Soil improvement techniques - Bypass Mechelen

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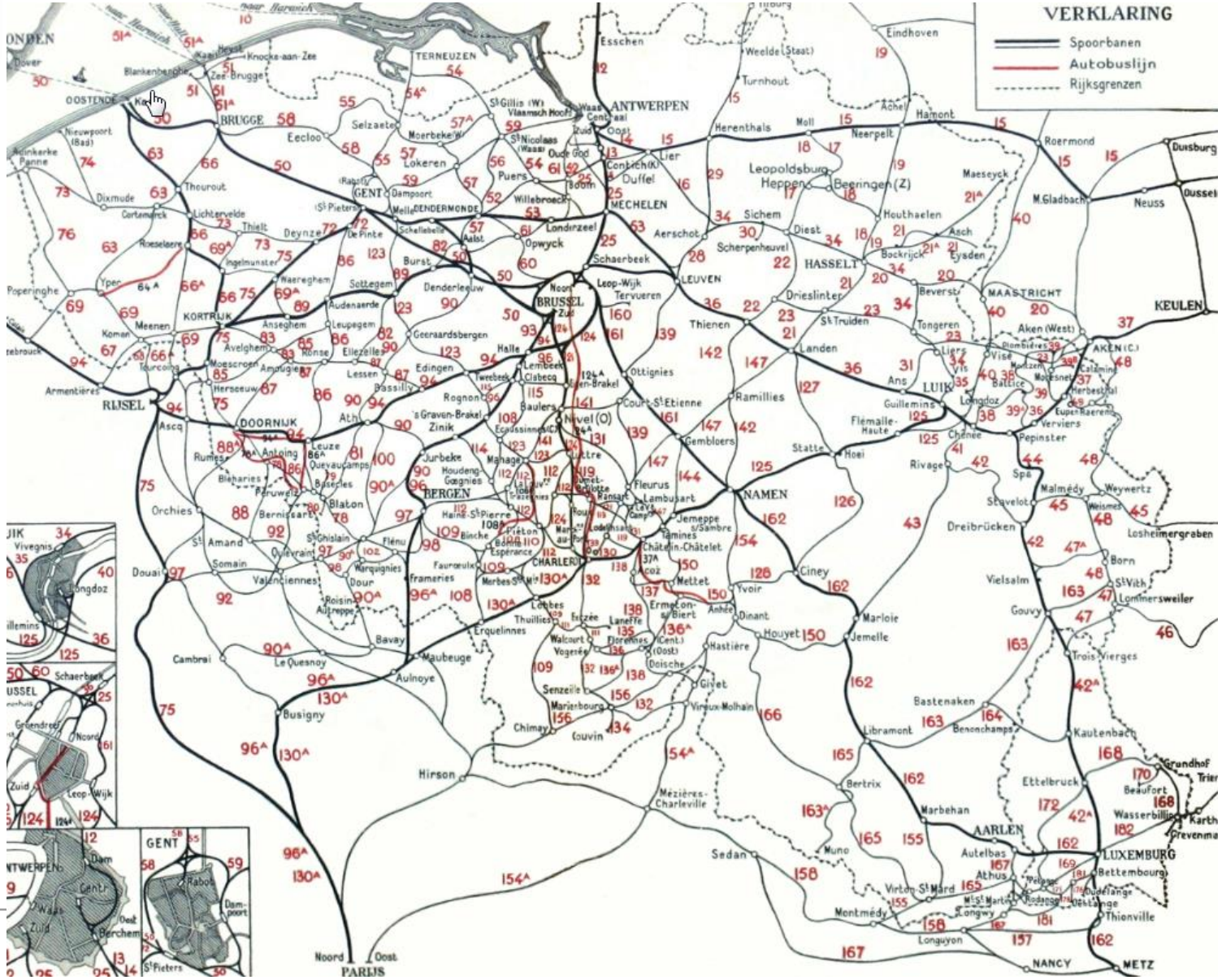
TUC RAIL
BELGIAN RAIL ENGINEERING

