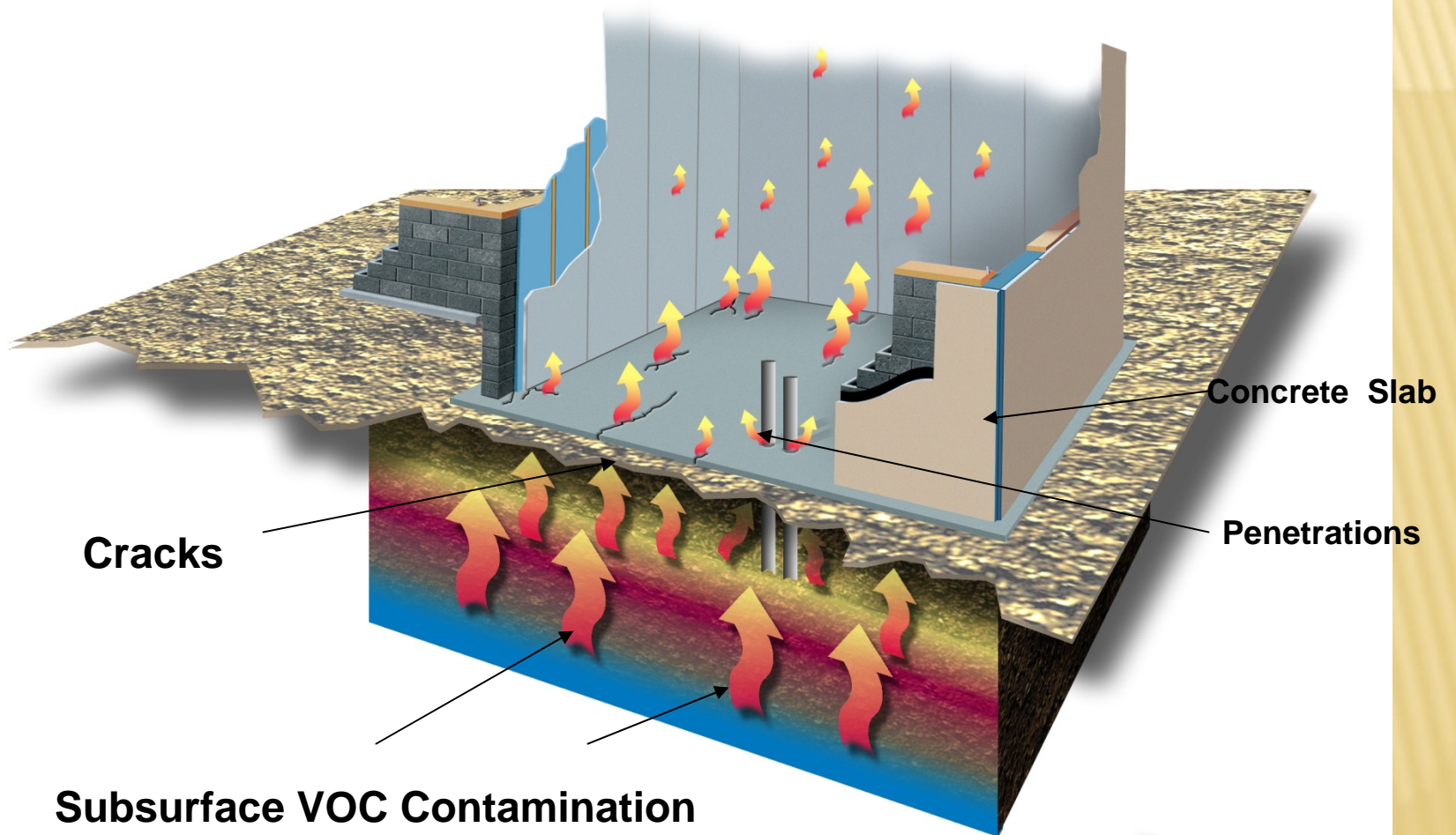

Brownfield Vapor Barriers: Chemical Compatibility, Testing and Advancements in Material Science

