Canada Geo-Solutions

Soil and Groundwater Problems Solved

Liquid Shoring

Slurry-Supported Excavation for Soil Removal without Mechanical Excavation Support, Dewatering or Backfill Import/Compaction

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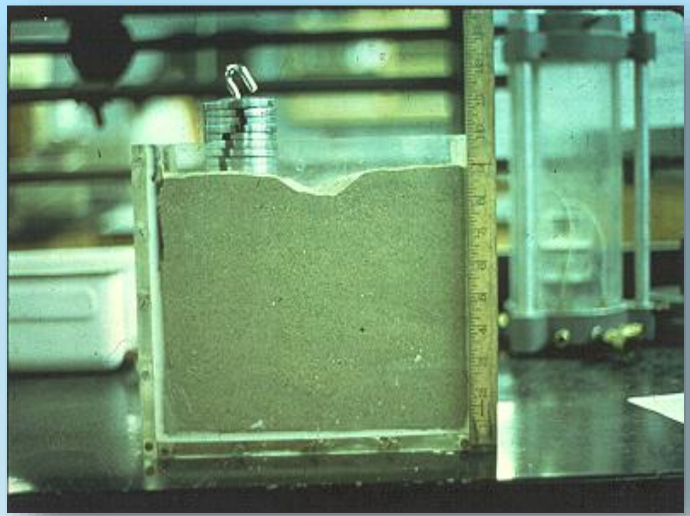
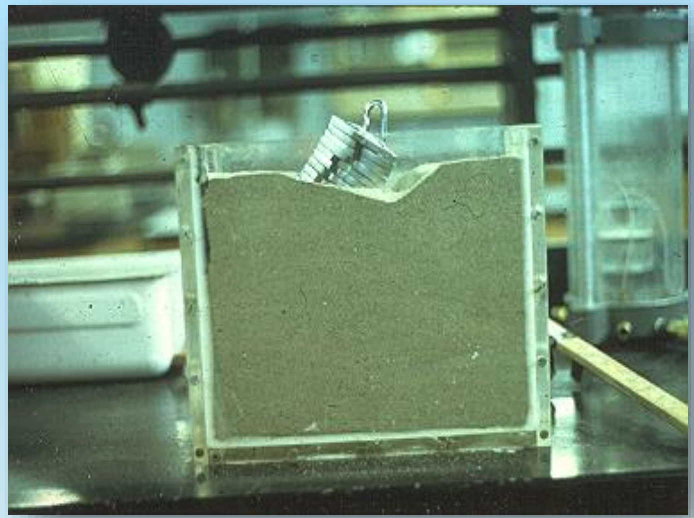
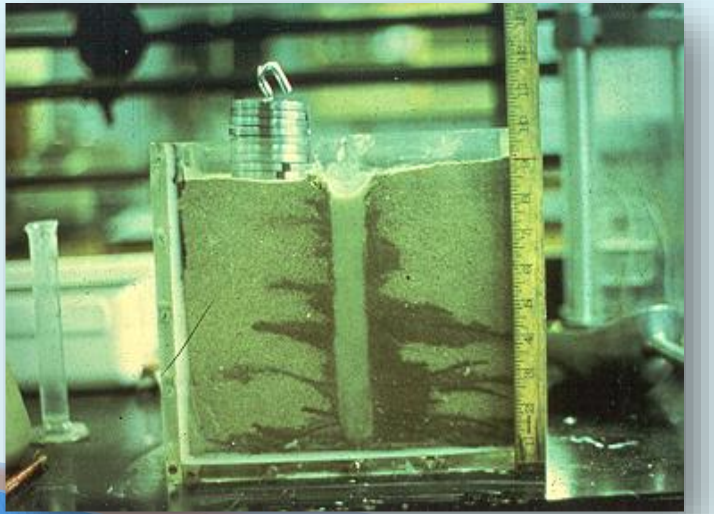
Slope-Backs, Sheeting, Secant Piles, Soil Mixing, Tie-Backs

