GROUND IMPROVEMENT WORKSHOP 11-12 JUNE 2010

PERTH, AUSTRALIA

# CONCEPT AND PARAMETERS IN COHESIVE SOILS WITHOUT ADDED MATERIAL


PRESENTED BY

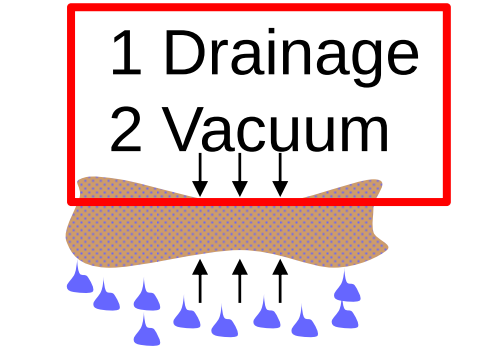
SERGE VARAKSIN

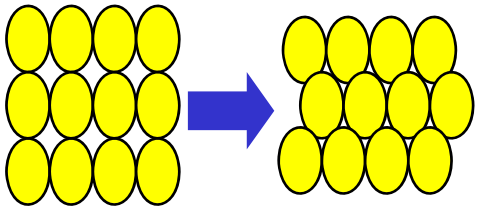
CHAIRMAN OF T.C. GROUND IMPROVEMENT

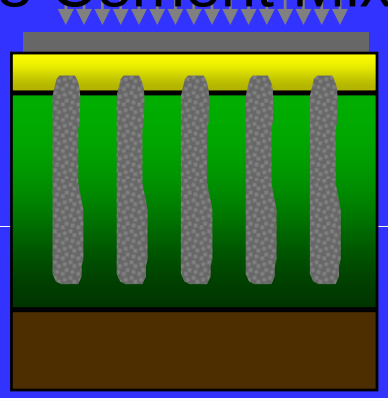

menard

# Soil Improvement Techniques

| | Without added materials | With added materials |
|---|---|---|
| **Cohesive soil**<br>**Peat , clay …** | 1 Drainage<br>2 Vacuum | 4 Dynamic replacement<br>5 Stone columns<br>6 CMC<br>7 Jet Grouting<br>8 Cement Mixing |
| **Granular soil**<br>**Sand , fill** | 3 Dynamic consolidation<br>4 Vibroflottation | |



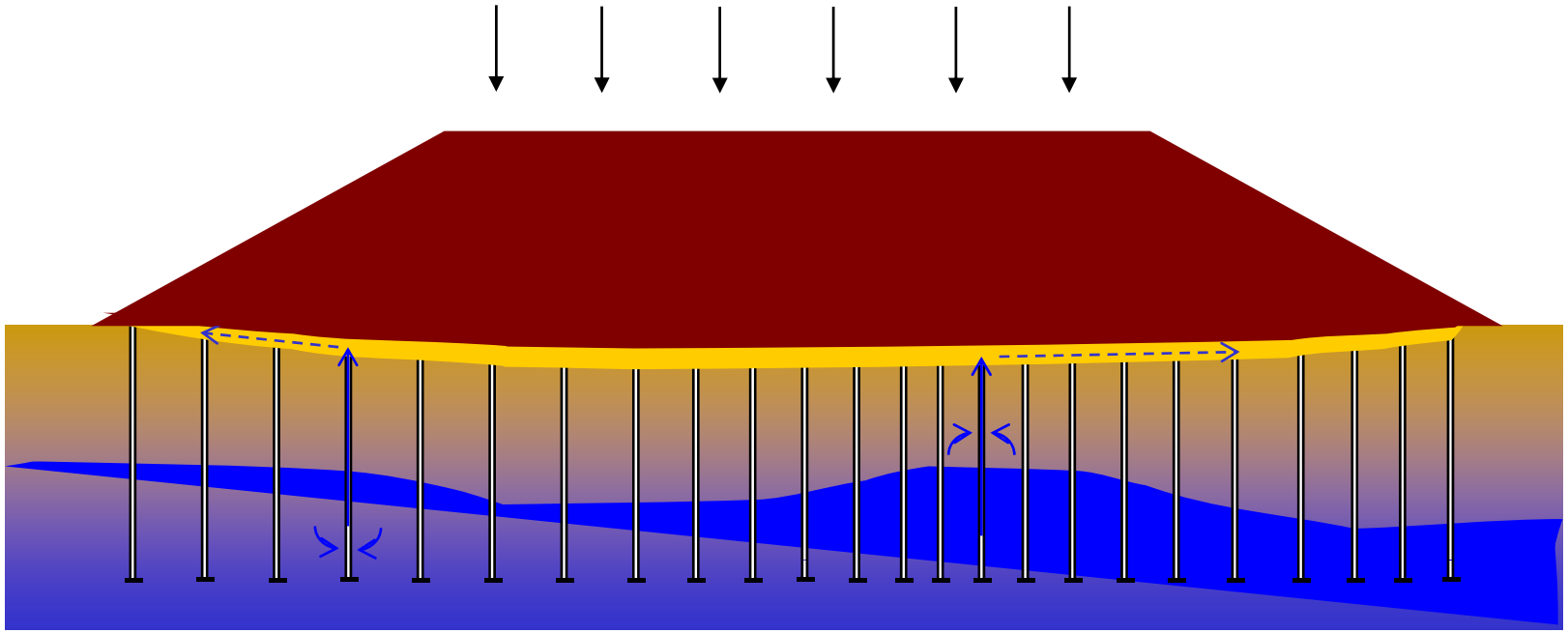




# Preloading with vertical drains

High fines contents soils

$\sigma=\sigma'+u$



# Vertical drains

## CONCEPT

-Stable subsoil for surcharge

-Soil can be penetrated

-Time available is short

-Some residual settlement is allowed

## PARAMETERS

1 – Depth

2 – Drainage path

3 – Cohesion

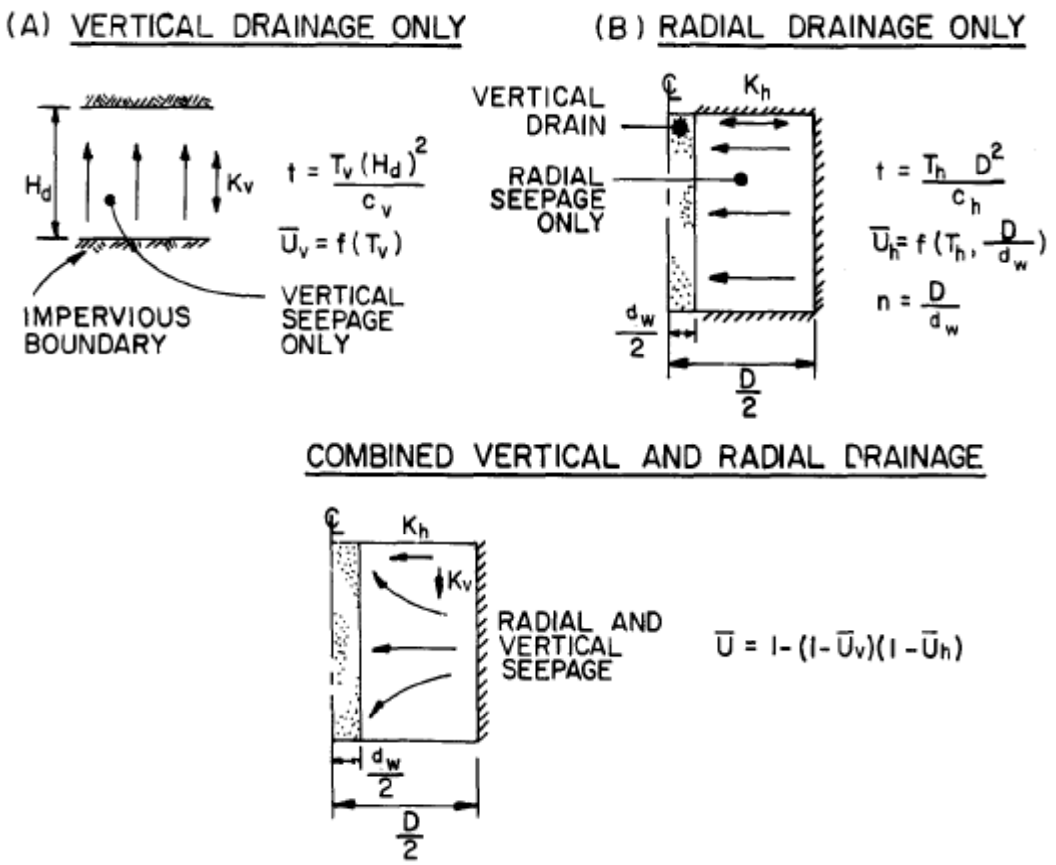
4 – Consolidation parameters

(oedometer, CPT)