Railwaynet in Belgium anno 1933

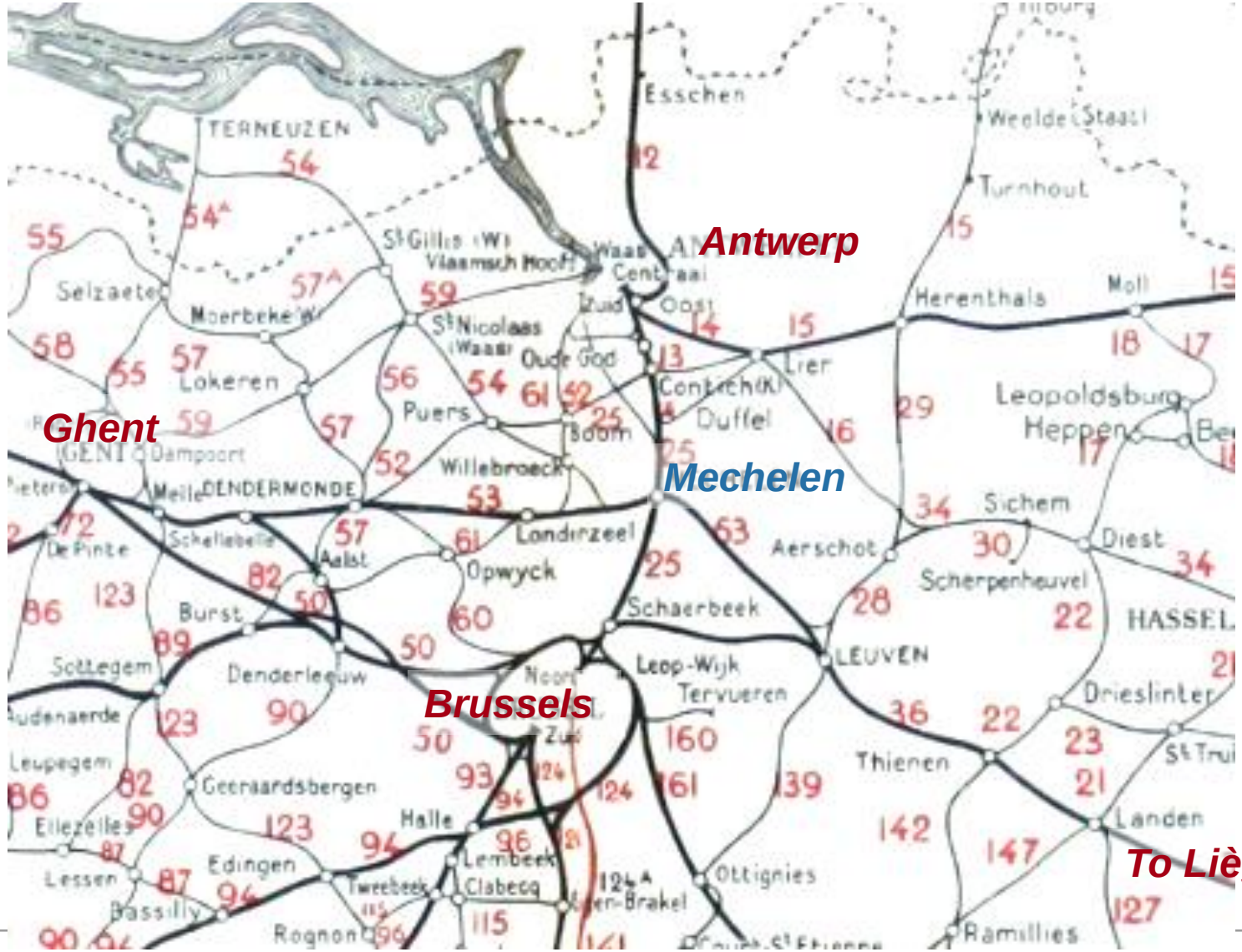


Mechelen station

- Mechelen (1835) the first trainstop for passengers

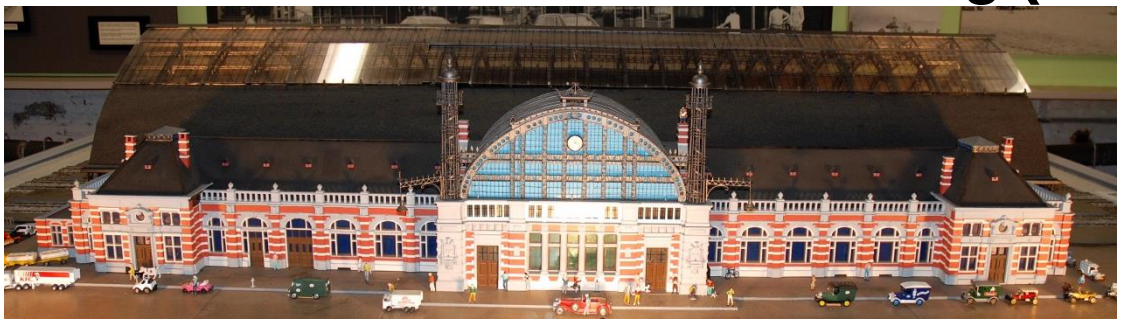
- Centre of first railwaynet in Belgium

Mechelen station



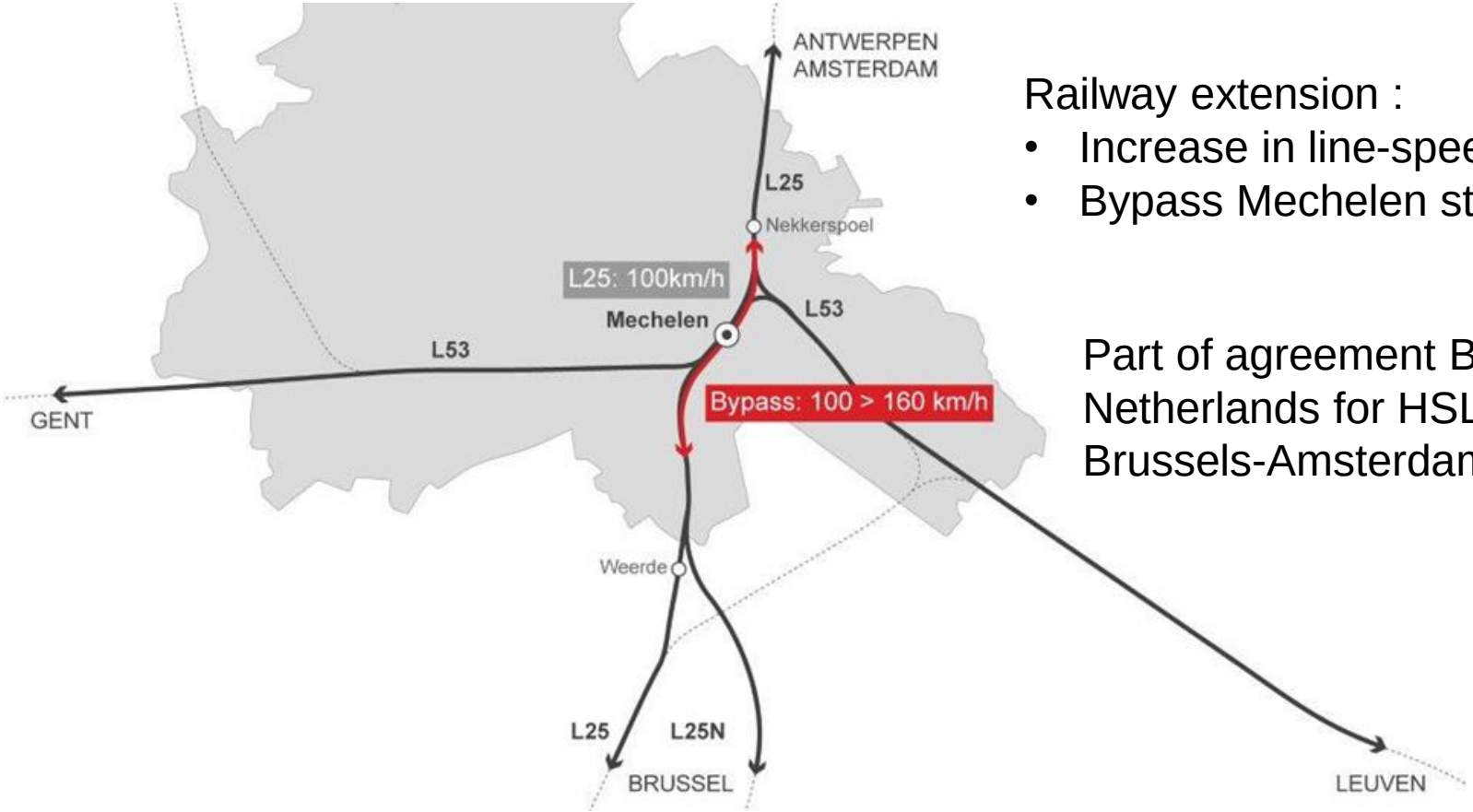
Mechelen station

- **Model of old station building (1888)**



- **Renewed in 1955 in modern building with 10 plateforms**

Projectscope : Road & railway extension



Railway extension :

- Increase in line-speed
- Bypass Mechelen station

Part of agreement Belgium-Netherlands for HSL link Brussels-Amsterdam

Different project zones 10/20/30

Railway extension project: integrated with

- **New station and underground parking facilities**
- **New road access and connections**
- **Bicycle / walkway network**

Some data on foundations/retaining walls

Piled foundations:

- CFA piles with enlarged hollow stem: 1.430 piles
- Cast in situ driven piles: 1.296 piles
- Tubular screw injection piles: 310 piles
- Closed end driven tubular piles: 51 piles
- Stone column soil improvement: 270 columns
- Open end tubular piles, micropiles, cased CFA-piles, …

Retaining walls:

- Sheet piles (permanent): 900 tons
- Combiwall: 750 tons
- Diaphragm wall: 2.200 m^3
- Cutter soil mix: 10.000 m^2
- Berliner walls, secant pile walls, soil nailing
- Permanent/temporary ground anchors/soil nails: > 1000

Stone column soil improvement

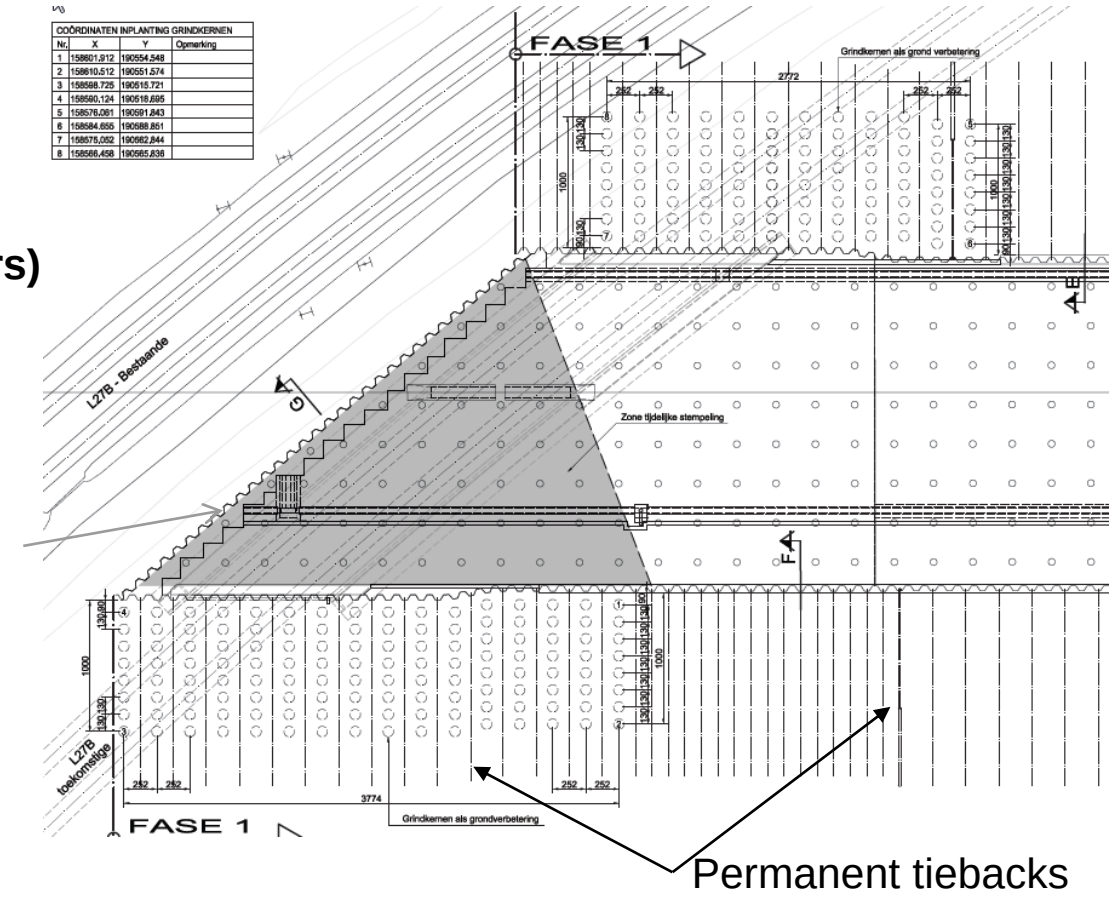
Railway extension project: integrated with

- **New station and underground parking facilities**
- **New road access and connections**
- **Bicycle / walkway network**

Stone column soil improvement

Dry bottom feed vibro replacement:

- **Relief soil pressure on sheet piles (50% less anchors)**

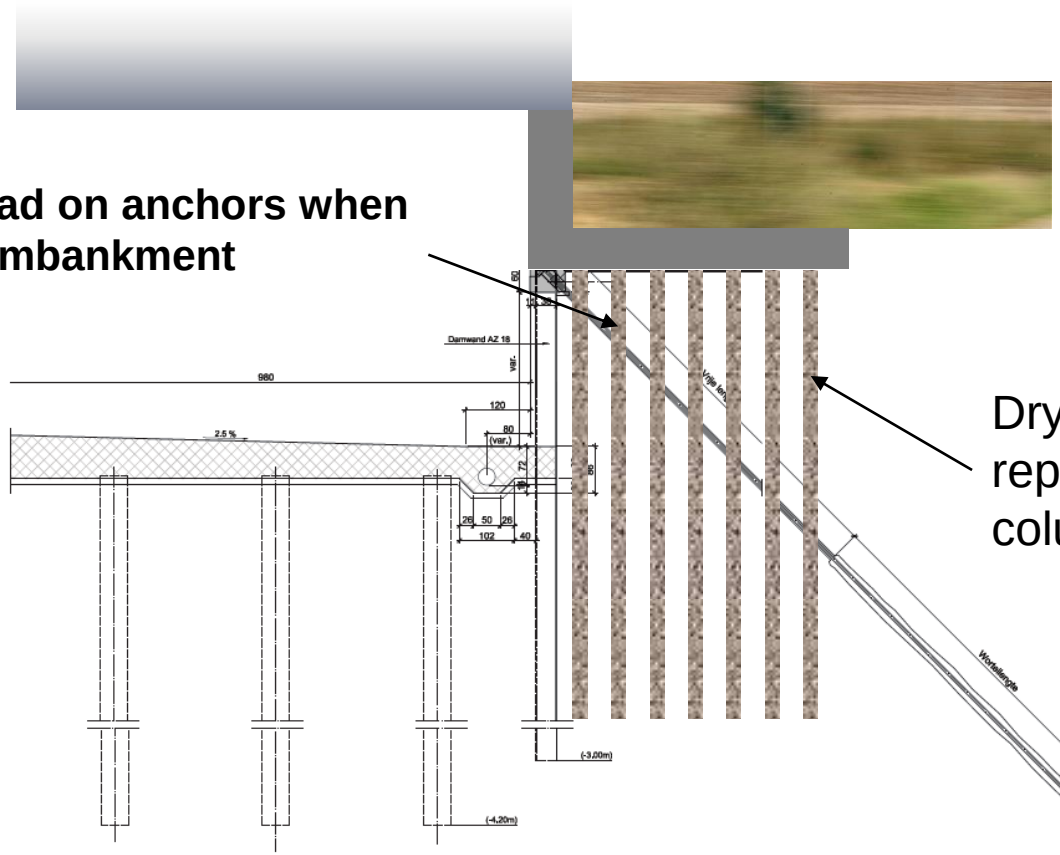


Sheet piles

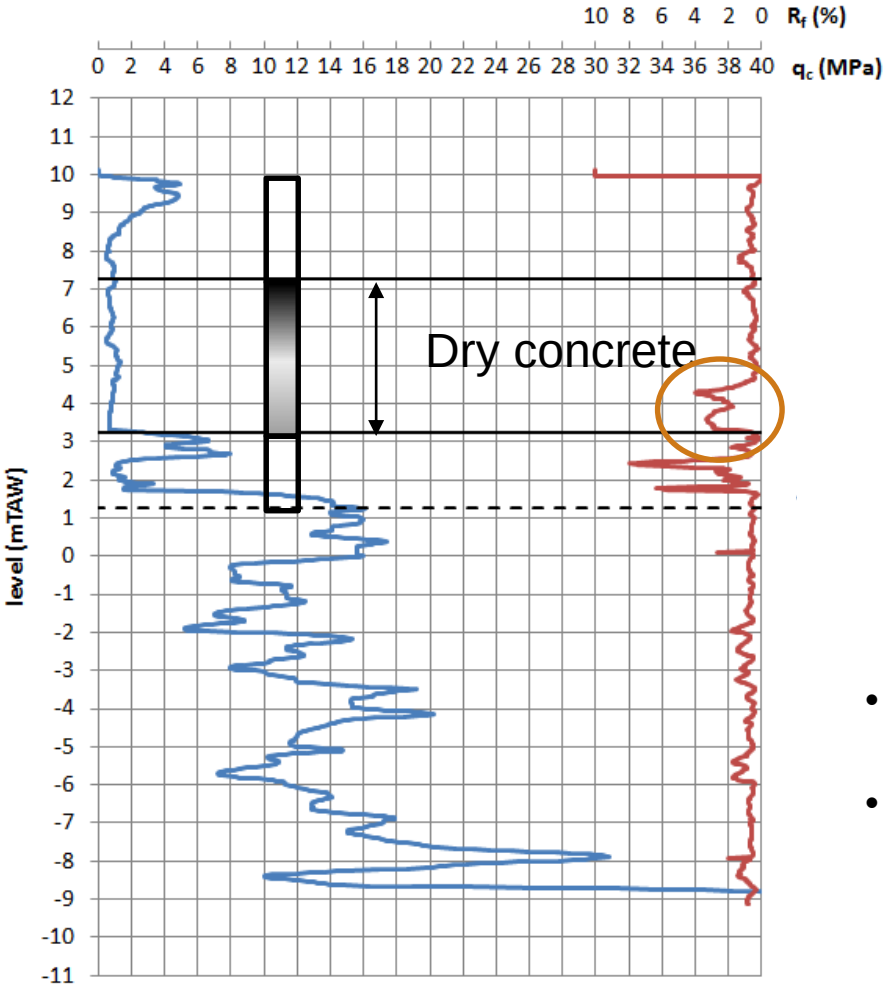
Permanent tiebacks

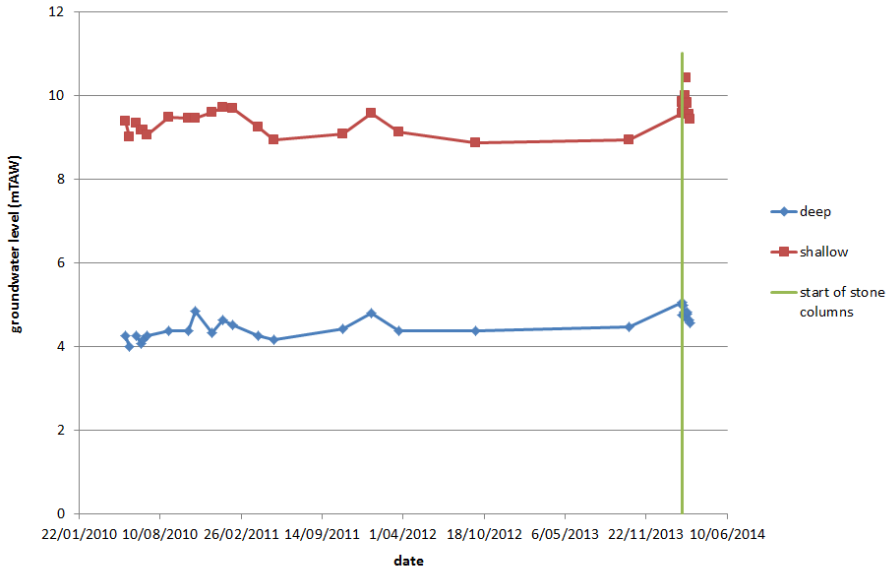
Stone column soil improvement

Relief vertical load on anchors when loaded by new embankment



Stone columns – hydrologic influence





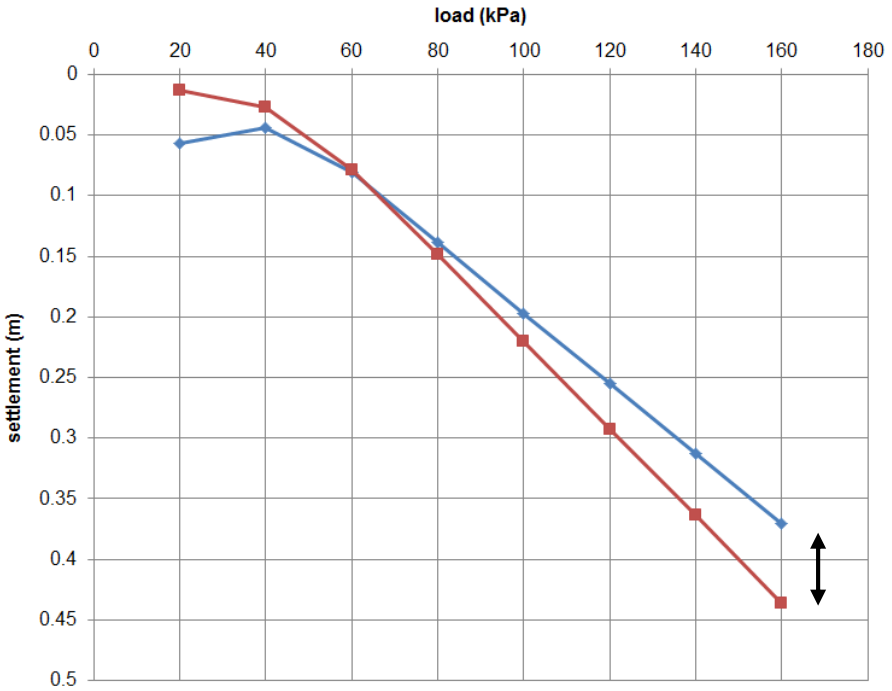
- Two aquifers which must remain separated (dry concrete plugging)
- Rise in groundwater head during installation (which quickly dissipates)