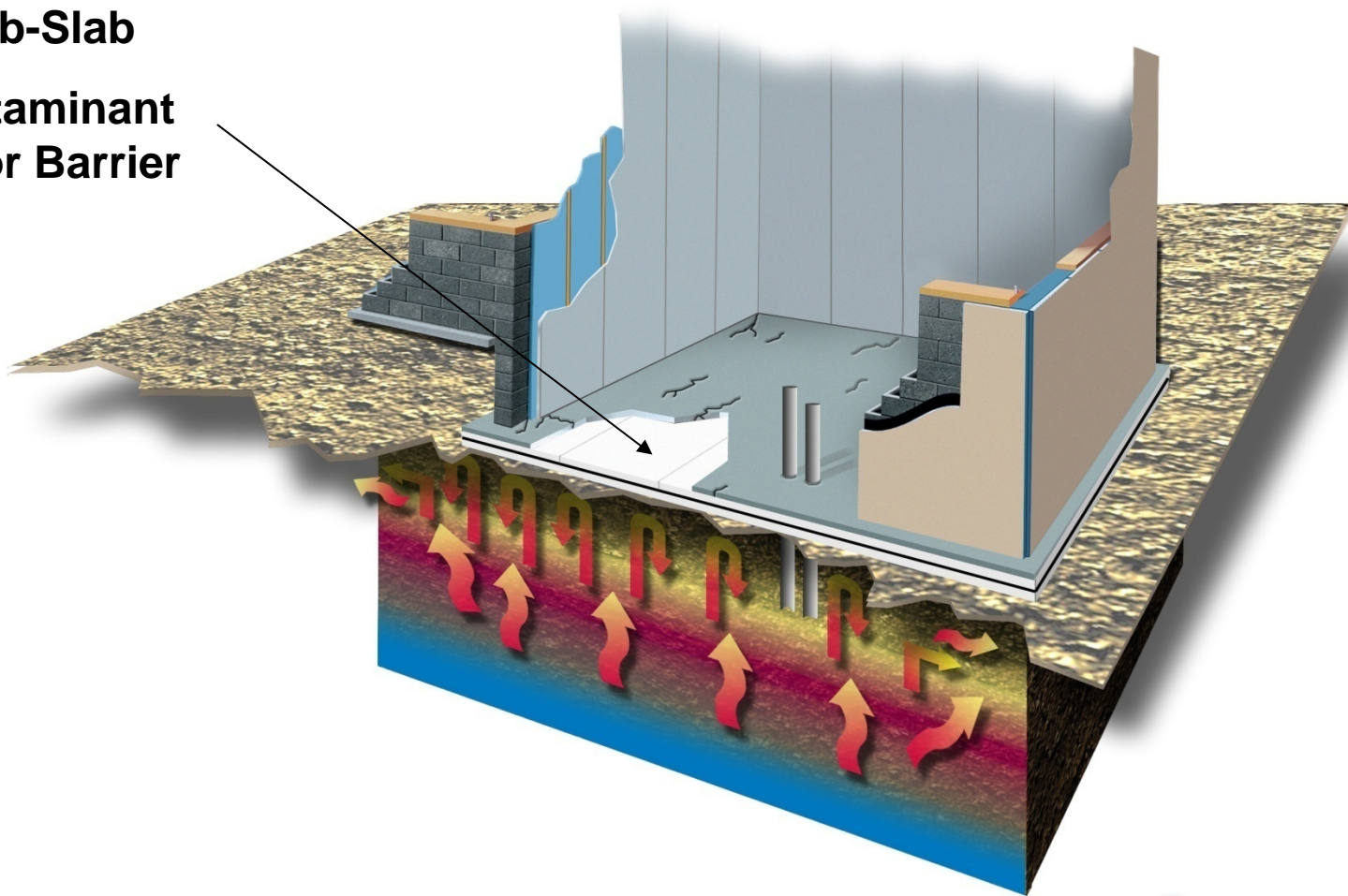
Todd Herrington

VAPOR INTRUSION



SUB-SLAB VAPOR INTRUSION BARRIER

Sub-Slab
Contaminant
Vapor Barrier



Contaminant Vapor Barrier Materials

Over the past five years two materials have generally been considered:

- **High Density Polyethylene (HDPE)**
- **Spray Applied Asphalt/ Latex**

High Density Polyethylene (HDPE)

- ✓ Excellent Chemical Resistance
- ✓ Very Low Permeance To VOCs
- ✓ Excellent Durability
- ~~X~~ Excellent Constructability
- ~~X~~ Cost Effective



High Density Polyethylene

Spray Applied Asphalt/Latex Membranes

- ✓ Excellent Constructability
- ✓ Excellent Durability (w/geofabric)
- ✓ Cost Effective
- ~~X~~ Excellent Chemical Resistance
- ~~X~~ Very Low Permeance To VOCs



Asphalt/Latex

Asphalt/Latex Membranes

Common Composition:

- Asphalt/ Latex Emulsions (bitumen/polystyrene) with clay or carbonate “builders”
- Spray Applied with CaCl_2 Solution

All of these Compositions are Lipophilic

- Tend to Adsorb VOC Vapors

VOC Transport Across Membranes

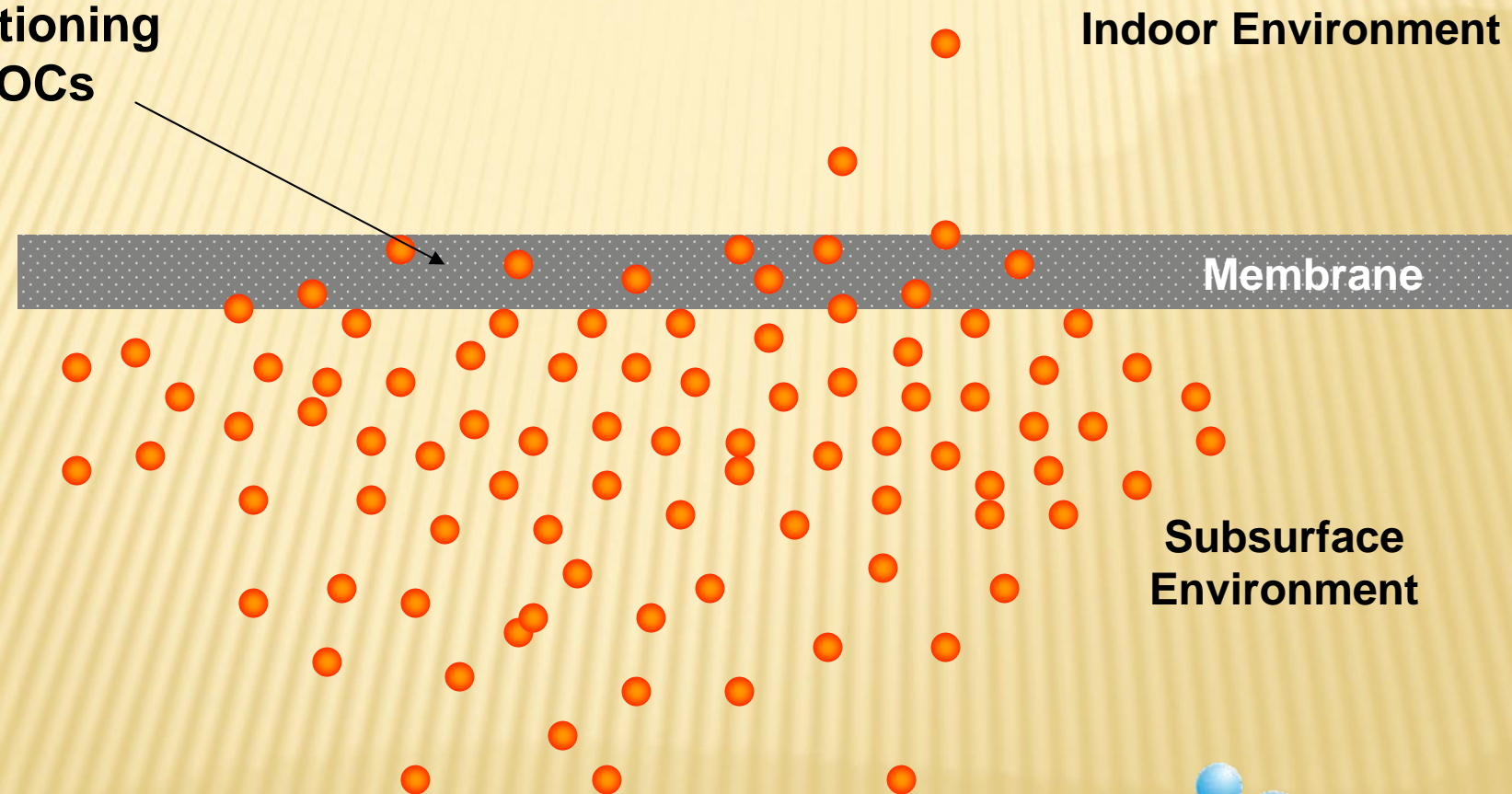
EARLY ADSORPTION (Partitioning)

