



CN King Road Grade Separation -

Case 2 Micropile Networks

(Workshop Paper # 24)

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Matthew Janes

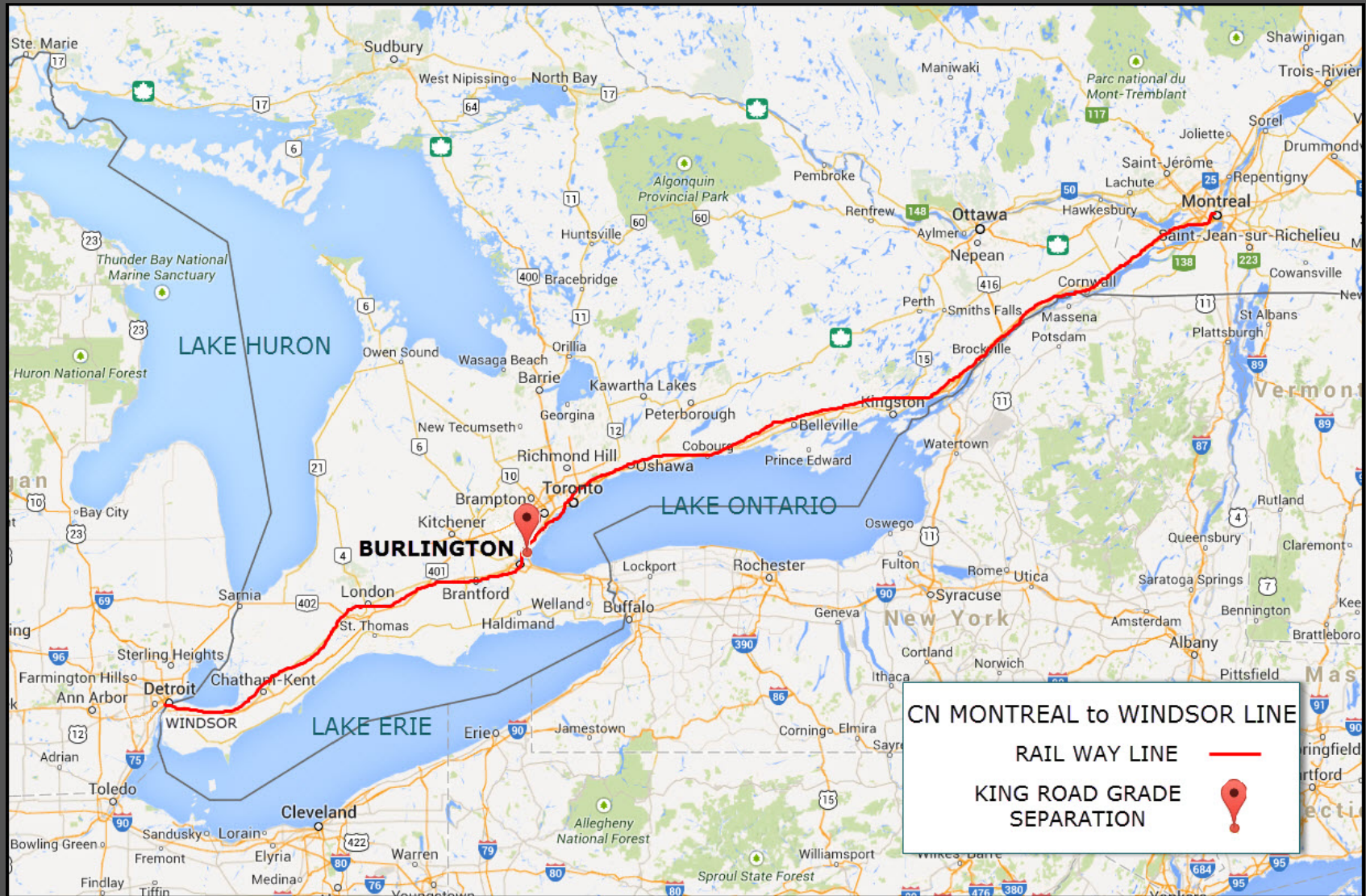


