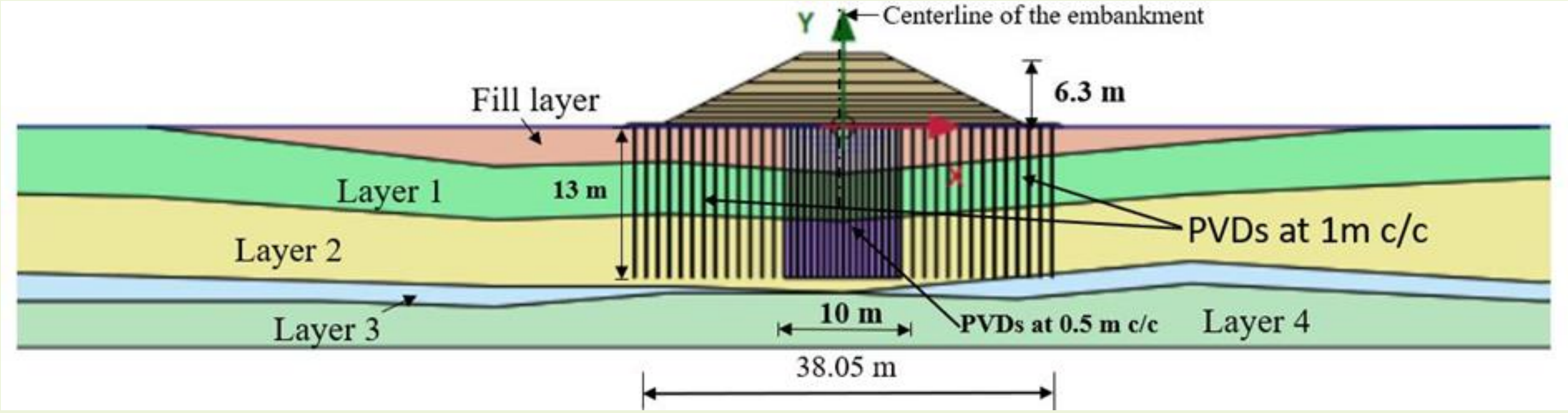
Influence of Non-Uniform Length of PVDs

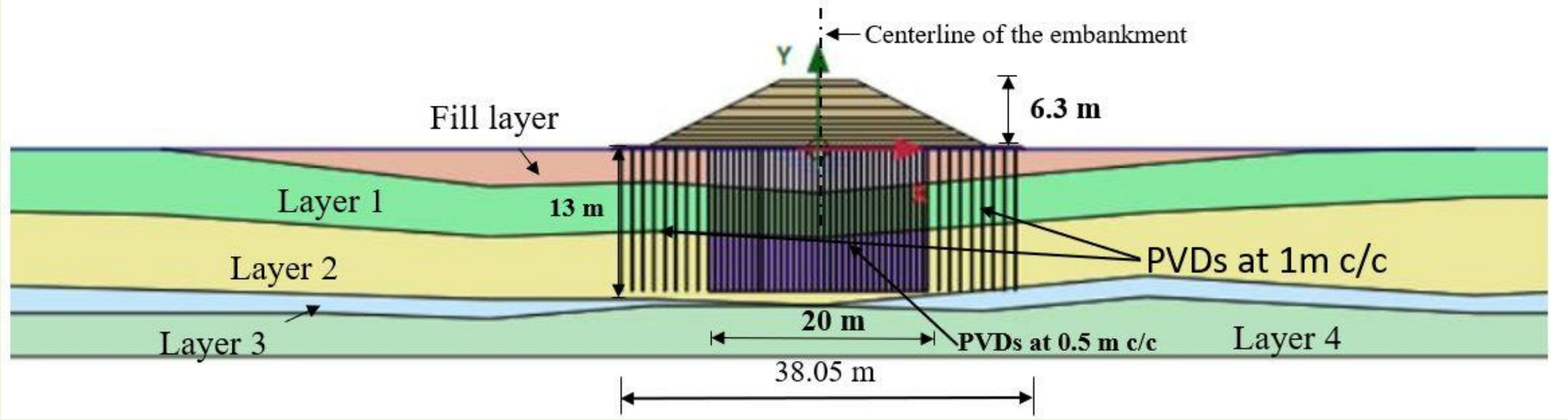




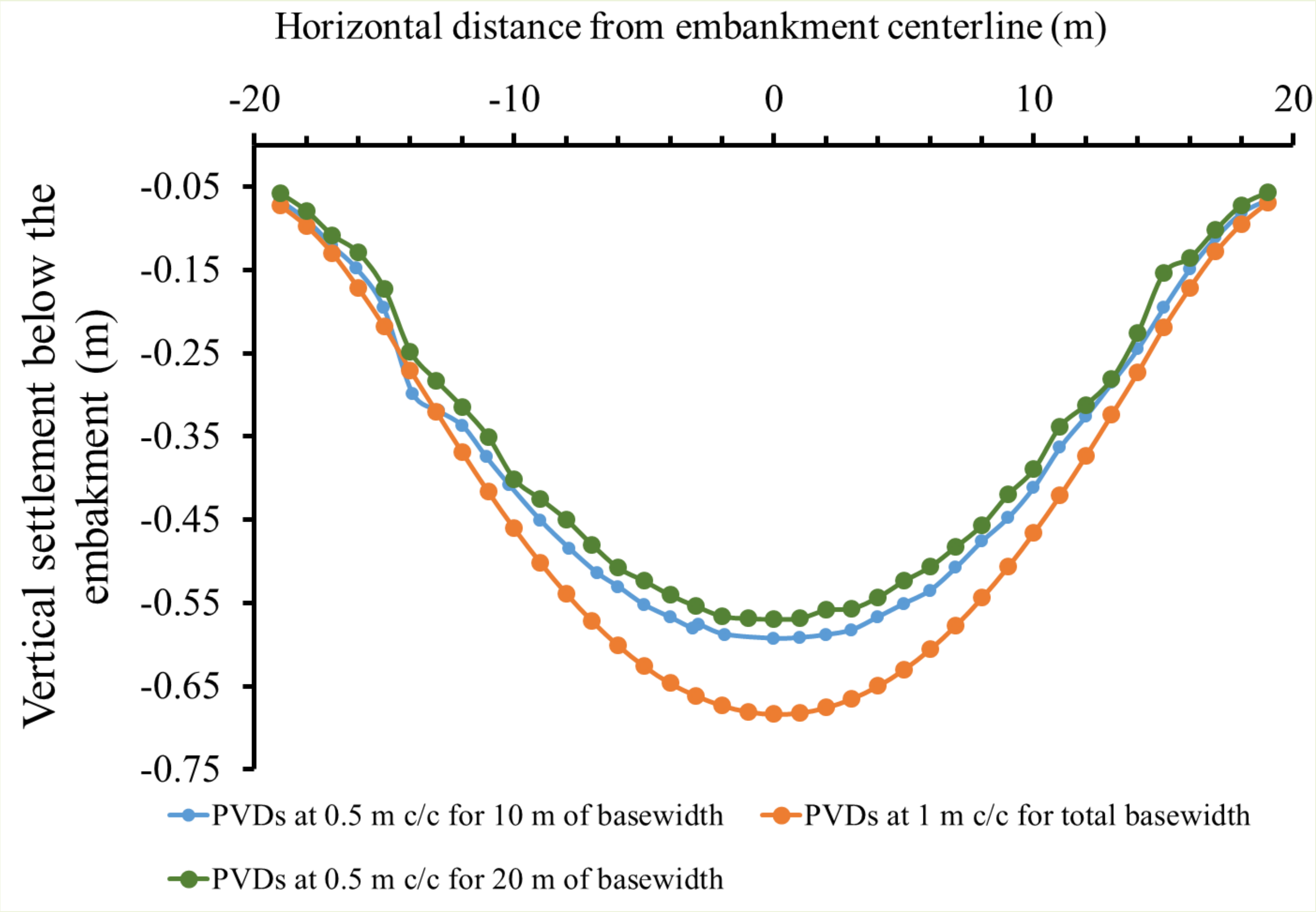


Influence of Non-Uniform Spacing of PVDs