Partitioning
of VOCs

Indoor Environment

Membrane

Subsurface
Environment

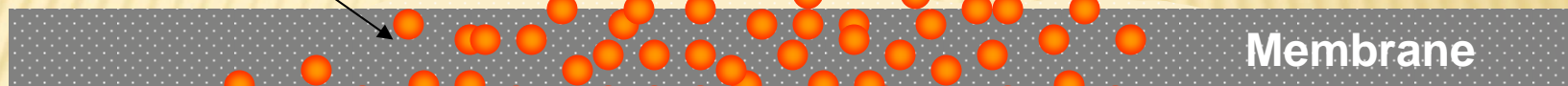


VOC Transport Across Membranes

NEAR SATURATION

Partitioning
of VOCs

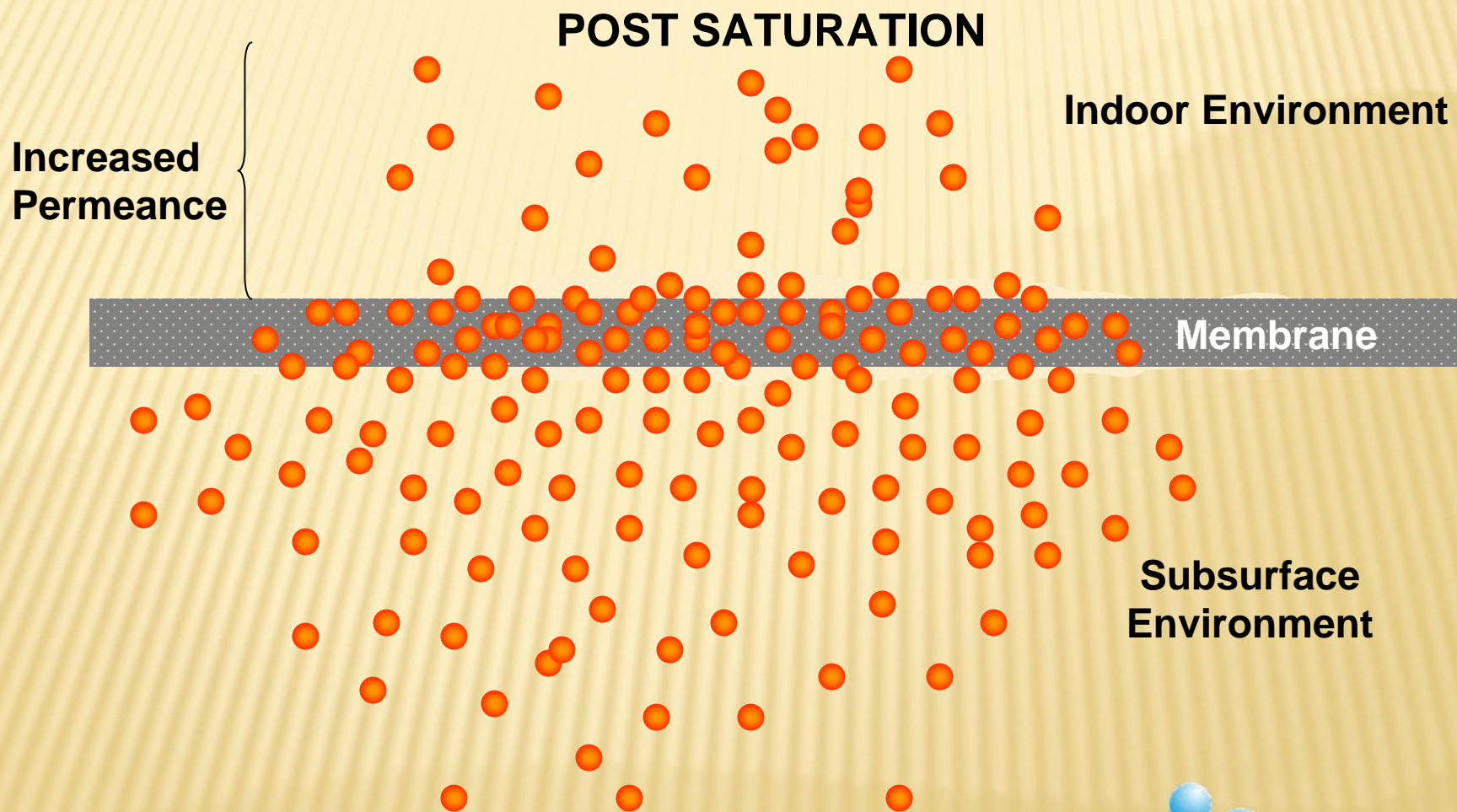
Indoor Environment



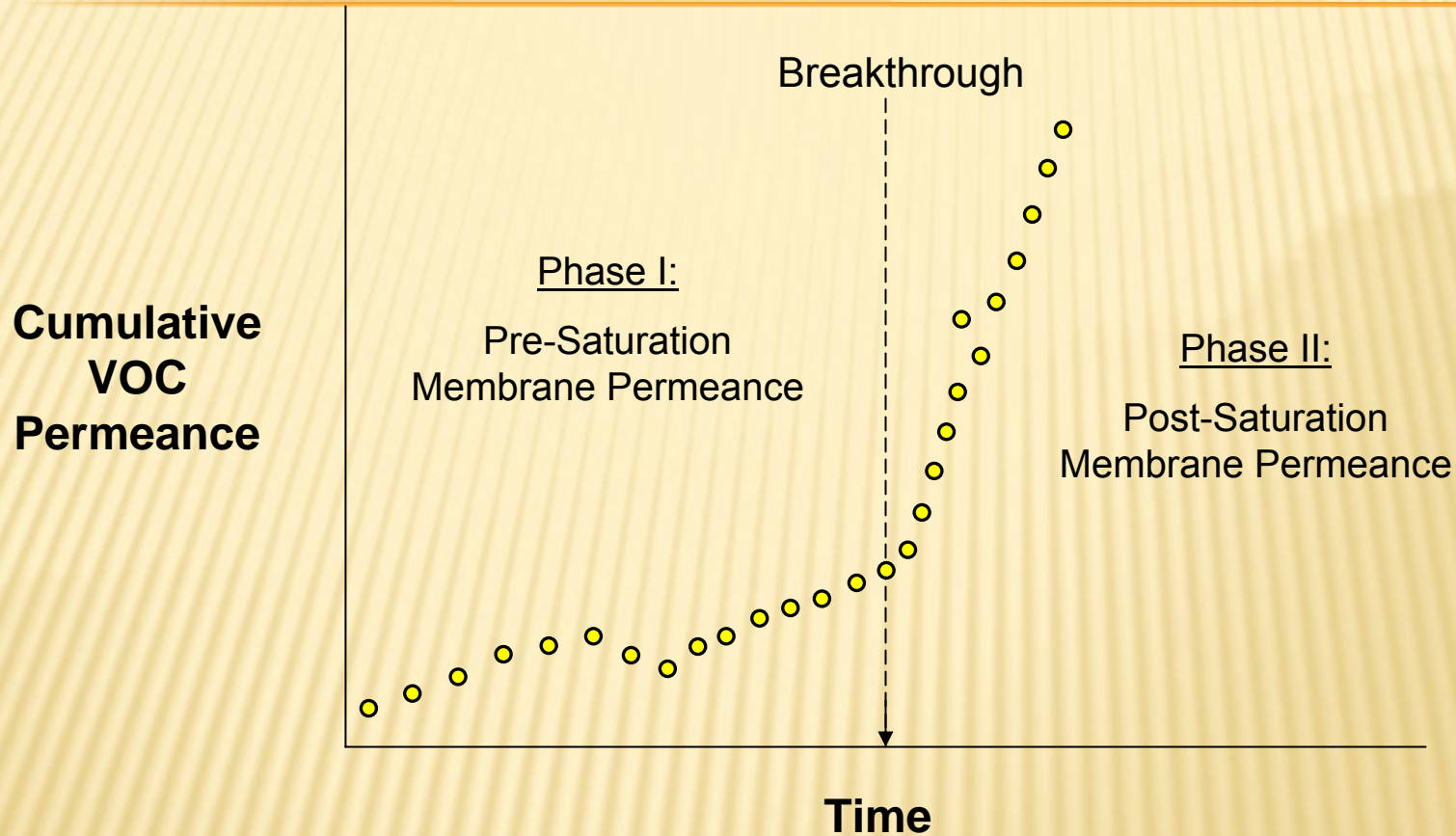
Membrane

Subsurface
Environment

VOC Transport Across Membranes



Permeance of VOCs Across Membranes



7-day Hexane Weight Gain Vapor Test (ASTM D 543)

Ingredient	Composition			
	(%)			
Bitumen	72.2	71.7	72.2	66.2
PSL	18.1	17.9	18.1	16.6