$e_O$, $C_C$, $C_V$, $C_R$, $C_\alpha$, t

CPT pore dissipation test

# Radial & Vertical Consolidation



# Vertical drains: material

High fines contents soils

Flat drain

5 cm , PVC

circular drain

*vertical drain + geotextile*

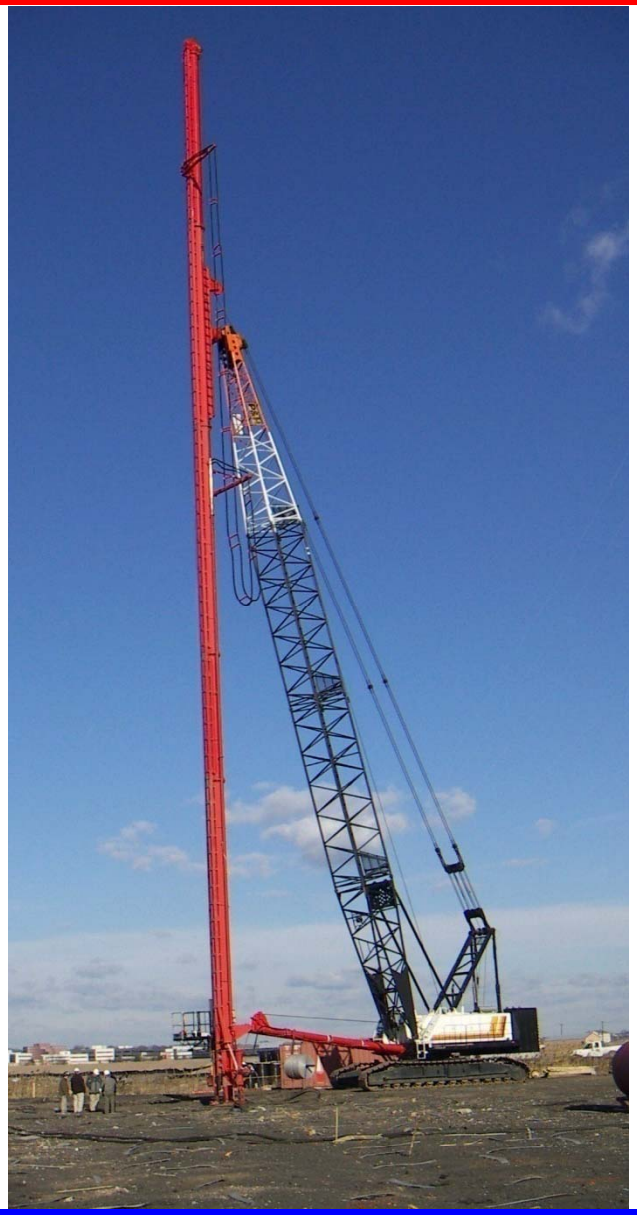
# Vertical drains: Static installation

High fines contents soils

Static installation of vertical drains

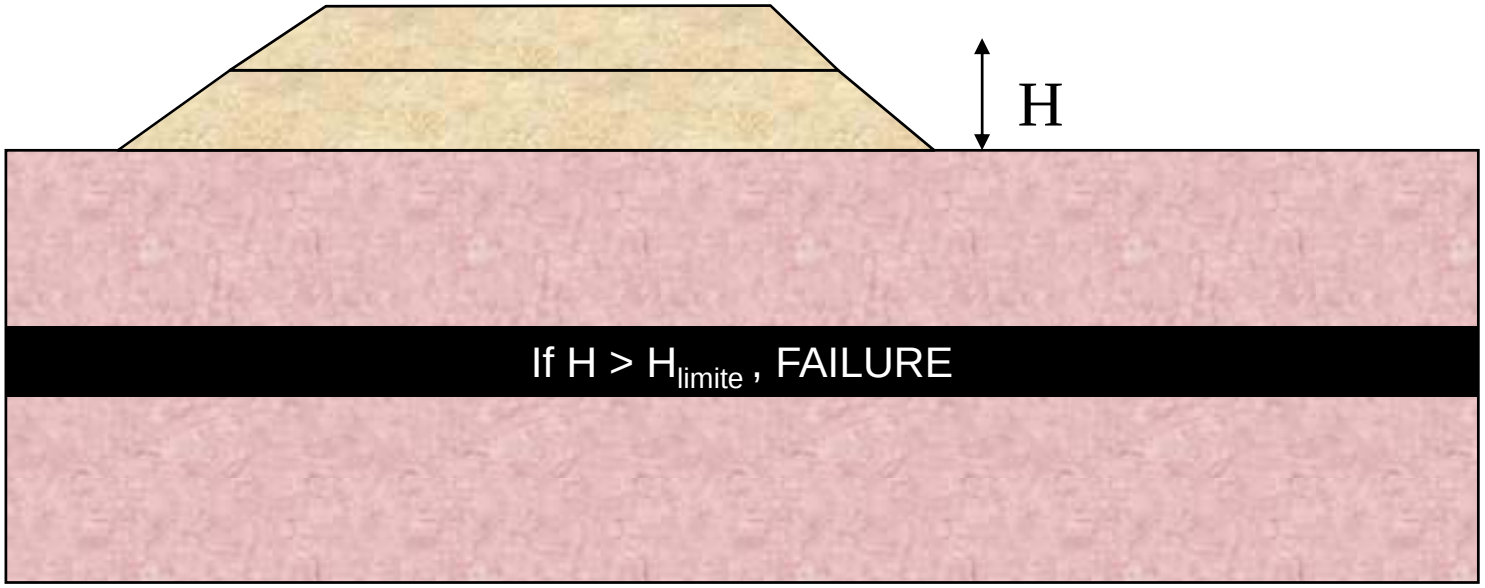
# Vertical drains: dynamic static installation

Mast= 56 m, depth= 43 m



Mast= 72 m, depth= 55 m

# Prealoading – limitations (high fines contents soils)




**Classical Method: Surcharge + Drain**
**Height of surcharge limited by Value of Cohesion of soft soil**

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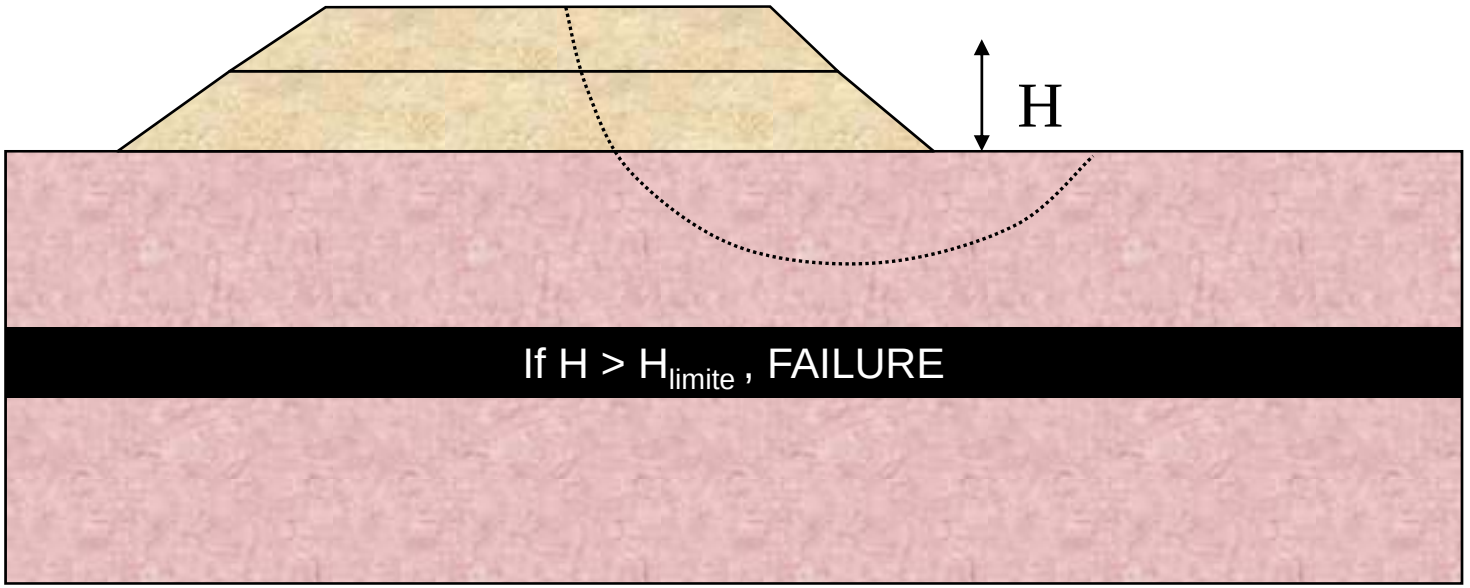


