International Workshop on Micropiles
Washington, D.C.
22 – 25 September 2010

UTILIZATION OF MICROPILES FOR HEAT EXCHANGE

By

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Lizzi Scholarship Recipient 2010

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What this presentation is about?

- Introduction
- Micropiles and Geothermal Energy
- Challenges of Energy Micropiles
- Virginia Tech on the road
- What is next?
- Summary

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Outline

- Introduction
- Micropiles & Geothermal Energy
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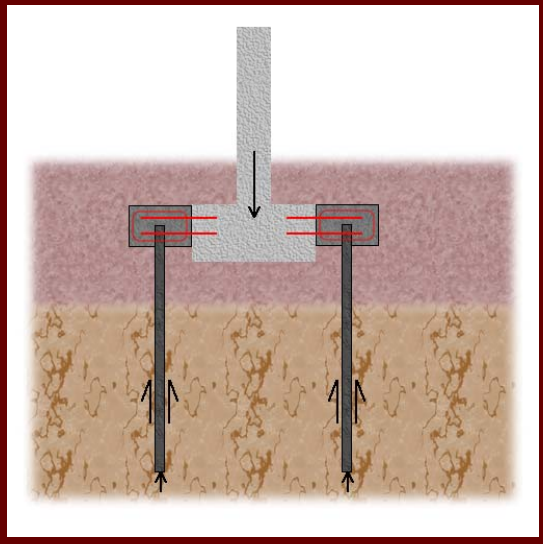
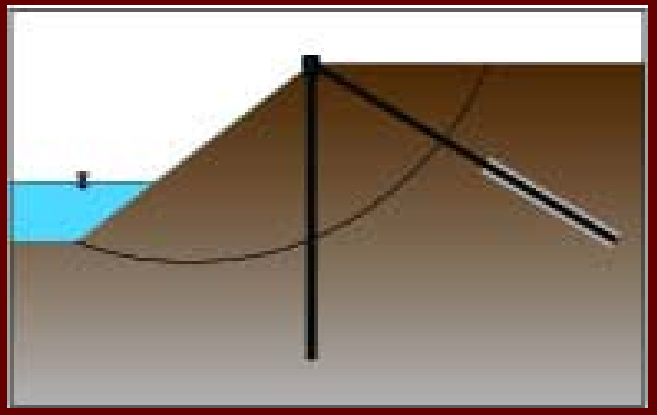
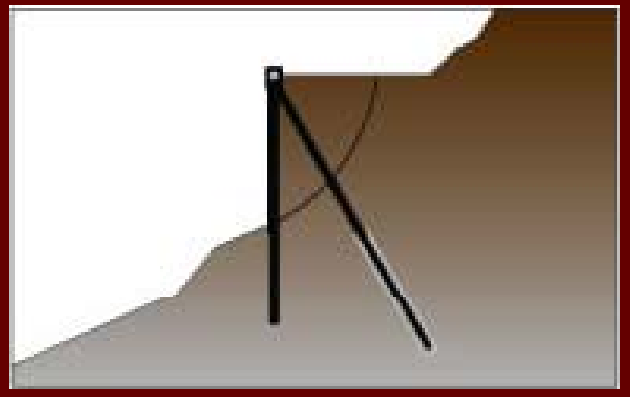
Replace deep foundations



Underpinning



Slope Stability



Side Support & Earth Retention

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Micropiles as Heat Exchangers

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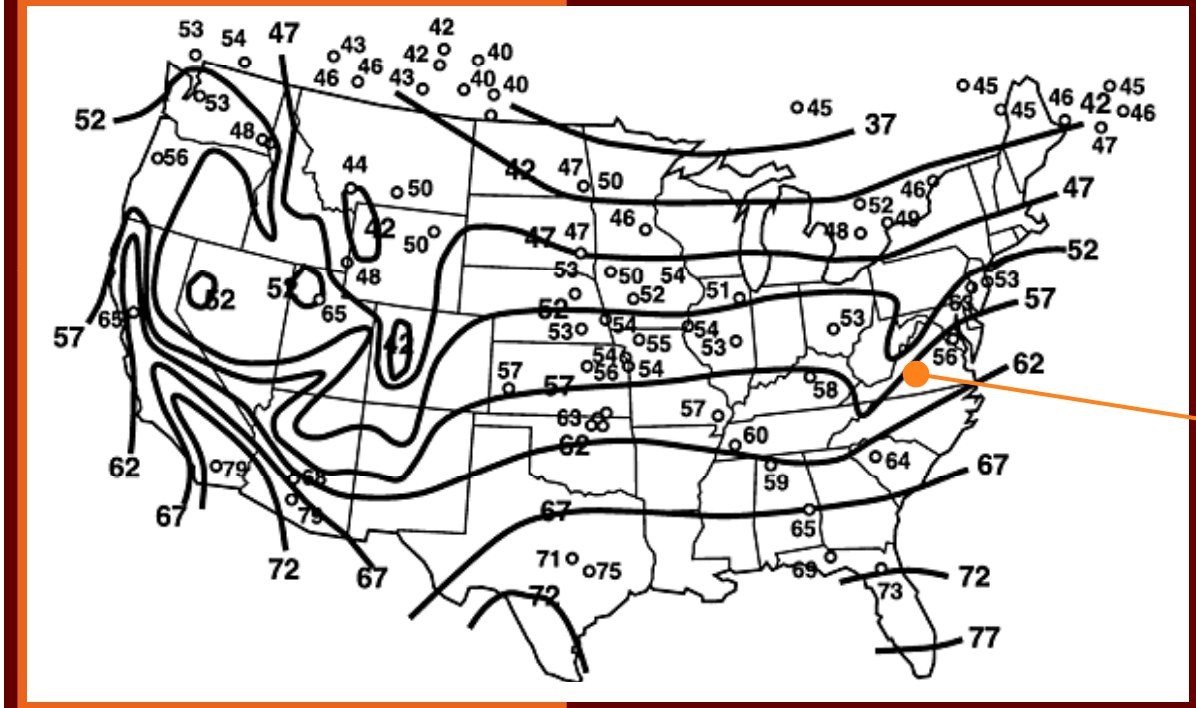