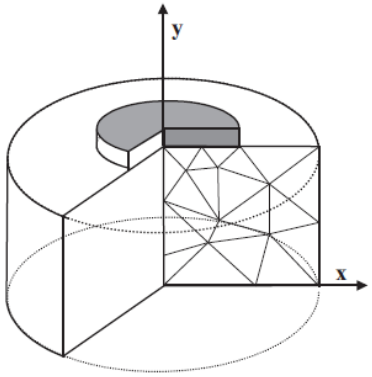
Stone columns – design

Design according to Priebe method

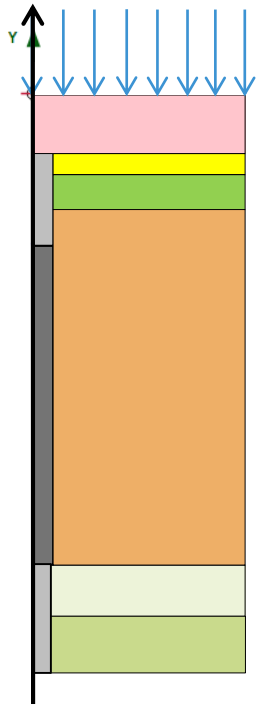
- **Settlement reduction (stiffer equivalent modulus used)**

FEM with plaxis model to compare





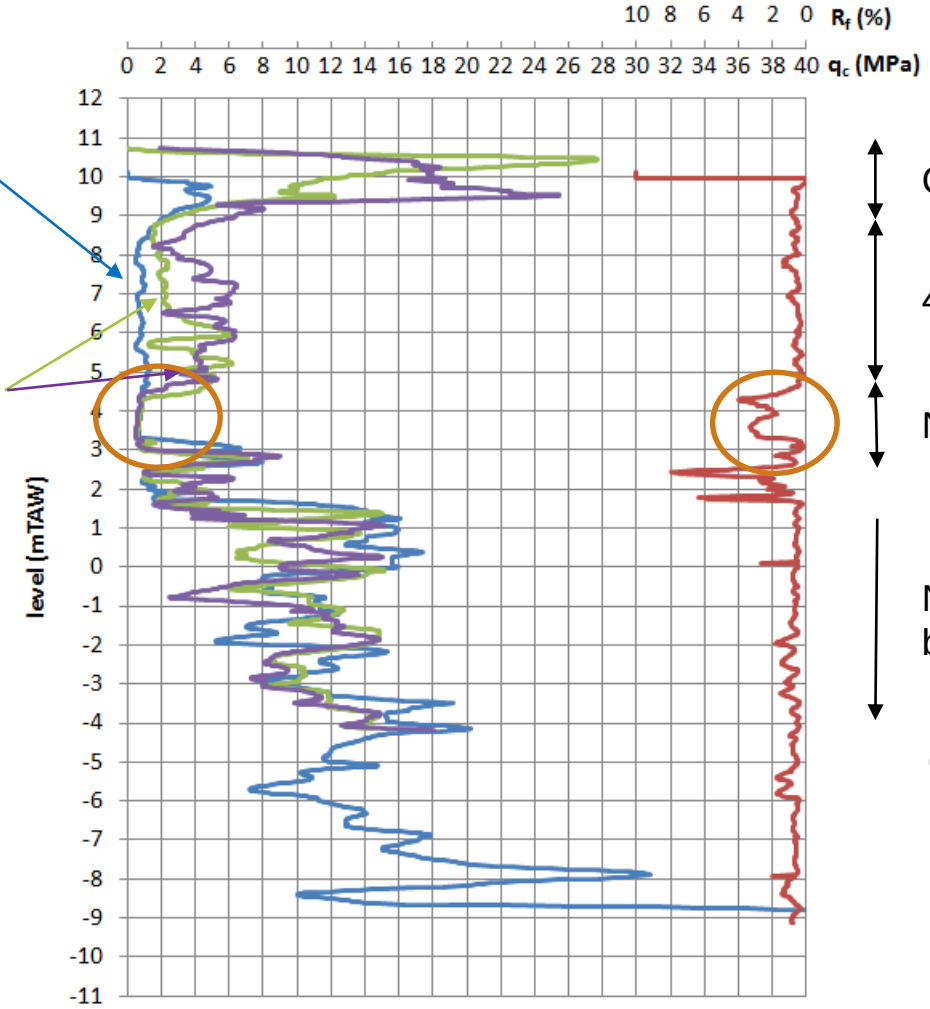
Priebe
Plaxis



F.E.M. (PLAXIS-axisemmetry (K=1)) does not take into account installation effects

Installation effects within group

CPT's: 4 weeks after column installation



Initial CPT

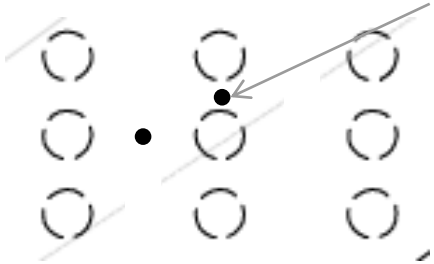
CPT's mid between columns

Compacted working platform

4 x qc in loose sand

No change in qc in clay layer!

No influence beneath columns

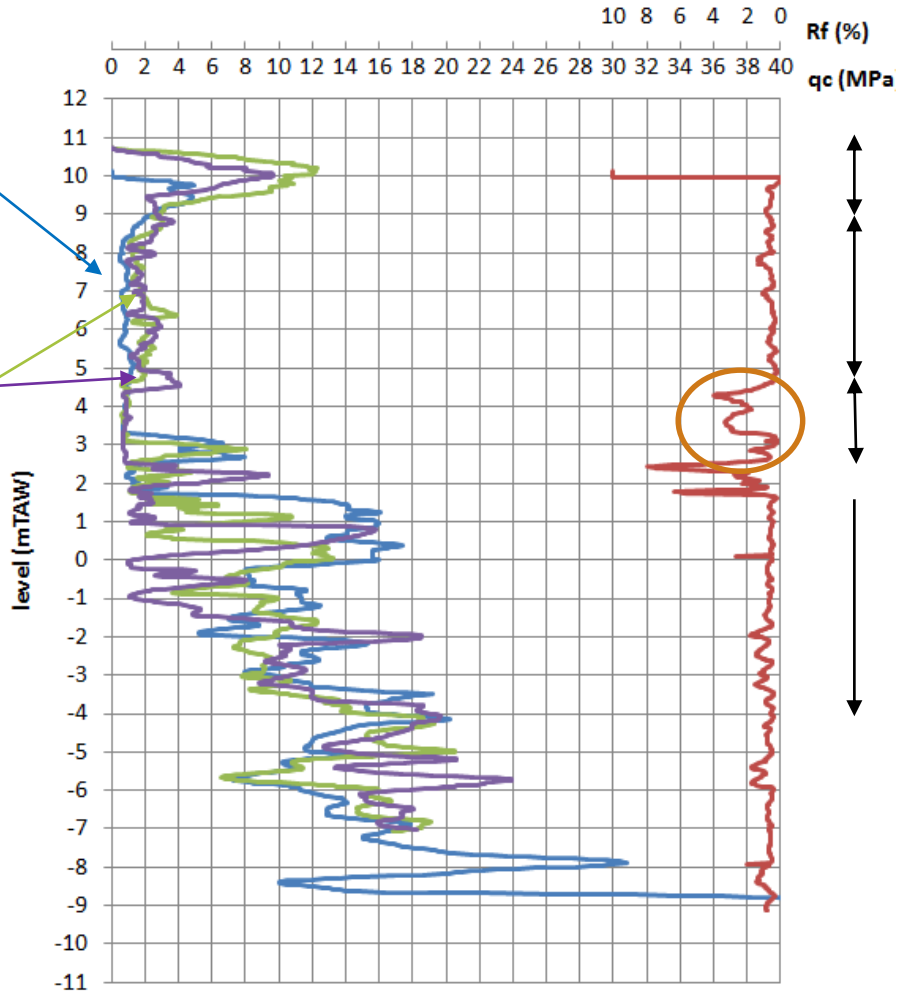


Installation effects next to group

CPT's: 4 weeks after column installation

Initial CPT

CPT's next to soil improvement (axis of sheet piles)