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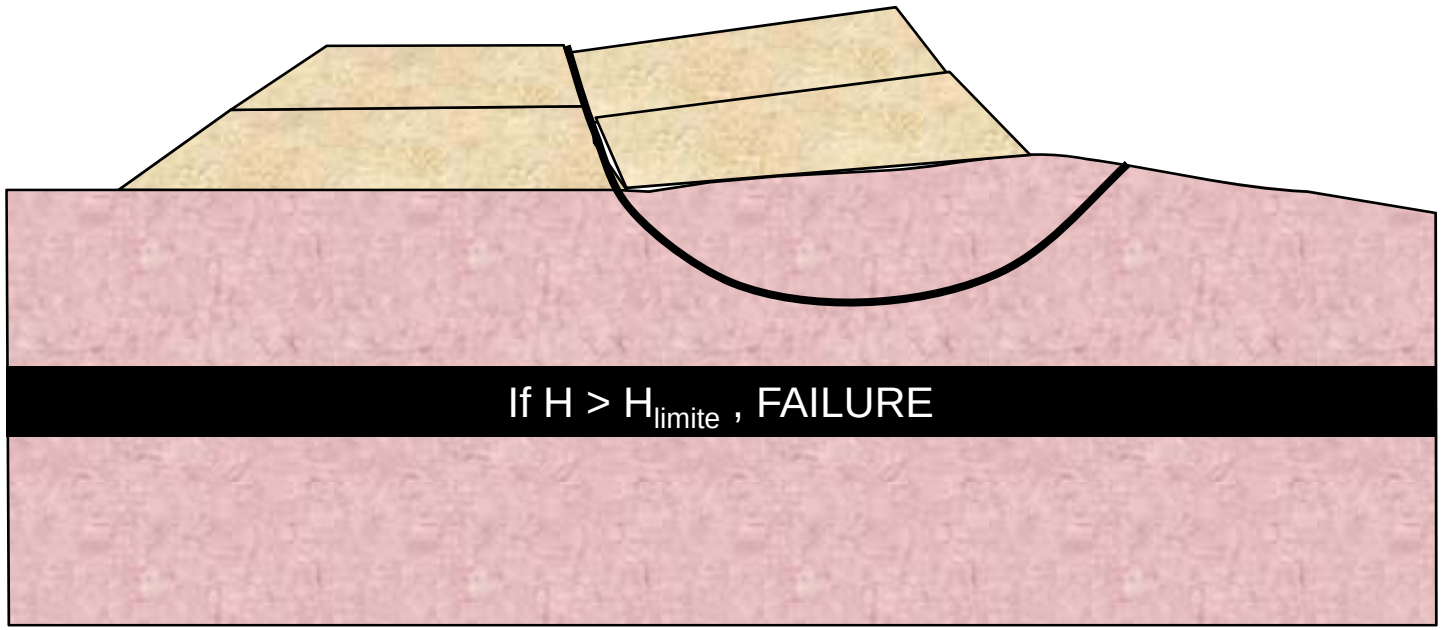


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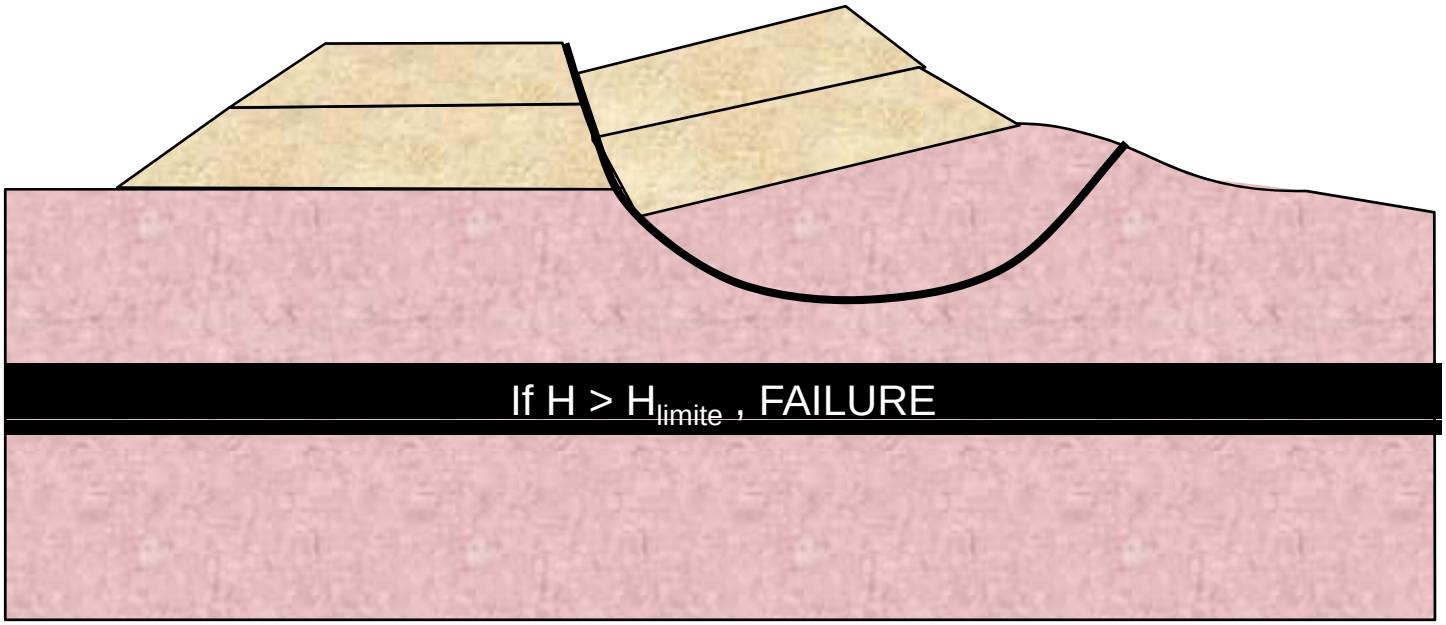


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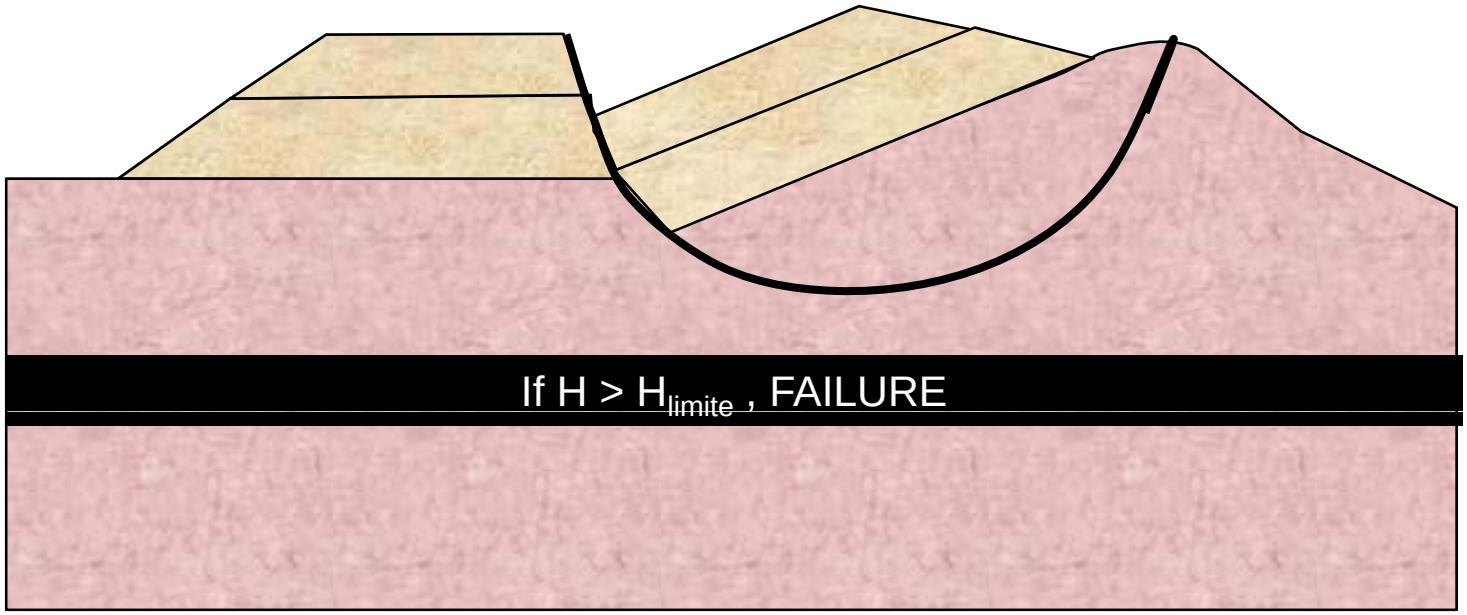


