



ISM 2019

AN APPROPRIATE METHOD FOR CONSTRUCTING DEEP FOUNDATIONS THAT MUST PENETRATE ARTESIAN AQUIFERS (A bigger problem than you may realize)

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Throughout history, these two equations have counted as immutable truths:

1. You mess with the bull = you get the horns
2. Penetrate an artesian aquifer = YOU'RE IN



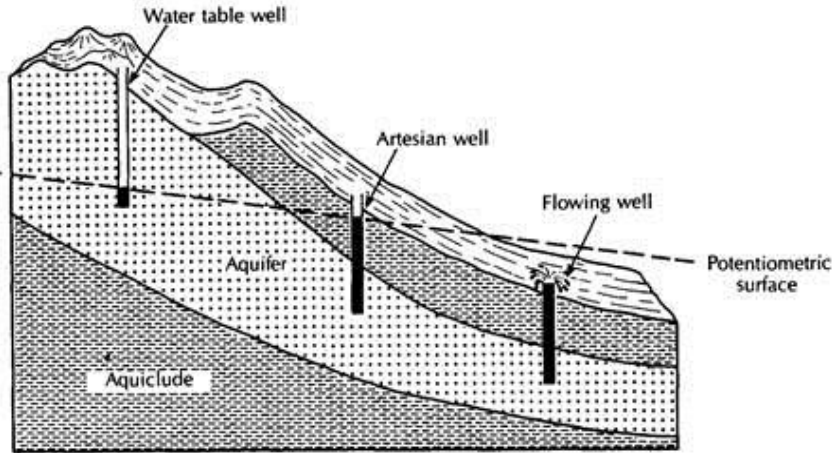
BIG TROUBLE!

(Whether you realize it or not)

Overview of today's presentation

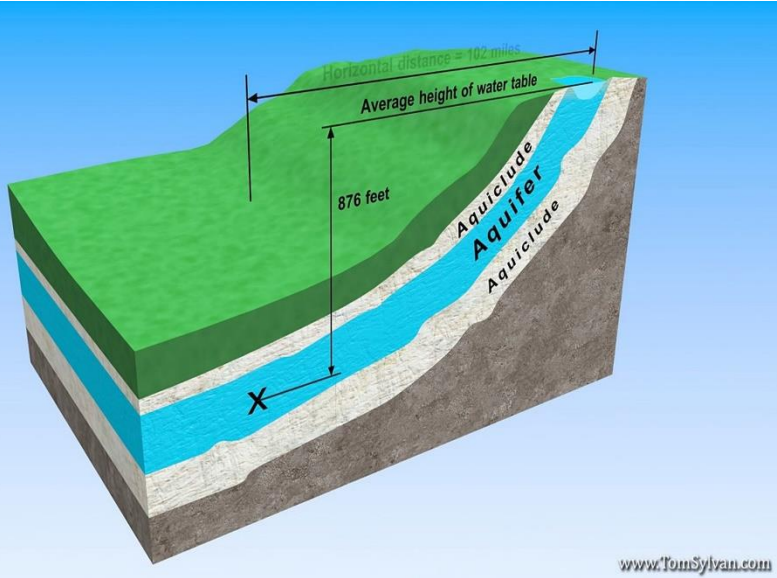
- Artesian aquifers 101: The Basics
- Artesian aquifers 201: Deep Foundations and Artesian aquifers (More often than not, strange bedfellows)
- Hydrogeology 301: Punching holes through the confining layer of an artesian aquifer – why so much trouble?
- Small-Diameter Drilling Construction 201: Continuous-Grout-Flush Method - basics
- Micropiles 301: Application of the Continuous-Grout-Flush Method as it relates to deep foundation construction (Why it Works at Artesian aquifers)
- Micropiles 301(cont'd): Why/How Grout-Flush works for taming Artesian Aquifers
- Case Study / Verification – Richmond Hill GO Station – Full magnitude tension load test performance analyzed
- Conclusions (Hint: It's all about the apertures)