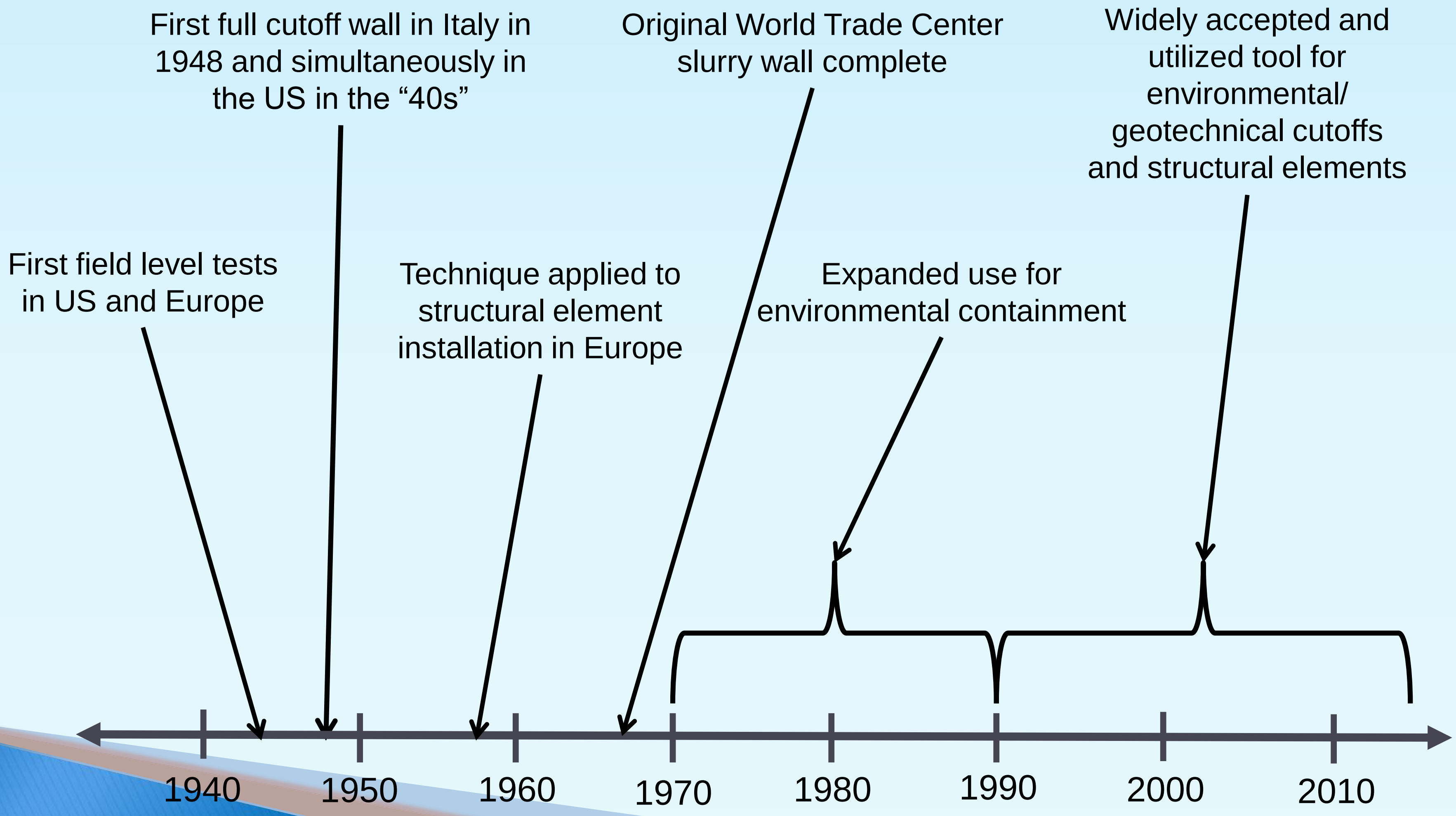
Liquid Shoring





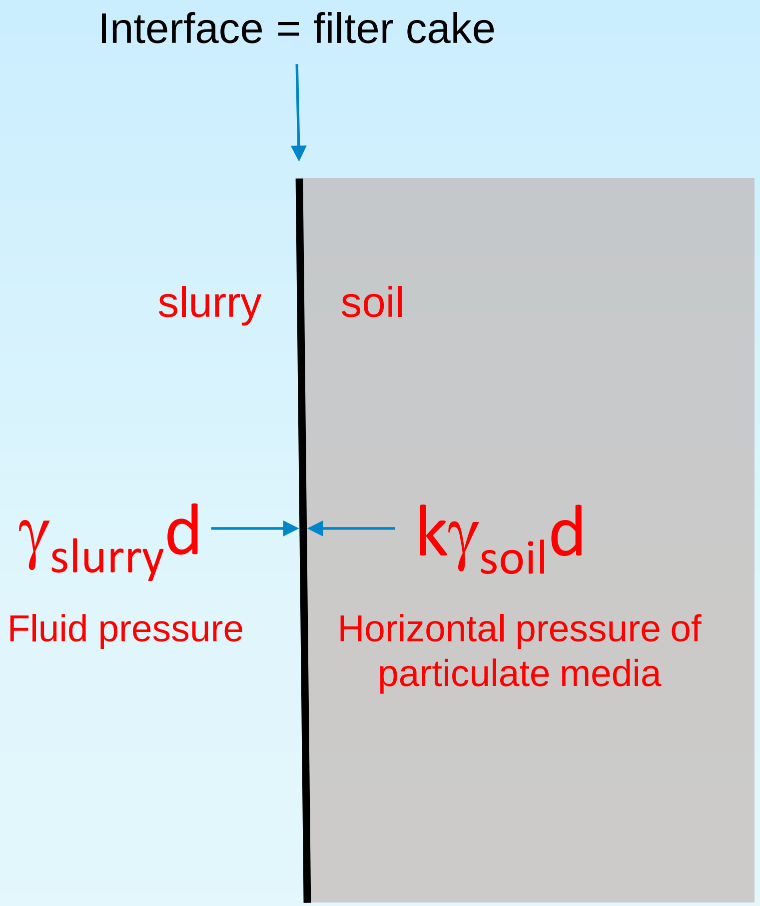


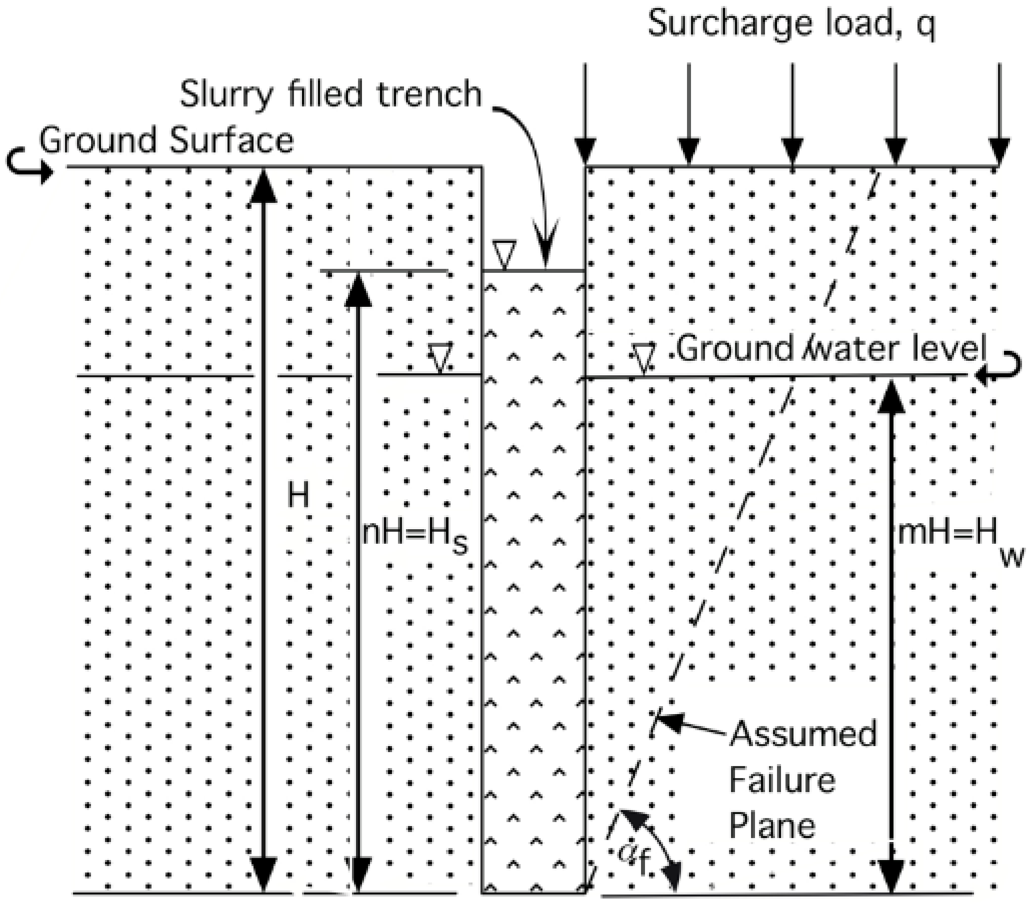
History – Slurry Walls



- Stability comes from plastering of the slurry on the trench wall (preventing soil movement), the strength of the filter cake as a membrane, the gelling and/or passive strength of the slurry, electro-osmotic forces, and the excavation geometry (bridging)

- In general (especially in long trenches in granular material) the lateral hydrostatic **pressure** of the slurry is the **most important stabilizing force** (Fitz, 2004).