CaCl ₂	0.7	1.4	0.7	0.7
CaCO ₃	9.0	9.0	0.0	16.6
Bentonite	0.0	0.0	9.0	0.0
% Weight Gain	15.0	12.5	14.1	10.9

Development of Improved Vapor Barrier

Q: How to improve chemical resistance of spray applied asphalt/latex?

A: Use HDPE to Encapsulate the asphalt/latex in a Composite Membrane!

Development of Geo-Seal™

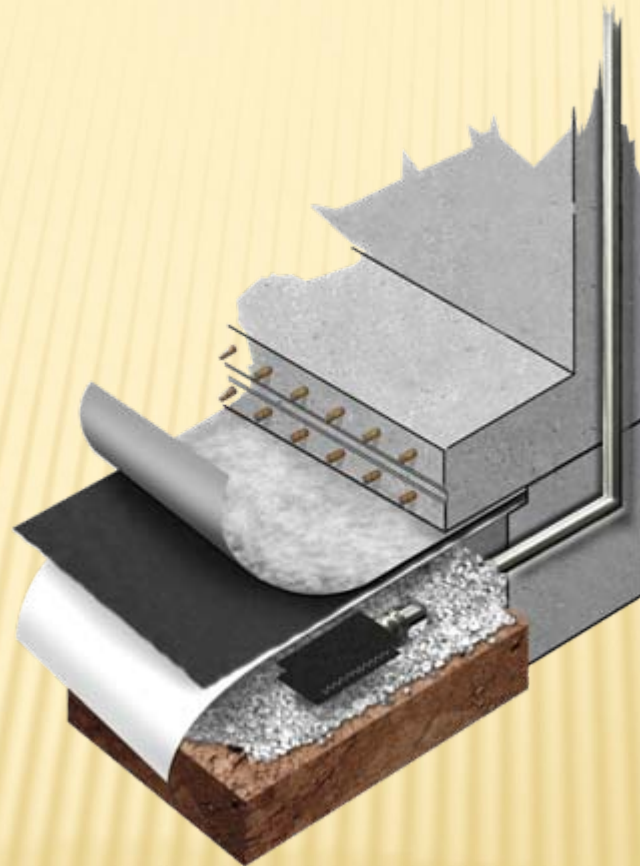
Composite membrane¹ was *best of both worlds*:

- Chemical Resistance & Low Permeance of HDPE
- Constructability and low cost of Spray Applied Membrane

¹Patents Pending (US and international)

