Assessment of an Aerated Floor System for Mitigating Vapor Intrusion

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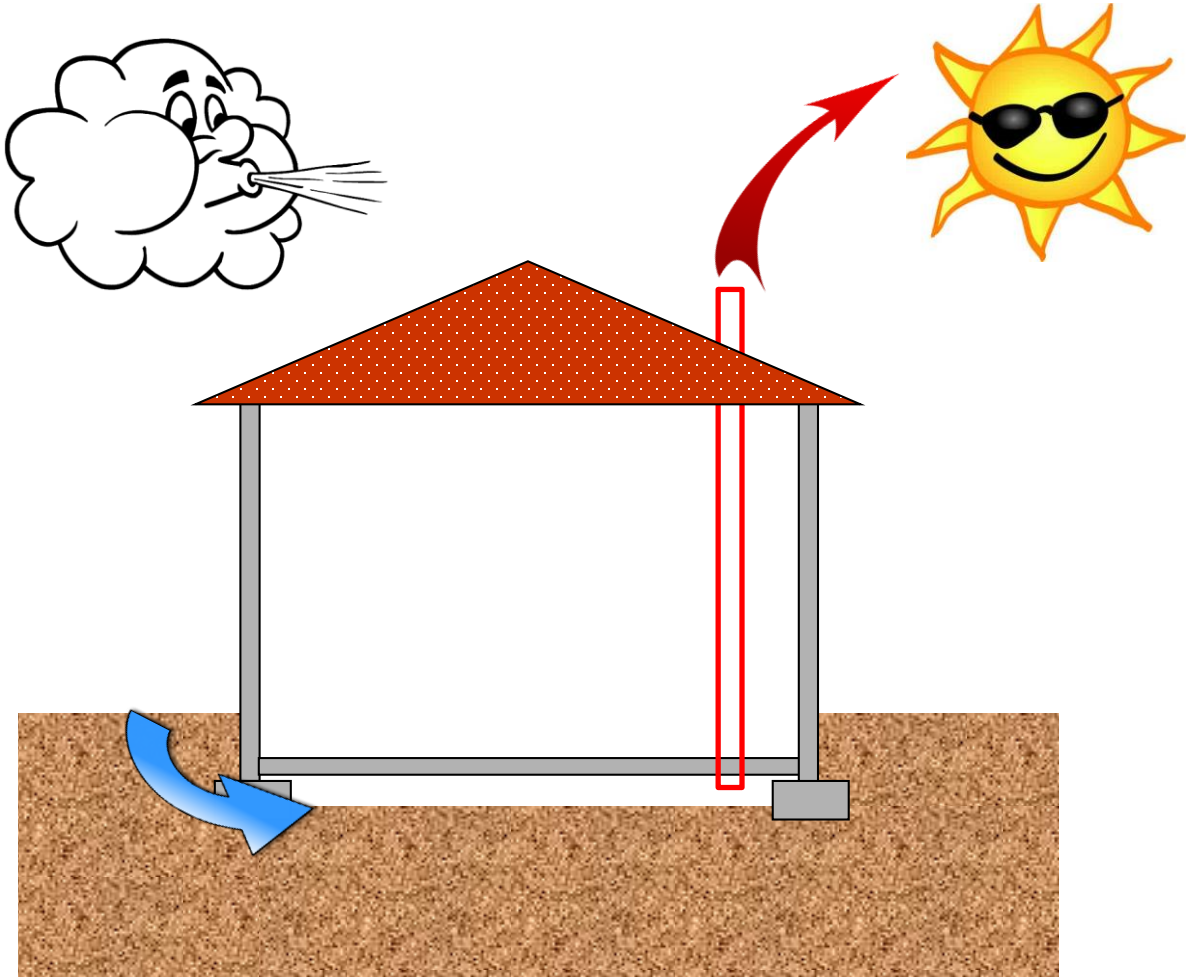
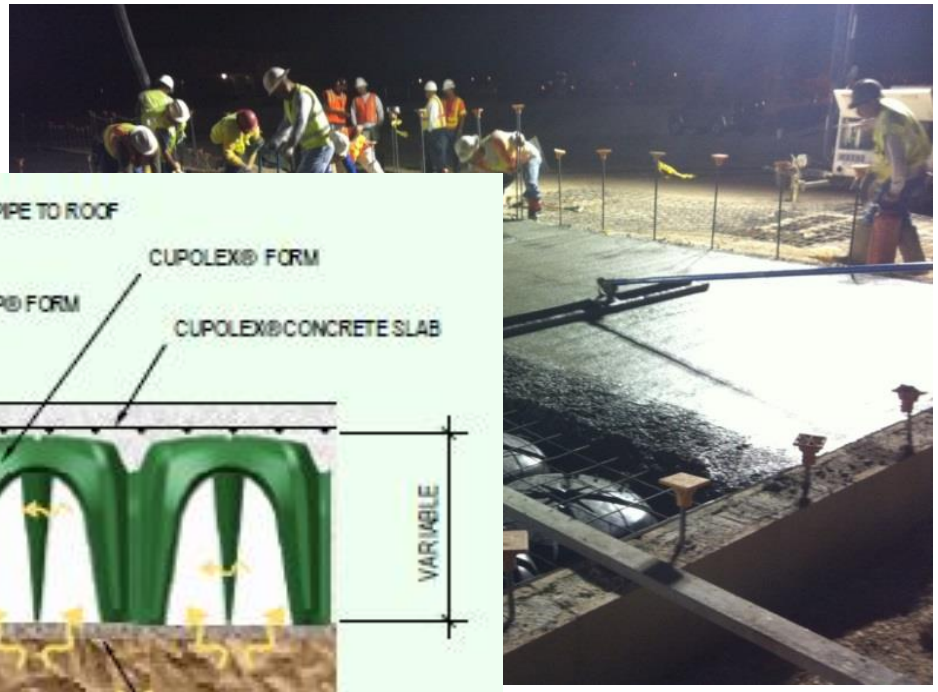
Passive Mitigation

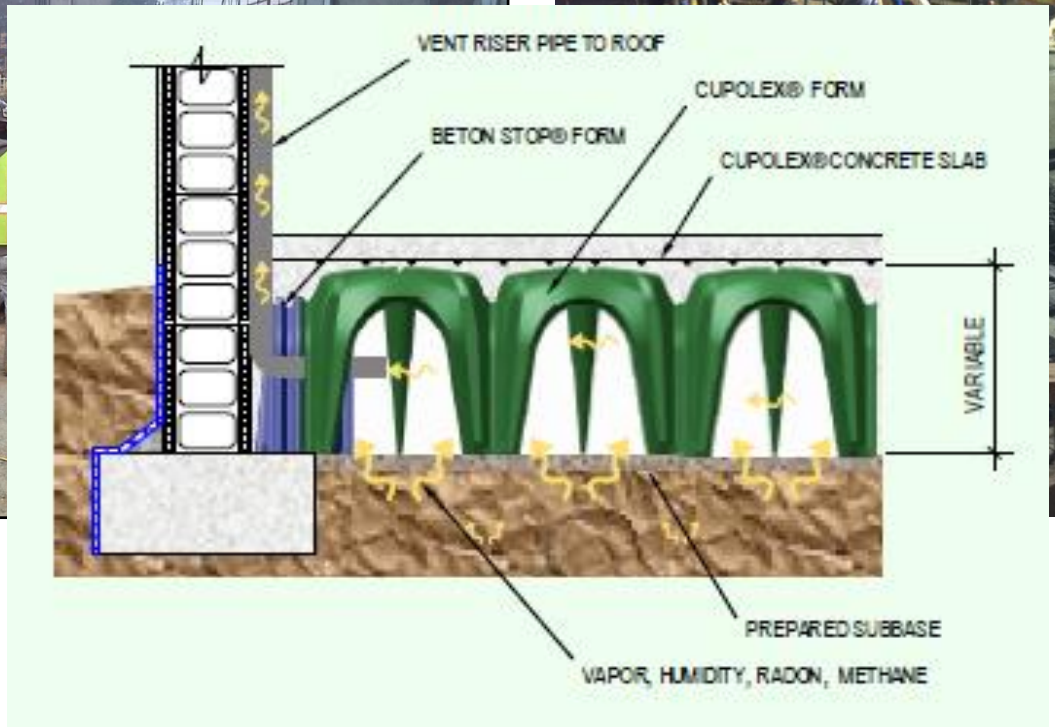
- No fans/electricity
- Naturally induced pressure gradients
- Need sufficient barrier, venting and/or negative pressures to mitigate VI
- How do you confirm performance?
- How do you assure continuing performance?
- Goal – intrinsically safe designs that minimize OM&M requirements