Artesian Aquifers 101



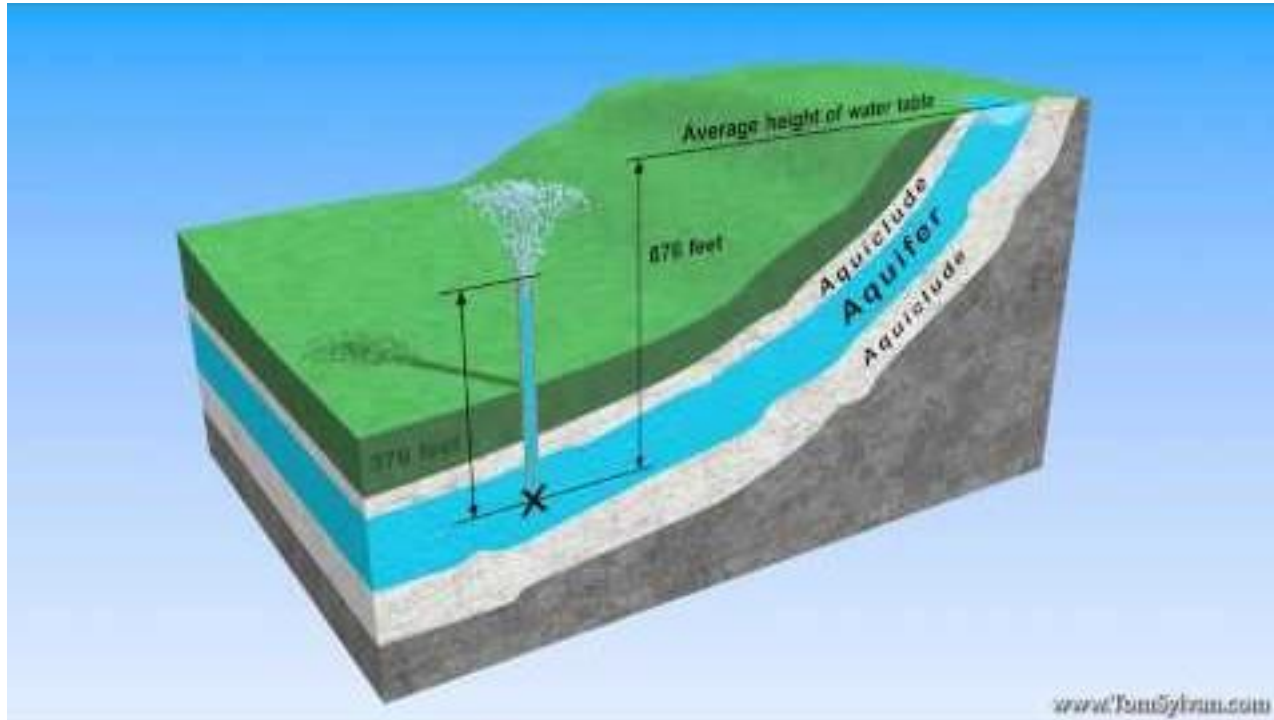
- Aquifer is confined (ie. **Capped and underlain** by impermeable soil or rock confining layer)
- Aquifer contains groundwater under positive pressure (Infinite recharge from a source at a higher elevation)
- Examples: springs, spring-fed lakes and ponds, quick sand (in rare cases)

Hydrogeology 301 / Artesian Aquifers 101



- Deep foundation installation, **done incorrectly or haphazardly**, will likely induce: an upward movement of the underground water potentially resulting in, **erosion, instability, and ground settlement (!!!)** **But Why?!?**

Why? : Apertures, Apertures, Apertures!





Artesian Aquifers 301

Problems with conventional deep foundations

- Installation can lead to apertures forming at interface between pile shaft and soil mass
- Apertures provide the opportunity for pressure relief of aquifer
- Pressure relief occurs in the form of flow
- Flow can lead to erosion ... continued flow leads to transport



Transport leads to...

Loss of bearing...

Settlement and....



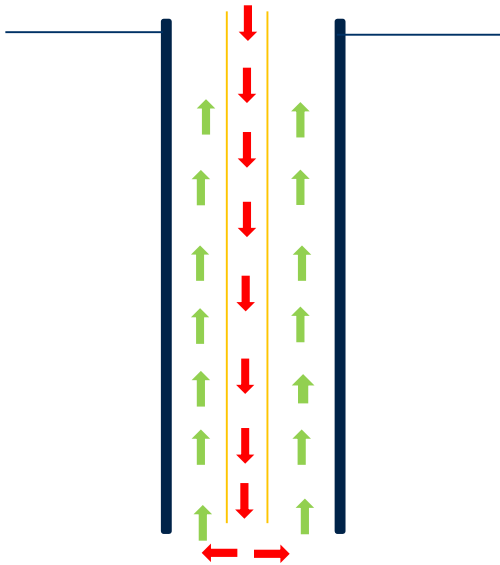
SINKHOLES!!!



Now let's change gears....

But what makes micropiles so darn awesome for punching into artesian aquifers?