$$F = \frac{2\sqrt{B}}{B-1}\tan\phi$$

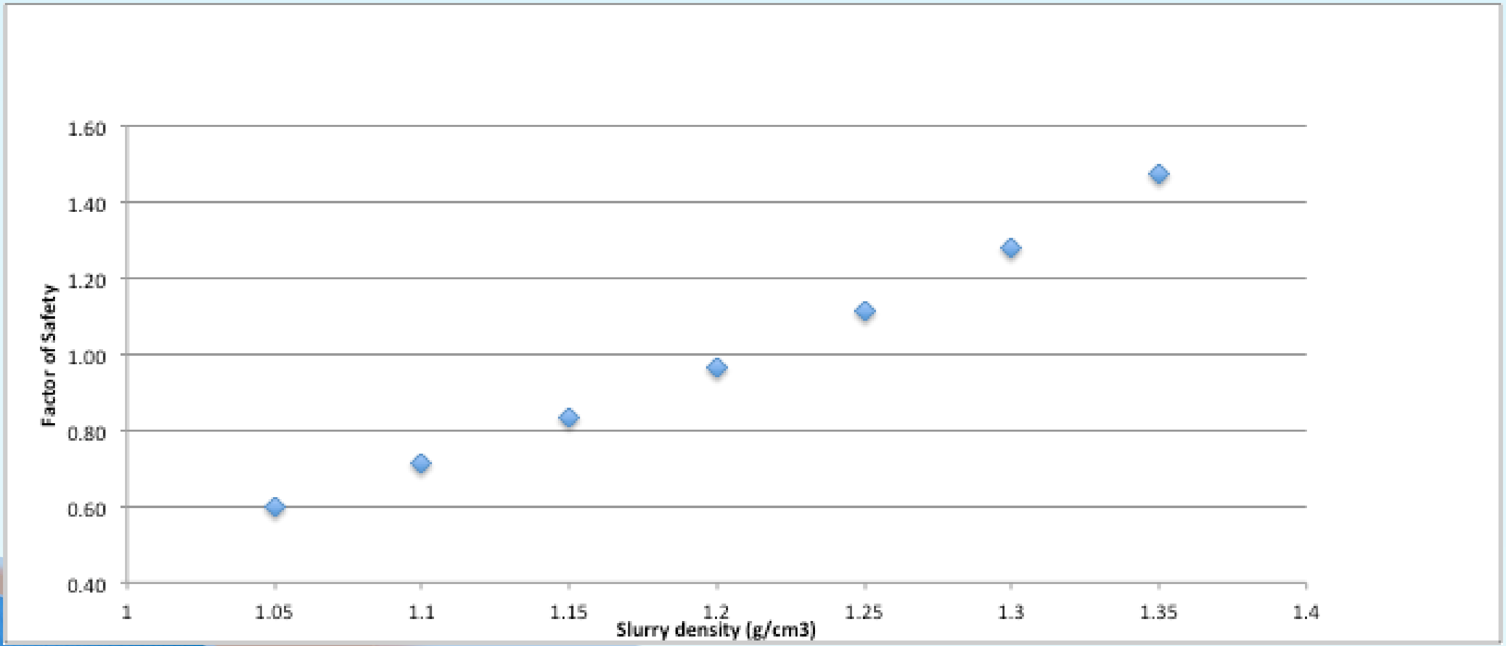
$$B = \frac{2q + H\left[\left(1-m^2\right)\gamma_m + m^2\gamma'\right]}{H\left(n^2\gamma_s - m^2\gamma_w\right)}$$

F = safety factor
ϕ= angle of internal friction
B = dimensionless stability index
q = surcharge stress
H = depth of the slurry trench
$m = H_w/H$ *where* H_w *is the ground water level*
$n = H_s/H$ *where* H_s *is the slurry level*
γ_m = moist unit weight of sand above the water table
γ' = effective unit weight of sand below the water table
γ_s = unit weight of the slurry

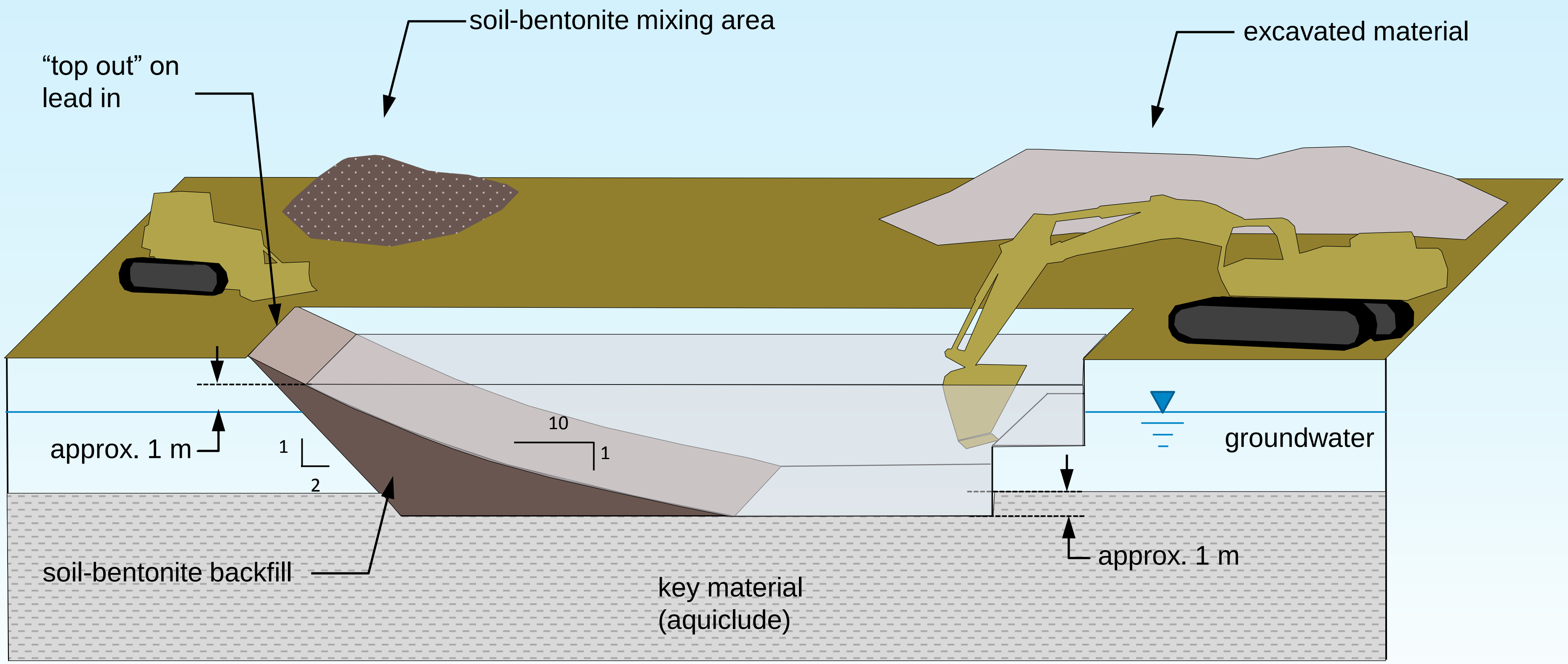
Schematic of (bentonite) slurry trench stability (Filz, *et al.,* 2004)