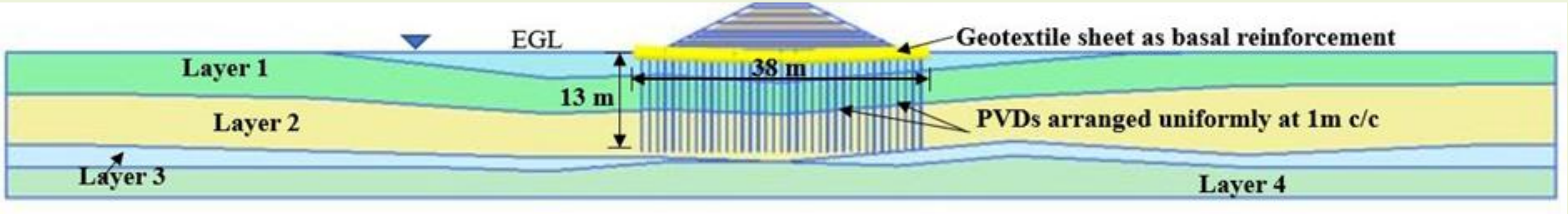


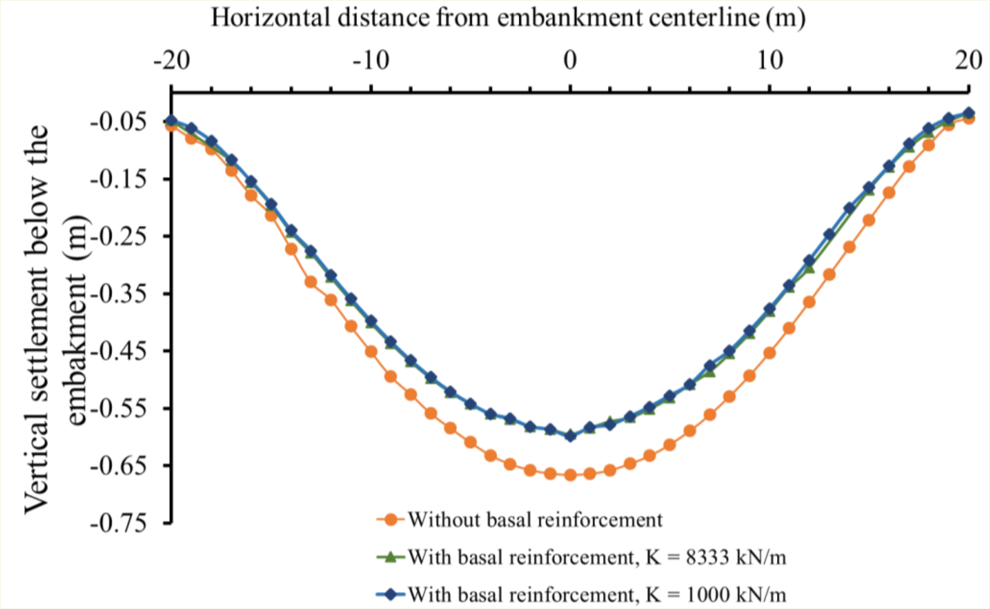


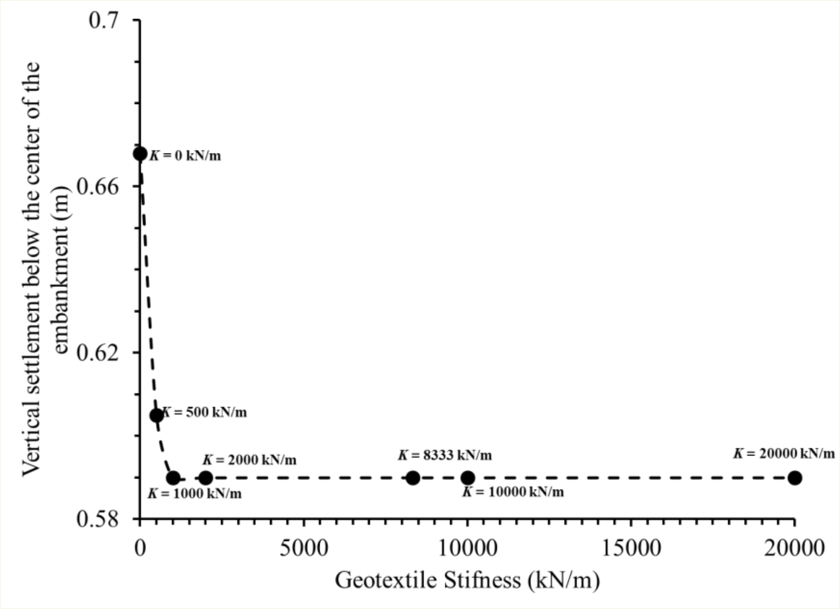
Influence of Non-Uniform Spacing of PVDs