All the benefits derived from CIRCULATION DRILLING

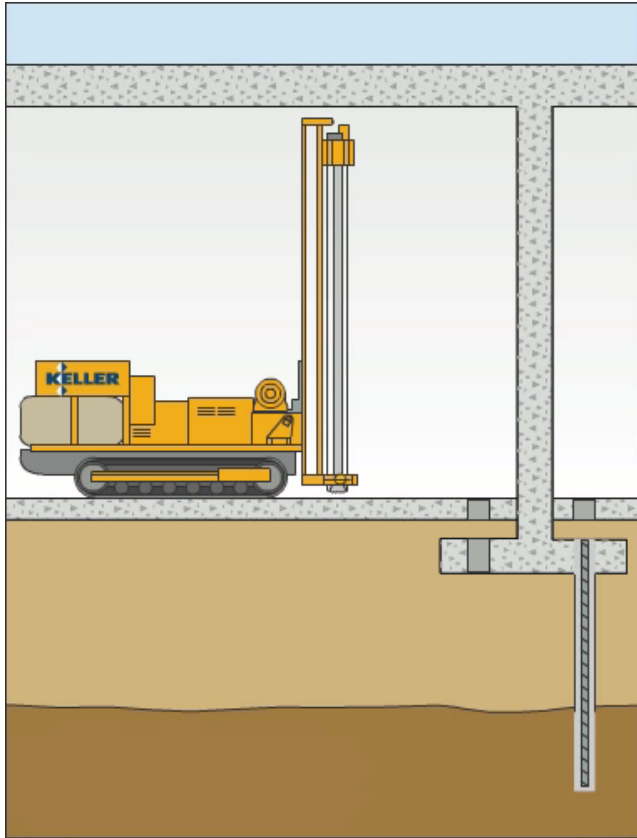


Circulation fluid:

- Aids in hole-making via erosion at the cutting face
- Flushes the cuttings up and out of the hole
- Actuates the down-hole hammer before taking on erosion and flushing roles

Micropiles – circulation drilling

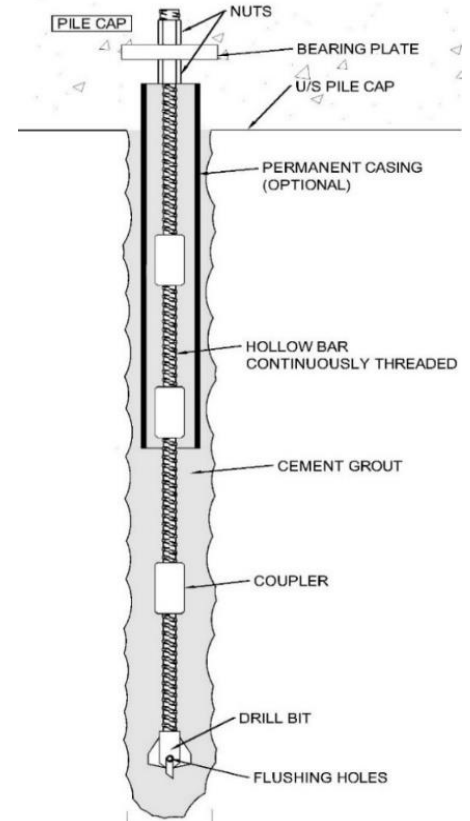
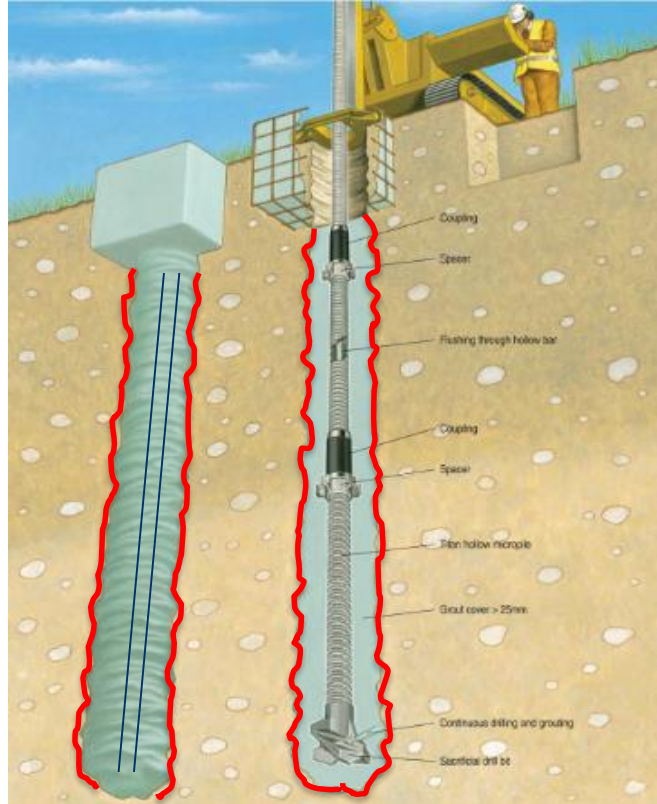
Note: Animation does not show continuous grout flush.