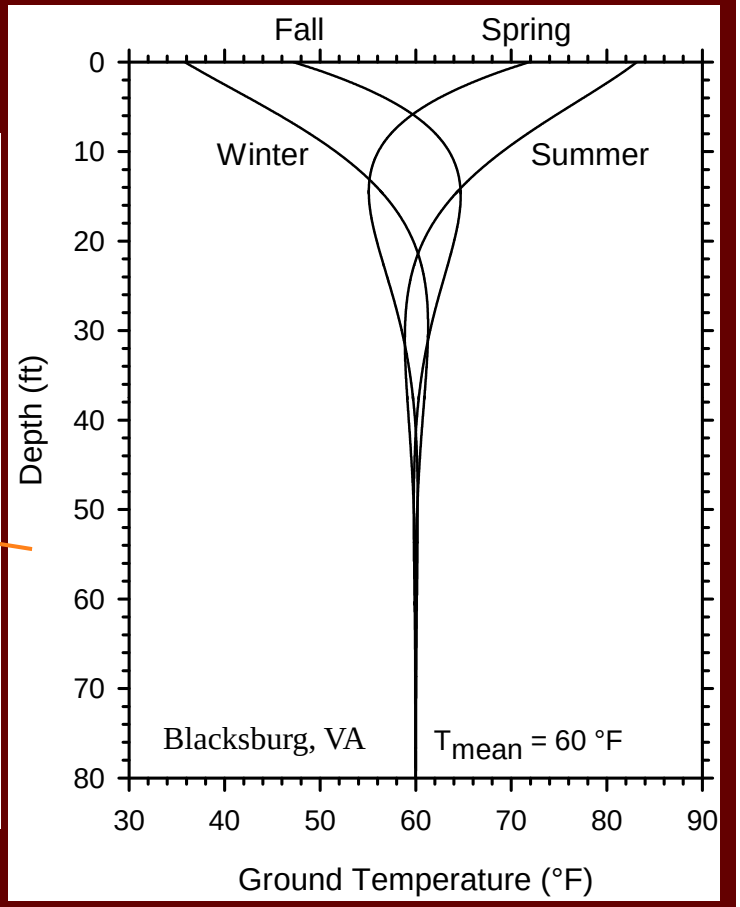

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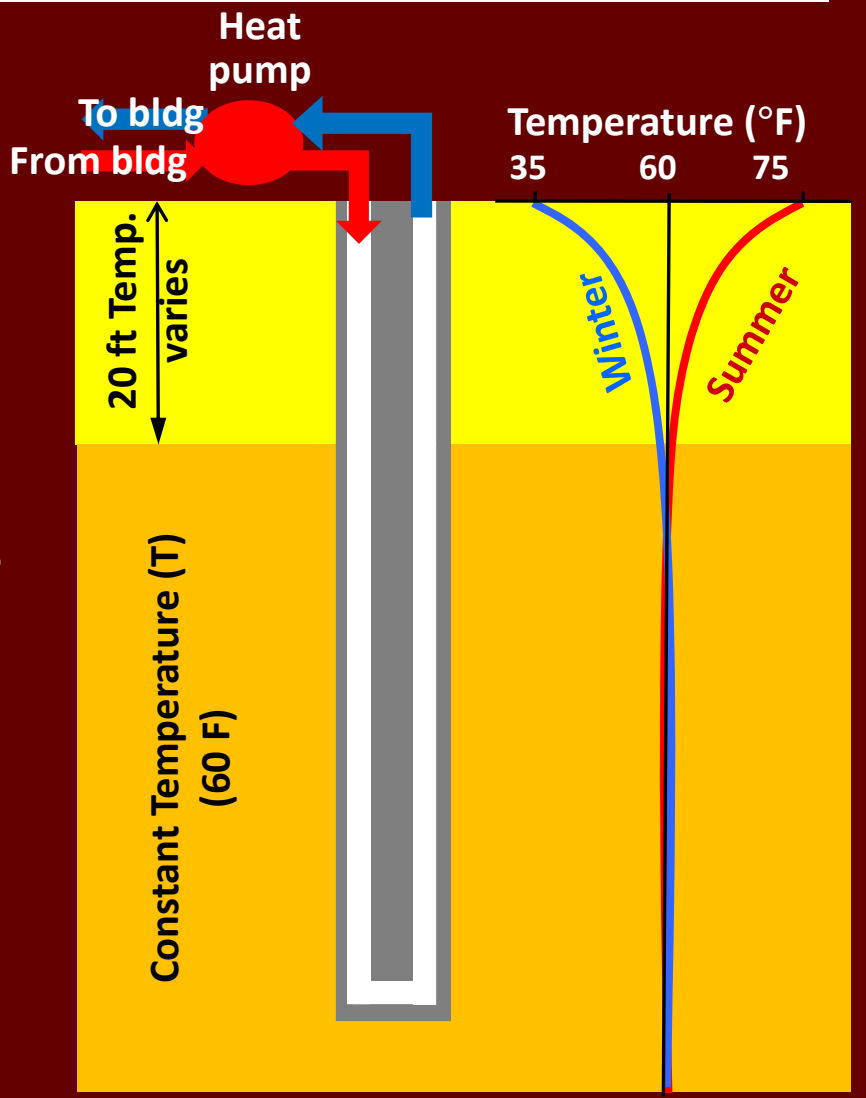
Micropiles for Energy Utilization

- circulation tubes
- Heat pump
- Geothermal fluid (water & antifreeze mix.)