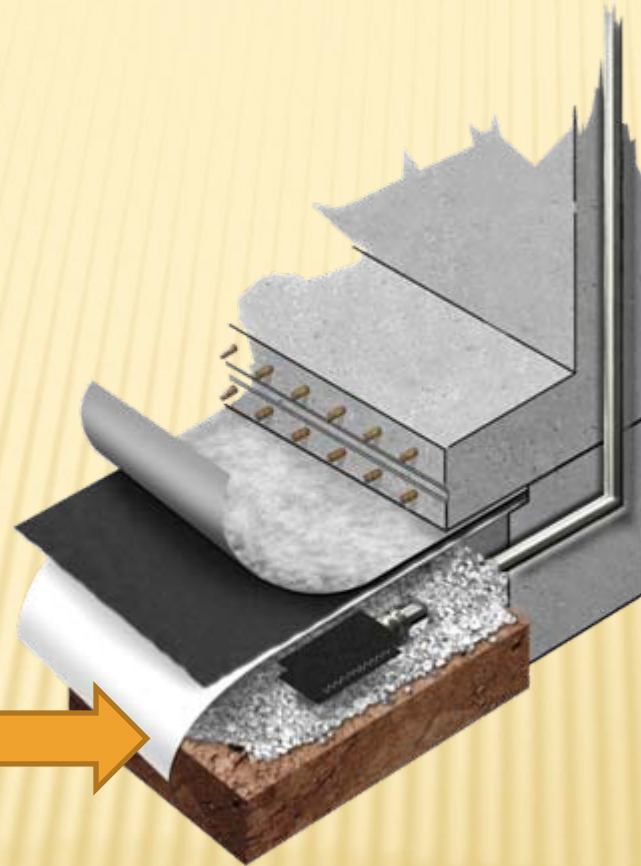
Geo-Seal™

Advanced Vapor Management Technology



Geo-Seal™

Advanced Vapor Management Technology

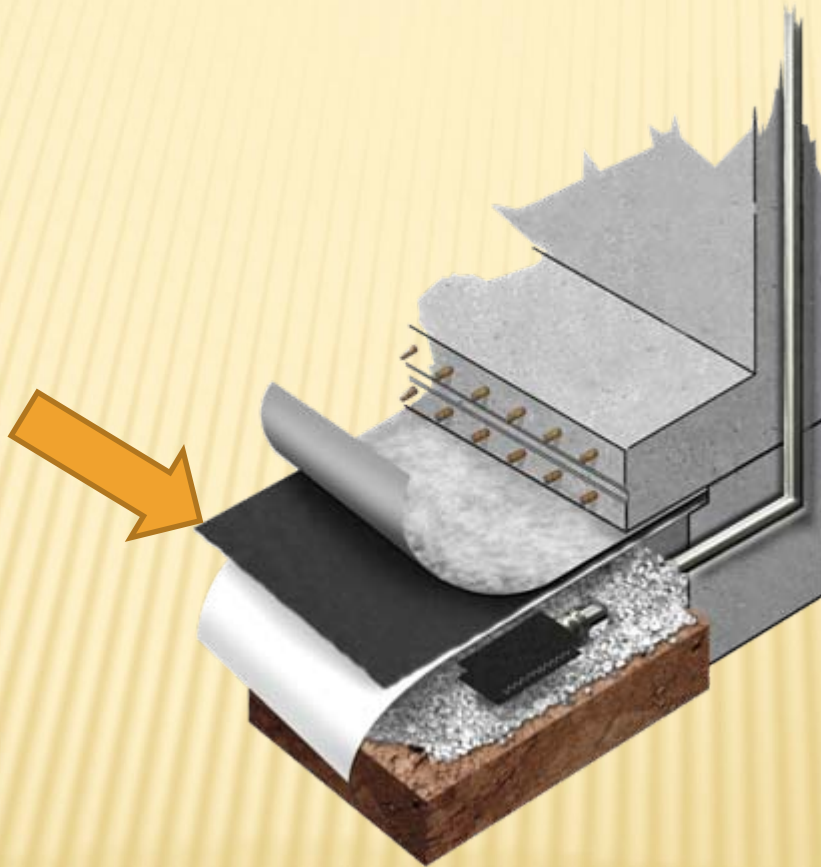


Geo-Seal *BASE*
HDPE/Polyolefin
Hybrid 1

Geo-Seal™

Advanced Vapor Management Technology

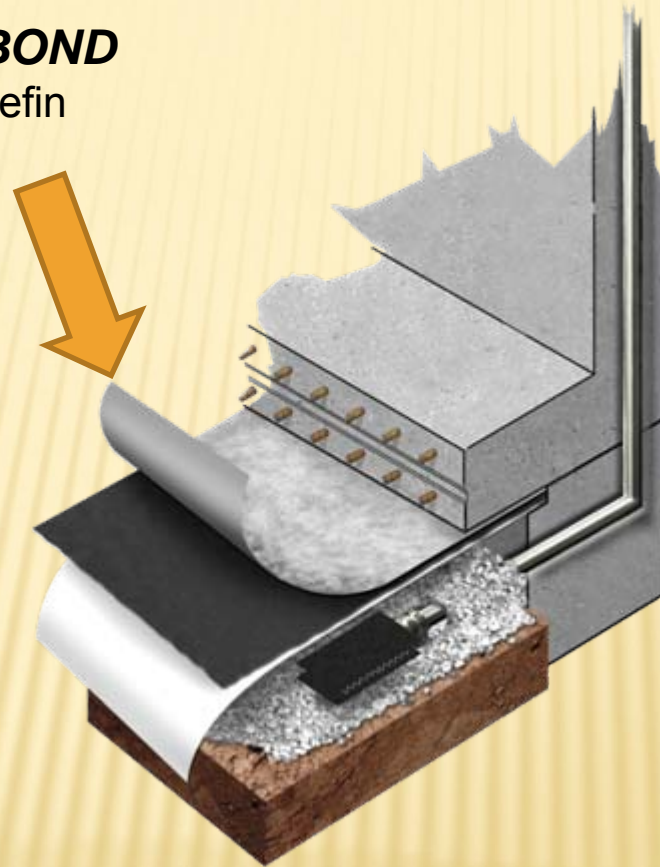
Geo-Seal CORE
Spray Applied
Copolymer Modified
Bitumen/polystyrene