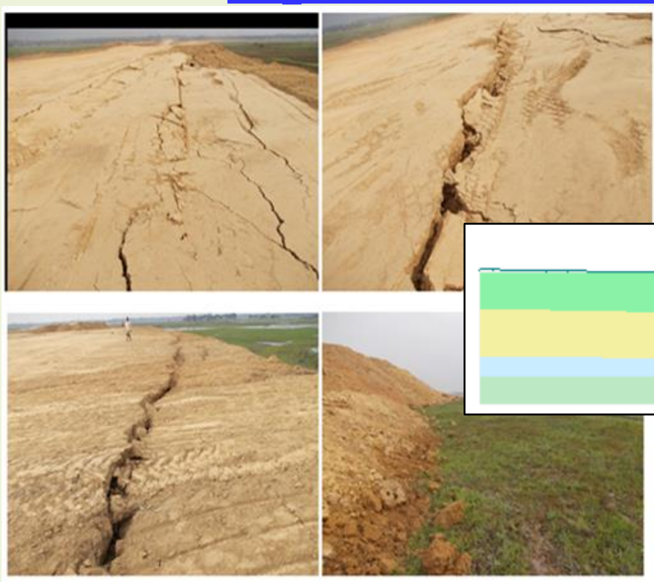
Influence of Tension Membrane

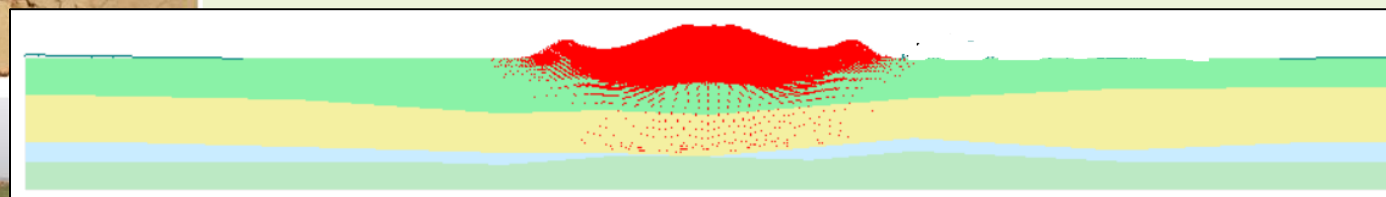


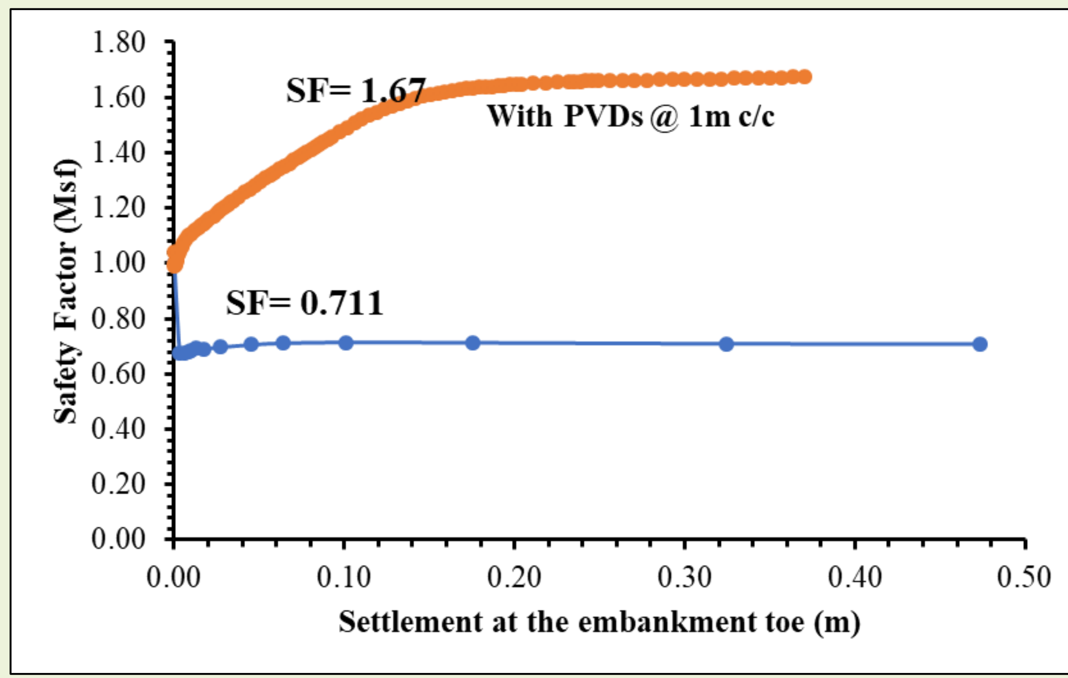




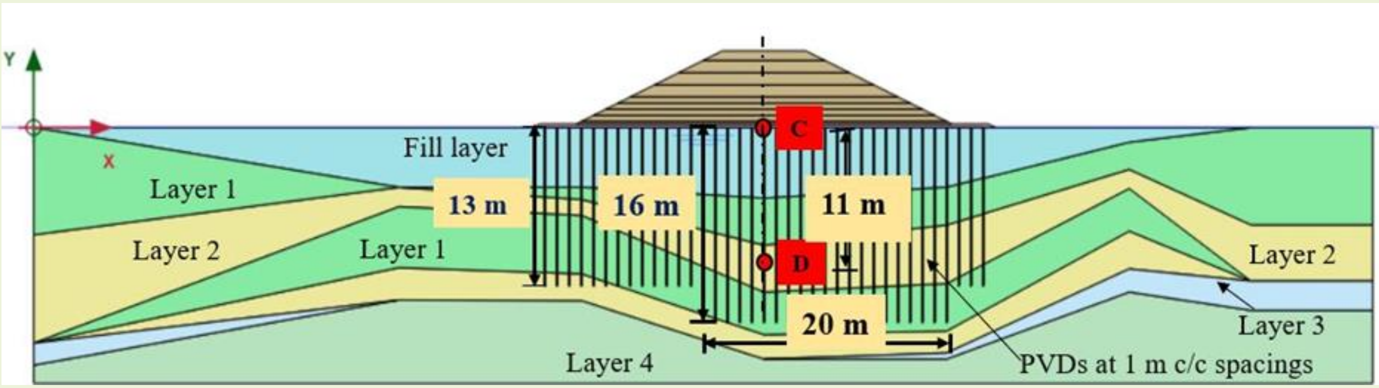