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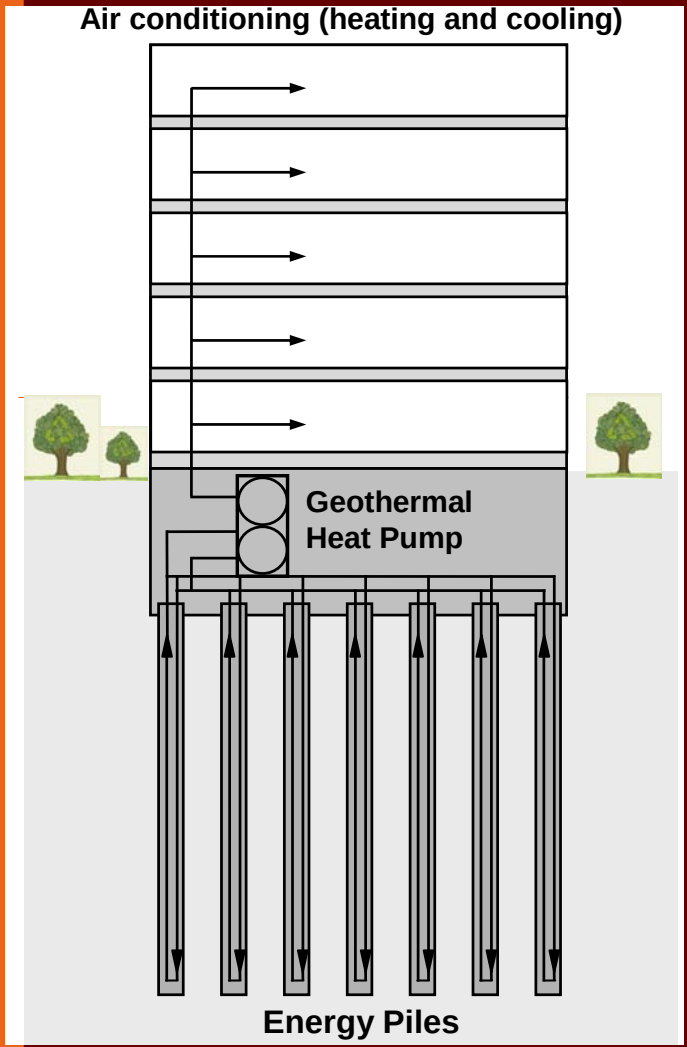