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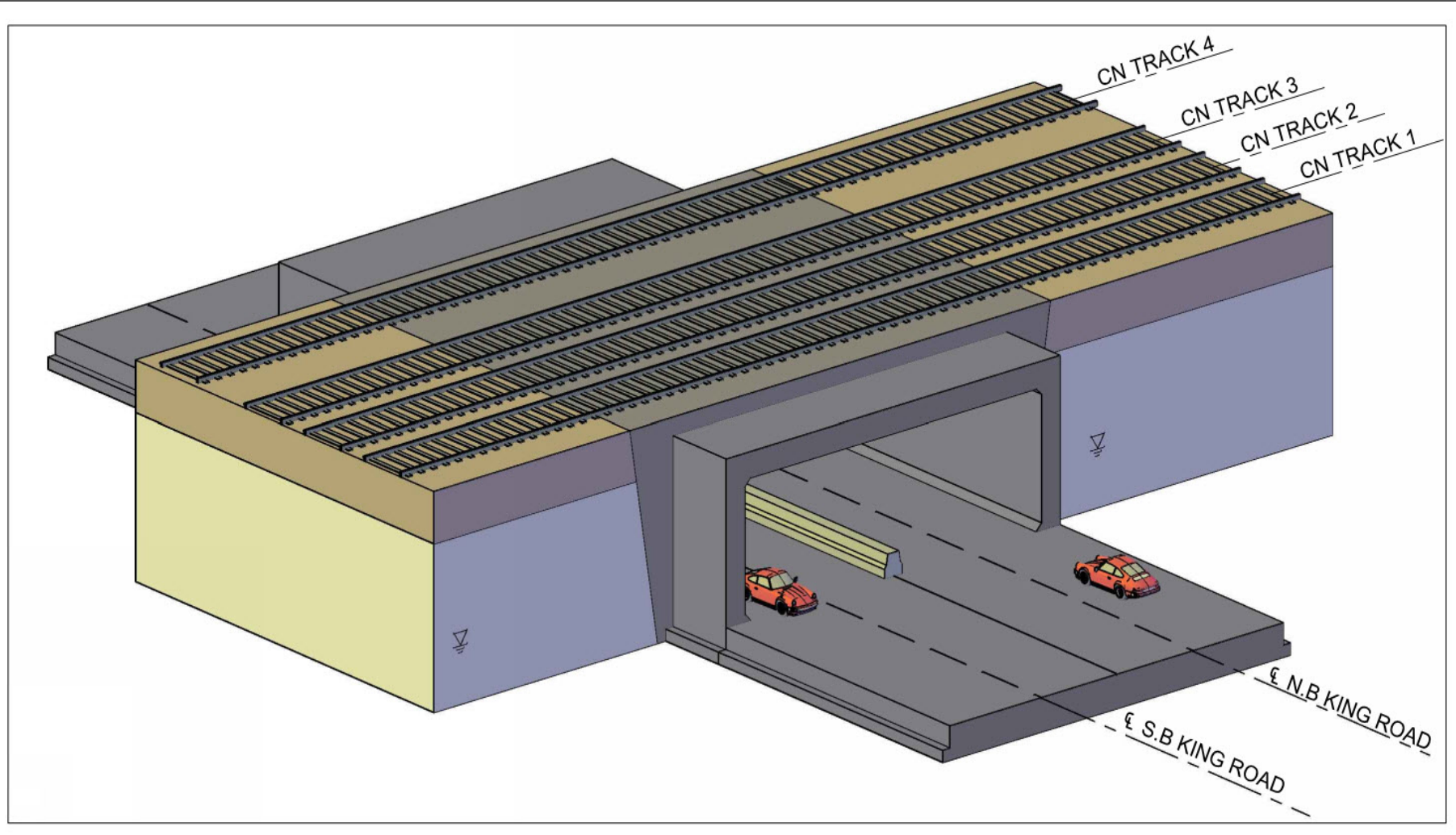
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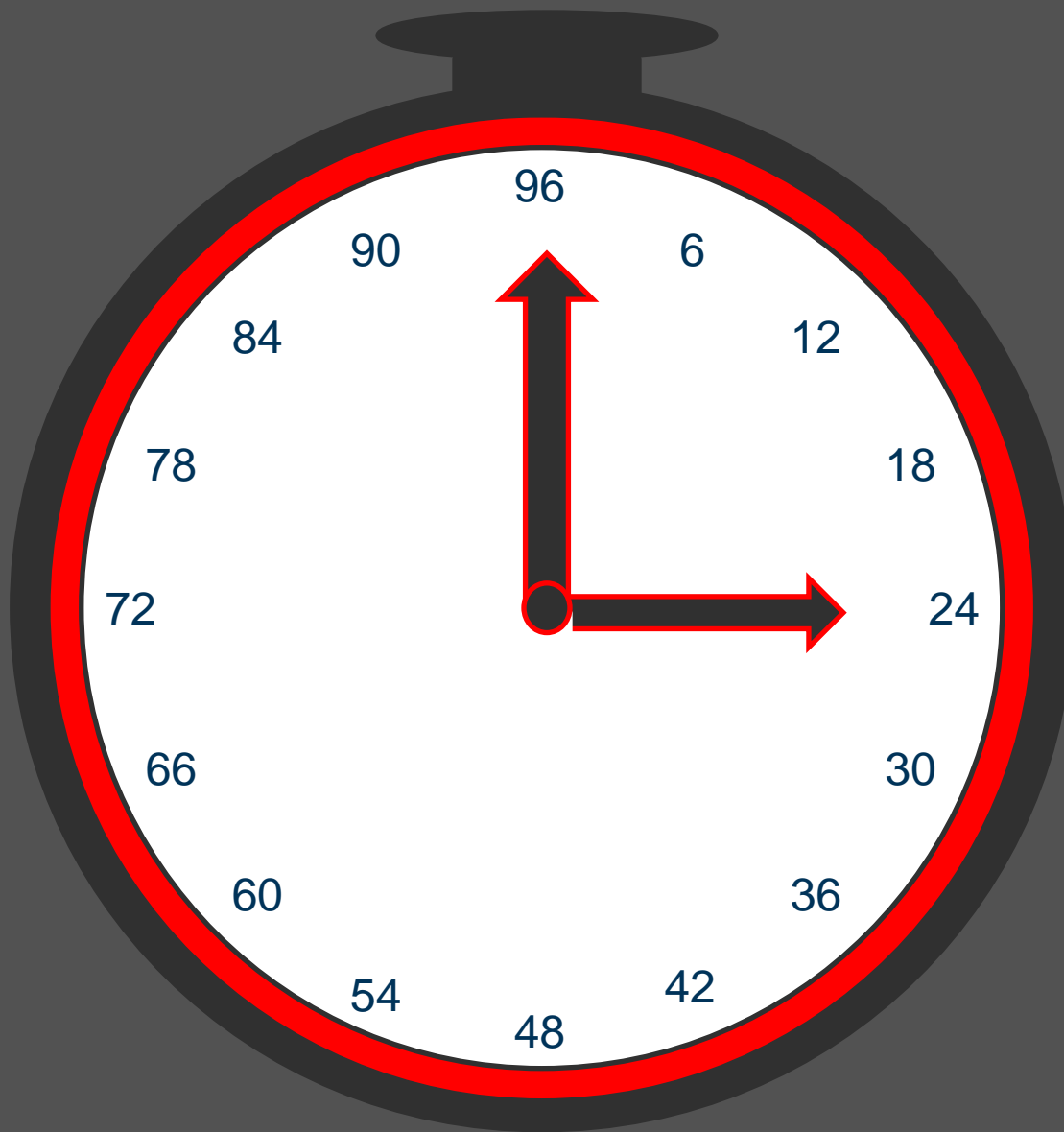
Burlington, Ontario, Canada