Under-Prediction of Stability

- 20 m deep slurry wall
- Silty, sandy site (f = 30°)
- Groundwater 2 m below the ground surface.
- No surcharge.
- Uniform sand density of 1.8 g/cm^3 the same both above and below the water table.
- Slurry level within 0.60 m of the top of the trench
- Initial slurry density of 1.05 g/cm^3 rises to 1.35 during excavation.

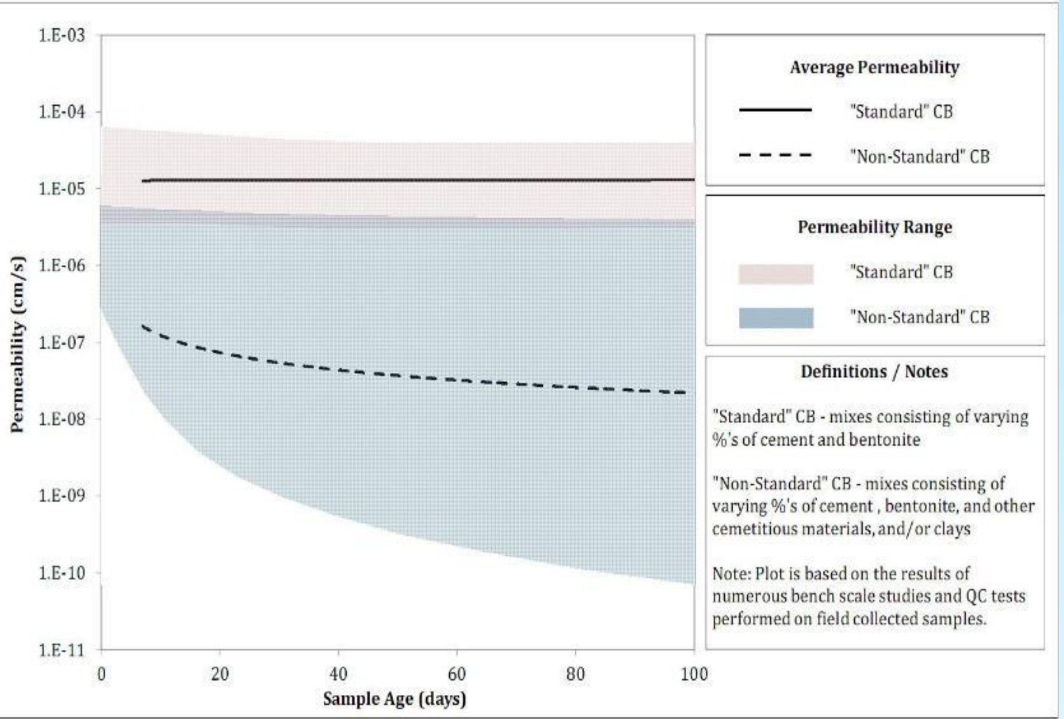


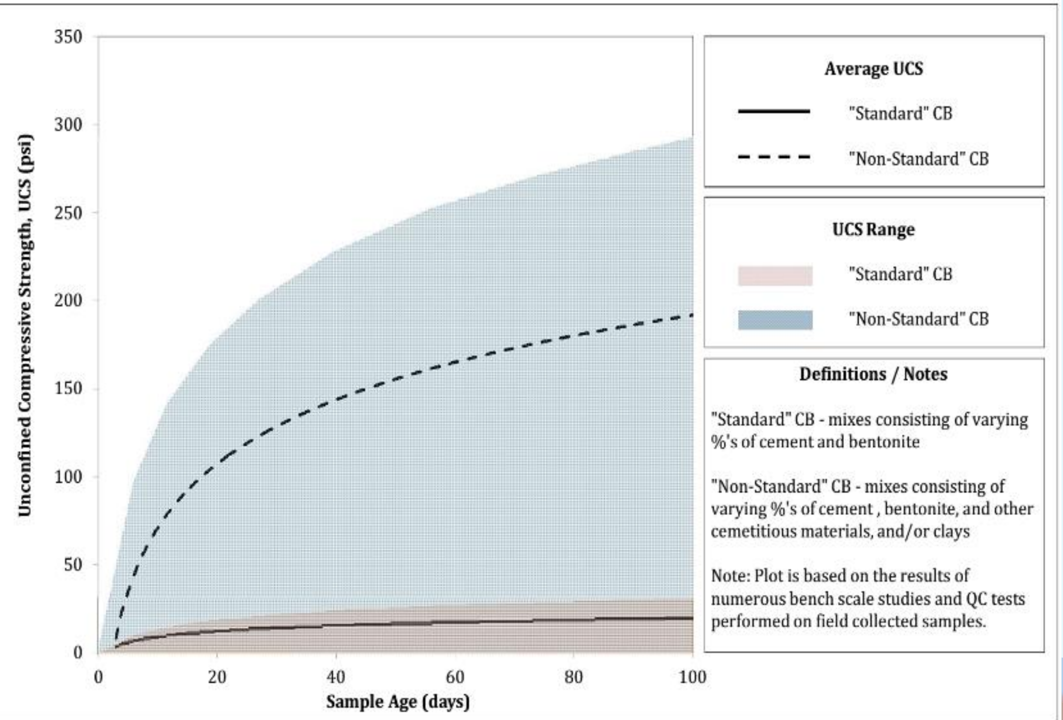
Soil-Bentonite (SB) Walls



Bio-Polymer Trench Excavation

Cement-Bentonite (CB) Slurry Walls
"One Step": Self Hardening





Cement-Bentonite

- Standard CB UCS improves somewhat over time
  - mostly complete after 28 to 56 days
- Non-standard CB (Slag Cement) improves dramatically over time
  - known improvement out to >112 days
  - Lower permeability than Standard CB

Slag-cement-bentonite

Conventional Slurry Trenching