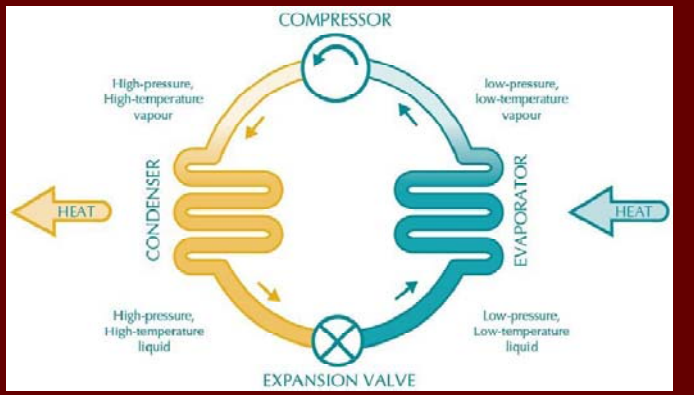

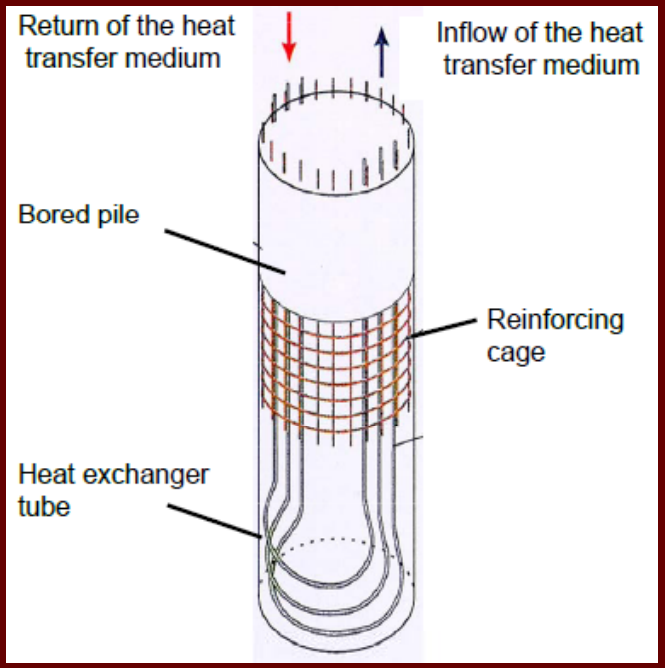

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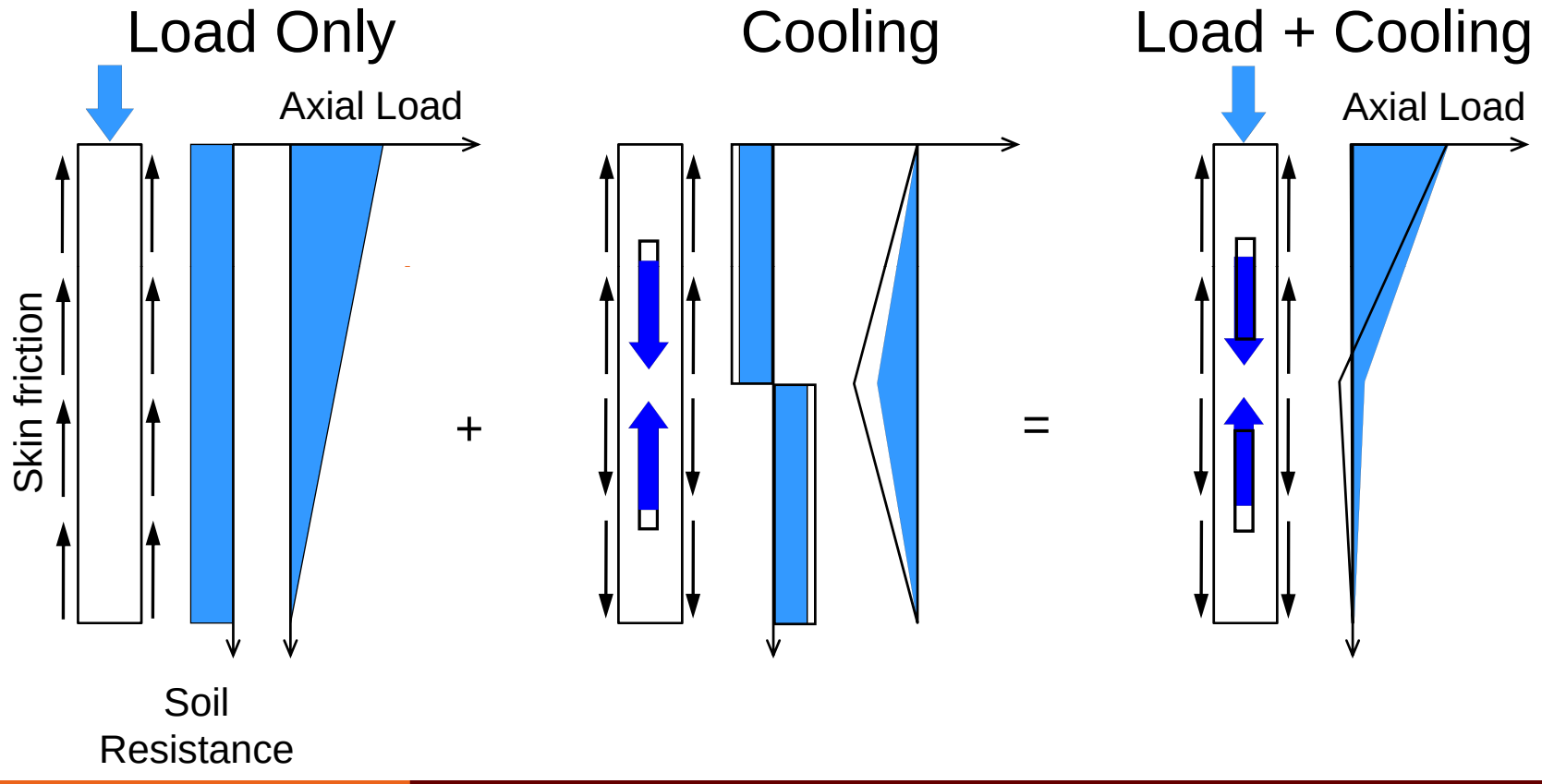
Challenges for the use of Micropiles as GHEX



Load carrying mechanism

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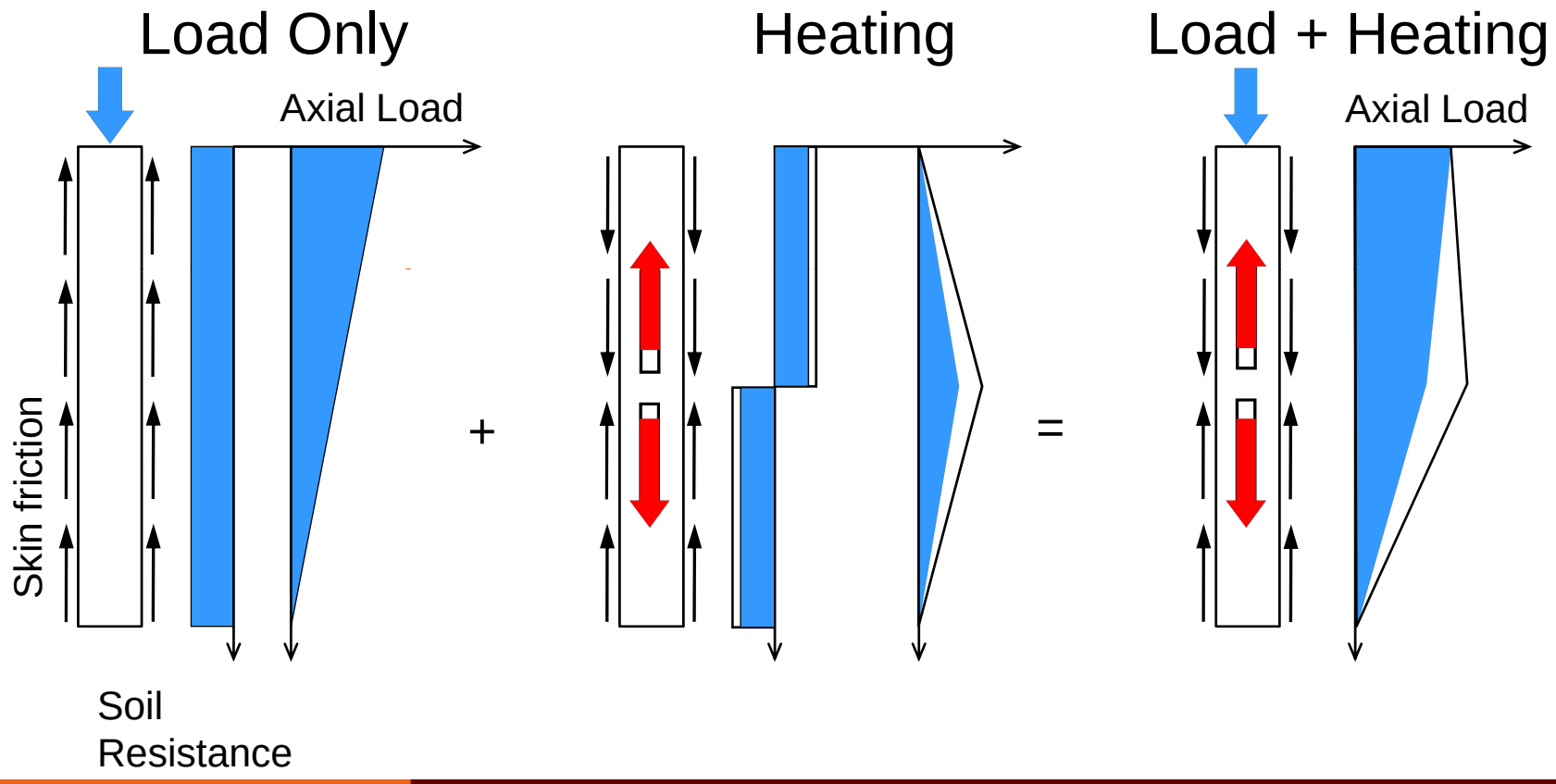