Advanced Vapor Management Technology

Geo-Seal *BOND*
HDPE/Polyolefin
Hybrid 2



Geo-Seal™

Advanced Vapor Management Technology

Geo-Seal *BOND*

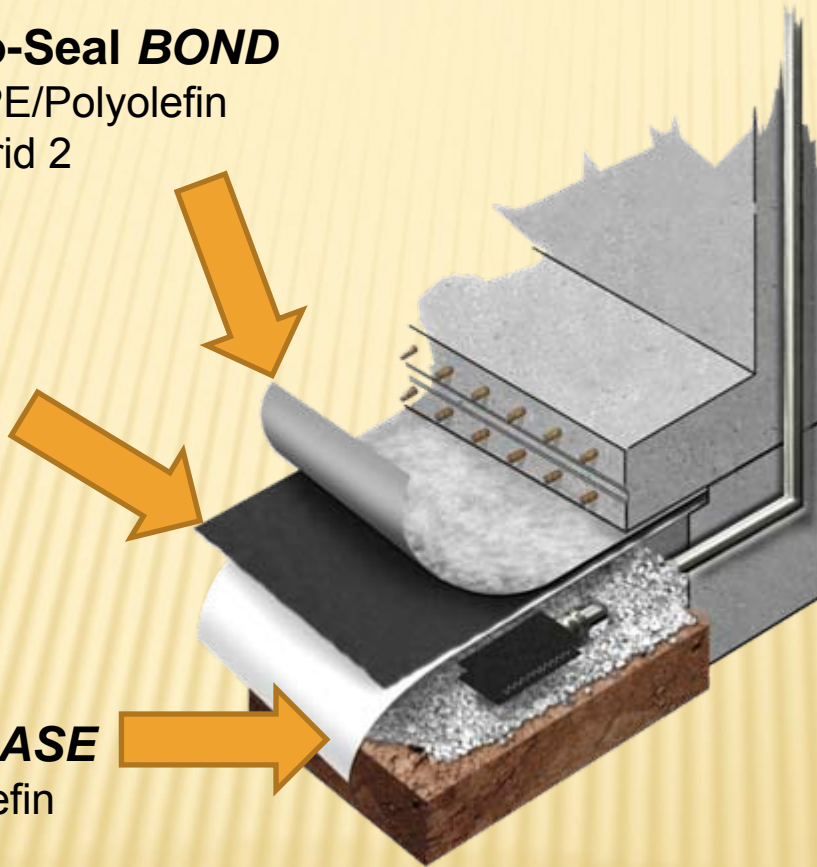
HDPE/Polyolefin
Hybrid 2

Geo-Seal *CORE*

Spray Applied
Copolymer Modified
Bitumen/polystyrene

Geo-Seal *BASE*

HDPE/Polyolefin
Hybrid 1



Geo-Seal™

Advanced Vapor Management Technology

Geo-Seal *BOND*

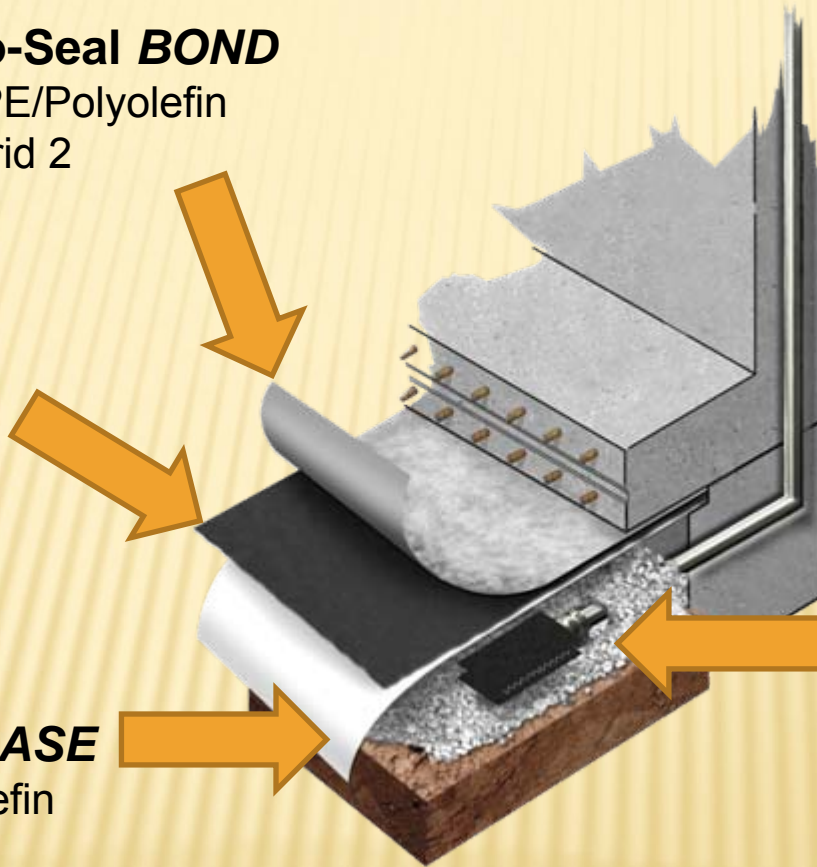
HDPE/Polyolefin
Hybrid 2

Geo-Seal *CORE*

Spray Applied
Copolymer Modified
Bitumen/polystyrene

Geo-Seal *BASE*

HDPE/Polyolefin
Hybrid 1



Geo-Seal *Vapor Vent*
HDPE Vent System

Solvent Exposure Testing

- PCE Saturated Vapors on One Side of Membrane
- 7 Day Test

Solvent Exposure Testing Modified ASTM D-543*			
	Pre-Test Weight (g)	Post-Test Weight (g)	Weight Gain
Asphalt/ Latex	4.24	4.7	10.80%
Geo-Seal™	3.87	3.95	2.10%

*Intertek Laboratories, Foxboro Mass. 2008

Solvent Exposure Testing

Results Indicate:

- Geo-Seal is 5X more resistant to VOC partitioning than simple asphalt/Latex membranes
- This is a result of HDPE encapsulation

Permeation/Diffusion Testing

Q: How to Accomplish Permeability Testing?

Others have reported Permeance/Diffusion Rates without considering VOC partitioning.....

- Very suspect methodology
- Overtime these rates may increase as membrane becomes saturated

Permeation/Diffusion Testing

Estimating the permeation rate solely on the amount of VOC that passes through a geomembrane surface area per unit time is incorrect for it does not account for partitioning...

Park, J.K., J.P. Sakti, and J.A. Hoopes. 1996. "Determination of Volatile Organic Compound Permeation Through Geomembranes". *Volatile Organic Compounds in the Environment, ASTM STP 126*, W. Wang, J. Schoor, and J. Doi, Eds., American Society for Testing and Materials, 1996, pp. 245-258.