Rapid Excavation / Tunnel Push



Owners: CN & City of Burlington

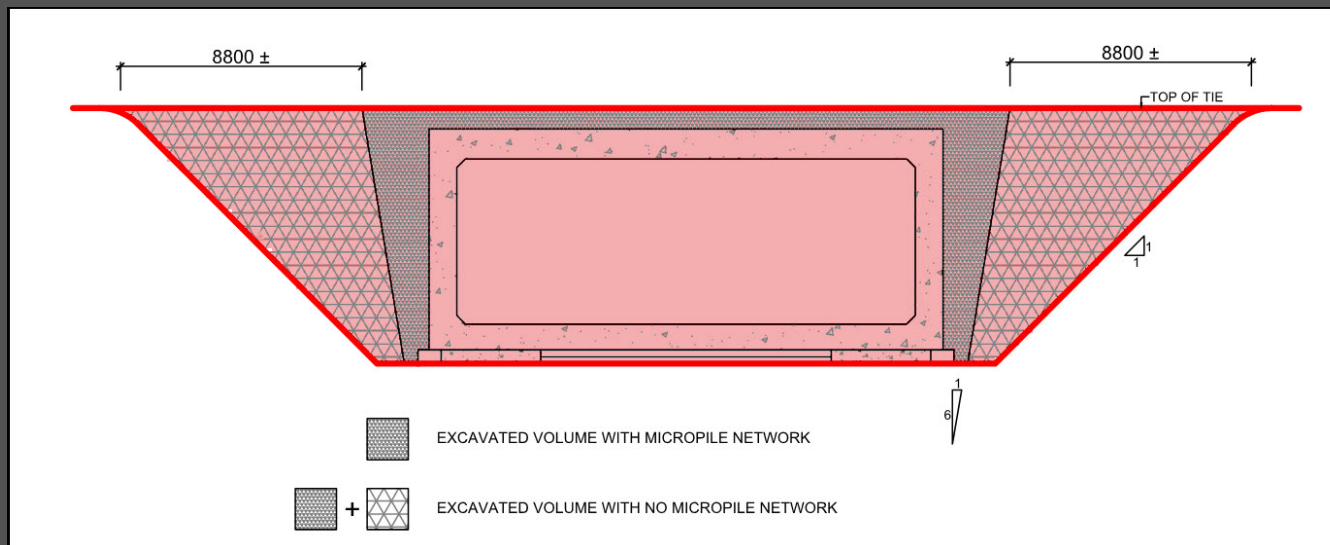


The problem:

- ◆ 5 m cut through high groundwater / thick sand layer, with known problematic dewatering
- ◆ Busy rail corridor (4 tracks; freight, passenger, commuter)
- ◆ Busy road traffic crossing
- ◆ Down time at a premium
- ◆ Numerous limitations to viable excavation support options