Load carrying mechanism

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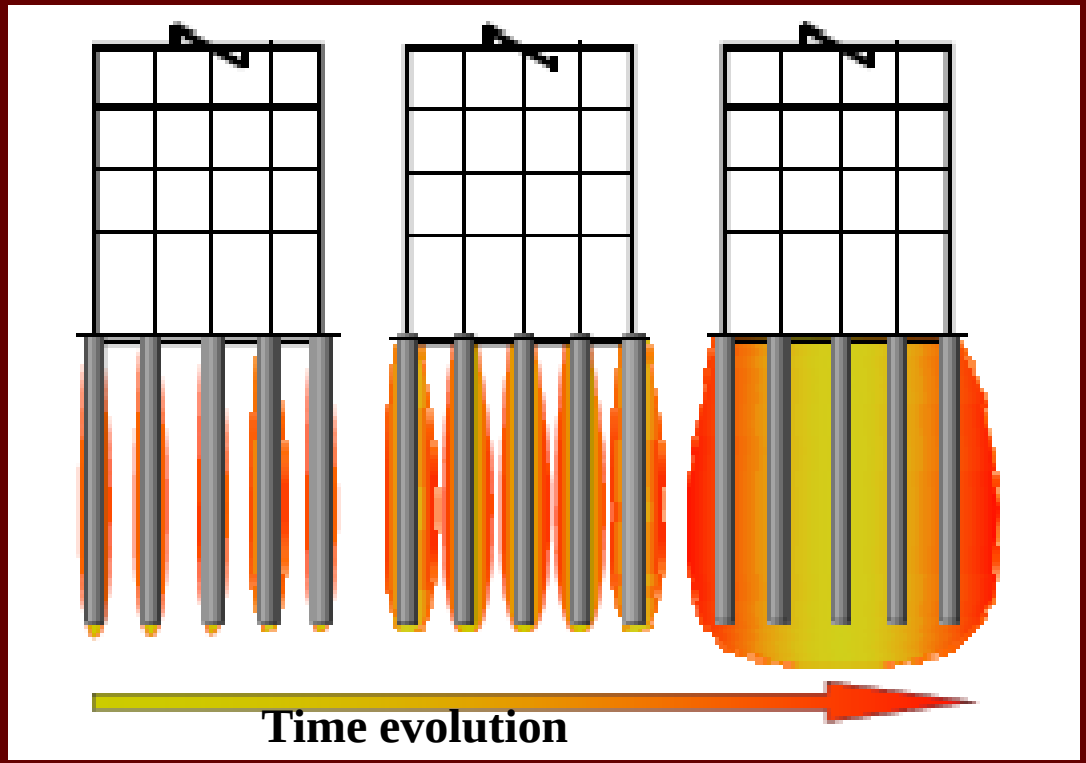
Challenges for the use of Micropiles as GHEX

- Long term thermal cycle loading effects



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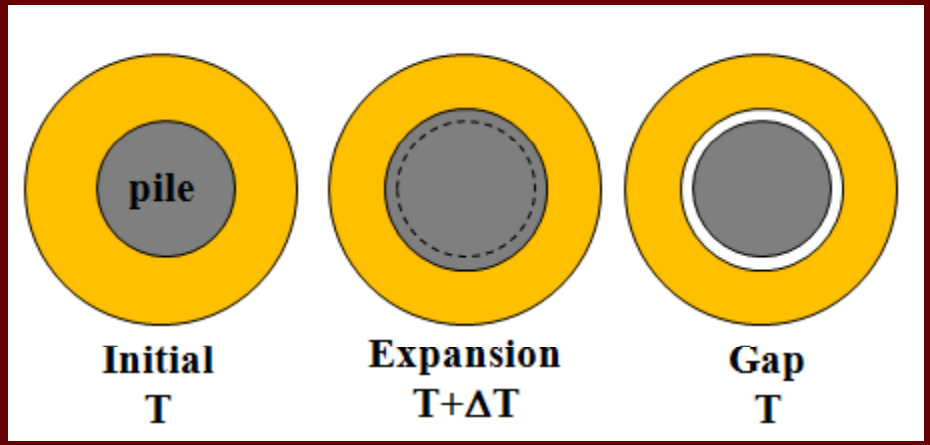
Challenges for the use of Micropiles as GHEX

- Overall thermo-mechanical response in short-term as well as long term



- Group effect under thermo-mechanical loads!!!!!