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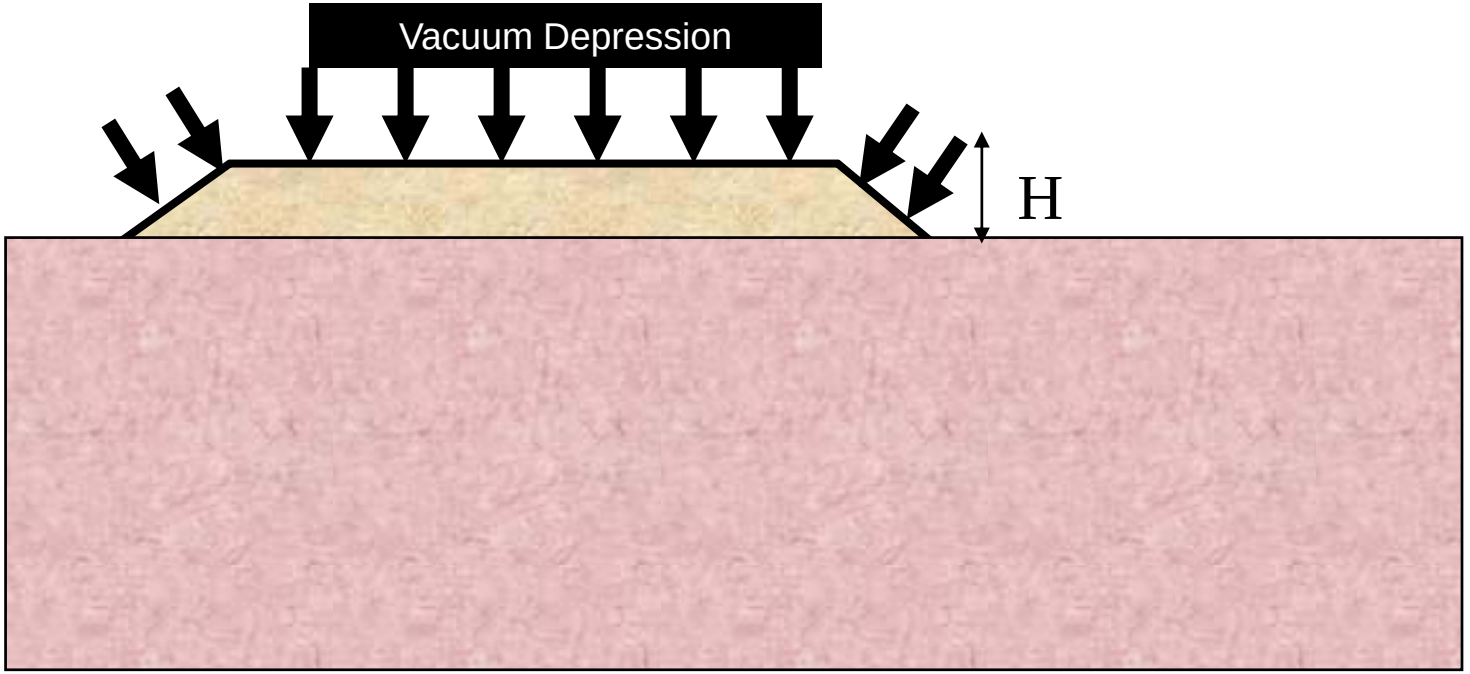


**Vacuum Method**
**No limitation: High Surcharge built up in limited period**

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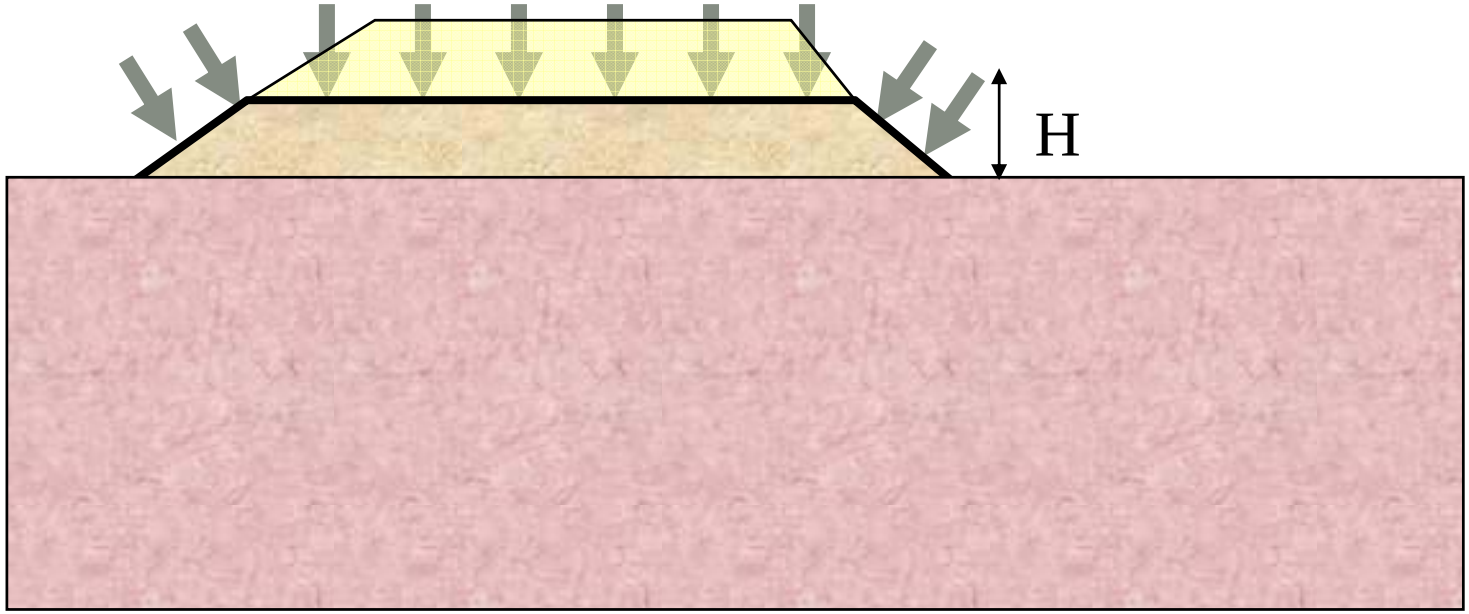


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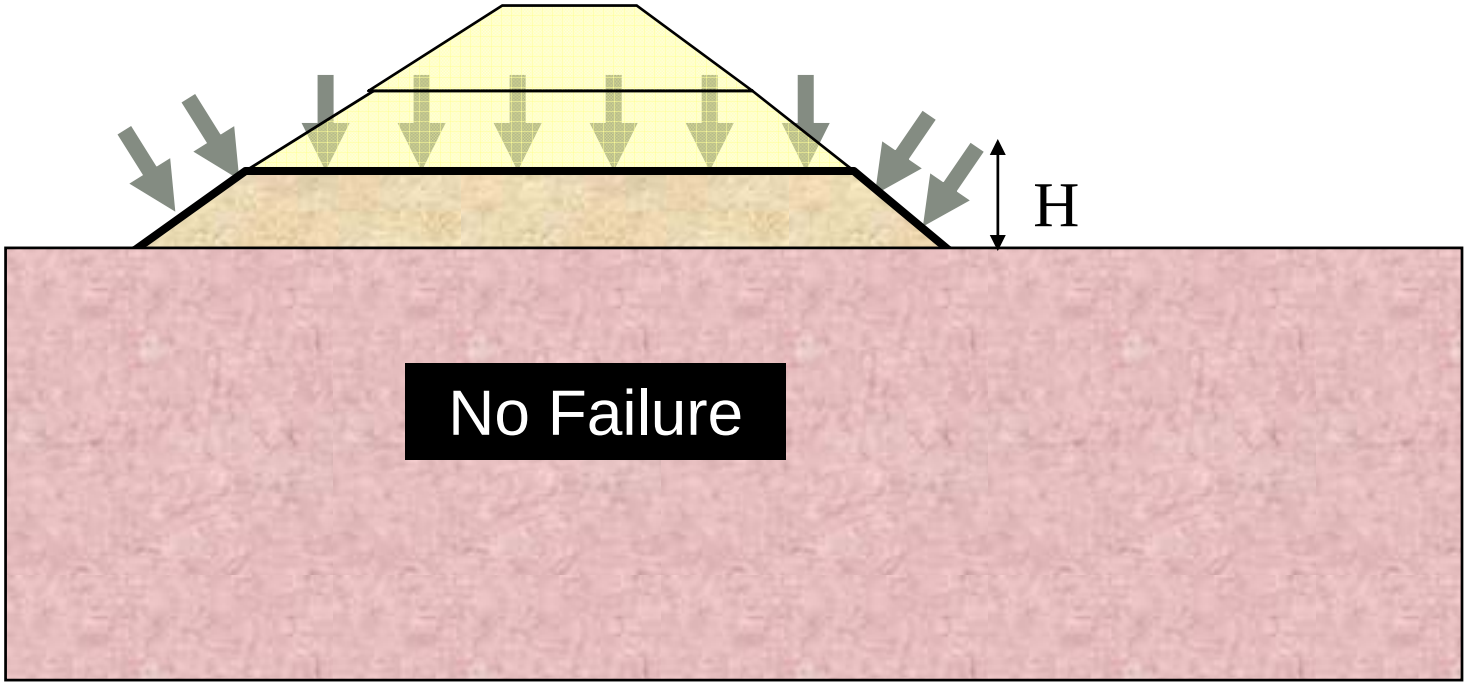