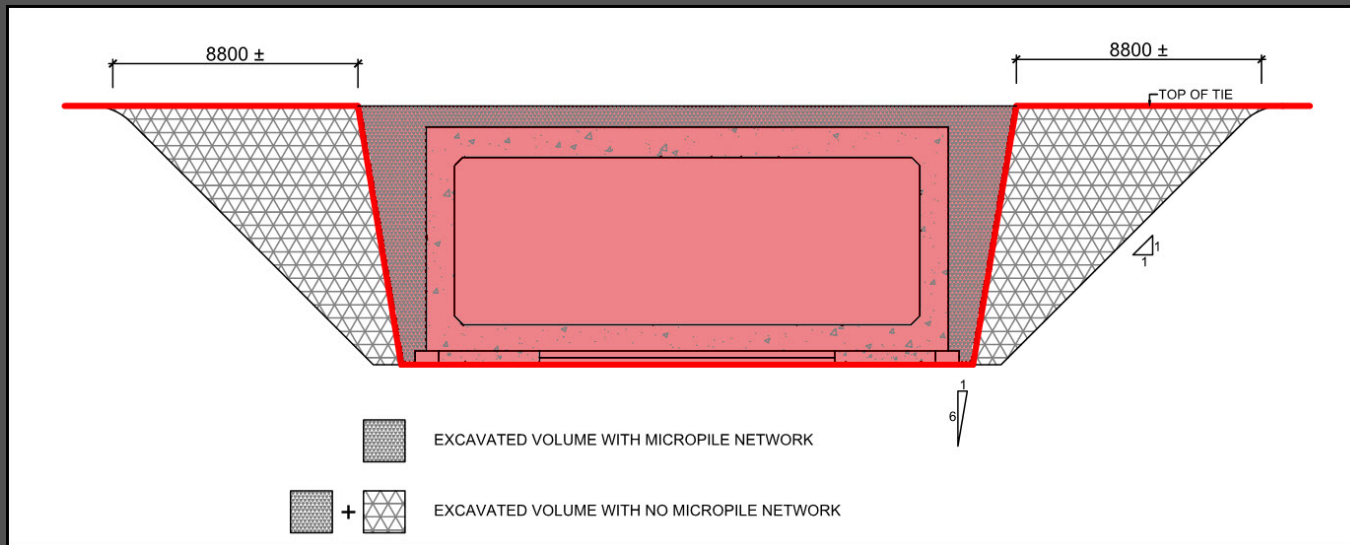
Two options:

- ◆ Option 1: open cut excavation
 - Longer duration
 - More volume of soil to cut
 - More volume of soil to backfill
 - Much more track and ballast to remove and replace (remember, 4 tracks)
 - Added risk of slope stability due to ground water



Two options:

- ◆ Option 2: excavation support
 - Would enable shorter excavation duration
 - Less volume of soil to cut
 - Less volume of soil to backfill
 - Much less track and ballast to remove and replace (remember, 4 tracks)
 - Reduced risk of slope stability due to ground water