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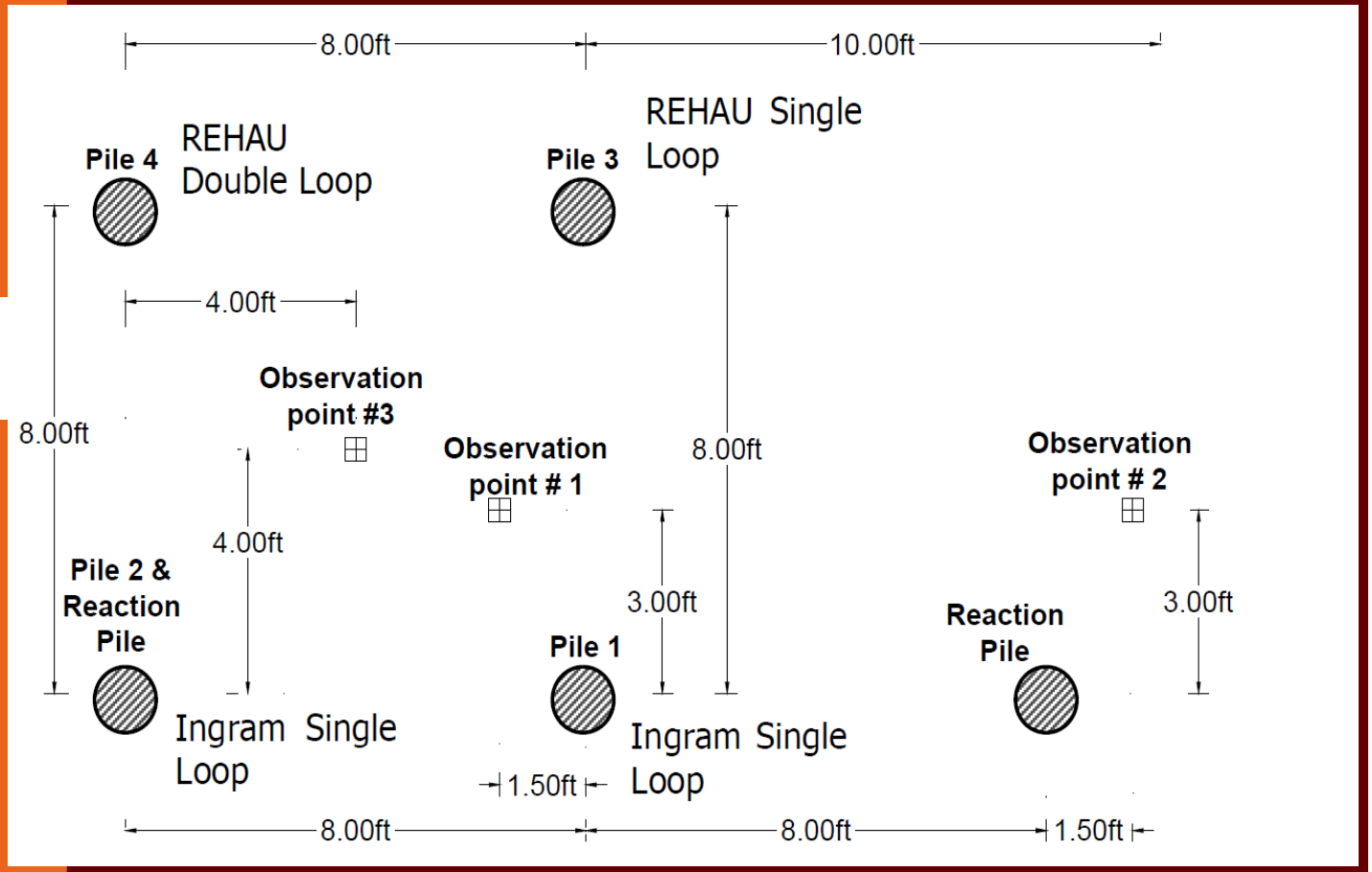
Virginia Tech Field Test



- Different tubes, tube configurations.

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Micropiles for Energy Utilization

- Virginia Tech Micro-pile Construction

Drilling

Installing Tubes

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Pressure test

Instrumentations

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Grouting

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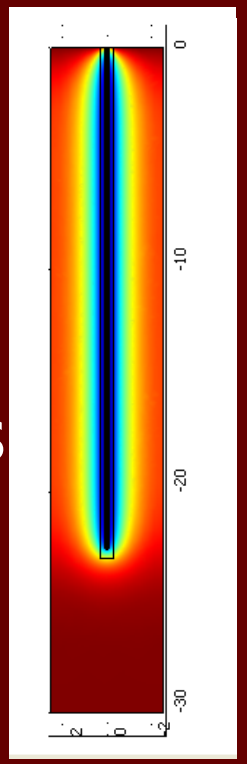
What is Next?

- Running field test
  - Thermal test
  - Thermo-mechanical test
- Numerical modeling and use of the field data for calibration purposes
- Generalization the results
  - Other field tests,
  - Laboratory thermo-mechanical tests on different soils



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Summary

- Micropiles are being used for different purposes, why not Geothermal?
- Different challenges need to be addressed and studied
- Field tests are the best way to investigate things to be built in-situ
- Results will be available once field test is performed.