Geosyntec consultants

Aerated Floor Systems





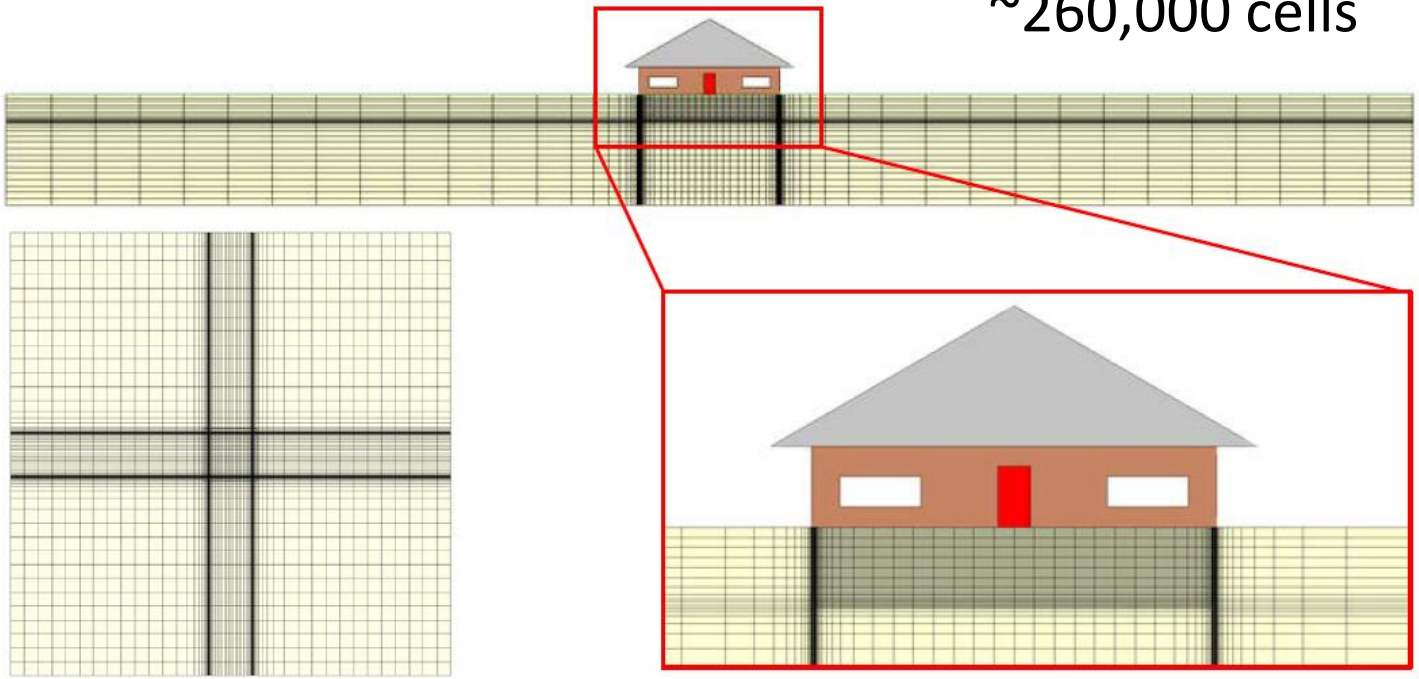
problems solved 2-clams

Aerated Floor Systems

3D CFD Model

- 3D computational fluid dynamics (CFD) model (ANSYS CFX)
- Advection/diffusion
- Prior models:
  - Abreu & Johnson [1]
  - Pennell *et al* [2]
  - Bozkurt *et al* [3]
  - Yao *et al* [4]
- Similar to approach of [2]
  - Except crack modeled