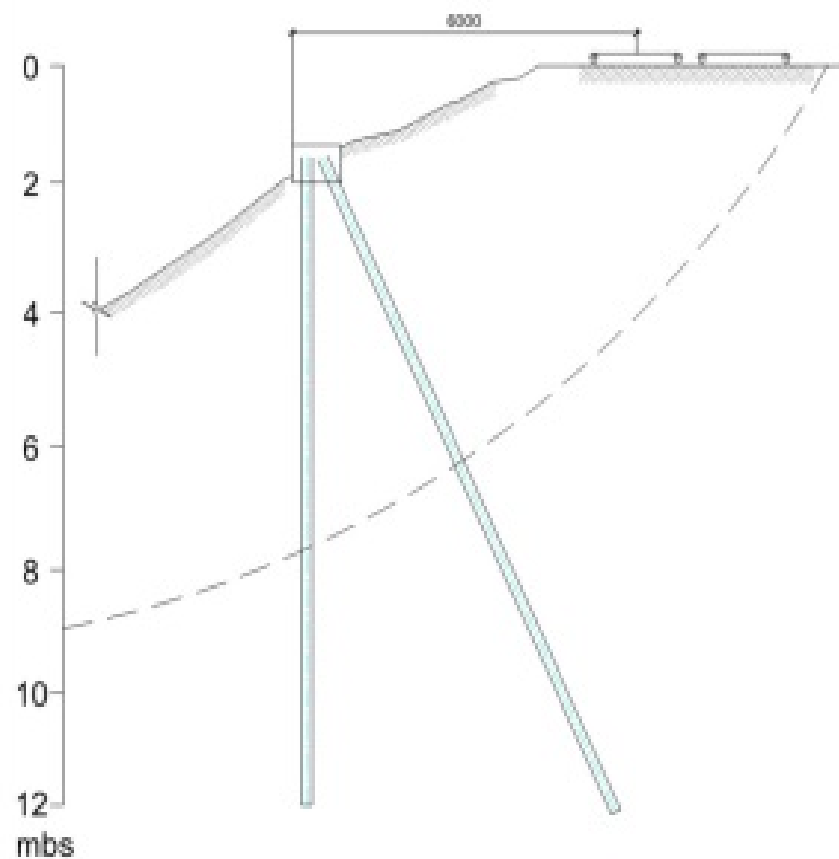


Excavation support: the constraints

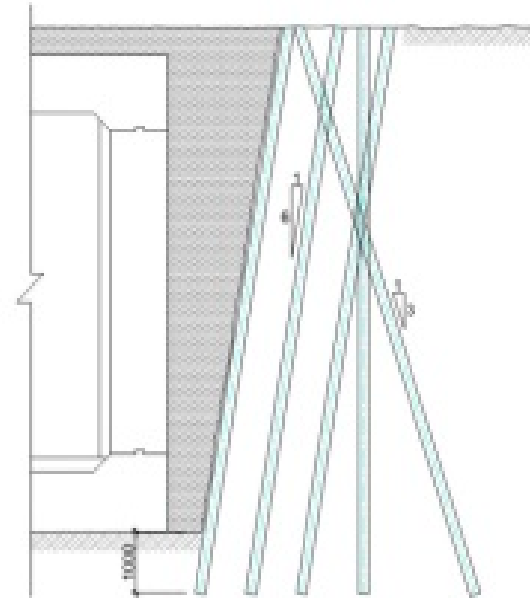
- ◆ Only opportunity to work was during brief (5 hour) night time windows in rail traffic (with one lane of roadway kept open to automobile traffic)
- ◆ High tolerance for movement, but excavation support had to be completely constructed prior to commencement of excavation
 - Walers, internal bracing, tie backs, shotcrete facing, ALL ruled out

The solution: Case 2 micropile networks (one per slope)

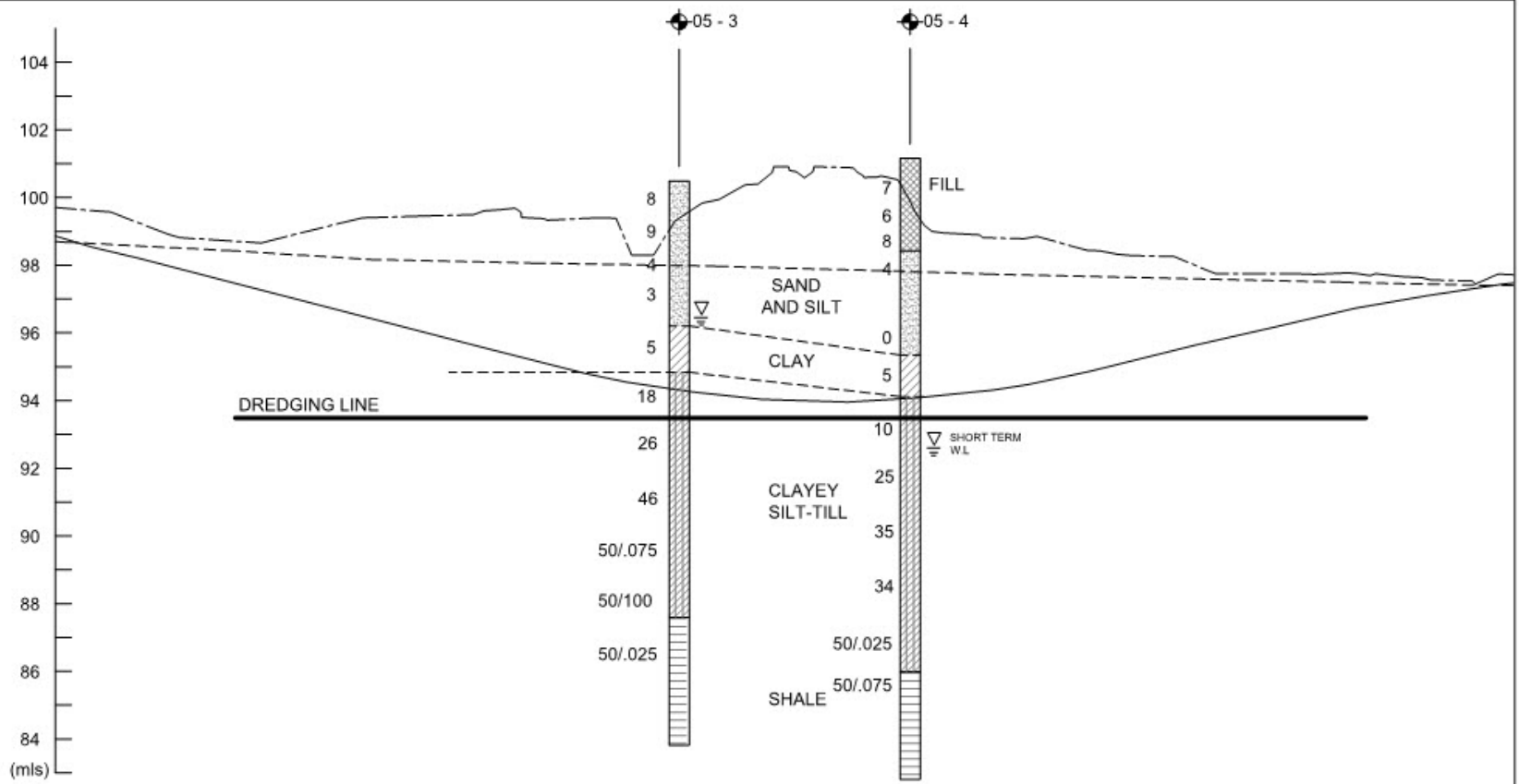
- ◆ Grout-flushed 40/20 hollow bar
- ◆ All work completed during brief (5 hour) night time windows in rail traffic
- ◆ Small, nimble equipment able to operate alongside rail and road traffic