Upheaval and Embankment Slope Failure

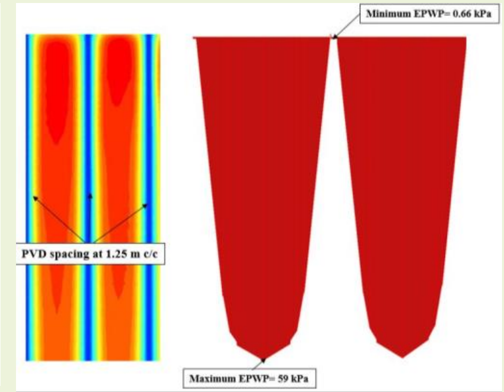


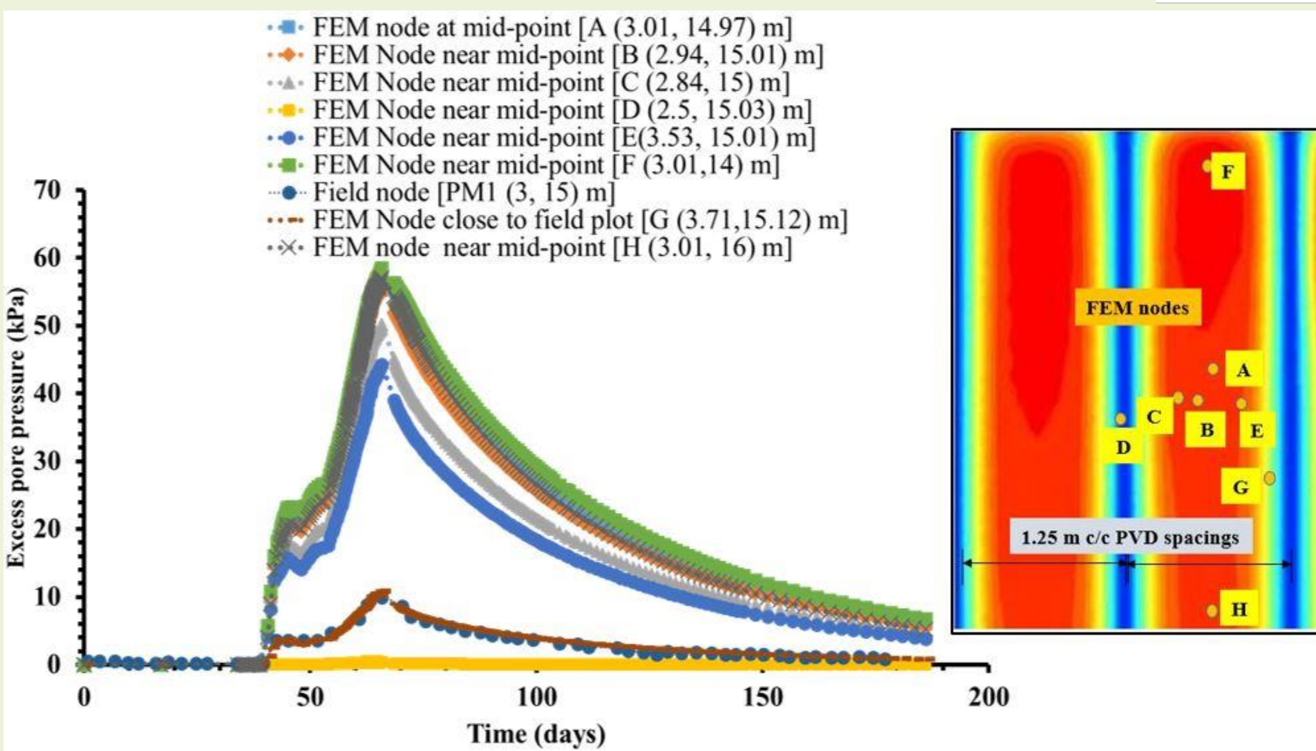




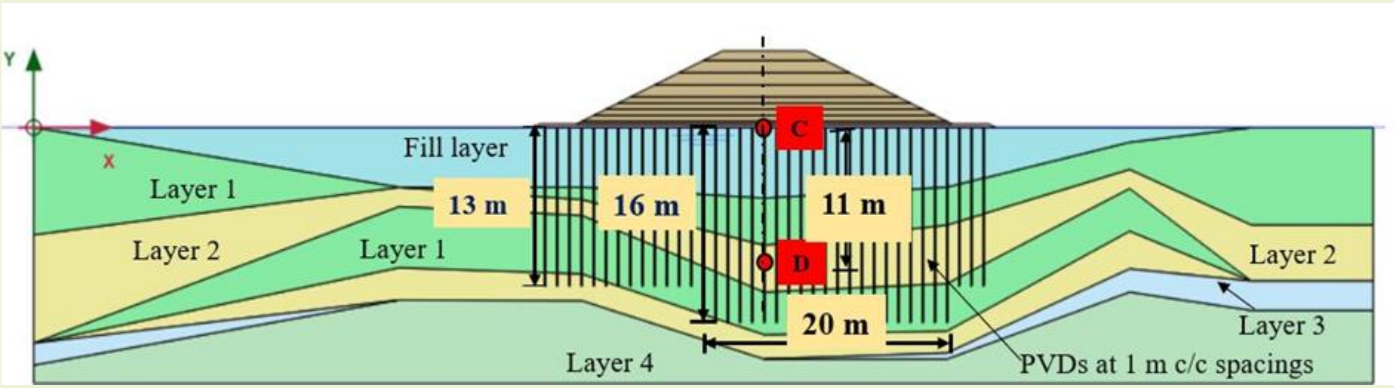
Reverse Assess the Disturbed Location of Sensor