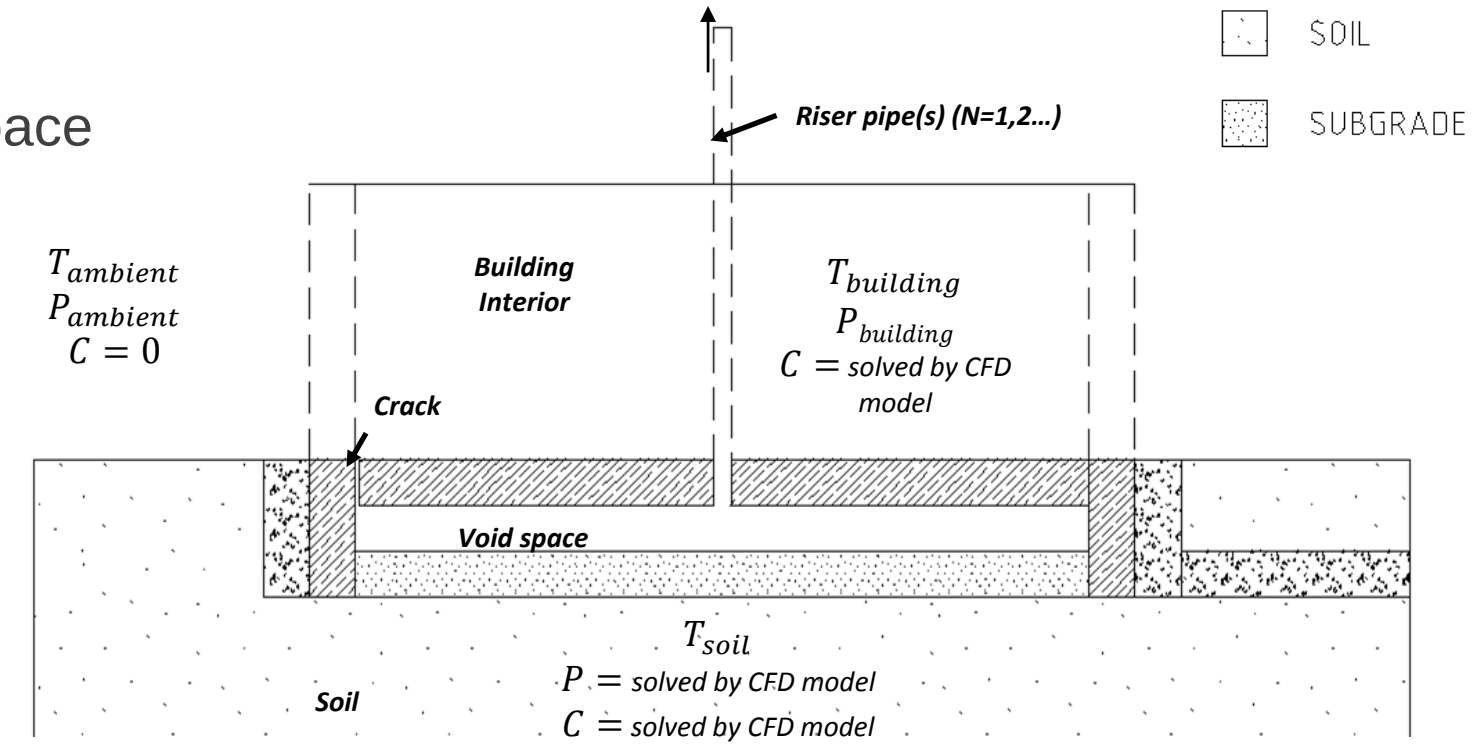
~260,000 cells



Plan View

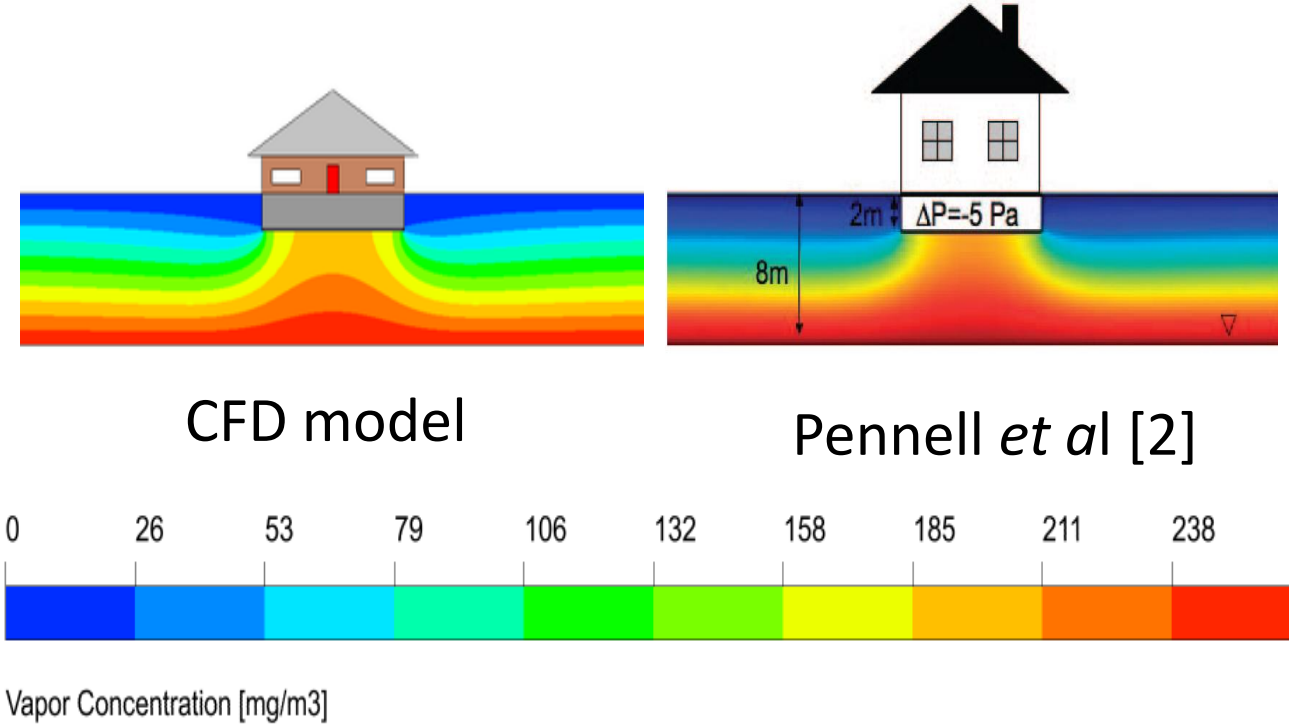
3D CFD Model

- Added the ability to model:
  - Cupolex® aerated floor void space
  - Riser pipe boundary
  - Preferential pathways



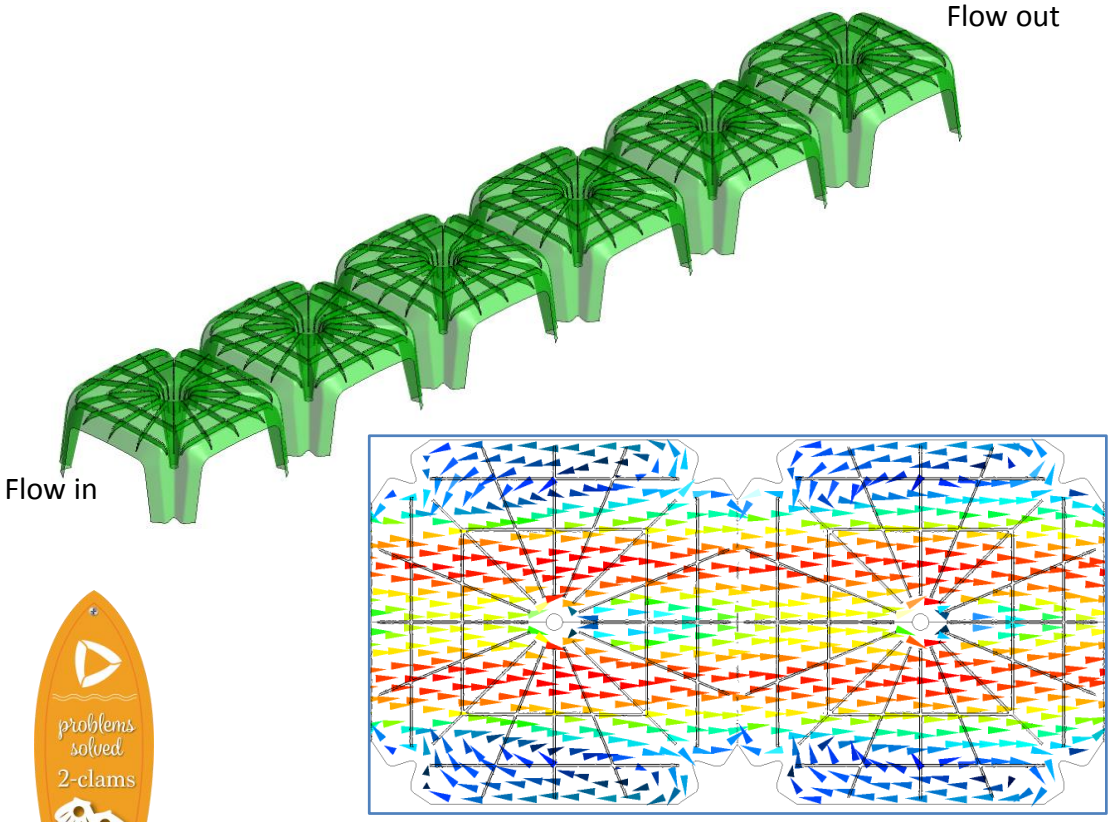
Model Verification

- Compared to results of Pennell *et al* [2] using same values and assumptions
- Sub-slab concentrations within ~5% in all modeled scenarios
- Difference in mass flux into building due to different modeling approaches
  - Diffusion/flow modeled in current model



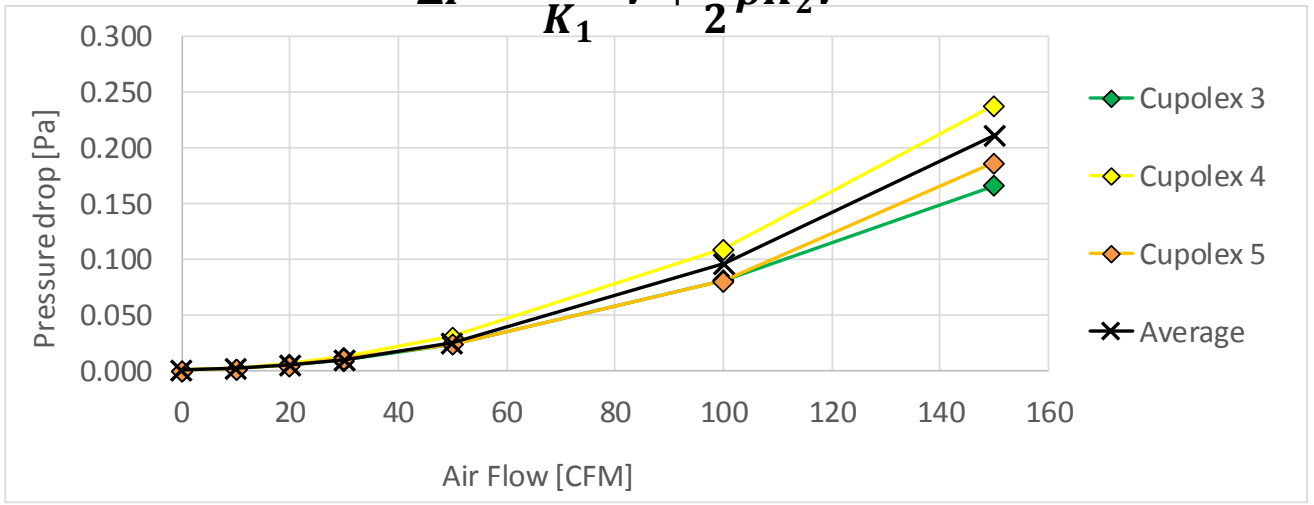
Modeling of Cupolex® Void Space

Modeled Cupolex® to determine pressure loss vs air flow rate



The following equation was used to calculate the laminar loss, K_1 and the turbulent loss K_2:

$$\Delta P = \frac{\Delta L \mu}{K_1} V + \frac{1}{2} \rho K_2 V^2$$



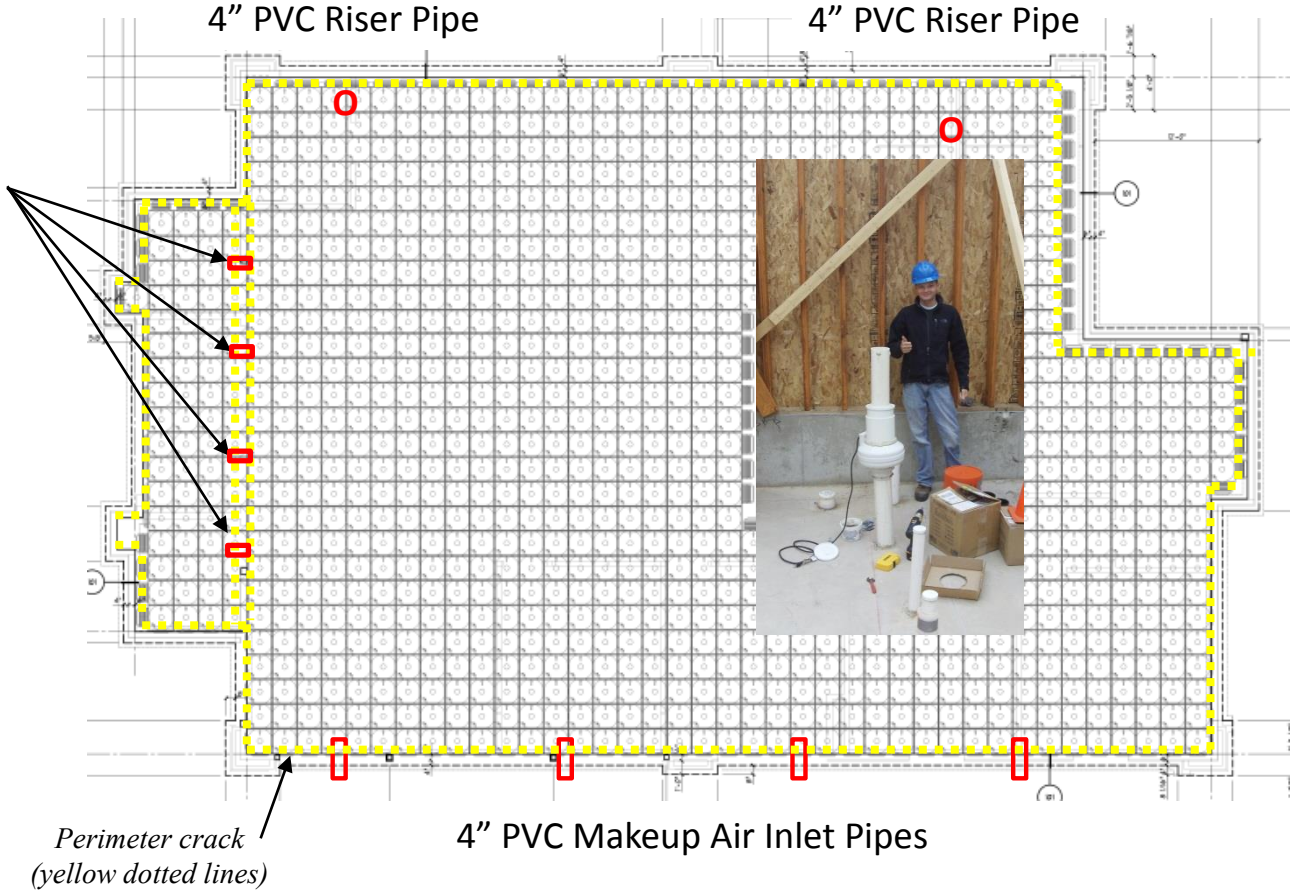
Bank Case History

Cupolex® aerated floor system

Bank Case History

Vacuum test performed

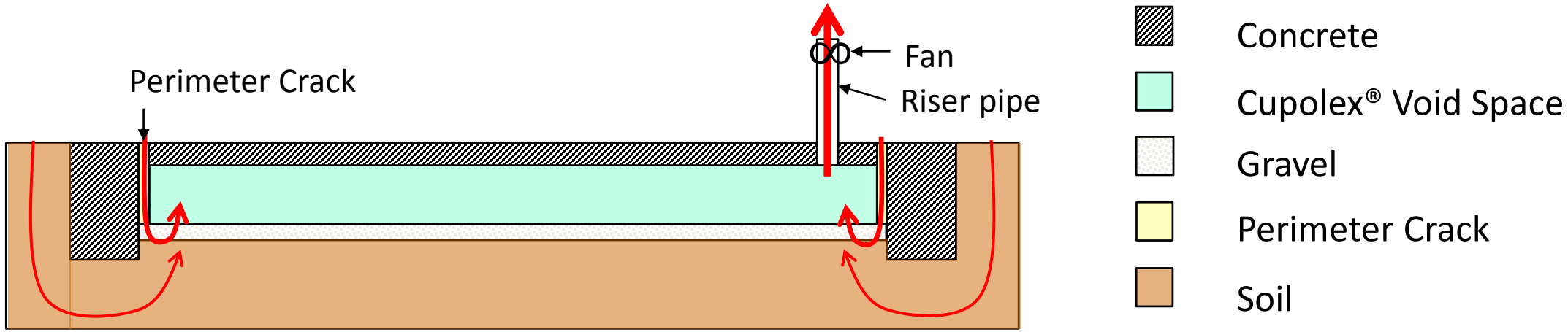
Location	Status	Void Space/Fan Vacuum (“ WC)		
		RP140	RP145	RP265
R1	FAN	-0.58	-1.03	-1.39
R2	CAP	-0.52	-0.78	-1.03
I1	CAP	-0.53	-0.79	-1.02
I2	CAP	-0.53	-0.77	-1.03
I3	CAP	-0.53	-0.77	-1.03
I4	CAP	-0.53	-0.78	-1.03
FLOW	CFM	50	80	110



Bank Case History Model Simulation

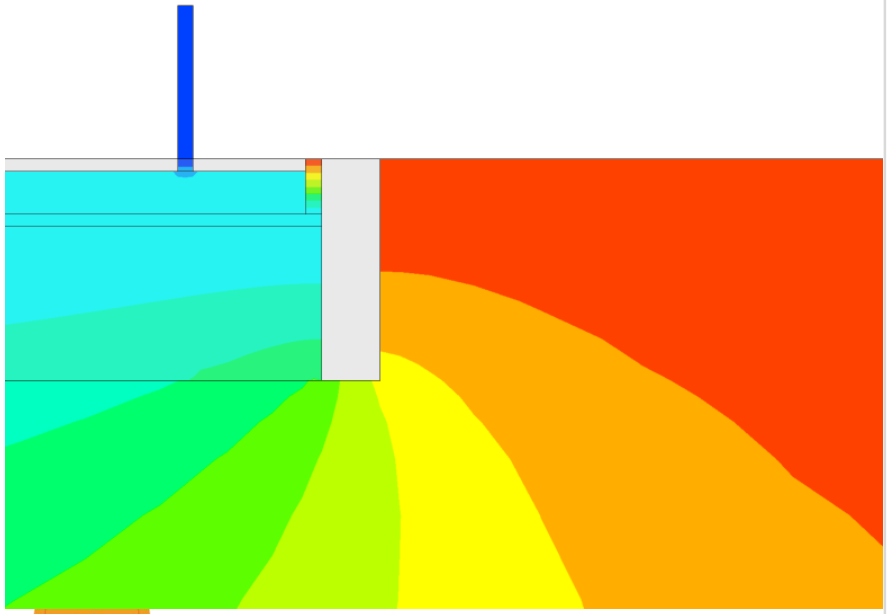
$$\Delta P = \frac{12 Q_{ck} \mu d_{ck}}{w_{ck}^3 P}$$

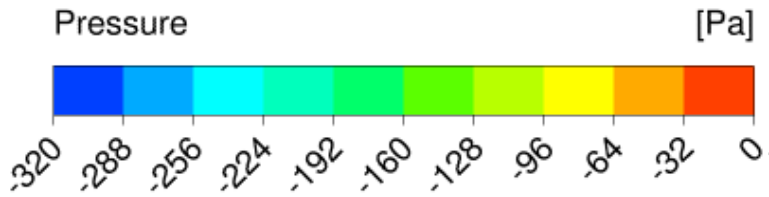
ΔP	Pressure loss through crack	253 Pa
m	Dynamic viscosity of soil gas	1.75x10^{-5} kg/ms
Q_{ck}	Flow through crack (model = real)	110 CFM
d_{ck}	Height of real crack	0.332 m
w_{ck}	Width of real crack	? [m]
P	Perimeter of real crack	96.1 m