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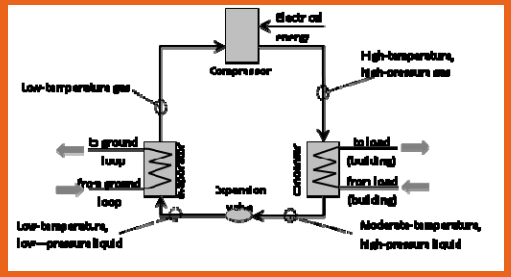
Required GHEX Length (L)

$$L = \frac{G \cdot c_p \left(T_{source,in} - T_{source,out} \right) R_{ghex}}{\left(\left(T_{ground} + T_{source,out} \right)/2 \right) - T_{ground}}$$



Where:

G : Mass flow rate of circulation fluid (lb/hr)

C_p : Specific heat of circulation fluid (Btu/lb/F)

T_{ground} : Undisturbed ground temperature

$T_{source,in}$: Temp. of the fluid entering ground loops

$T_{source,out}$: Temp. of the fluid leaving ground loops

R_{ghex}: Total thermal resistance of GHEX

G, c_p, and T_{ground} *are in fact constant known parameters for a specific design*

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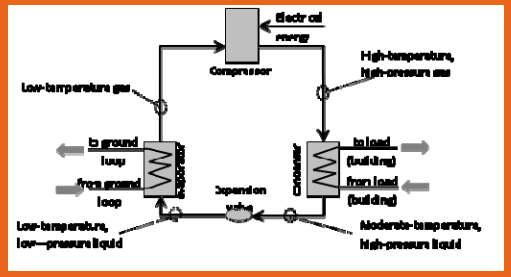
Required GHEX Length (L)



- *$T_{source,out}$ controlles efficiency of the heat pump. Typically choose;*

$T_{source,out} = T_{ground}$ + (20 to 30F) for summer

$T_{source,out} = T_{ground}$ - (10 to 20F) for winter

- *Assuming coefficient of performance (COP) between 2 and 4, then $T_{source,in}$ by;*

$$L = \frac{[(8.01 \times D \times f_l) \times W \times (T_{source,out} - T_{source,in})] + [W \times 3.413]}{(D \times 3.413)}$$

D: density of circulation fluid

f_l : volumetric flow rate of circulation fluid

W : watts of electrical power entering heat pump

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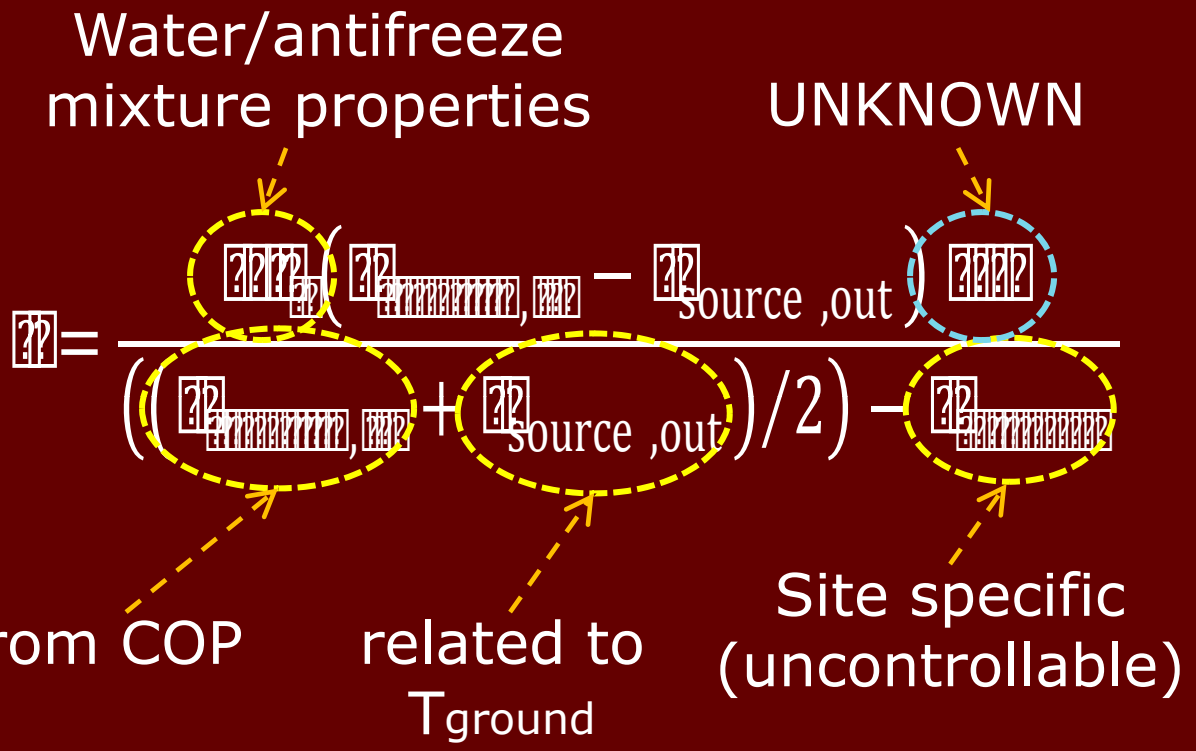
Required GHEX Length (L)



Therefore, the less the resistance
the less the required length (L)