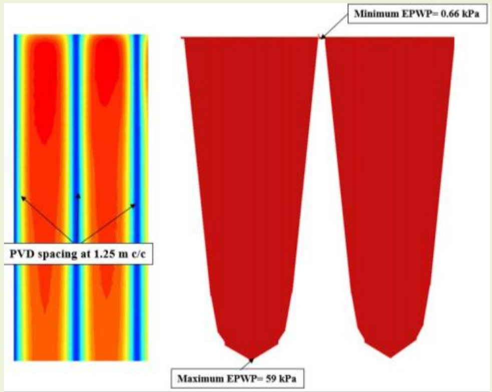


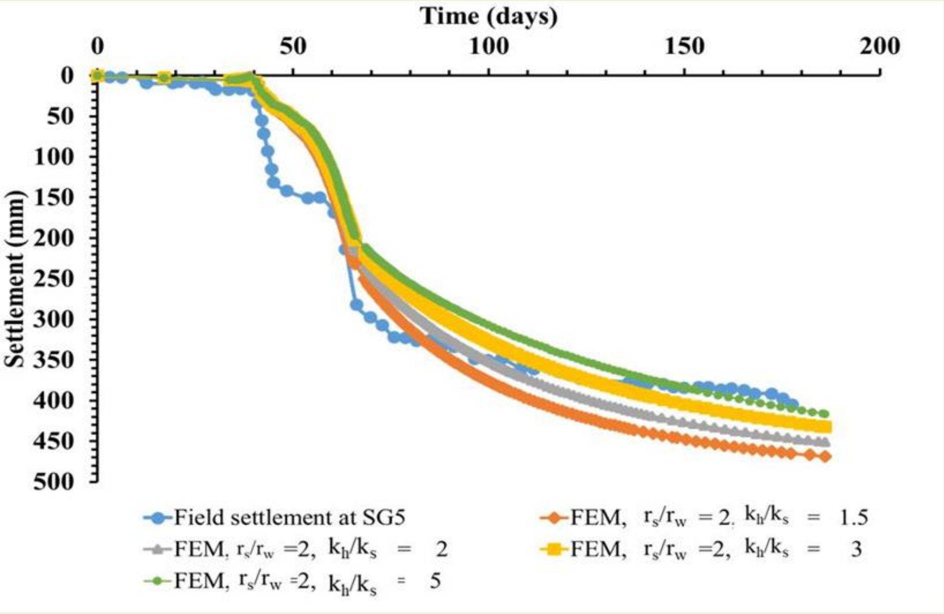


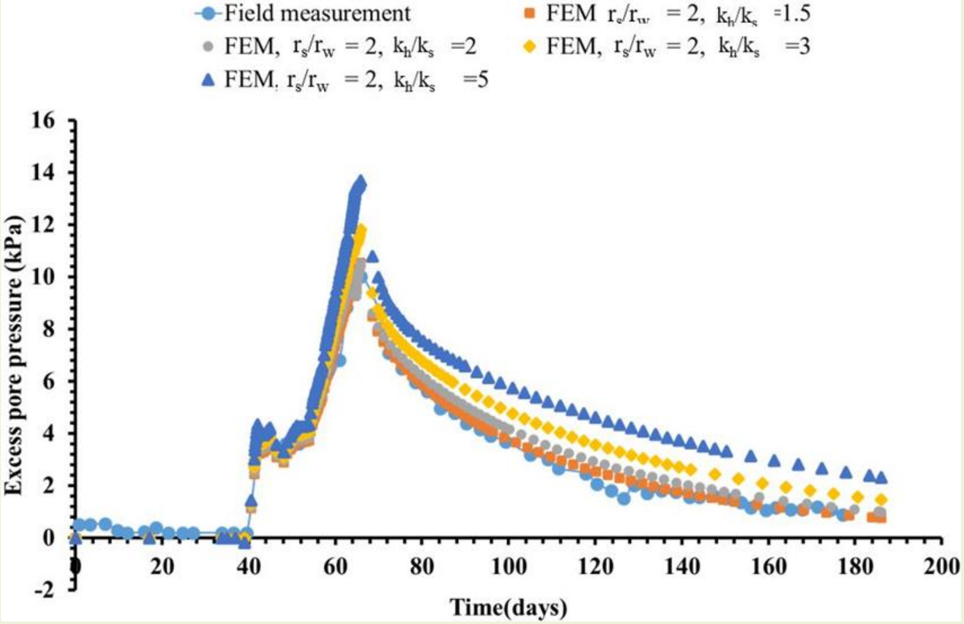


Reverse Assess the Smear Parameters (r_s and k_s)