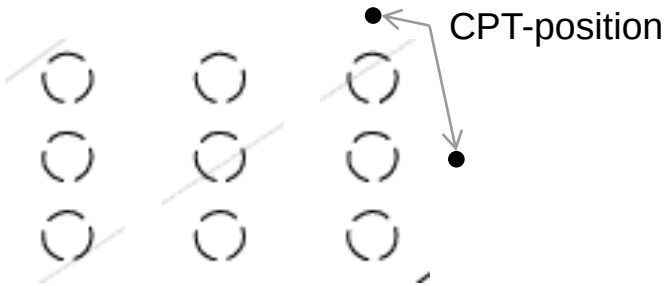


Compacted working platform

2 x qc in loose sand

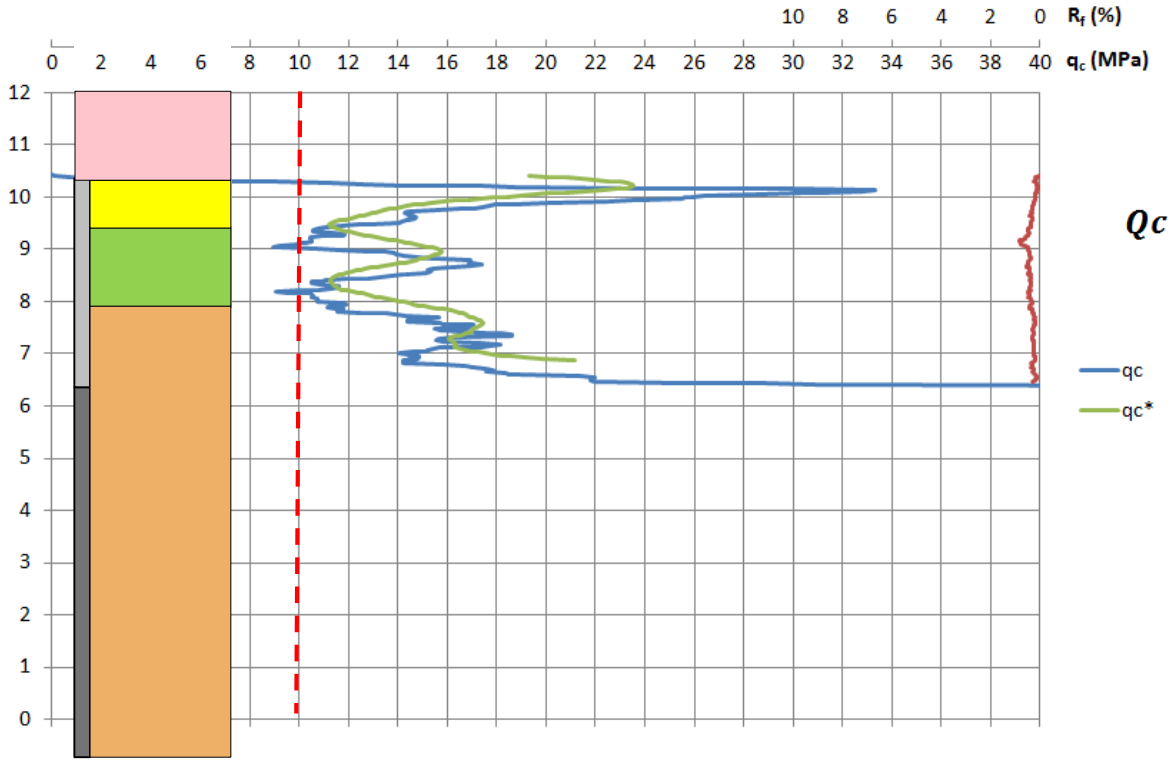
No change in qc in clay layer!

No influence beneath columns



Stone columns – QC/QA

CPT's through column centre to check compaction/presence of dry concrete (and level)

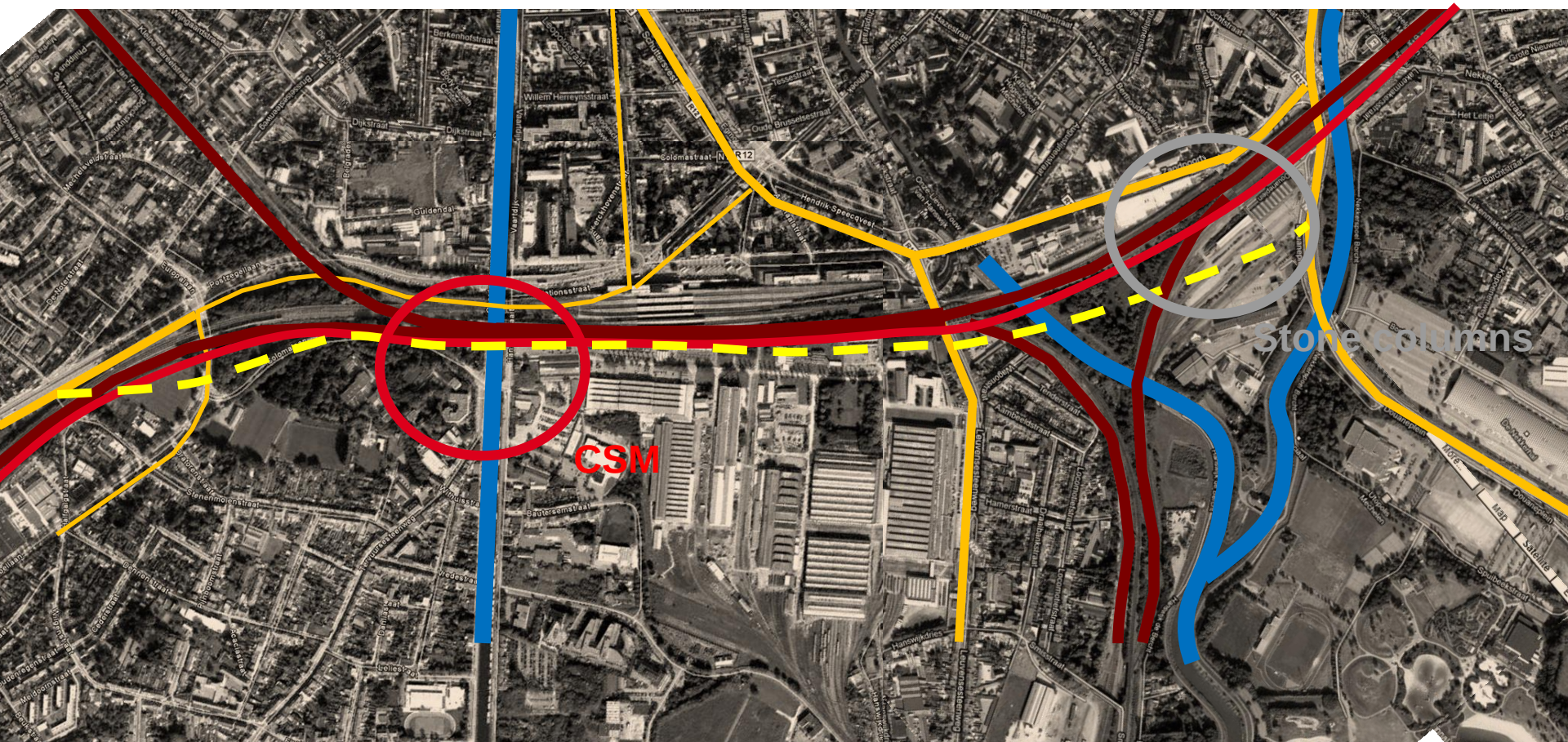


$$Qc = 2.\int_z^{z+0,5} q_c'(z)dz \geq 10\ MPa,$$

Soil mix soil improvement

Railway extension project: integrated with

- **New station and underground parking facilities**
- **New road access and connections**
- **Bicycle / walkway network**