- Small equipment and suitable for boulder-rich deposits; **heavy duty;** **light touch**
- Construction: circulation drilling using:
 - synthetic polymer slurry only OR
 - Water only OR
 - Air only OR
 - Bentonite only OR
 - combination of air & water
 - Most common application

Continuous grout-flush* micropiles

*A special variety of circulation drilling

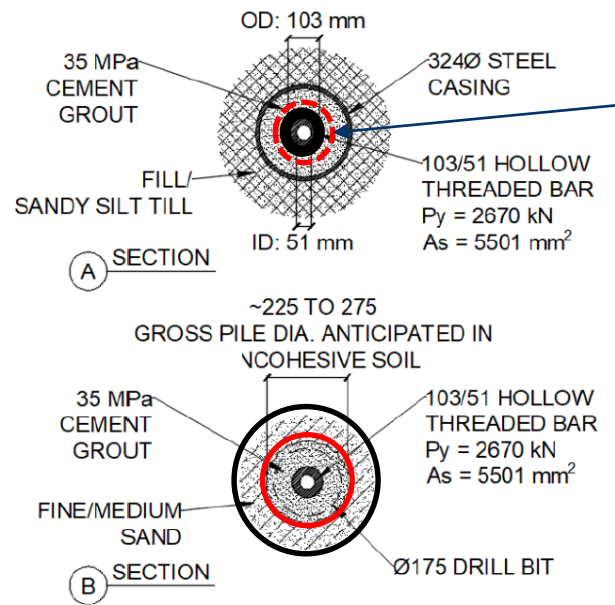
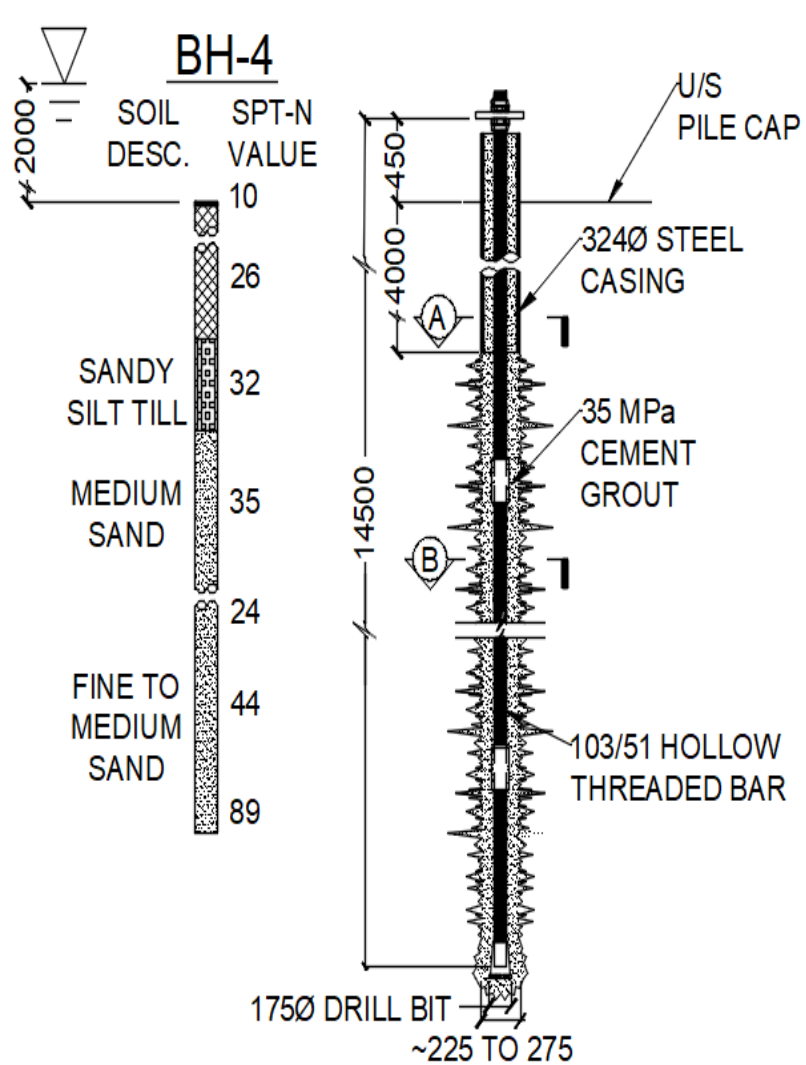


GROSS PILE DIA.
VARIES - APPROX.
1 - 2 x DRILL BIT DIA.