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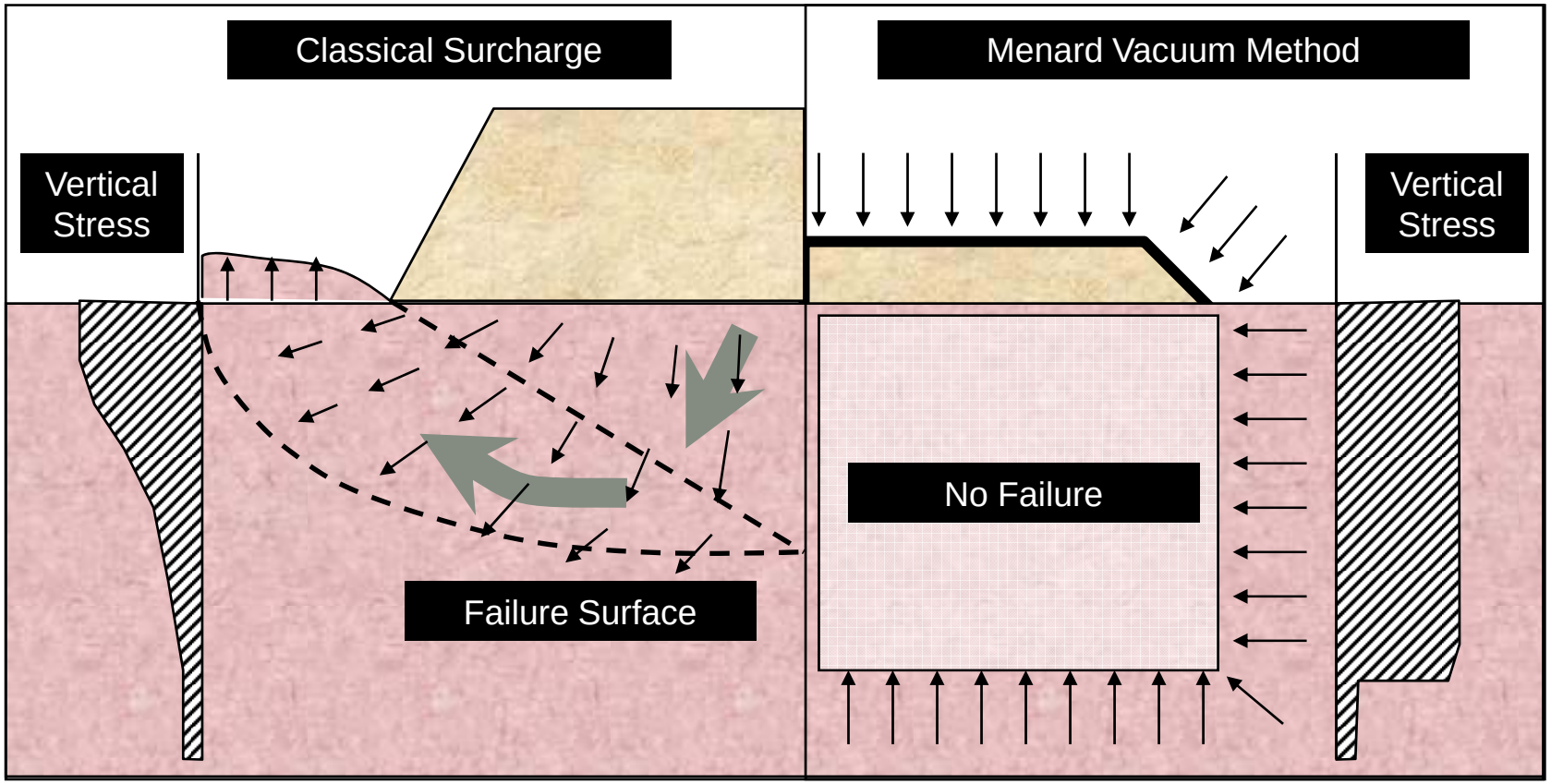
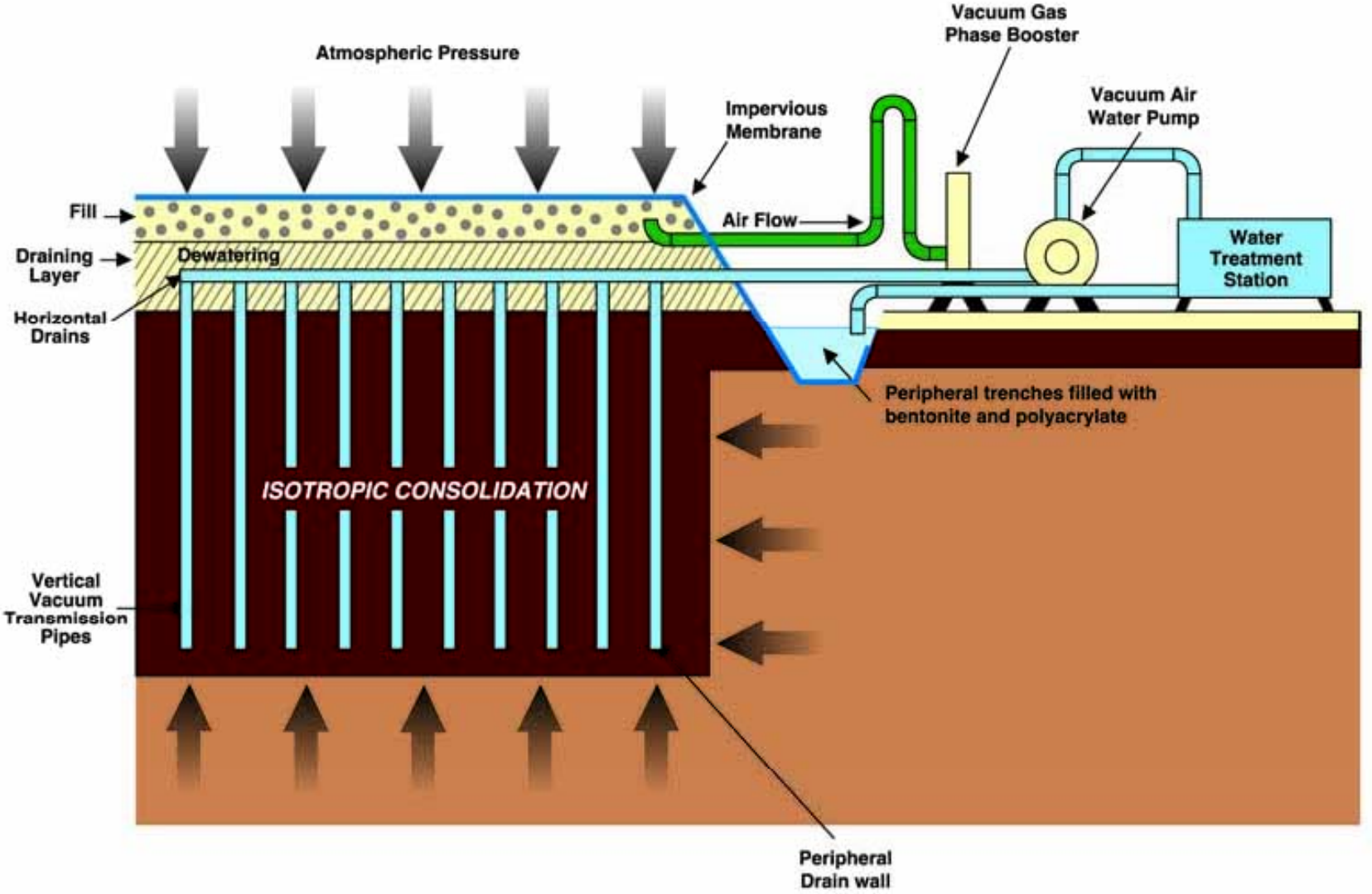


# Vacuum Consolidation (high fines contents soils)




VACUUM (J.M. Cognon patent)