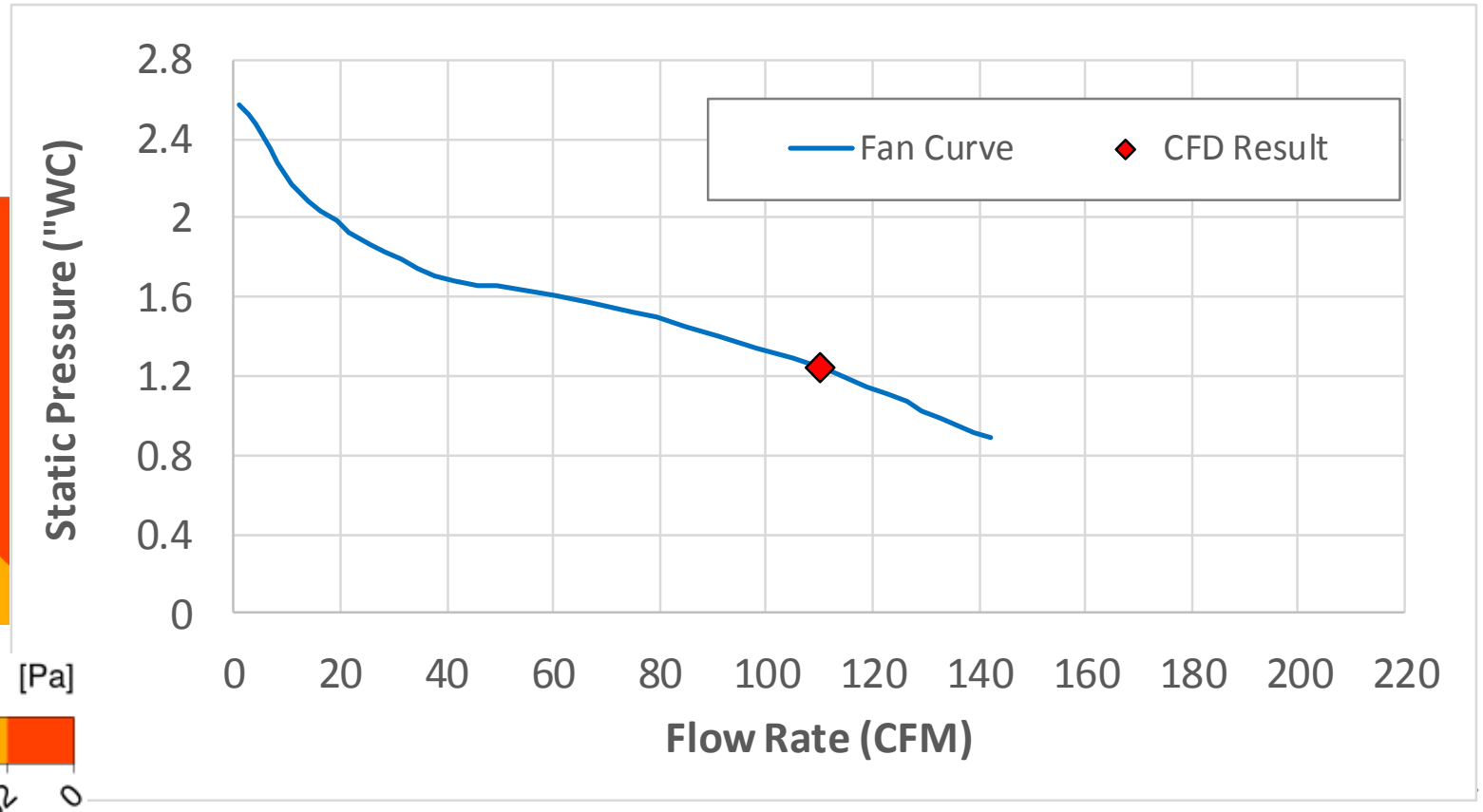


Active system modeled

- Modeled fan flow/pressure fit actual fan curve (RP-145) adjusted for elevation

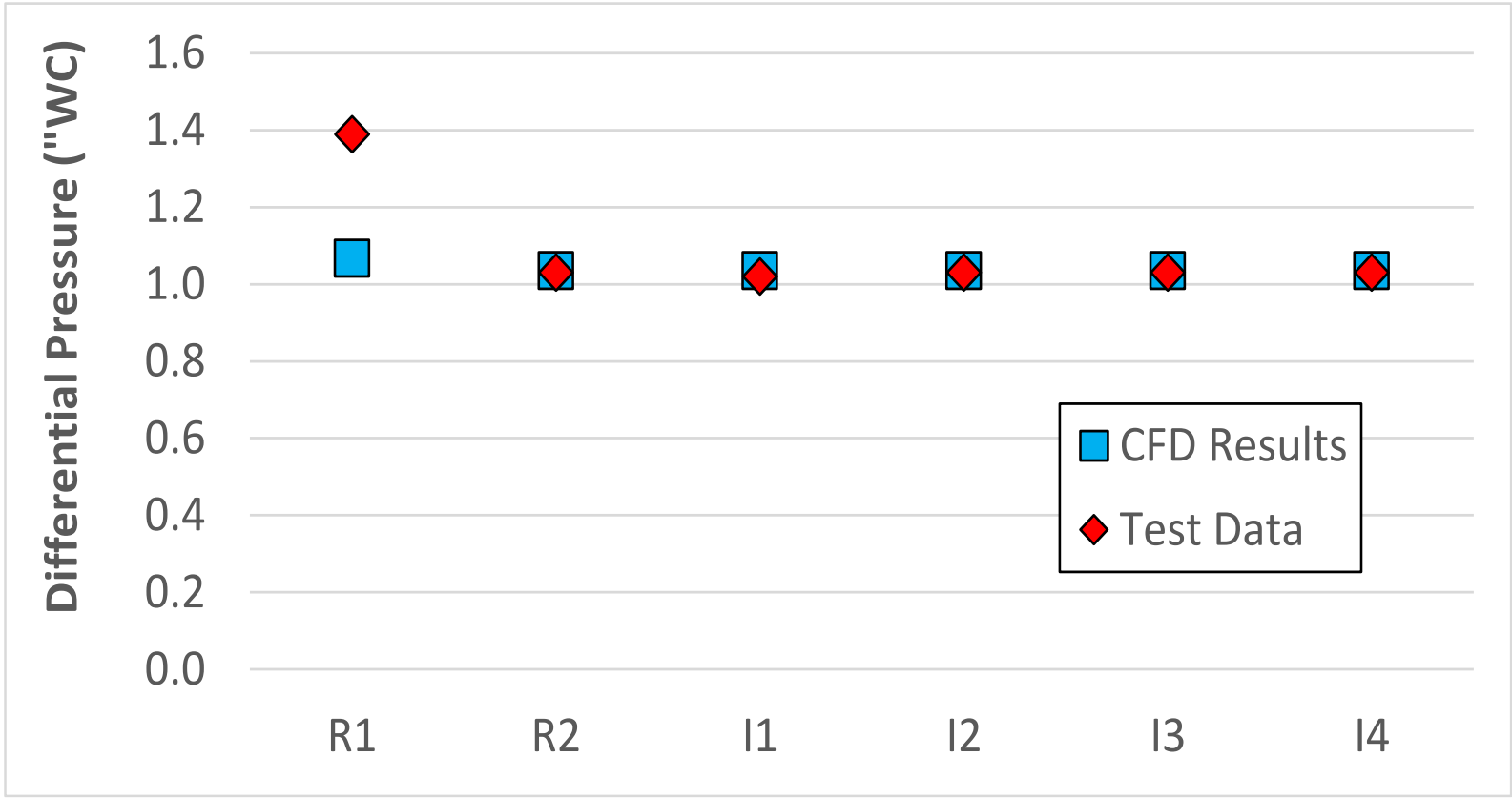






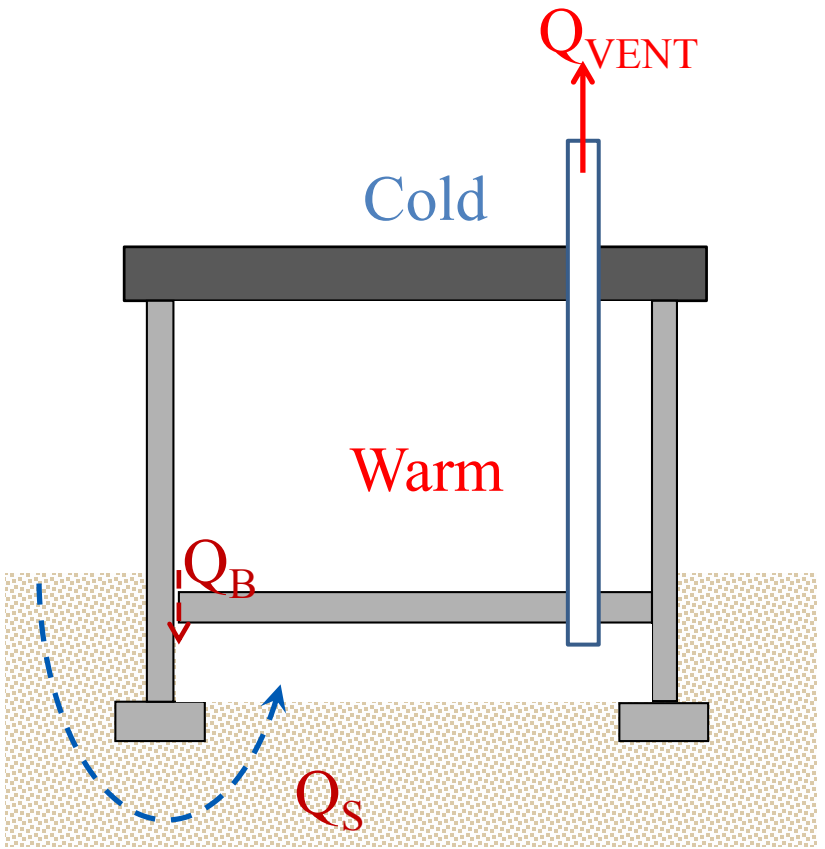
Active system modeled

- Modeled void space vacuum matched observed
- Riser pipe (R1) vacuum matched when similar measurement points in pipe compared