Cement-Bentonite (CB) Dyke Repair
Kingston Fossil Plant, Kingston TN (2011 to 2013)
TVA/Stantec

- Dike failure: 4.1M m3 (5.4M cy) of coal ash released
- Slag cement-bentonite shear panels to reduce liquefaction potential of perimeter embankment + reconstruct failed sections.
- 19.2 km of slurry wall (351,000 m^2)
- 13.7 m to 19.8 m deep, Typ. 0.9 m wide.
- Target strength of 1.4 to 2.0 MPa (200 to 400 psi)
- BFSCB samples continued to cure well beyond 56 days [9 month old core sample hit 20 MPa/3000 psi (sic)]
- With the BFSCB mix used, adjacent panels cold be connected up to 21 days later before being considered a cold joint.

Slurry-Supported Excavation

Same governing principals as for slurry trenching

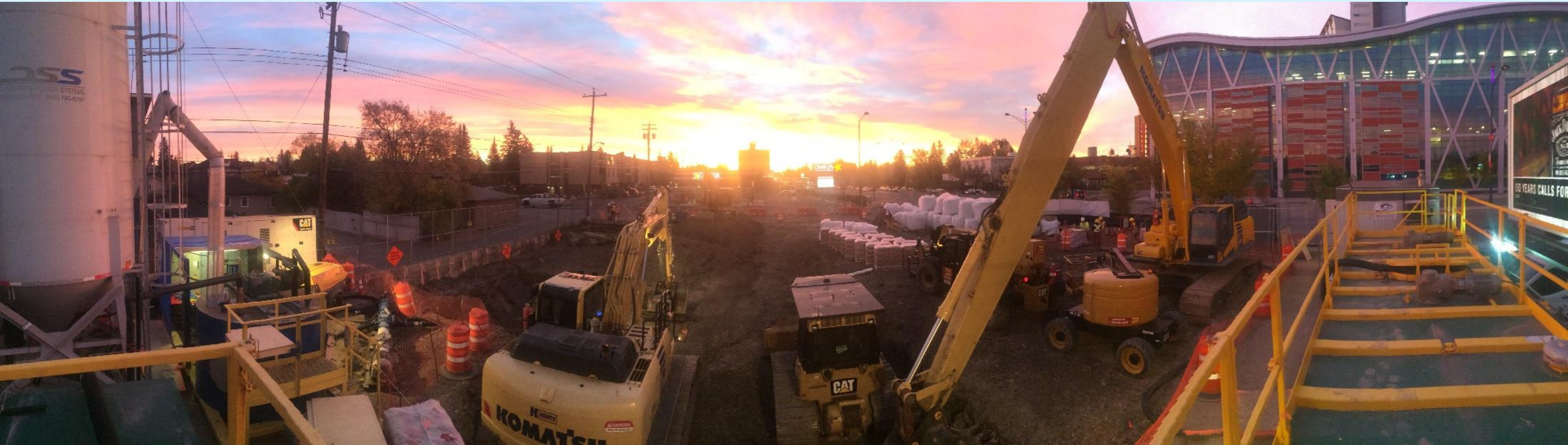
- CB slurry sets up in 1 to 2 days
- Alternate excavation cells (“piano key” or “checker board”) to avoid excavating next to fresh cell