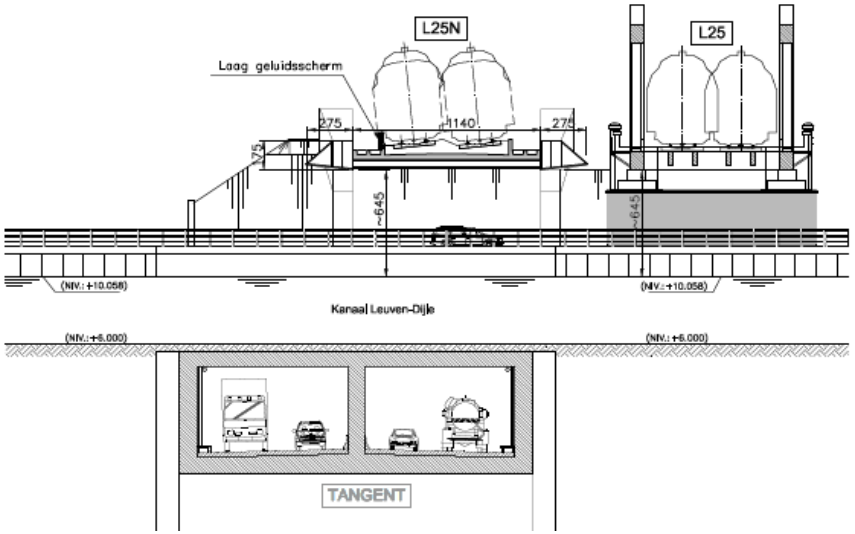


Soil mix soil improvement

Cutter soil mix:

- Retaining wall
- Water (cut-off) wall
- Soil improvement

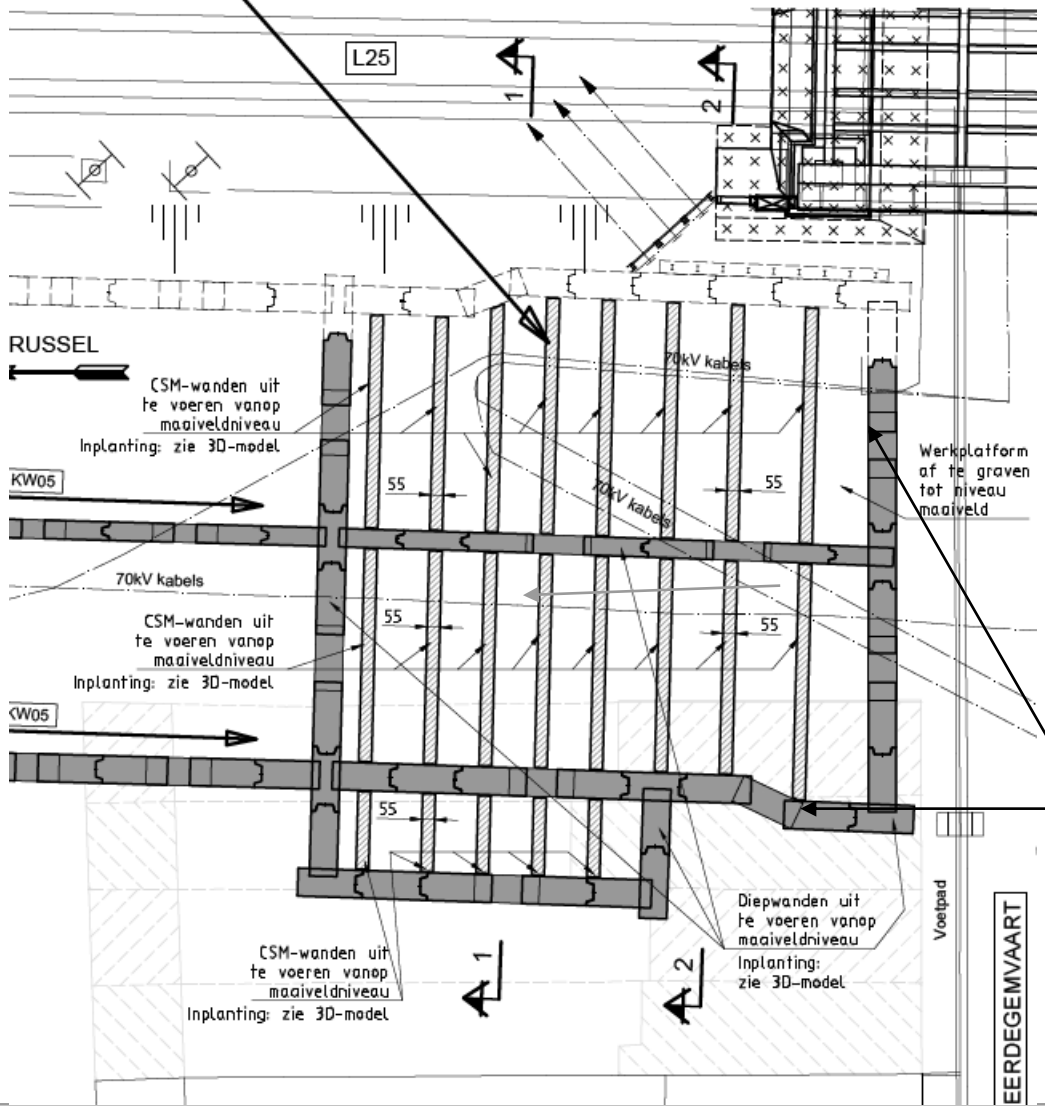
Soil mix soil improvement



Transverse lamellae of CSM is used as strut wall between diaphragm walls

Soil mix soil improvement

Soil mix lamellae



Existing railway bridge

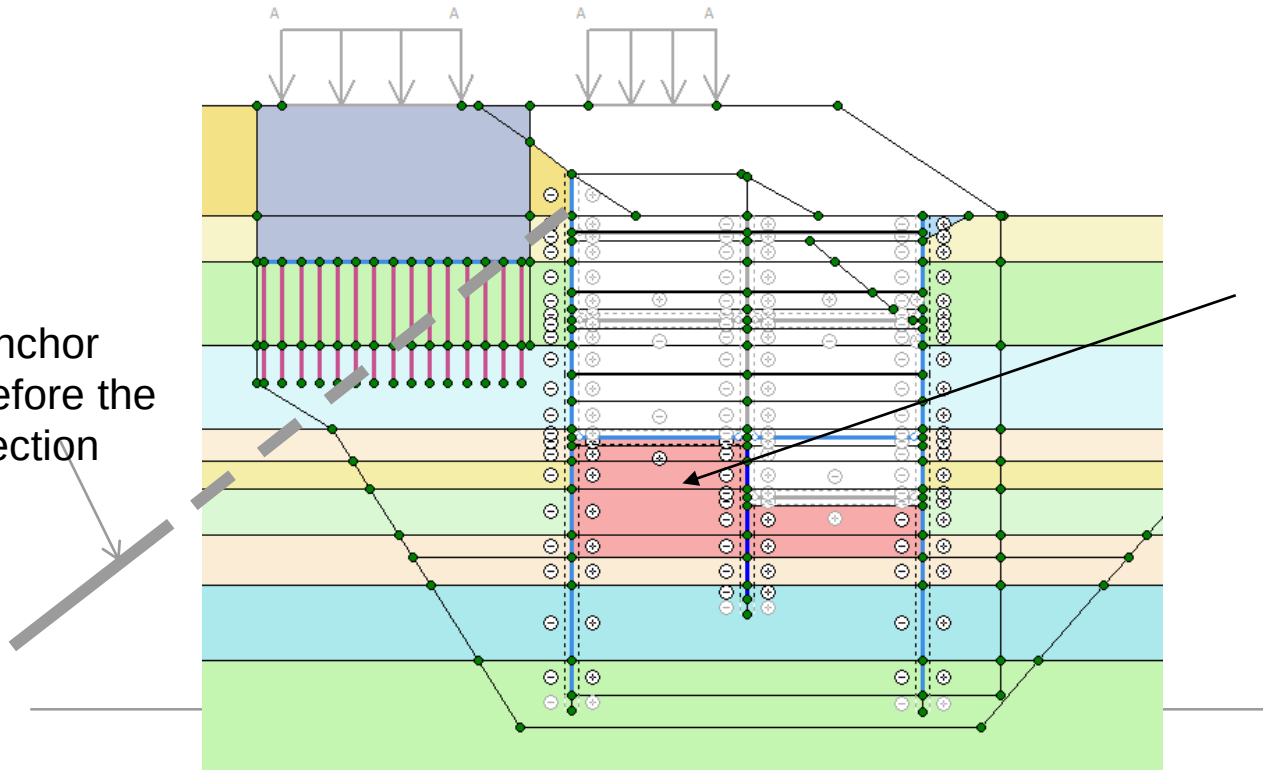
Diaphragm walls

Soil mix soil improvement – design

Design with Plaxis 2D model

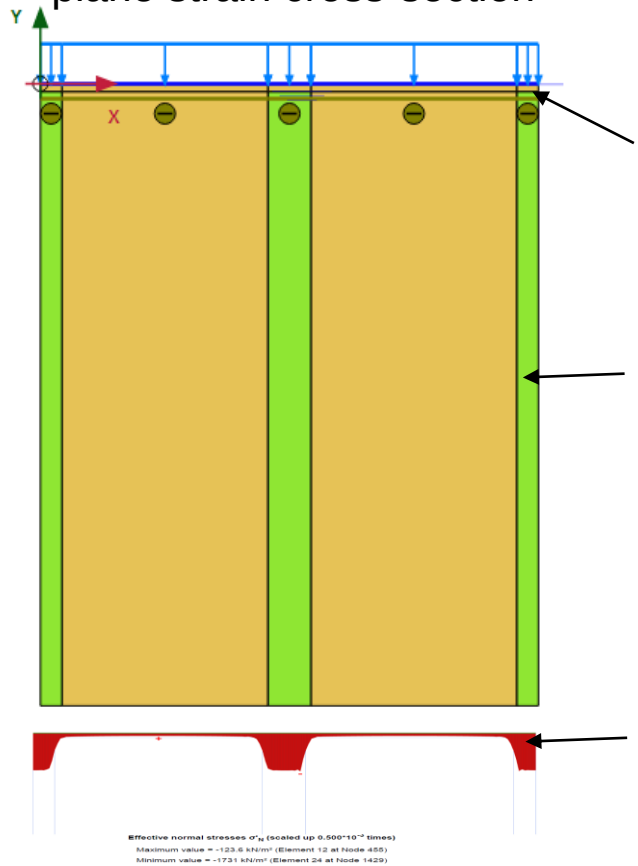
- **CSM Lamellae executed prior to excavation**
- **Reduction of displacements, bending moments (-50%) and strut loads**

Existing railway bridge



Soil mix soil improvement – design

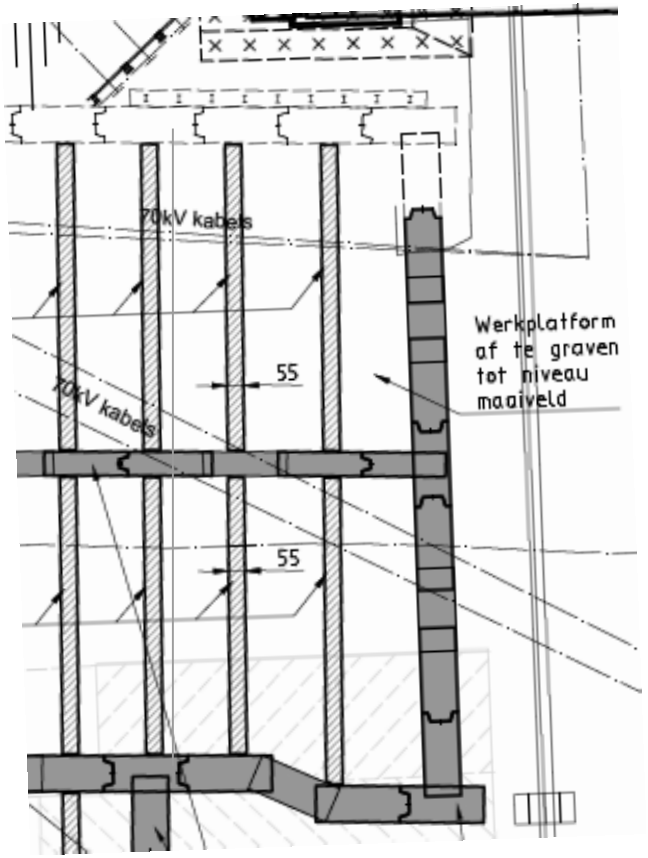
Top view:
Applied pressure from 2D plane strain cross-section



Execution aspect:
Soil void between diaphragm wall and csm wall

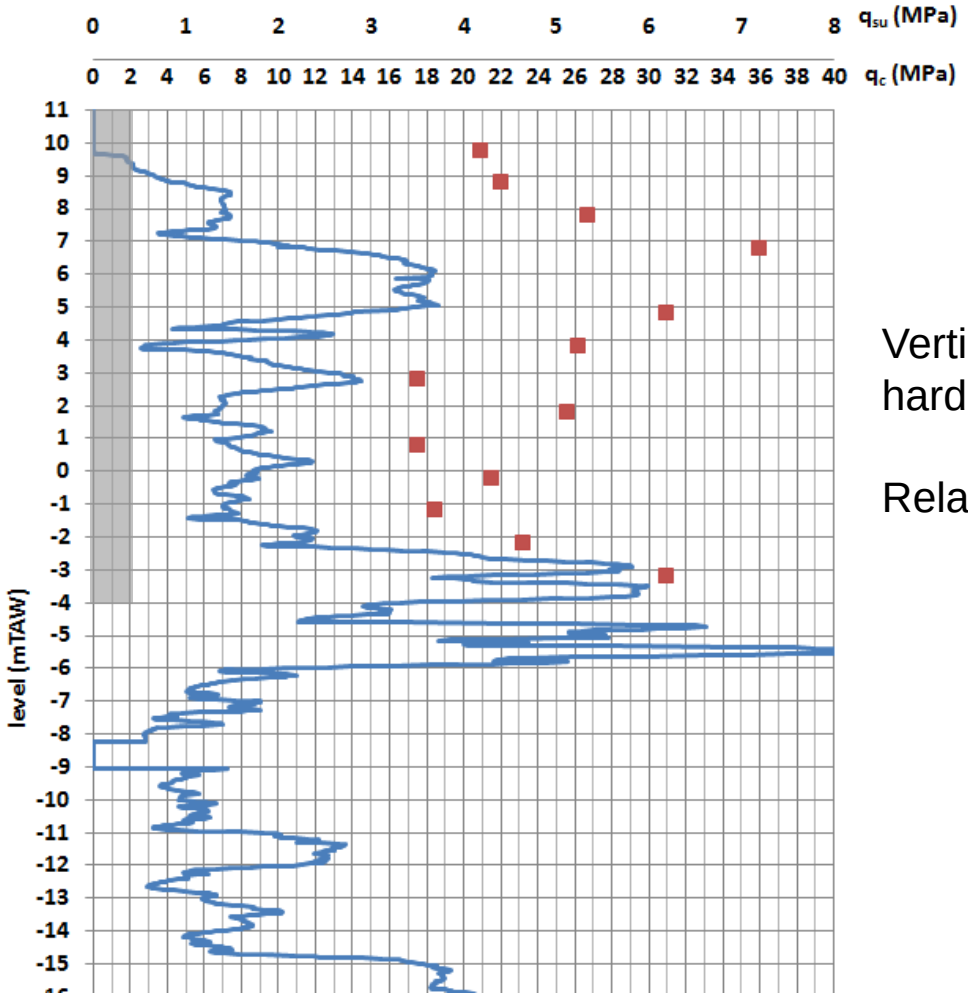
csm wall

Concentrated forces



Soil mix soil improvement – on site

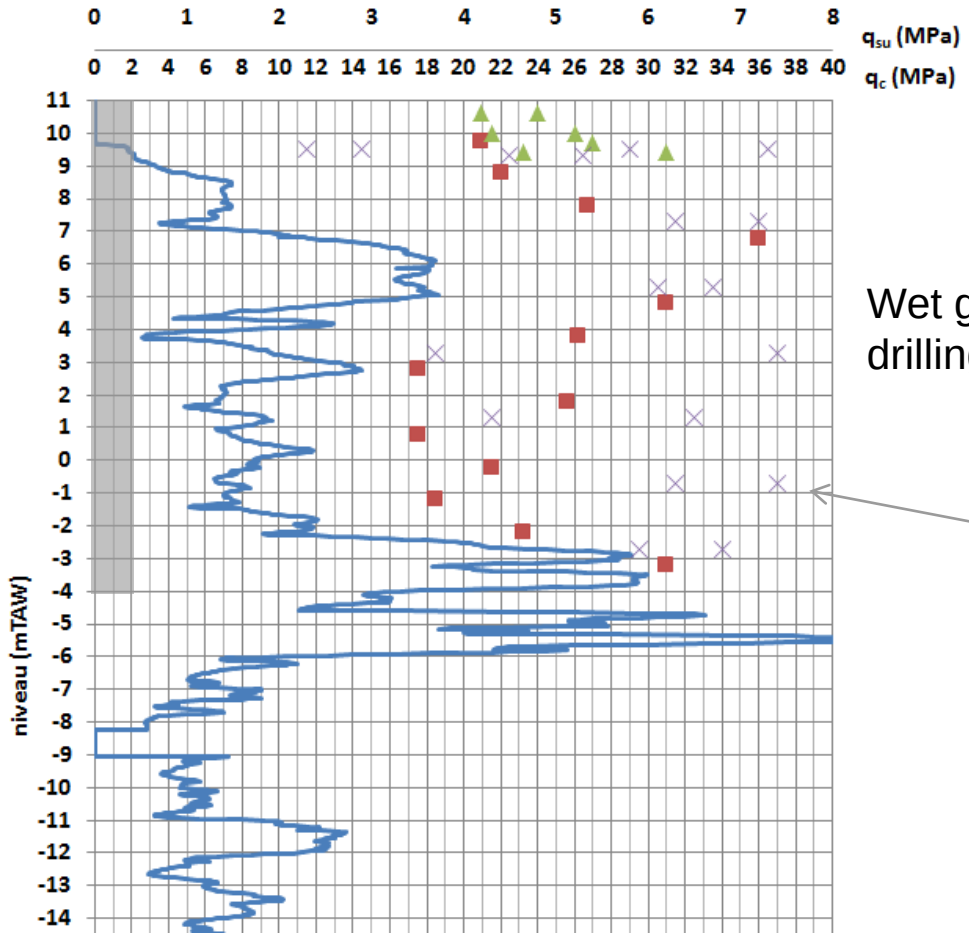
Soil mix – QC/QA



Vertical core drilling in hardened test pile

Relation q_c ~ q_{su}?