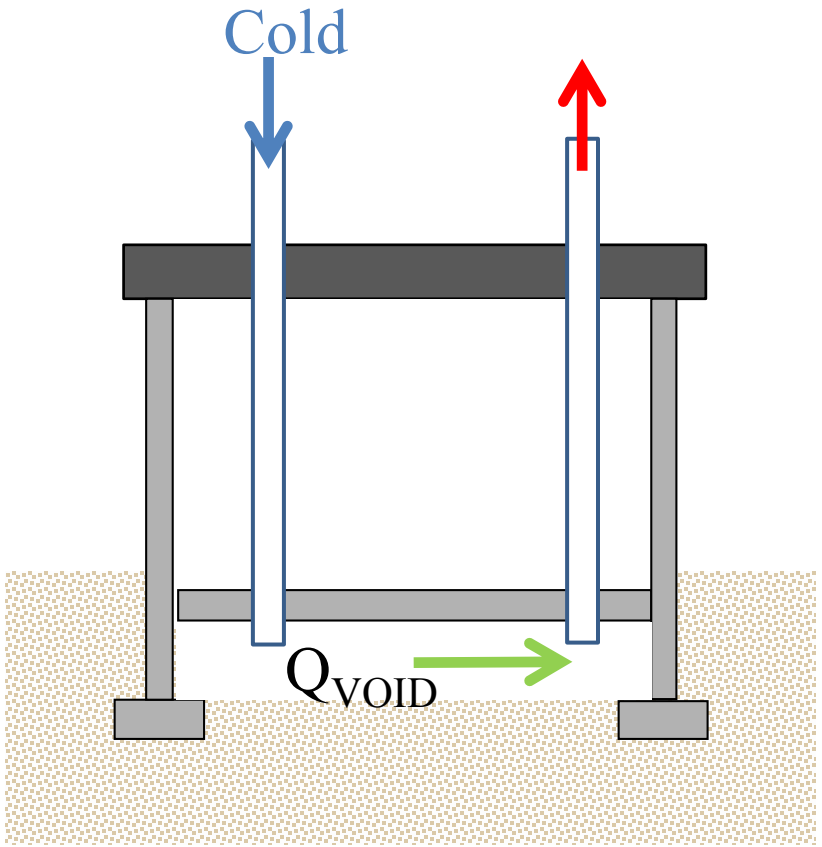
AFS Passive System Modes

- Single Riser
  - Relies on stack effect vacuum
  - Low air flow



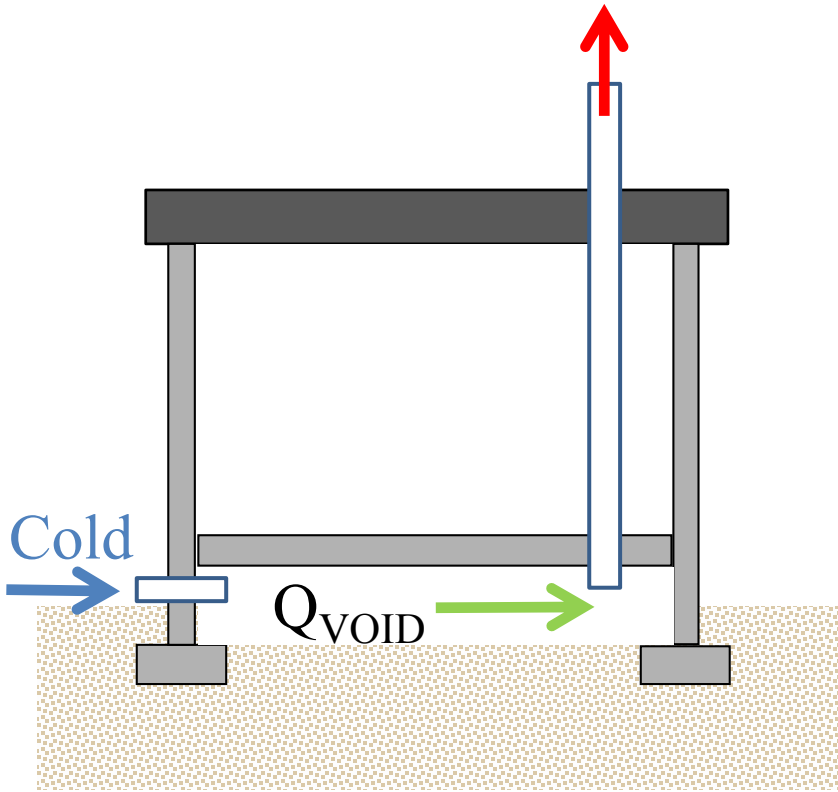
AFS Passive System Modes

- Double Riser
  - Relies on stack effect vacuum
  - Second riser provides makeup air
  - Lower vacuum levels than single riser
  - Higher air flow