- Added stability from geometry (squarish vs. long and thin)
- Primary limitation: keeping up with slurry loss rate

Bulk Excavation of Former Service Station

Calgary, AB (2016)

- Kleinfelder (Confidential Owner)
- Groundwater in a loose to medium-dense silty sand at a depth of 4 to 5 m
- Slot cuts overlapped to create slurry-supported cells ("piano keys") up to 649 m^3
- 2 days allowed for slurry set up
- 10,232 m^3 excavated from up to 12 m below the work platform (13 m total)
- Cured slurry target of >276 kPa UCS and $<1x10^{-7}$ cm/s.
- On selected samples, UCS testing was continued out to 35 days and hydraulic conductivity testing was continued out to 56 days: maximum observed UCS of 869 kPa; minimum observed conductivity of 7.0 x 10^{-9} cm/s.



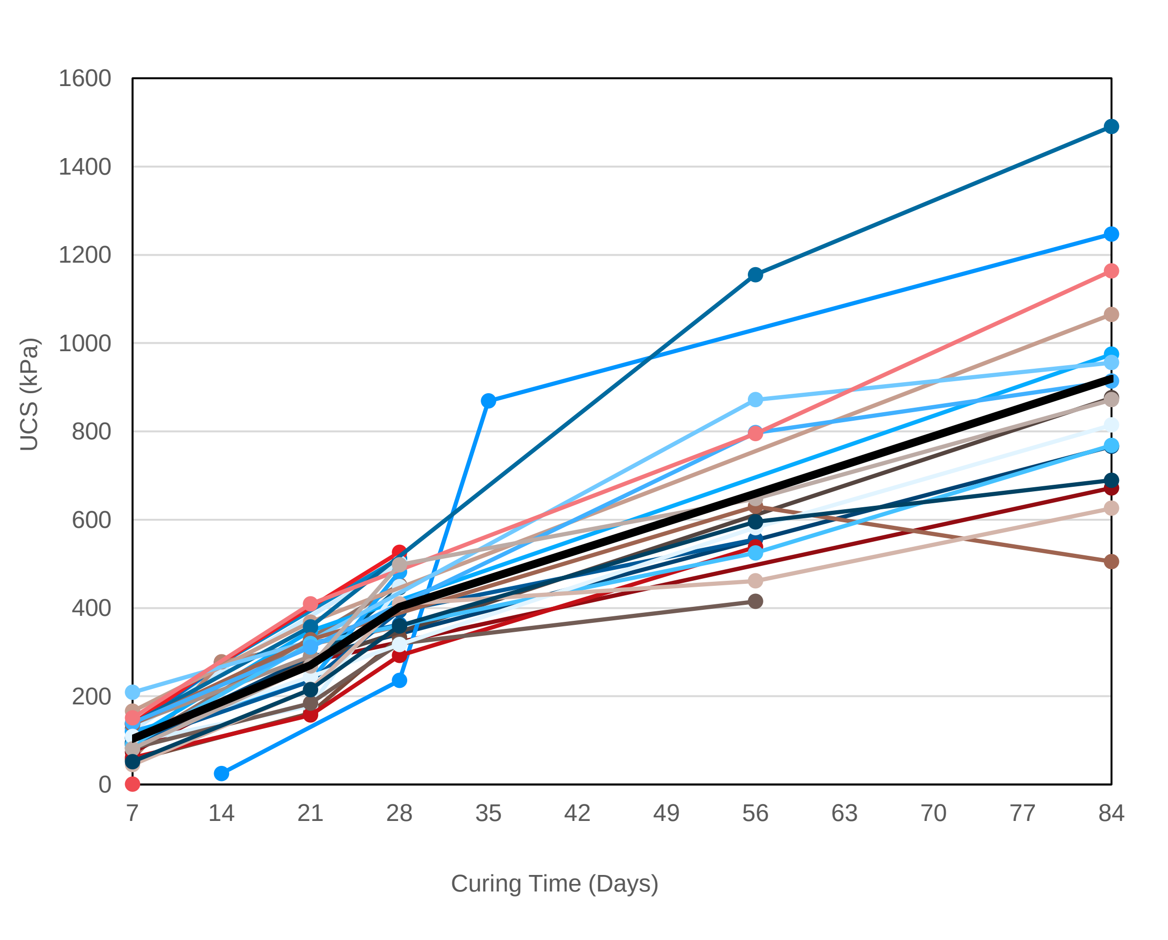
Lots of Slurry =
Lots of Water

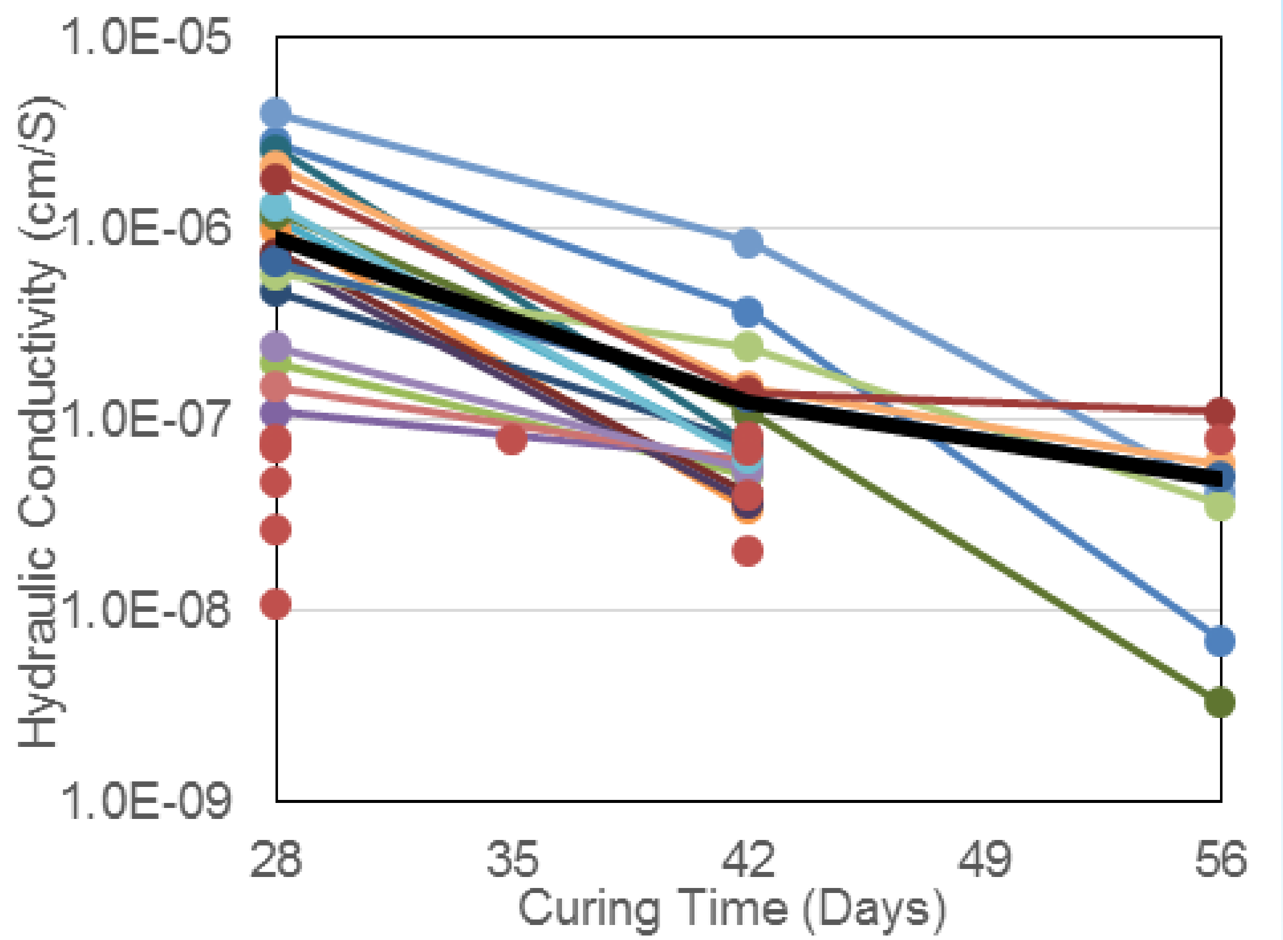
Salvage Clean Material

Remove Obstructions & “Drain Holes”


CAT
314E L CR
FINNING
DANGER
DANGER
OVERHEAD
POWERLINES


KOMATSU
CAT


UCS (kPa)
1600
1400
1200
1000
800
600
400
200
0
7 14 21 28 35 42 49 56 63 70 77 84
Curing Time (Days)


Hydraulic Conductivity (cm/S)
1.0E-05
1.0E-06
1.0E-07
1.0E-08
1.0E-09
28 35 42 49 56
Curing Time (Days)

- “Dig-able” even at relatively high UCS
- Attractive kryptonite colour fades with curing

- Saturated soil
- Entrained slurry
- Slow set
- Vibration


KOMATSU
CAT

CB Slurry Excavation

Technical papers, case studies, specifications:

http://www.geo-solutions.com/technical-papers

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Reach Further