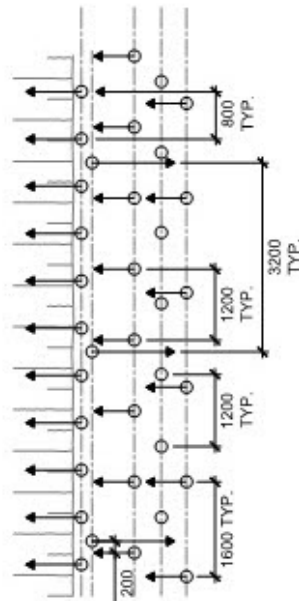
CASE 1 EXAMPLE



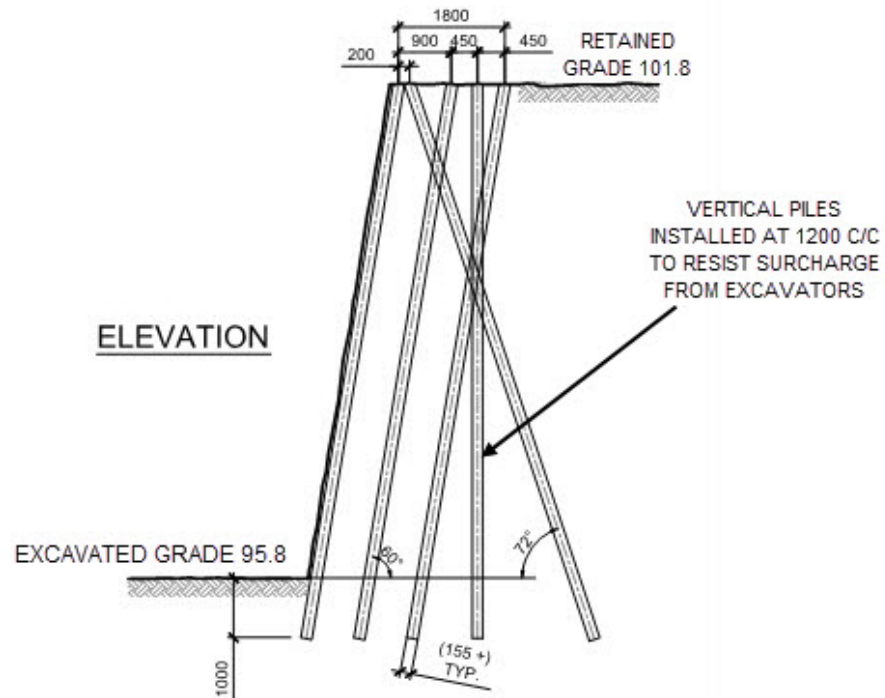
CASE 2 EXAMPLE



PLAN



ELEVATION







Design approach:

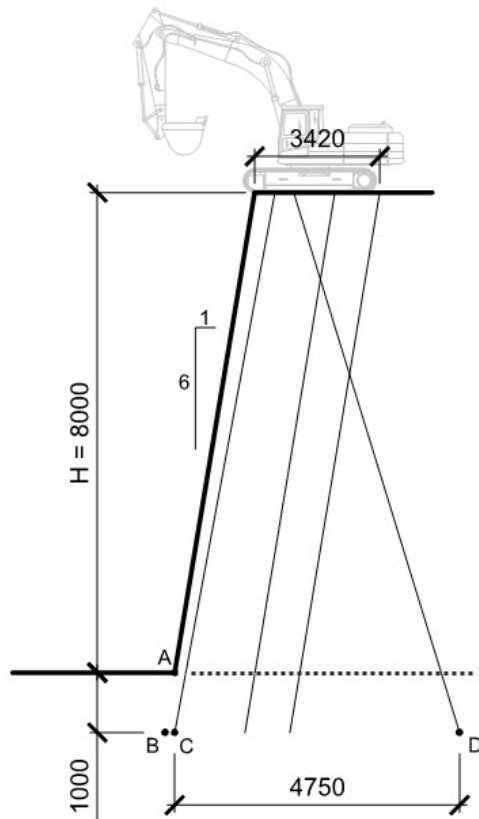
- ♦ the design and stability analysis is based on the micropiles forming a reinforced soil mass which is similar to a dam. The matrix is analysed for plastic deformation of the soils between the micropiles and the structural failure of the micropile in either compression/ tension or shear. The driving force is simply that anticipated by Rankine or Coulomb wedge failure theory. Analysis of the face support or stability is generally empirical. The soil will arch between the exposed micropiles with varying effectiveness based upon grain size, grain size distribution, cohesion and moisture content. The changing nature of the soil upon continued exposure must be evaluated, as well as the effects of exposure on intended face performance. For example, the soil might be expected to effectively arch but spall – such a scenario would be acceptable in terms of structural performance but unacceptable for worker entrance to the base of the cut face.