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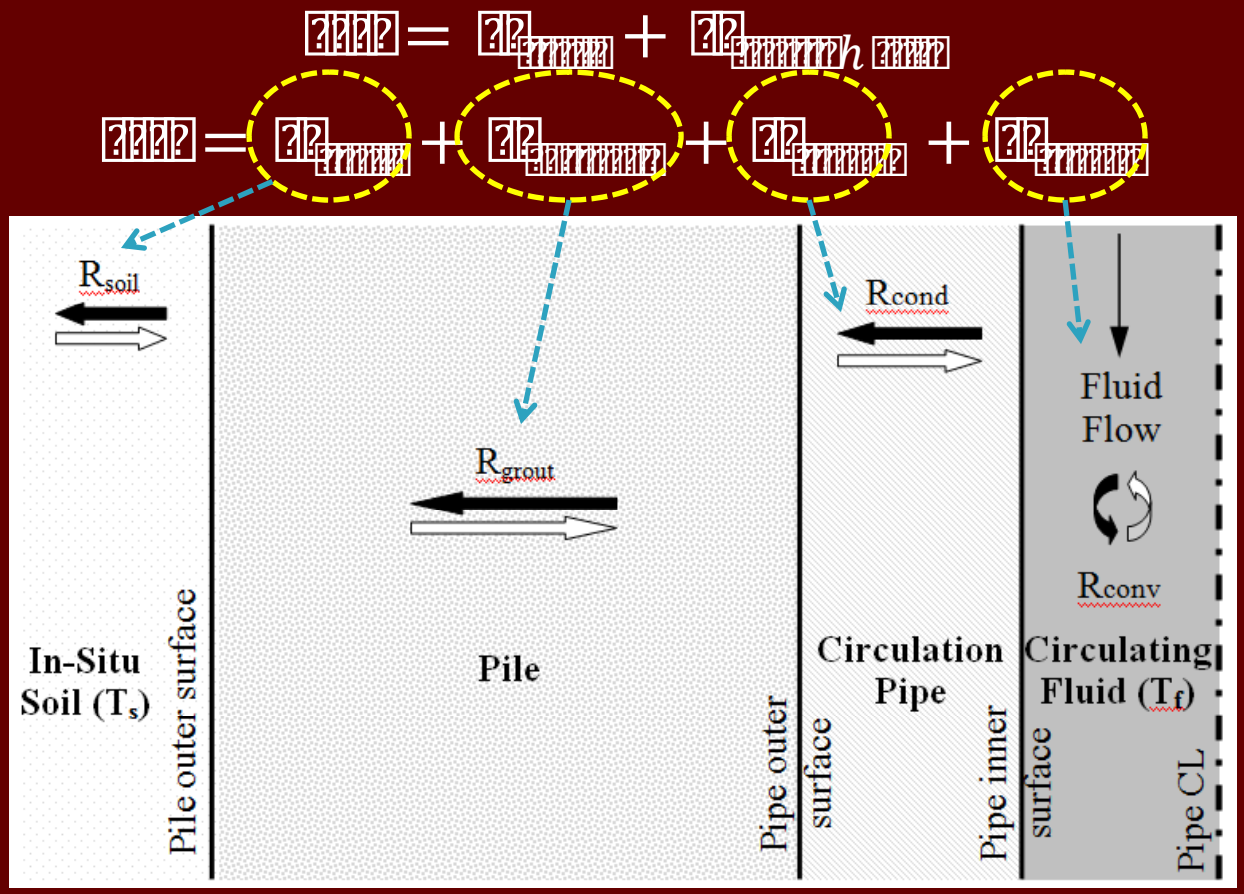
Total Resistance of the GHEX



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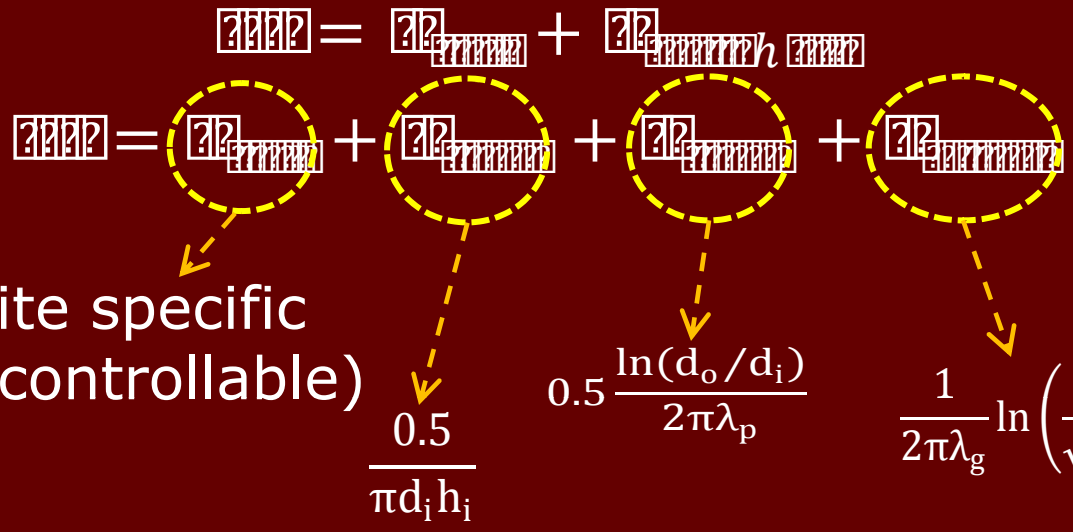
Total Resistance of the GHEX



where;

d_i : inner diameter of the tube

d_o : outer diameter of the tube

d_b : borehole diameter

λ_p, and *λ_g* : thermal conductivities of tube and grout, respectively

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Total Resistance of the GHEX

$$R_{grout} = \frac{1}{2\pi\lambda_g}\ln\left(\frac{d_b}{\sqrt{2}d_o}\right) \qquad R_{conv} = \frac{0.5}{\pi d_i h_i} \qquad R_{pipe} = 0.5\,\frac{\ln(d_o/d_i)}{2\pi\lambda_p}$$

- Since changes in d_o, d_i, and λ_p is not significant for typical applications. Then, only R_{grout} *can be reduced.*
- *Using thermal grout increases* λ_g.
- Smaller d_b gives lower R_{grout}.
- Then, micropiles are better than large diameter piles or caisons

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