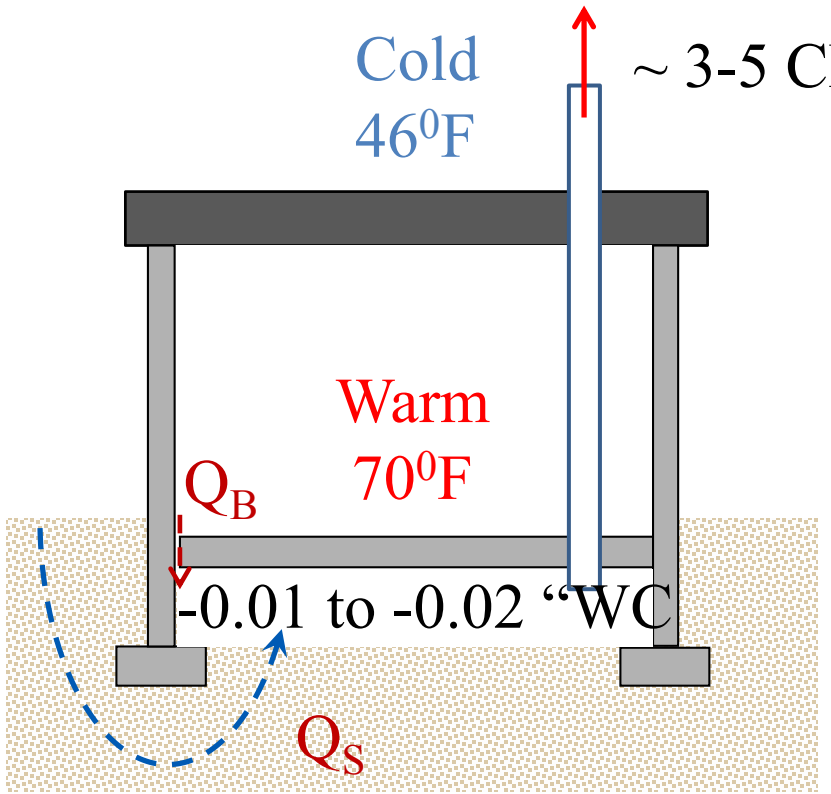


AFS Passive System Modes

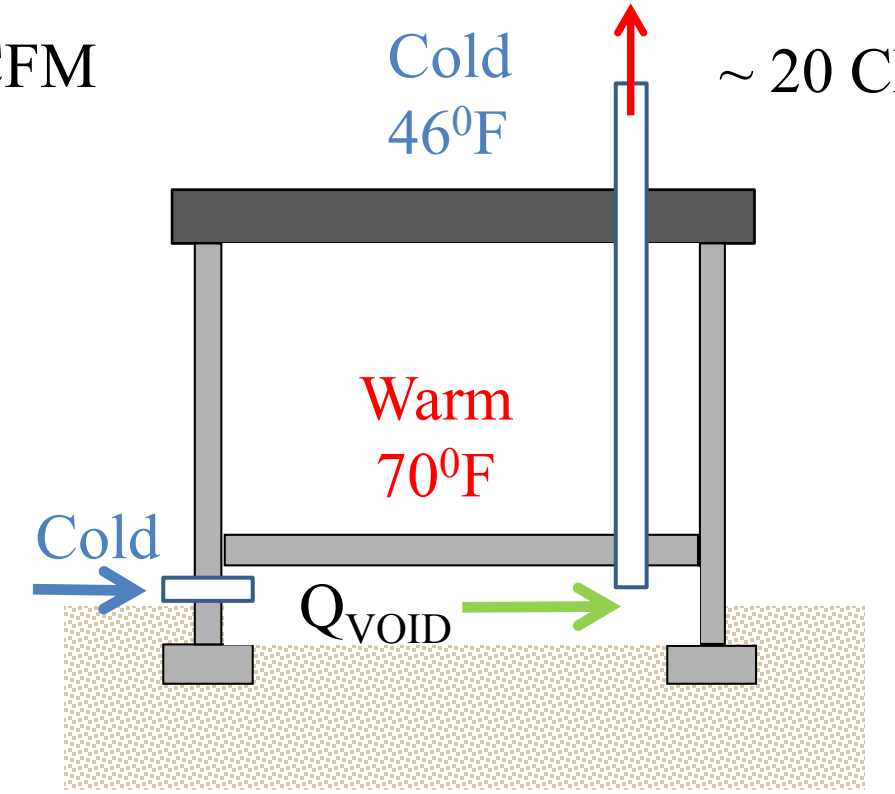
- Ground level air inlets
  - Relies on stack effect vacuum
  - Inlets provide makeup air
  - Enhances stack effect
  - Increases air flow (compared to vertical riser inlet)