# Vacuum Consolidation

## CONCEPT

-Soil is too soft for surcharge

-Time does not allow for step loading

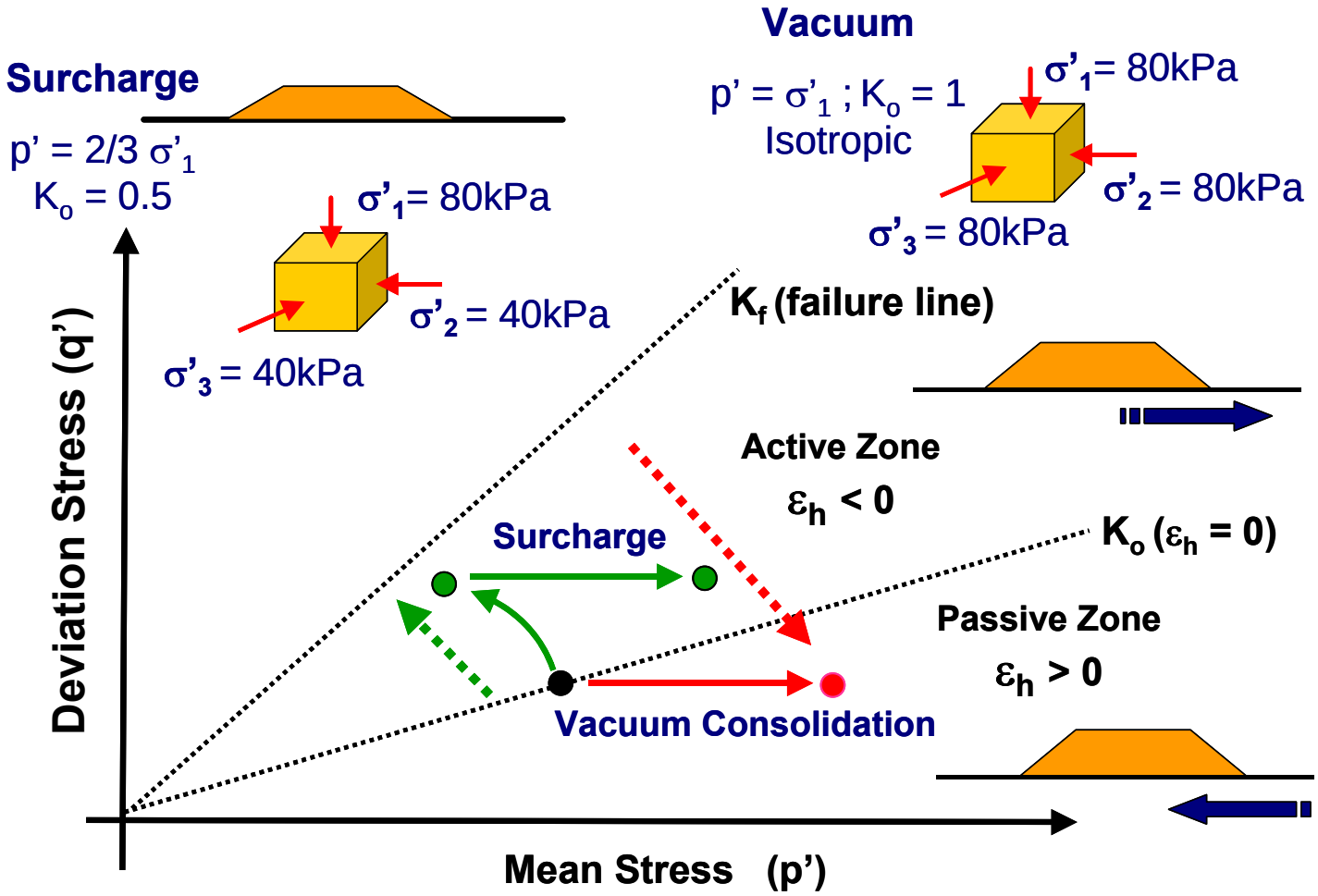
-Surcharge soil not available

-Available area does not allow for berns

## PARAMETERS

1 – Depth
2 – Drainage path
3 – Condition of impervious soil
4 – Watertable near surface
5 - Absence of pervious continuous layer
6 – Cohesion
7 - Consolidation parameters (oedometer, CPT)
$e_O$, $C_C$, $C_V$, $C_R$, $C_\alpha$, t,
CPT dissipation test
8 – Theoretical depression value
9 – Field coefficient vacuum
10 – Reach consolidation to effective pressure in every layer
11 – Target approach

# Stress path for Vacuum Process



# Vacuum installation

## Vacuum installation : vertical drains installation

high fines contents soils

## Vacuum installation: horizontal drains installation

high fines contents soils

Mechanical installation

Path to pumping system

# Vacuum installation

Menard Vacuum: membrane installation

# Vacuum installation

Menard Vacuum: pumping station

# Case history: Lübeck Harbour (Germany) - 1997


Before

# Case history: Kimhae STP (Korea) - 1998

Waste Water treatment plant
(soil profile : 40 m deep of soft clay)

# Case history: Kimhae STP (Korea) - 1998

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**17 m of fill on a clay SPT = 0 and $C_u$ < 2 t/m$^2$ !!!**
**Initially, impossible to put more than 1.5m without slope failure**
**Average settlement: 4.55m**
**Min settlement: 3.55 Max settlement: 6.05m**
**Pumping time: 7-9 months**

# Case history – EADS Airbus Plant, Hamburg (Germany)

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General overview of Airbus site