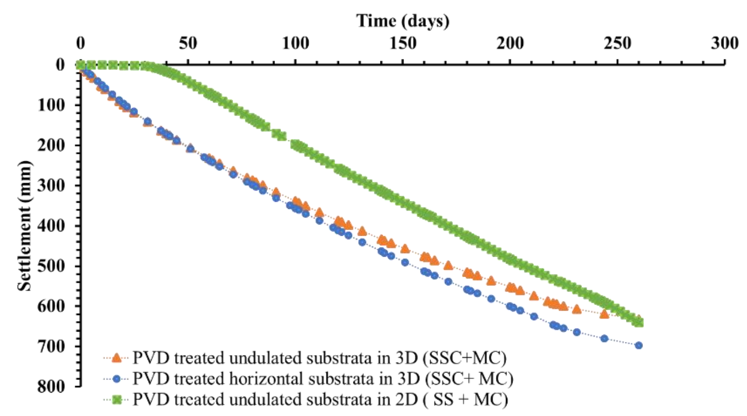


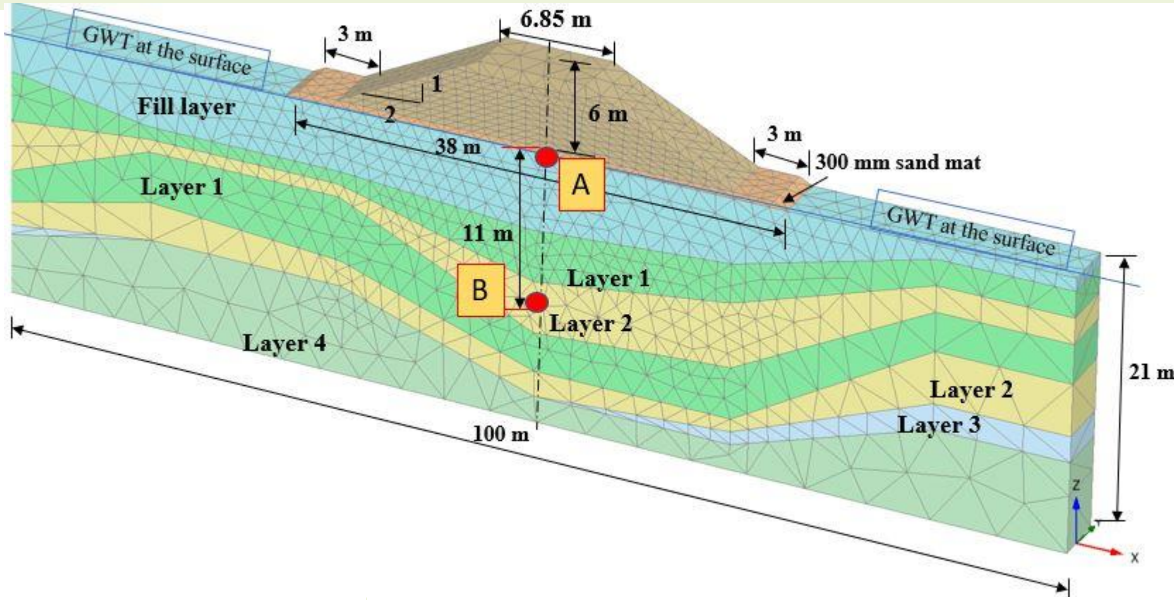


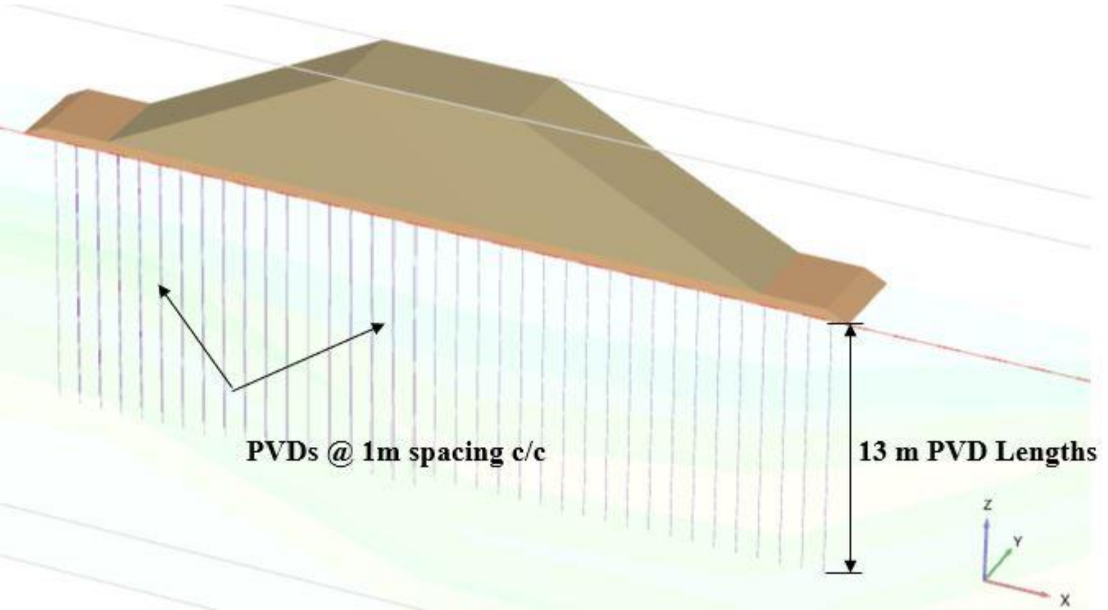


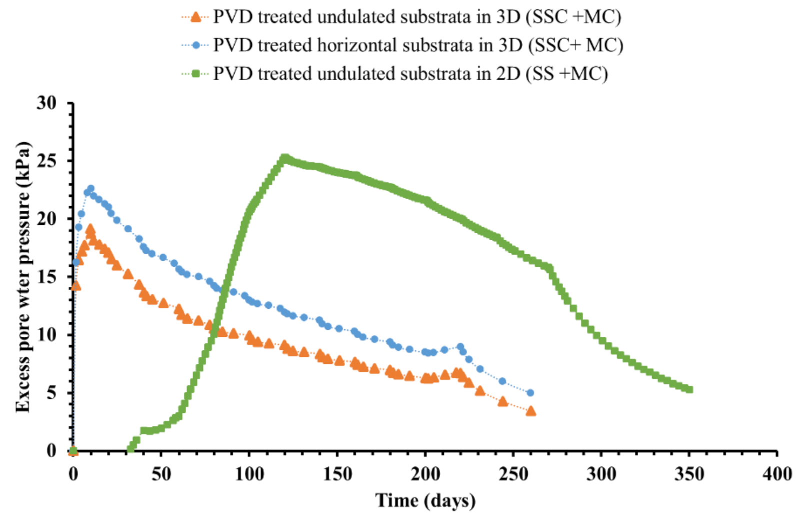


3D Modeling of the PVD-Treated Embankment









Advanced Knowledge is AVAILABLE

Are we ready to implement it?