Soil mix – QC/QA

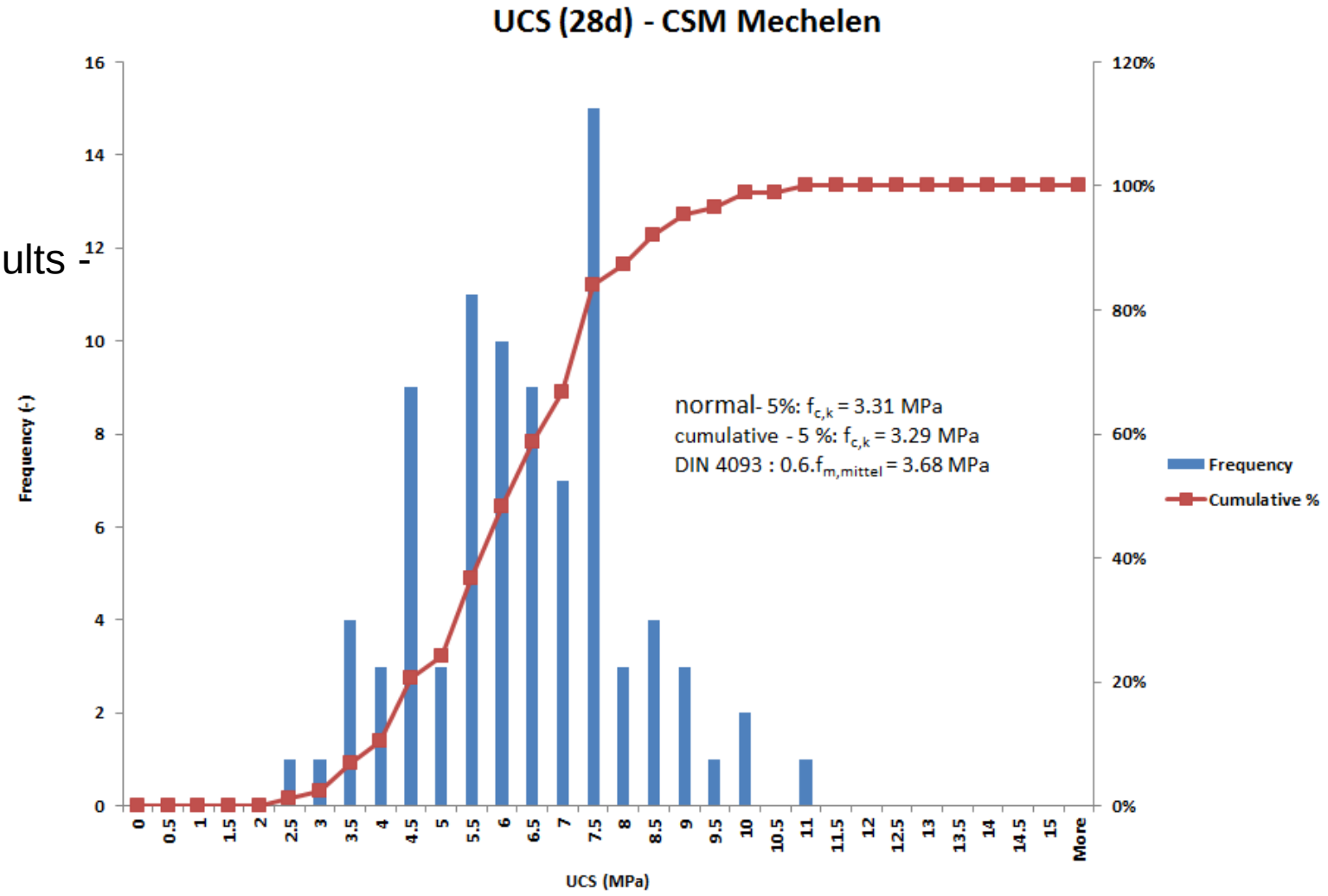


Wet grab & horizontal core drillings: larger scatter

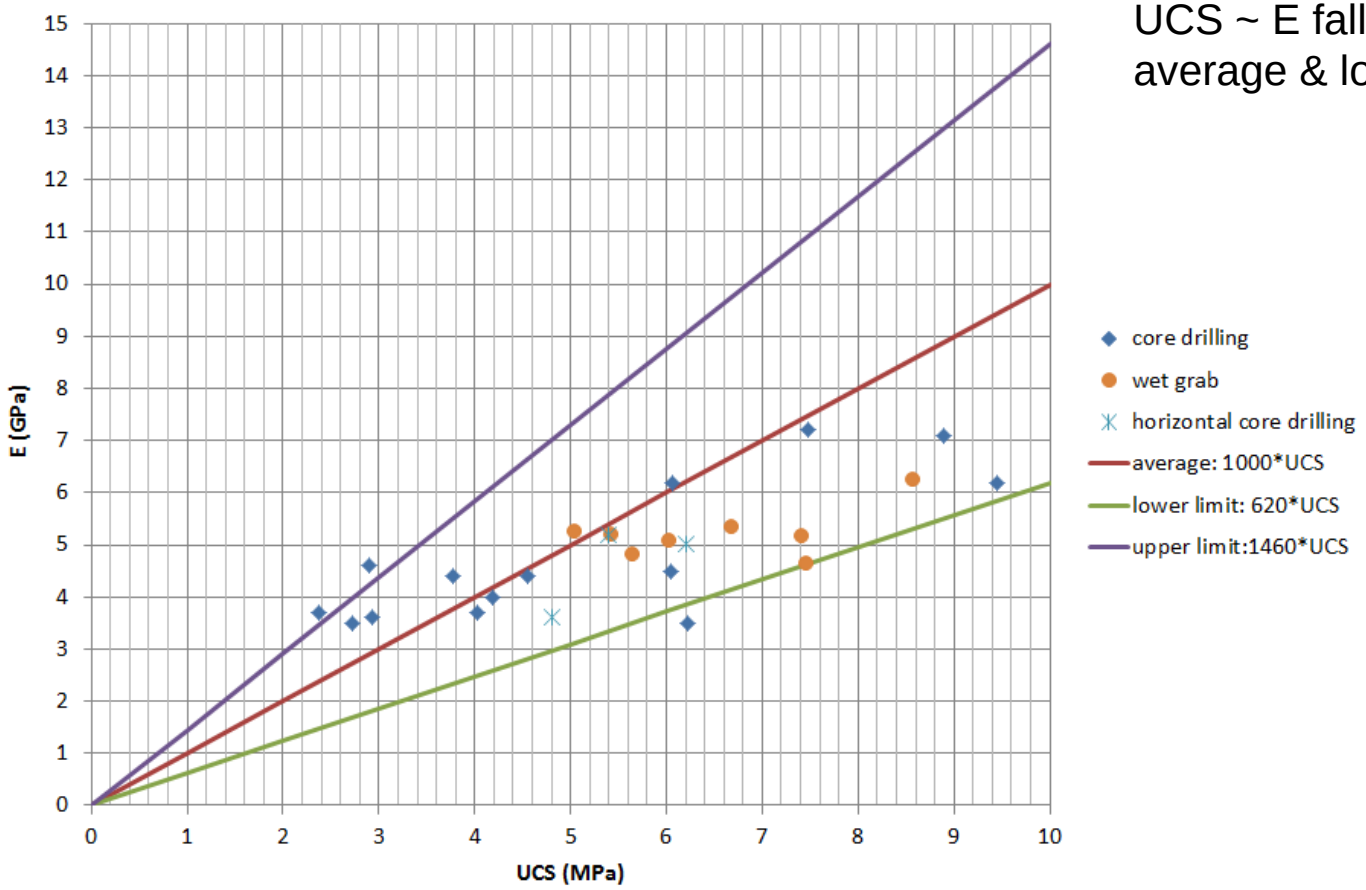
Wet grab at depth with sealed container during production

Soil mix – QC/QA

87 test results - combined methods



Soil mix – QC/QA



UCS ~ E falls within average & lower limit

Thank you for your attention!!