$$\gamma = 21 \text{ kN/m}^3$$

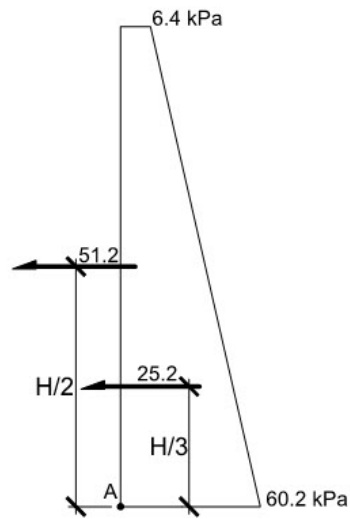
$$\phi = 31^\circ$$

$$K_a = 0.32$$

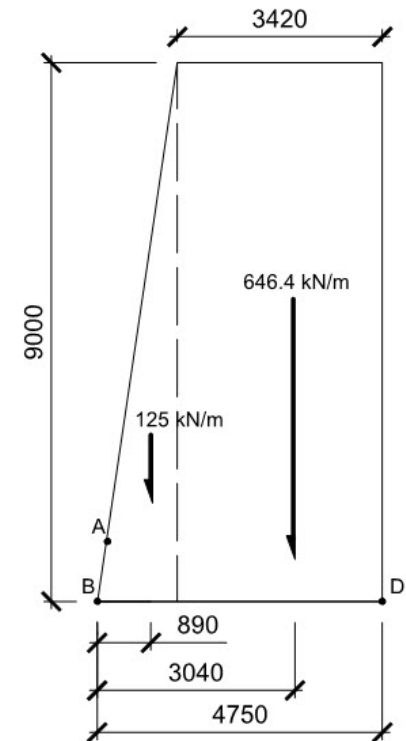
$$P_{\text{surcharge}} = 20 \text{ kPa}$$



STABILIZED BLOCK



DRIVING FORCES



RESISTING FORCES

Resistance to sliding from:

- ◆ Base shear at the horizontal plane coincident with the micropile tips
- ◆ Not from toe embedment like a Case 1 structure

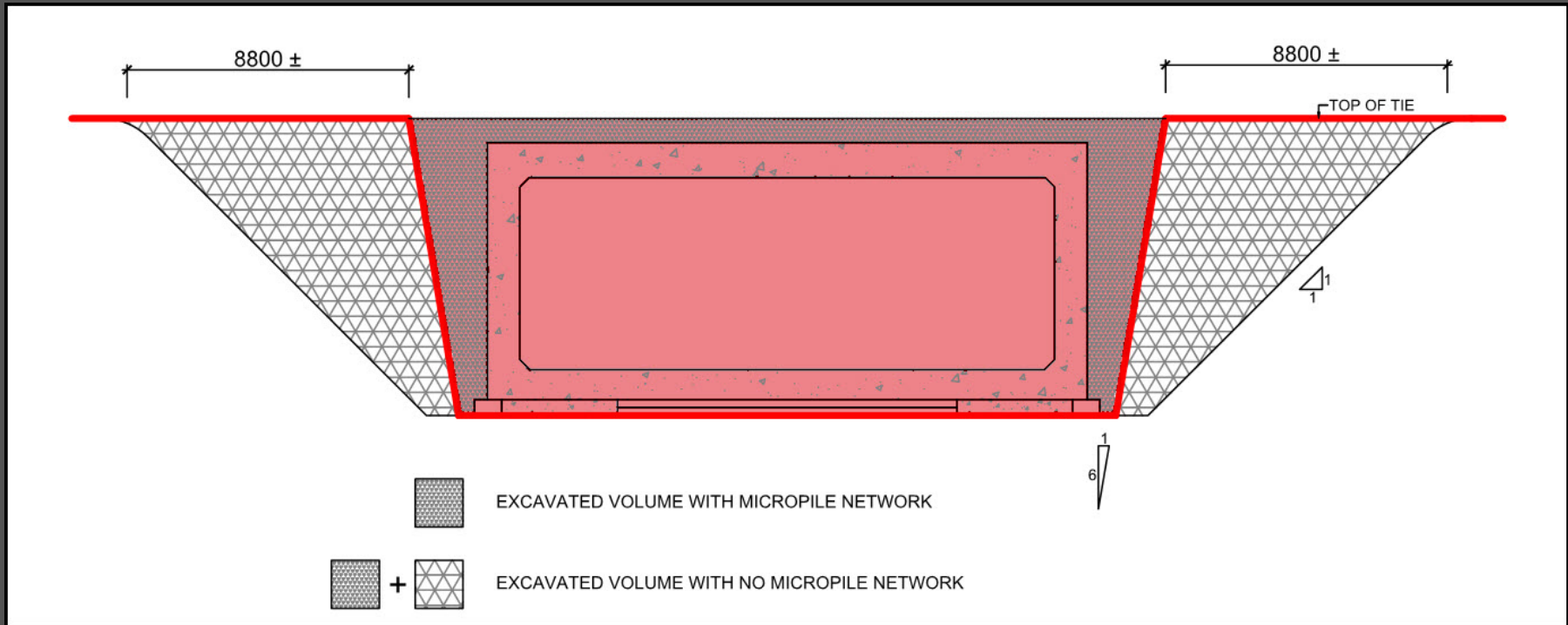
Resistance to overturning from:

- ◆ Gravity mass bounded by slope face (in front) and vertical plane coincident with the tip of the back raked micropiles
- ◆ Self-weight of entire soil mass (soil plus piles)
- ◆ Bearing resistance acting over entire footprint
- ◆ Not from deep anchorage into soil beyond the active wedge (like a Case 1 structure)

Testing and inspection

- ◆ Test section dug and exposed for 10 days
- ◆ Inclinatorometer not installed

We've seen what was supposed to happen



Now for what actually happened ...



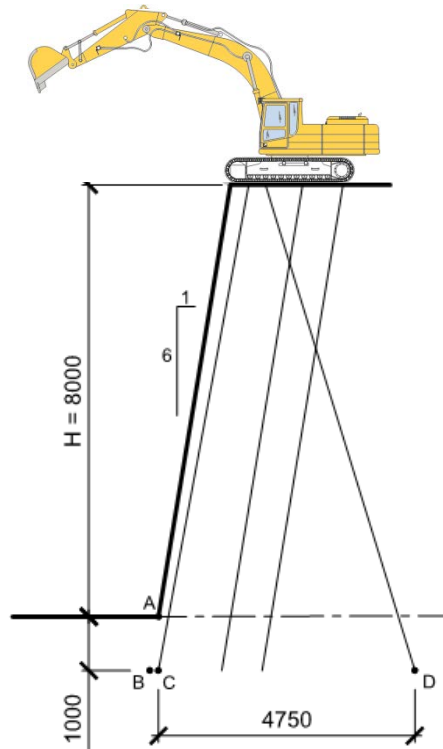




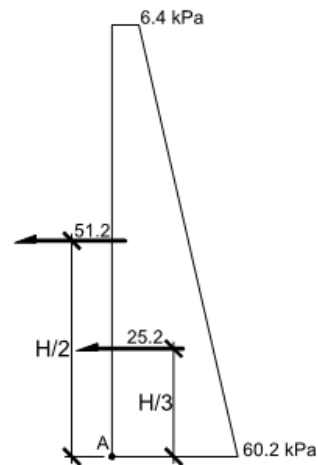




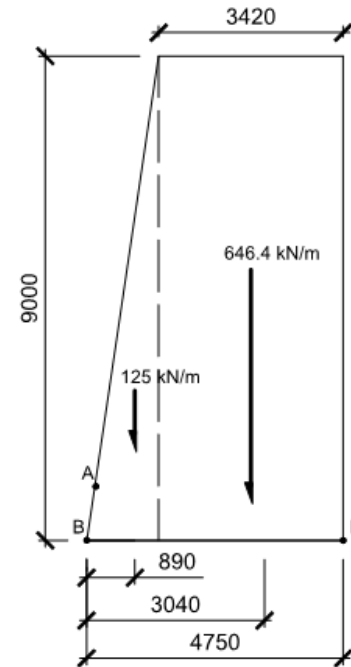
$$\begin{aligned}\gamma &= 21 \text{ kN/m}^3 \\ \phi &= 31^\circ \\ K_a &= 0.32 \\ P_{\text{surcharge}} &= 20 \text{ kPa}\end{aligned}$$



STABILIZED BLOCK



DRIVING FORCES



RESISTING FORCES

Concluding Remarks

- ◆ Case 2 structure proved useful for supporting large excavators during first stages of the shutdown
- ◆ Cost of this solution not favourably comparable to other methods, but much more constructable (ahead of time within the rail corridor, and requiring no pre-stressing / facing / bracing) compared to every other method
- ◆ They may have destroyed the micropile networks, but the client was very happy with the work!

Thank you

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