Bank Building Passive System Data

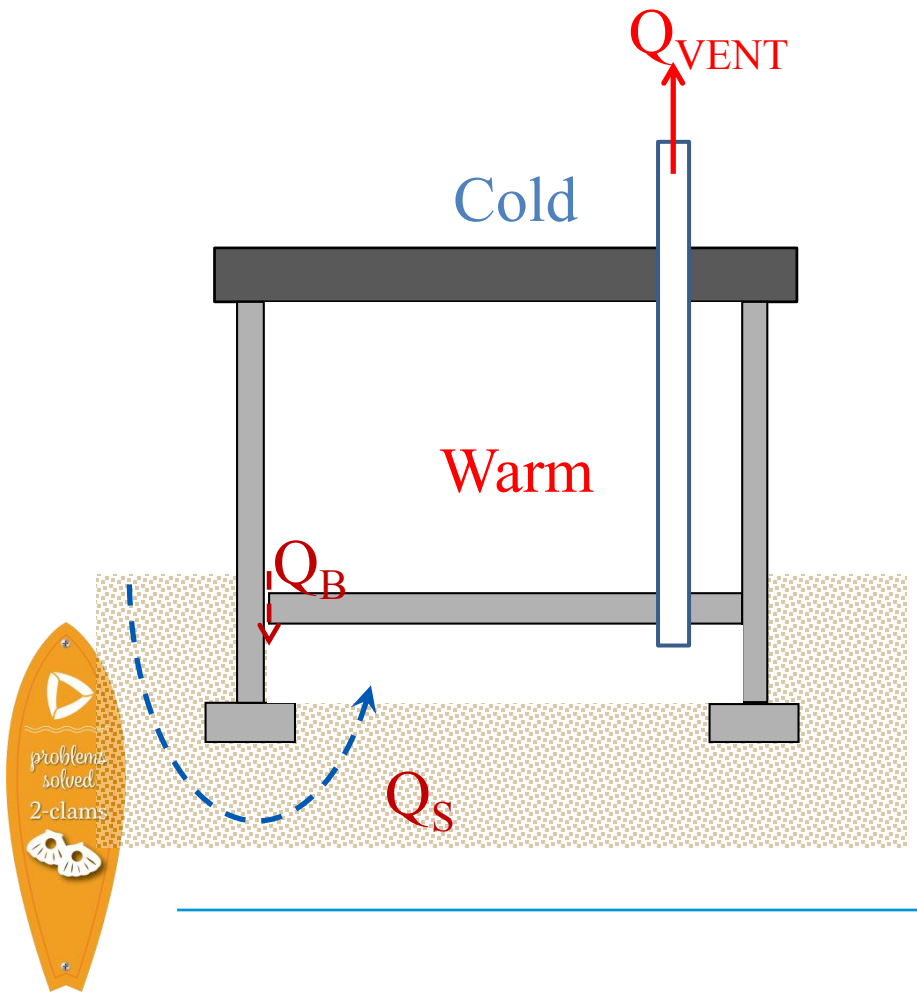


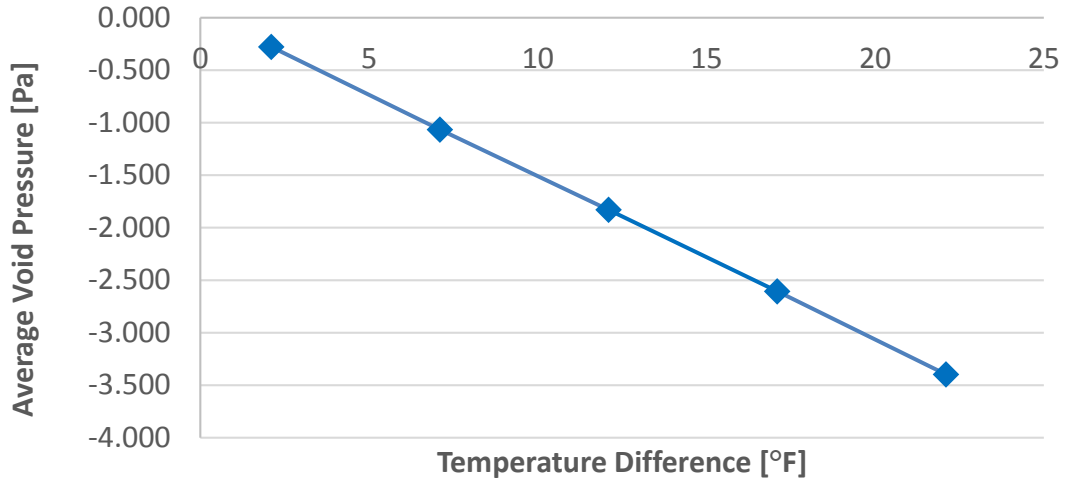
A) Single riser, no inlet

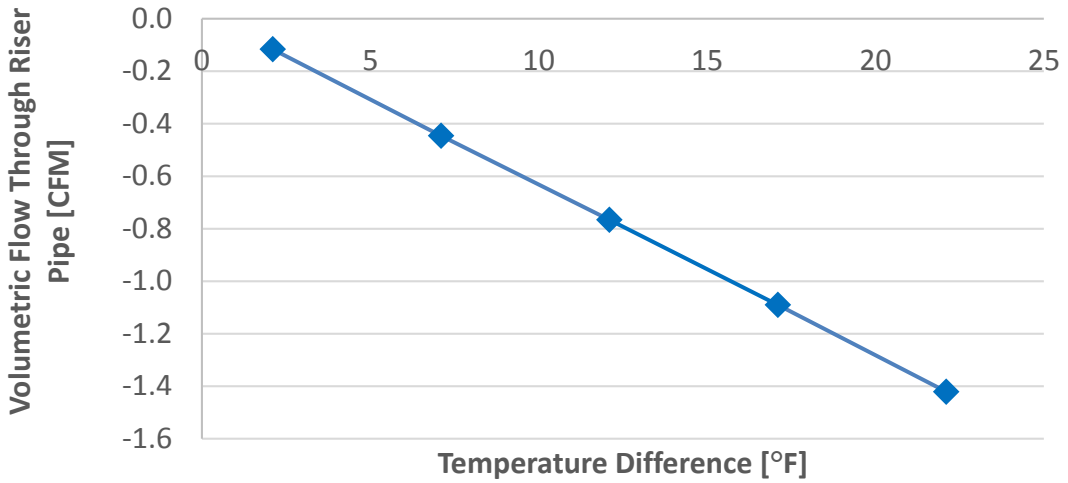


B) Ground level inlet

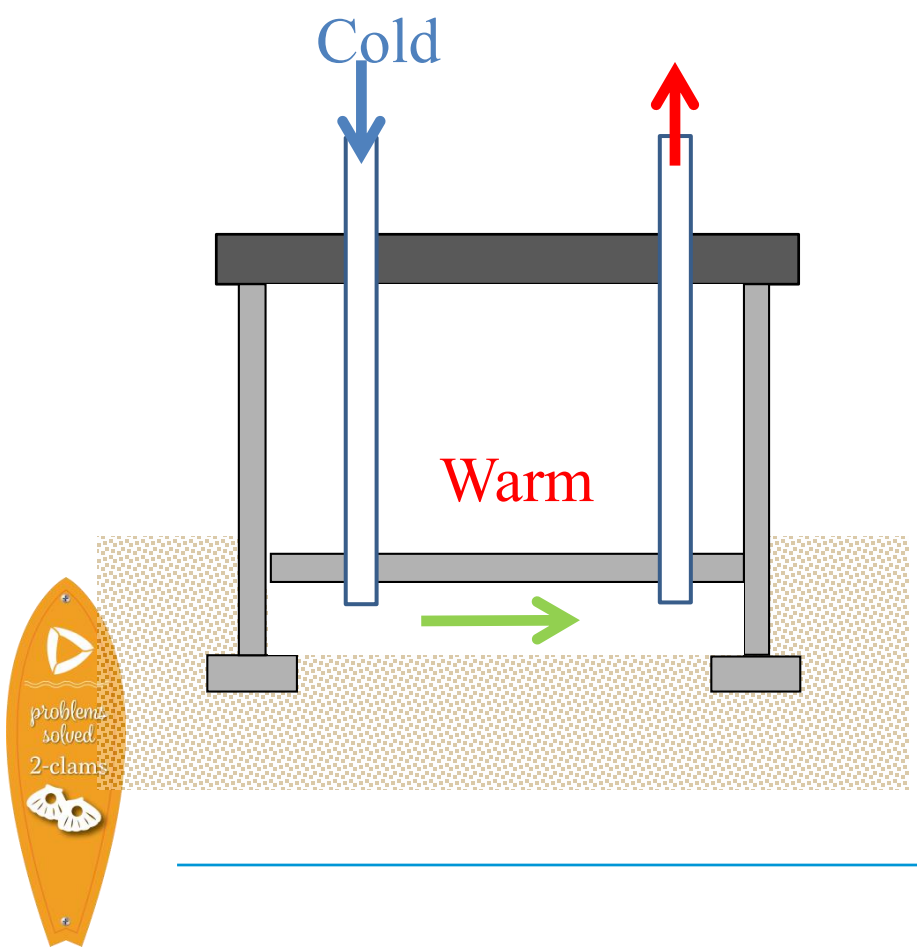
AFS Passive System CFD Modeling

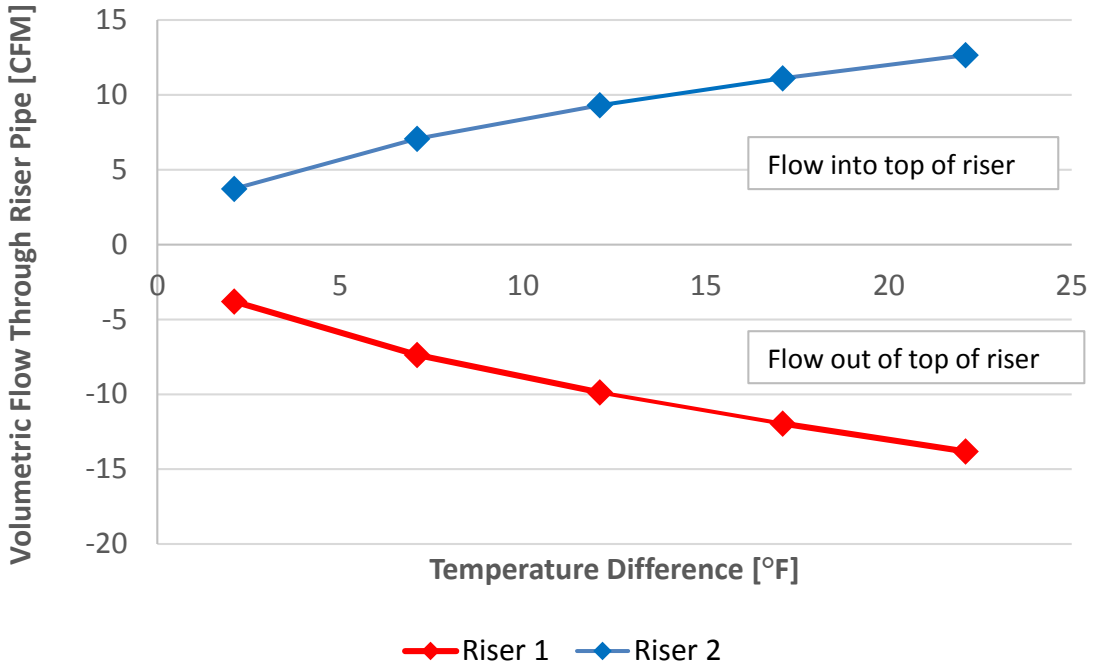






AFS Passive System CFD Modeling





Next Steps

- Modelling
  - Various riser pipe/inlet configurations
  - Wind effects
  - Optimizing vacuum/flow
  - Mass flux/concentration modelling (i.e. including vapour)
- Field Tests
- Proof of Concept
  - intrinsic passive operation
- Design procedures

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References

[1] Abreu, L. D. V. and Johnson, P. C. 2005. *Effect of Vapor Source-Building Separation and Building Construction on Soil Vapor Intrusion as Studies with a Three-Dimensional Numerical Model*. Environ. Sci. Technol. **39** pp. 4550 – 4561.

[2] Pennell, K. G., Bozkurt, O. and Suuberg, E. M. 2009. *Development and Application of a Three-Dimensional Finite Element Vapor Intrusion model.* J. Air & Waste Manage. Assoc. **59** pp. 447 – 460.

[3] Bozkurt, O., Pennell, K. G. and Suuberg, E. M. 2009. *Simulation of the Vapor Intrusion Process for Nonhomogeneous Soils Using a Three-Dimensional Numerical Model.* Ground Water Monit. Rem. **29**(1) pp. 92 – 104.

[4] Yao, Y., Shen, R., Pennell, K. G. and Suuberg, E. M. 2011. *Comparison of the Johnson-Ettinger Vapor Intrusion Screening Model Predictions with Full Three-Dimensional Model Results*. Environ. Sci. Technol. **45**(12) pp. 2227 – 2235.

Questions?

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