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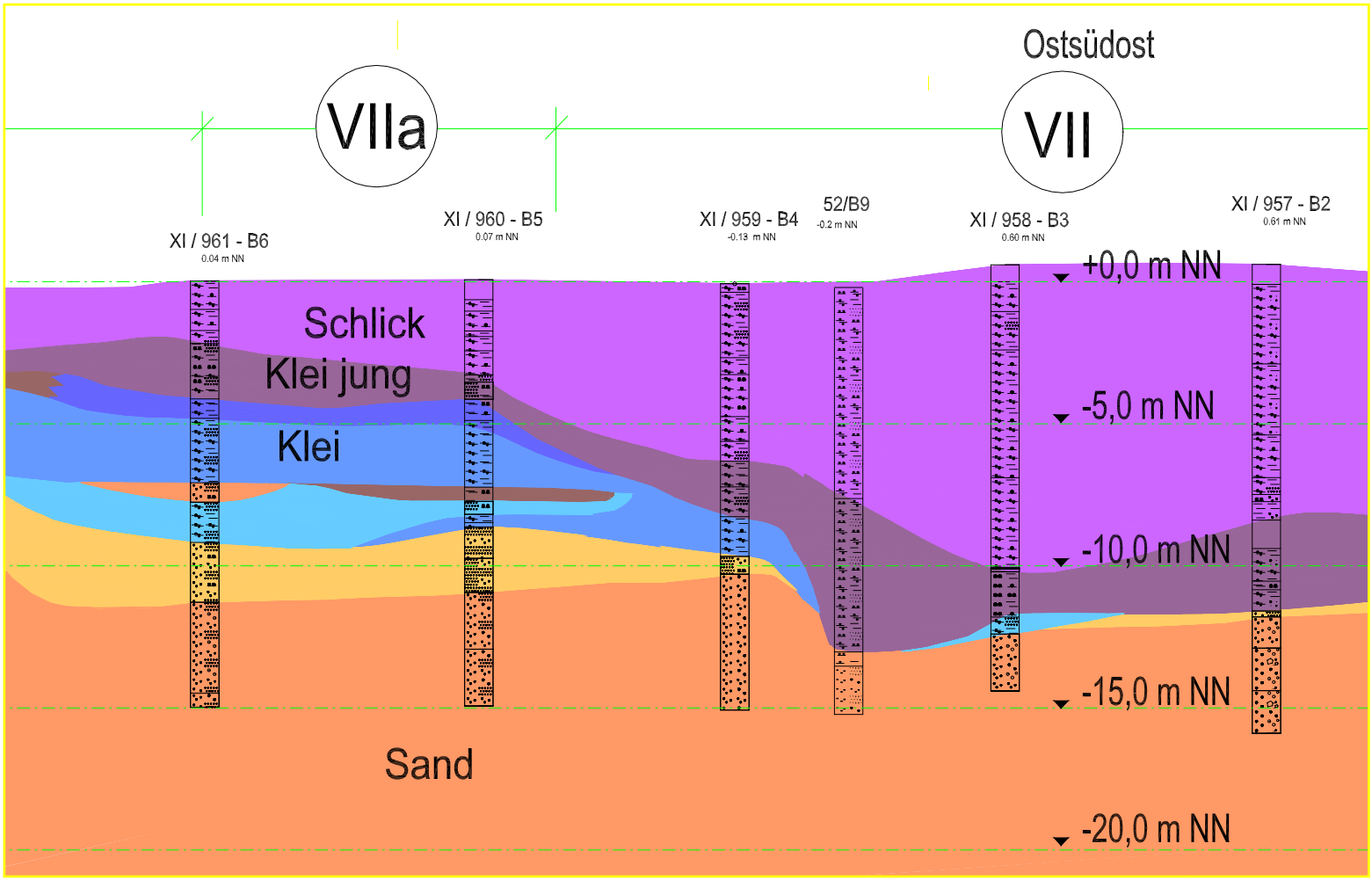
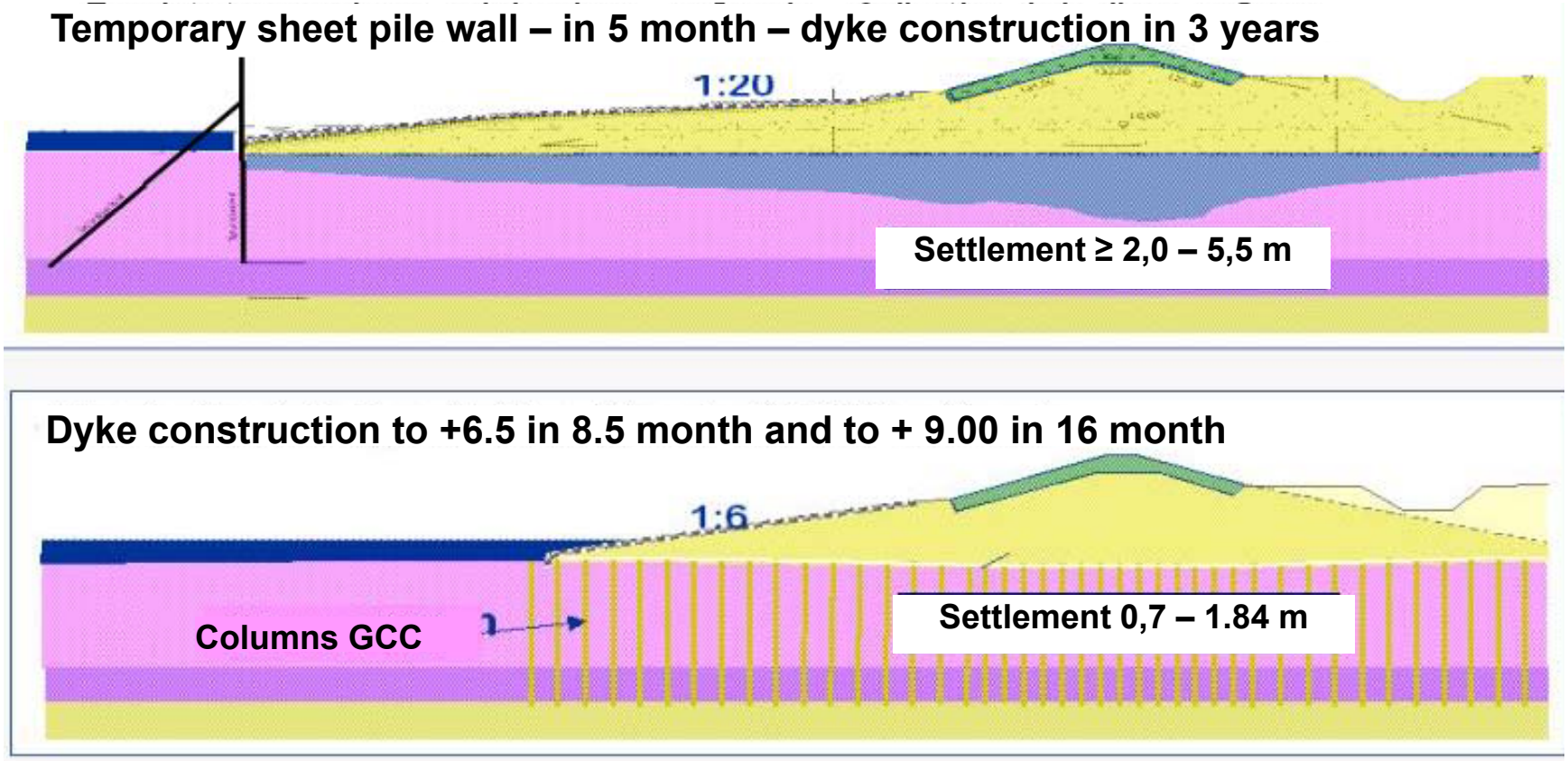


# Basic design and alternate concept of Moebius-Menard



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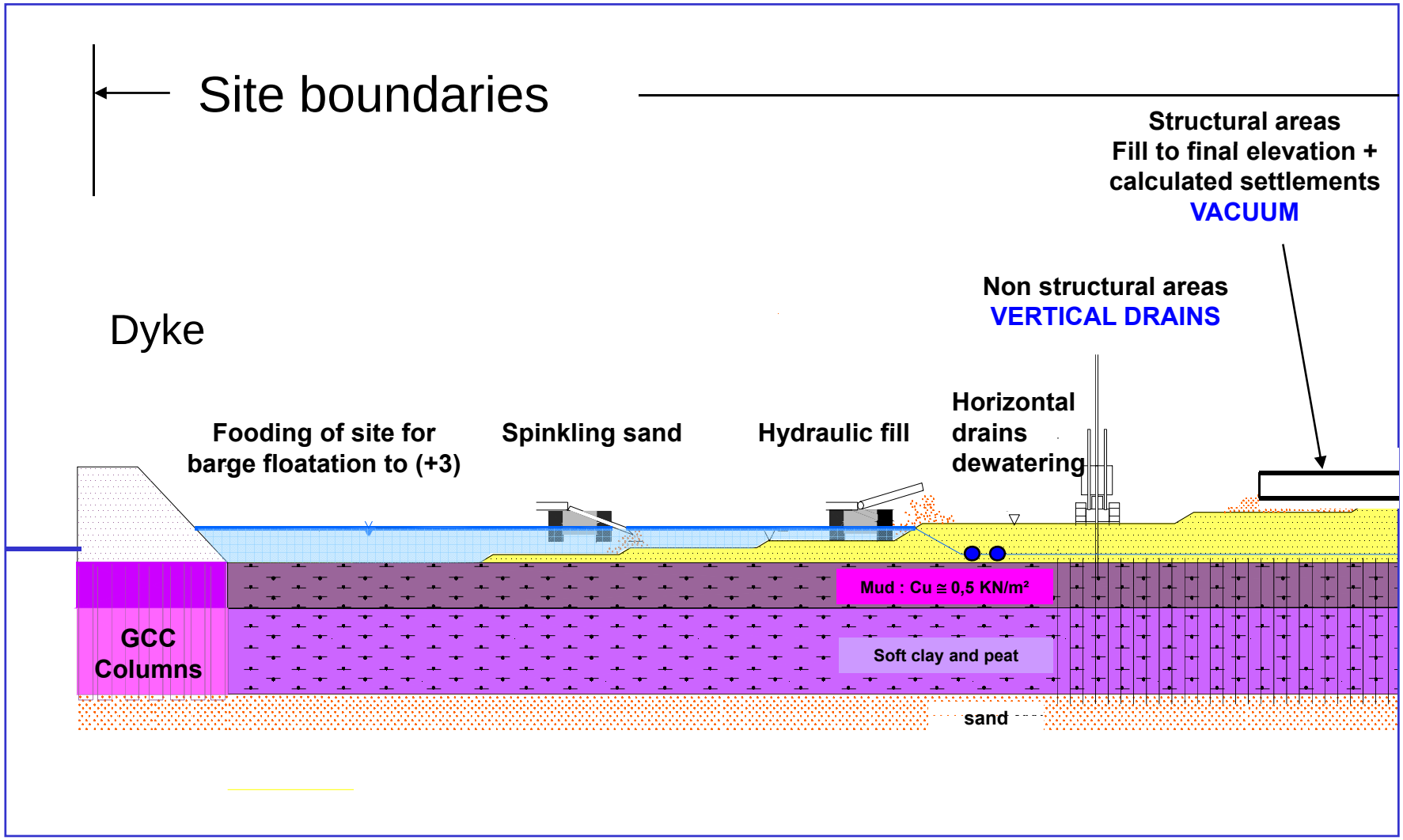

# Subsoil characteristics

| Soil type | Water content | Density | Shear strength | | Deformation Modulus (under $\sigma_z$ = 100 kN/m²) | Coefficient of consolidation | Coefficient of secondary consolidation |
|---|---|---|---|---|---|---|---|
| | W (%) | $\gamma/\gamma'$ – kN/m³ | $\delta'(°)/c'$ (kN/m²) | $C_u$ (kN/m²) | $E_S$ (MN/m²) | $C_V$ (m²/year) | $C\alpha$ (-) |
| *Mud* | 142 | 13/3 | 20/0 | 0.5-5 | 0.8 | 0.35 | 0.03 |
| Young clay | 119 | 14/4 | 20/0 | 2-10 | 0.9 | 0.35 | 0.03 |
| Clay | 70 | 15/5 | 17.5/10 | 5-20 | 1.5 | 0.5 | 0.02 |
| Peaty clay | 139 | 14/4 | 20/5 | 5-20 | 0.9 | 0.4 | 0.03 |
| Peat | 240 | 11/1 | 20/0 | 5-15 | 0.5 | ≥ 0.4 | 0.04 |

# Case history – EADS Airbus Plant, Hamburg

How to move on the mud !