Permeation Testing

Q: *How to accomplish Permeability Testing?*

A: Saturate the membrane Prior to Testing.

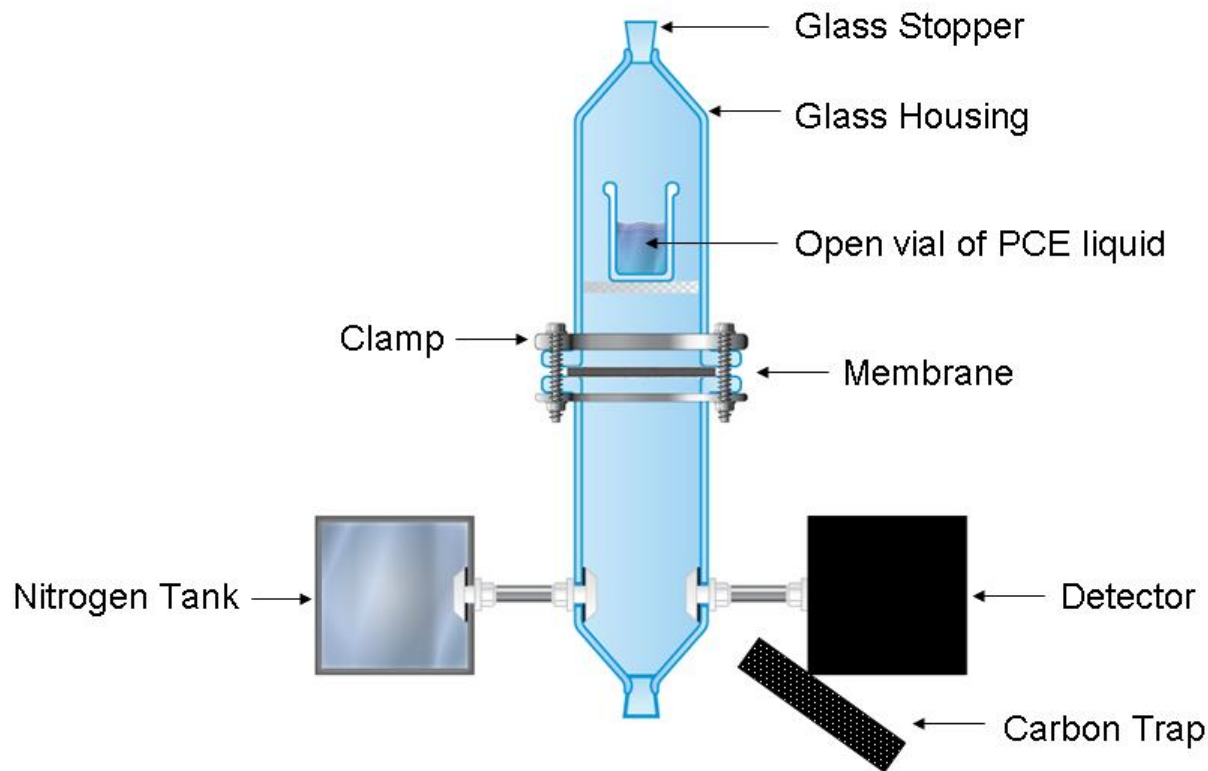
- Removes concern about partitioning impacting permeance
- Represents Long Term resistance requirement

Permeation Testing

ASTM F 739: Standard Test Method for Permeation of Liquids and Gases through Protective Clothing Materials under Conditions of Continuous Contact

Permeation Testing

Test Cell Set Up



Permeation Testing

- 24 hour saturation period
- 8 hour permeation period w/ Gas VOC
- Double compartment apparatus

Results of Comparative Permeation Testing under Gaseous VOC Challenge*

Barrier Material	VOC Contaminant	Breakthrough Time (minutes)	Steady-State Perm Rate (ug/cm ² /min)
Asphalt/ Latex	PCE	450	5
Geo-Seal	PCE	No Breakthrough	<0.01

*Intertek Laboratories, Foxboro Mass. 2008

Permeation Testing

Results of Gaseous Challenge Indicate:

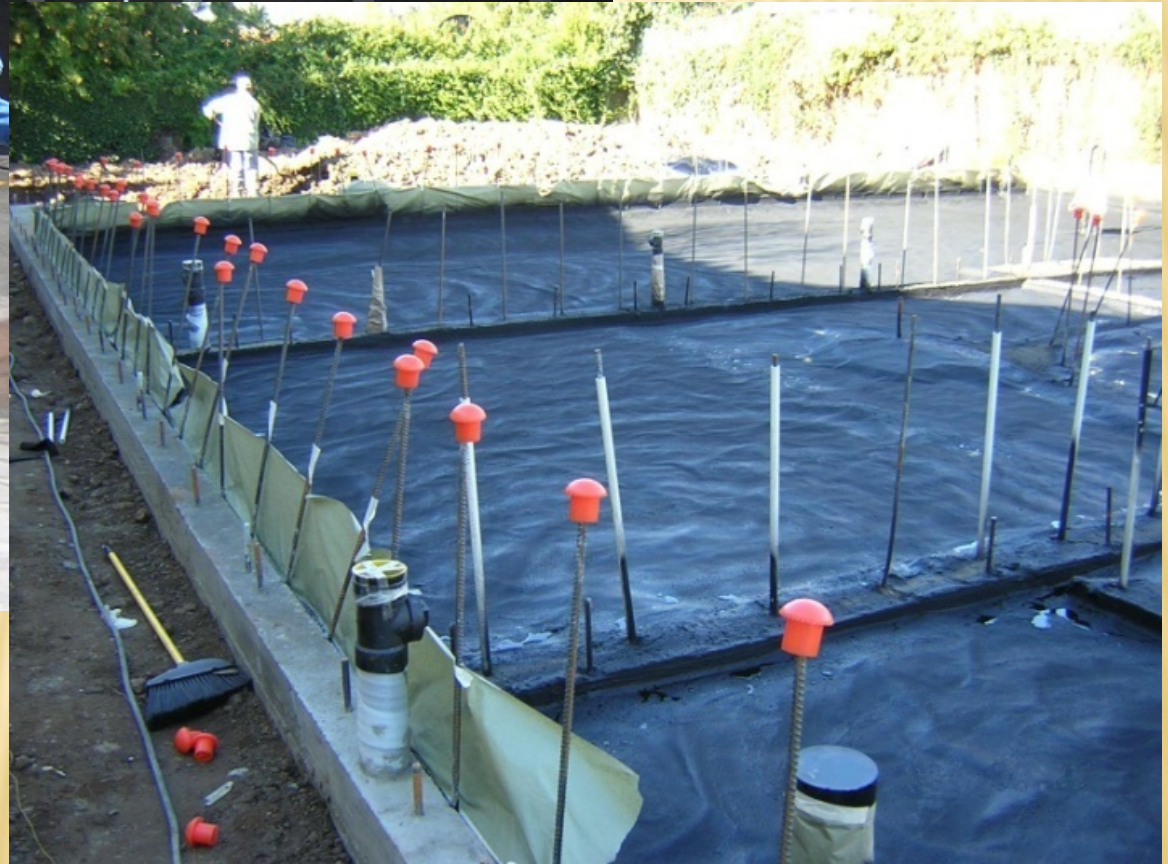
Geo-Seal:

- Resisted Permeance Breakthrough
- Asphalt/Latex did breakthrough with significant VOC permeance

Application and Sealing of BASE Layer



Application of CORE



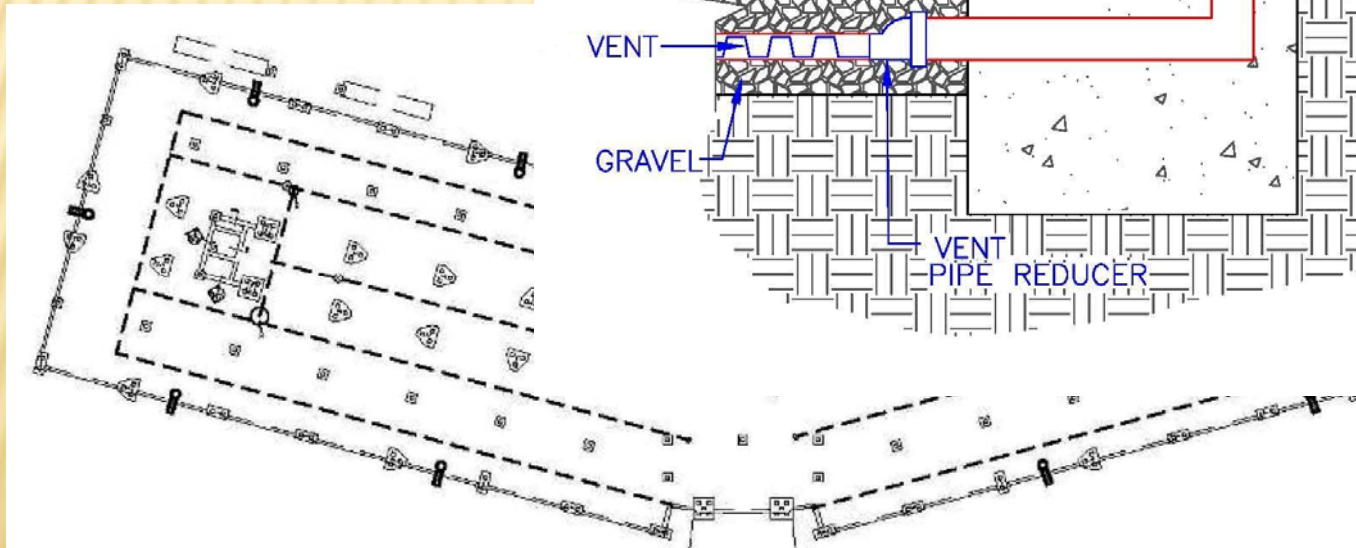
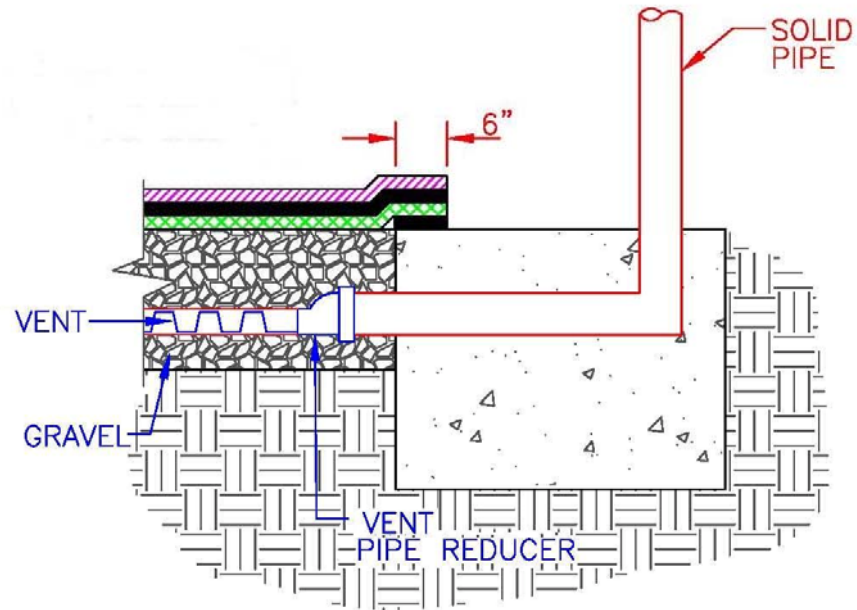
BOND Layer Under Steel



VaporVent Low Profile Gas Collection and Vent System

- Active
- Passive
- Material Options
 - Polystyrene
 - HDPE

VENT RISER DETAIL



QA/QC Measures

- Manufacturer and 3rd party inspection
- Coupon sampling
- Depth Gauge testing
- Applicator network
- Smoke testing
- Other factors:
 - Color of the membrane
 - Multiple layers of redundancy
 - Competitive Warranty



635 S. Hobart Street. Los Angeles, CA



Center for Jewish Life. Palo Alto, CA





Advanced Vapor Management Technology

- ✓ Excellent Chemical Resistance
- ✓ Very Low Permeance To VOCs
- ✓ Excellent Constructability
- ✓ Excellent Durability
- ✓ Cost Effective



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