Acknowledgments

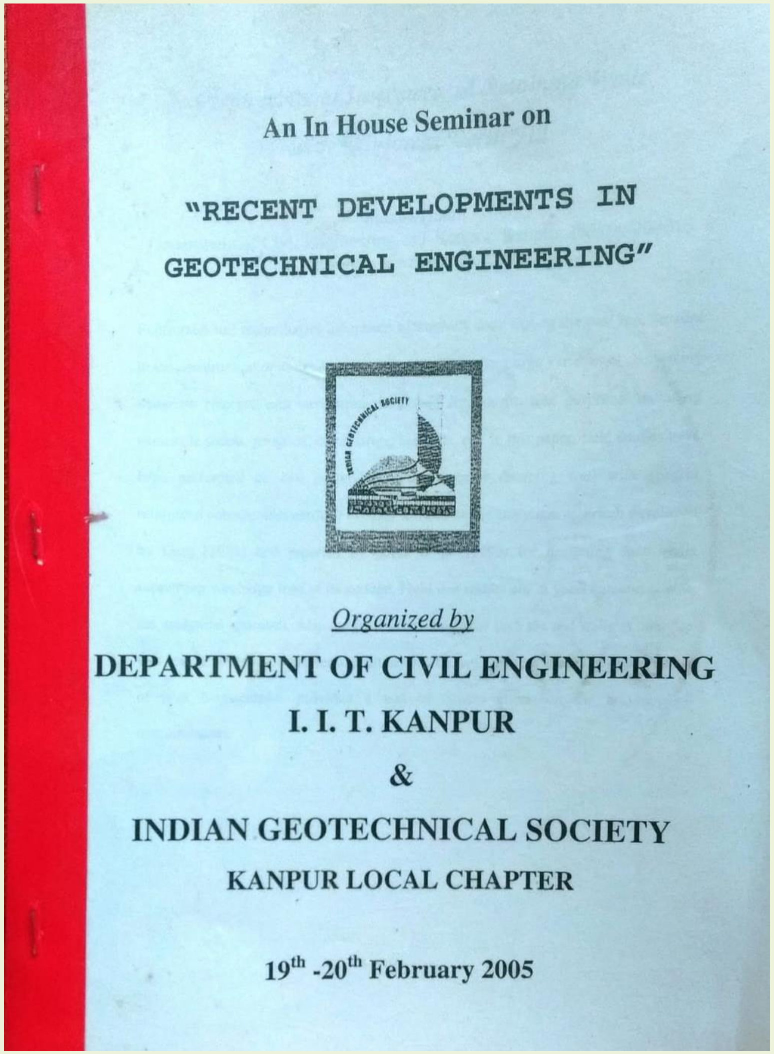
- **North-East Frontier Railway (NFR) Officials and Team**
- **CE Testing Kolkata**
- **Techfab India, Mumbai**
- **Dhirendra Group of Companies, R&M, Mumbai**
- **IGS Kanpur Local Chapter and IIT Kanpur**