# Case history – EADS Airbus Plant, Hamburg

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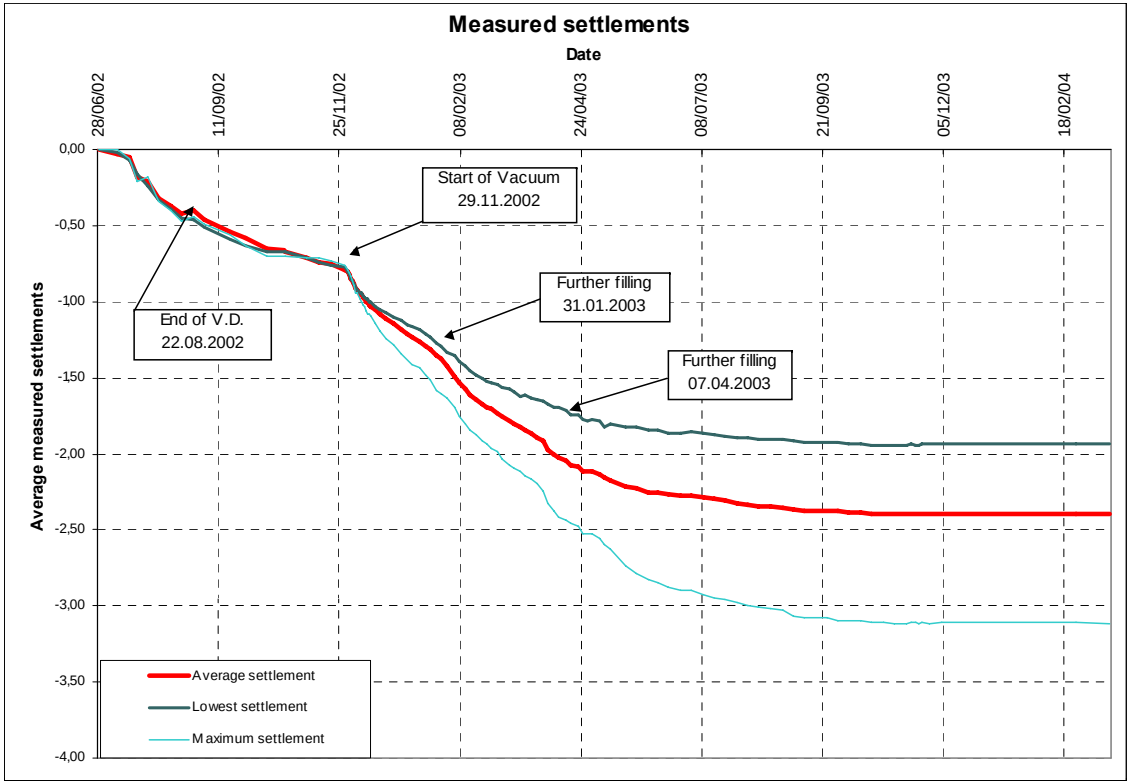
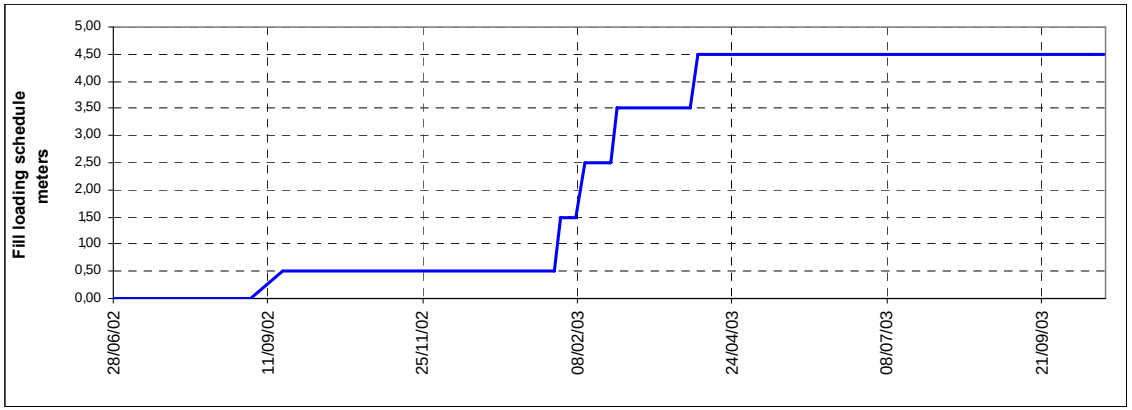
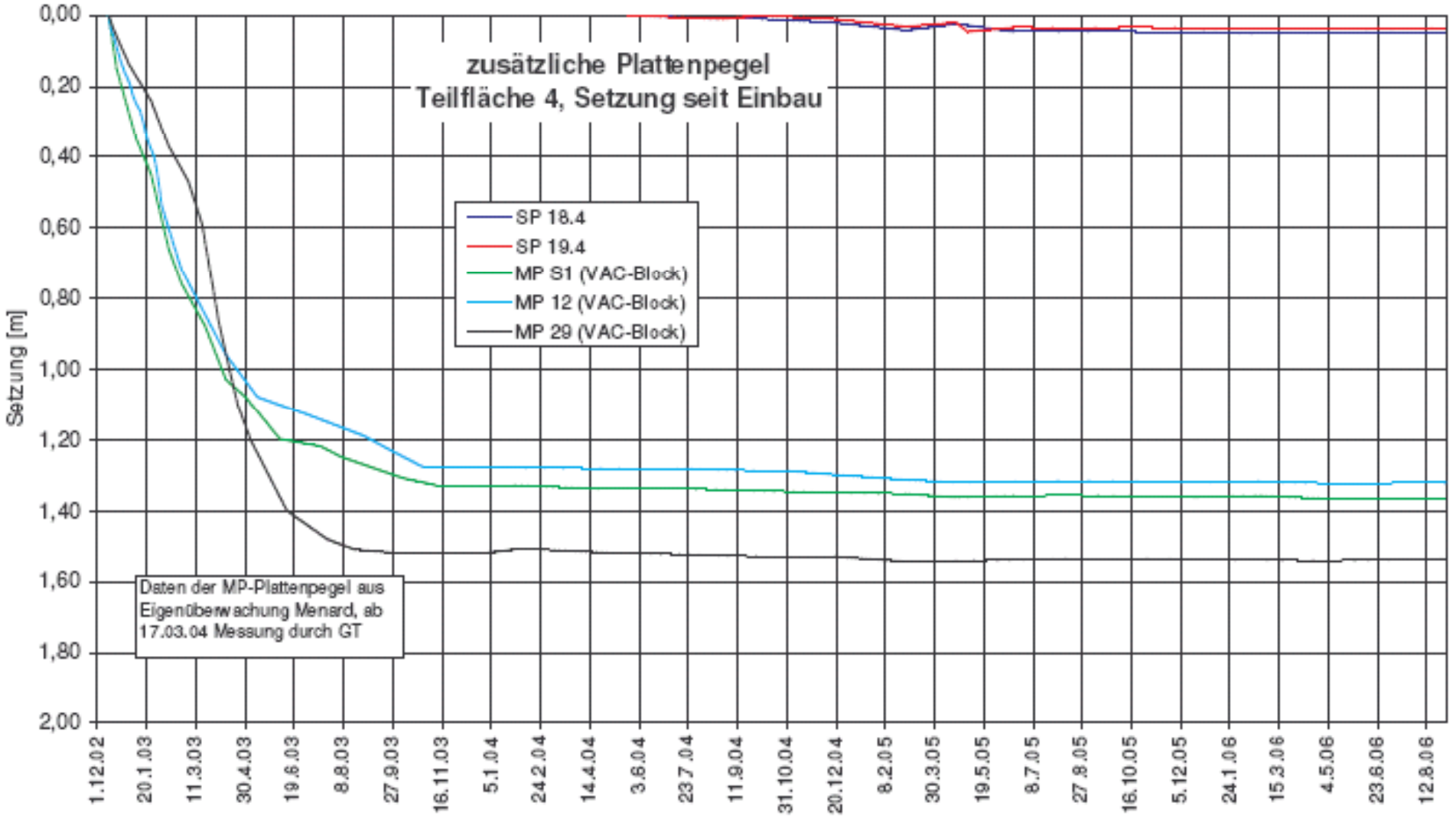
# Vacuum Taxiway – Construction of the impervious wall

# Long time behaviour



# Long time post construction settlement records



# Case history – EADS Airbus Plant, Hamburg

# Thank You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