Case history - Richmond Hill GO Station, Toronto

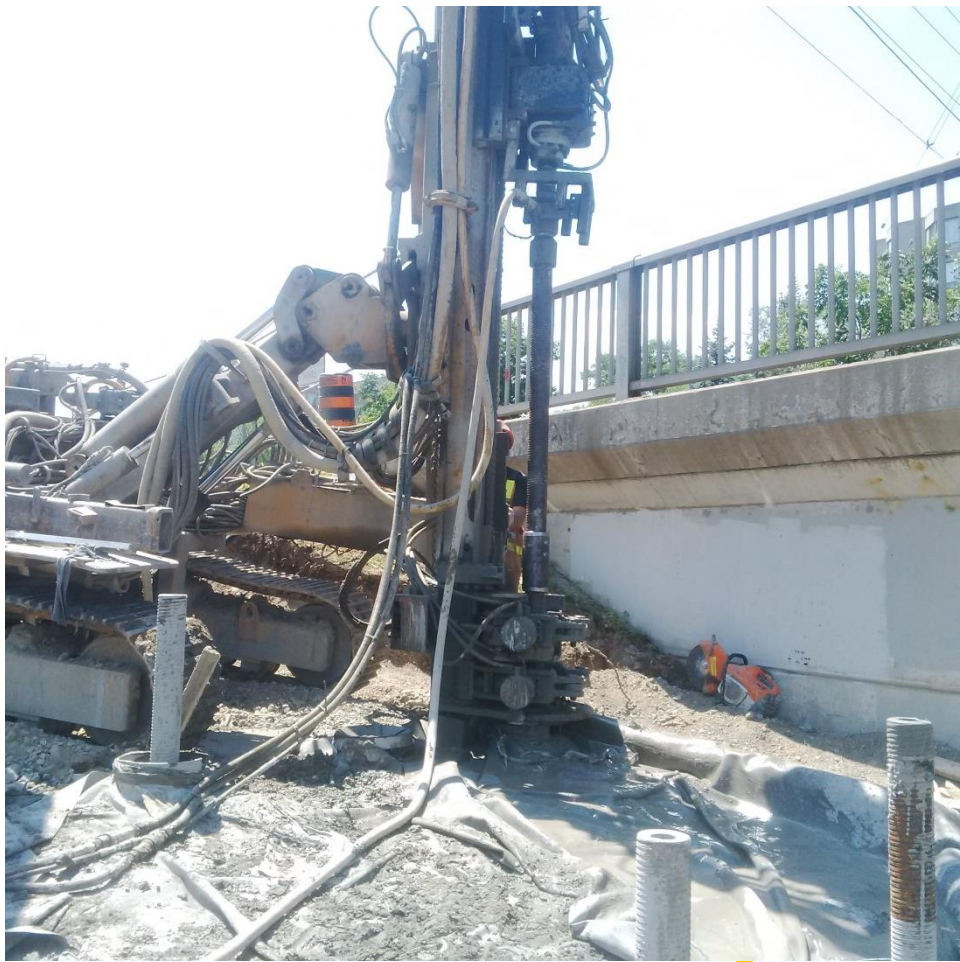


- An artesian aquifer with a head pressure of 2 metres above ground elevation
- Deep foundations were advanced into the soil layer coincident with the artesian aquifer
- Artesian aquifer locally notorious for causing problems



Anticipated gross tile diameter in non-cohesive soil





Verification



- Sacrificial pre-production test piles were loaded to 2000kN
- Grout-to-soil adhesion = 421 kPa



Conclusions

- The method was effective in managing washout during construction; and post-installation wicking
- Pre-production tension load tests at Richmond Hill GO verified the suitability of the installation technique
- A safe and reliable process for future deep foundations construction where artesian aquifers must be penetrated





Owner



Constructor



Structural Engineer




Geotechnical Engineer

Super fantastic thanks to...



Emily Reaver
Hayward Baker in Baltimore

BEST ANIMATIONS



Now that we know how NOT to, and more importantly, HOW TO construct deep foundations that must penetrate artesian aquifers...

Remember what W said...





Thank You!

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