Dr. Murali Krishna
IIT Tirupati

Dr. Kaustubh Dasgupta
IIT Guwahati

Samrat Ghose
IIT Guwahati

A Pleasant Nostalgia



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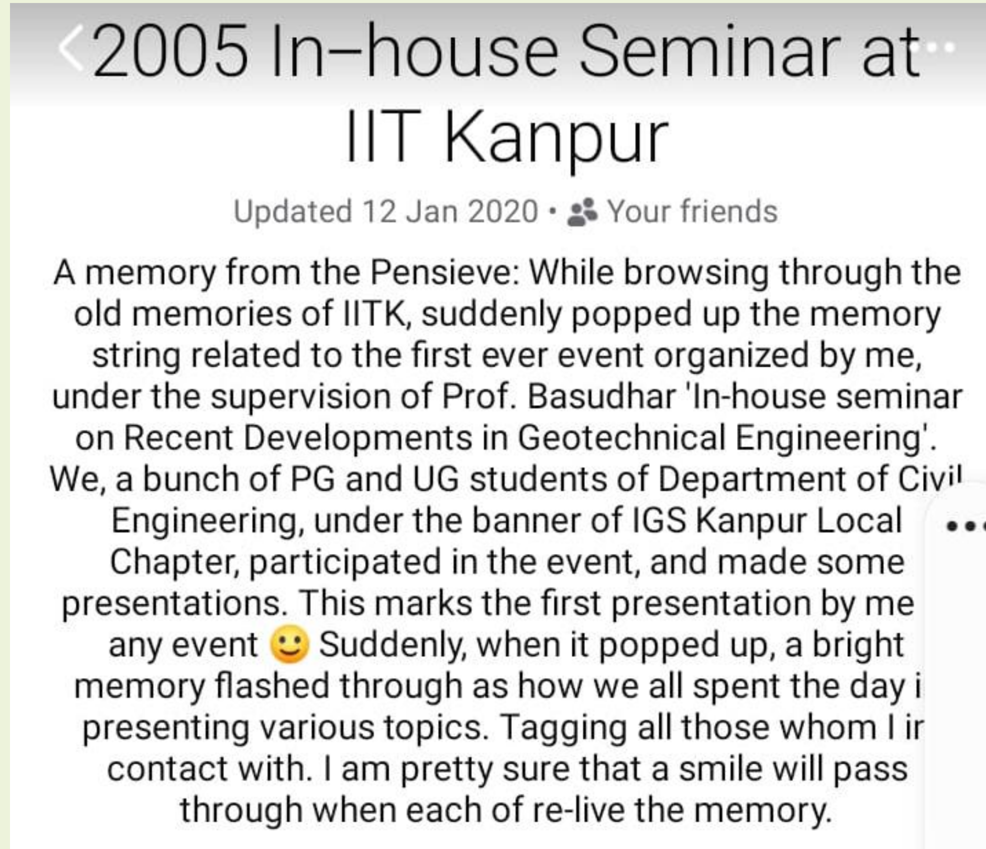
INDIAN GEOTECHNICAL SOCIETY

KANPUR LOCAL CHAPTER

19th -20th February 2005



2005 In-house Seminar at IIT Kanpur

Updated 12 Jan 2020 · Your friends

A memory from the Pensieve: While browsing through the old memories of IITK, suddenly popped up the memory string related to the first ever event organized by me, under the supervision of Prof. Basudhar 'In-house seminar on Recent Developments in Geotechnical Engineering'. We, a bunch of PG and UG students of Department of Civil Engineering, under the banner of IGS Kanpur Local Chapter, participated in the event, and made some presentations. This marks the first presentation by me any event 🙂 Suddenly, when it popped up, a bright memory flashed through as how we all spent the day i presenting various topics. Tagging all those whom I ir contact with. I am pretty sure that a smile will pass through when each of re-live the memory.

2004-2008

Chairman: Prof. P. K. Basudhar

Secretary: Arindam Dey

Thank You for Patient Hearing

http://www.iitg.ac.in/arindam.dey/homepage/index.html#

https://www.researchgate.net/profile/Arindam_Dey11