Design of Below Sub-slab Vapour Management System for a Commercial Building

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1. Vapour intrusion is real
2. Worst cases are easiest to detect
3. Chronic effects at lower concentrations more difficult to assess
Vapour intrusion ("VI") is a potential exposure pathway at many sites.

Typically concern is chronic impacts, but may also be safety concerns or odour issues for few sites.

There are an increasing number of identified sites with significant vapour intrusion impacts, but most of these are chlorinated solvent sites, with few petroleum hydrocarbon sites.

Many sites also have methane issues (woodwaste, peat, landfilled materials).
• VI is becoming of significant interest to regulators, industry & stakeholders

• Case studies and modeling indicate VI highly dependent on site specific conditions – this is challenging for generic criteria approach

• Attenuation factor “alpha”

\[ \alpha = \frac{C_{\text{air}}}{C_{\text{soil vapour}}} \]
Mitigation Options

- Institutional controls on land use
  - Deed restrictions or other mechanisms

- Engineering controls
  - Subslab depressurization ("SSD") with active venting (interim measure for existing buildings)
  - Barrier with passive or active venting (new buildings)
  - Contaminant treatment or removal

- Intrinsically safe building design
  - Lower floors with well ventilated parking garages
  - HVAC design and operation to maintain positive pressure in buildings at all times
## ITRC (2007) Guidance

### Table 4.1
Comparison of Mitigation Methods

<table>
<thead>
<tr>
<th>Technology</th>
<th>Typical Applications</th>
<th>Challenges</th>
<th>Range of Installed Costs</th>
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</thead>
<tbody>
<tr>
<td>Passive Barriers</td>
<td>New construction; crawl spaces; often combined with passive or active venting, sealing openings in the slab, drains, etc.</td>
<td>Preventing tears, holes; may not suffice as a stand-alone technology; some states do not accept. Ensuring caulking seals cracks in floors, etc.</td>
<td>$0.50-$5/ft²; thinner, less expensive barriers likely to be inadequate</td>
</tr>
<tr>
<td>Passive Venting</td>
<td>New construction; low vapor flux sites; should be convertible to active system if necessary</td>
<td>Relies on convective flow of air due to wind and heat stack effects; air flows and suction typically far less than achieved by fans</td>
<td>$0.75-$5/ft²</td>
</tr>
<tr>
<td>Sub-Slab Depressurization (SSD)</td>
<td>New and existing structures; sumps, drain tiles, and block wall foundations may also be depressurized if present.</td>
<td>Low permeability and wet soils may limit performance; otherwise, highly effective systems</td>
<td>$1-$5/ft²; residential systems typically in the $1-2/ft² range</td>
</tr>
<tr>
<td>Sub-Membrane Depressurization (SMD)</td>
<td>Existing structures, crawl spaces</td>
<td>Sealing to foundation wall, pipe penetrations; membranes may be damaged by occupants or trades people accessing crawl space.</td>
<td>$1-$6/ft²; residential systems typically in the $1.50-2/ft² range</td>
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<tr>
<td>Sub-Slab Pressurization (SSP)</td>
<td>Same as SSD; most applicable to highly permeable soils</td>
<td>Higher energy costs and less effective than SSD; potential for short-circuiting through cracks</td>
<td>$1-$5/ft²</td>
</tr>
<tr>
<td>Building Pressurization</td>
<td>Large commercial structures, new or existing; sensitive receptors</td>
<td>Requires regular air balancing and maintenance; may not maintain positive pressure when building is unoccupied</td>
<td>$1-$15/ft²; heavily dependent on size and complexity of structure</td>
</tr>
<tr>
<td>Indoor Air Treatment</td>
<td>Specialized cases only</td>
<td>Typically generates a waste disposal stream; effective capture of air contaminants may be difficult; energy-intensive, with significant O&amp;M burden</td>
<td>$15,000-$25,000 per application not atypical; actual costs heavily dependent upon type of technology employed</td>
</tr>
<tr>
<td>Sealing the Building Envelope</td>
<td>Cracks and holes in existing buildings</td>
<td>Access to perforations, permanence</td>
<td>Highly dependent on the extent of sealing required</td>
</tr>
</tbody>
</table>
No standard practice for design

Mitigation requirements are site specific (costs may not be insignificant)

Guidance on methane mitigation includes: UK CI REA reports 149 & 665 (Assessing risks posed by hazardous gases to buildings), British Standards 8485:2007; California guidance: Los Angeles, San Diego
Common approach consists of vapor barrier and passive vent pipes in coarse-grained fill layer

Wide range barrier materials

- **Conventional**: Polyvinyl chloride (PVC), high density polyethylene (HDPE), **Newer**: Synthetic fibre-reinforced Linear Low Density Polyethylene (LDPE) with aluminium composite, STEGO 15 mil polyolefin with taped seams, Liquid boot asphaltic emulsion

- How do you design barrier layer?
  - Strength, elongation, permeance or vapor diffusivity, chemical compatibility, connections, penetrations

Pipe stacks may be connected to wind turbines, or provisionally active system
New Building Mitigation
(Case Study 1)

- Recent approximate costs for supply only (not including installation) for commercial slab-at-grade building project in Vancouver, BC (62,500 SF)
  - 30 mil PVC Vapor Barrier: $3.75 / SM
  - 15 mil Layfield Vapoflex: $1.90 / SM
  - 4 oz/sq in. protective geotextile above liner: $1.52 / SM
  - Sch. 40 PVC perforated piping: 7.50/m
  - Wind turbines: $200/each
  - Pea gravel surrounding vent pipes: $50/m³
New Building Mitigation
(Case Study 1)
30 mil PVC Membrane
Soil Gas Ventilation System Design

Gas Flow in Soil
- \( q = k \ \Delta P_{\text{soil}}/\mu \Delta X_{\text{soil}} \)
- \( k = \) soil air permeability
- \( \mu = \) viscosity of gas
- \( \Delta P_{\text{soil}} = \) pressure drop in soil; easy to solve analytically for 1-D flow

Gas Flow Into & Through Pipe
- \( P_{\text{LO}} = C \ (V_1/4005)^2 \)
- \( P_{\text{LP}} = f \ LV_2^2/D^2g \)
- Total Loss = \( \Delta P_{\text{pipe}} = P_{\text{LO}} + P_{\text{LP}} \)
- \( \Delta P_{\text{pipe}} < 0.1 \ast \Delta P_{\text{soil}} \)

Golder has developed spreadsheet model for design
When Is A **GAS VAPOR BARRIER** Required Or Necessary?

Former Manufacturing Facilities, MGP, Gas Station, Dry Cleaner, Tank Farm, and Landfill Sites

![Former Manufacturing Facility](image1)

![Former Gas Station](image2)

![Former Landfill](image3)

![Former Dry Cleaner](image4)

![Former MGP Site](image5)

![Former Tank Farm](image6)
LIQUID BOOT® Spray-Applied GAS VAPOR MEMBRANE

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Costco-Ocean Township, New Jersey
Constructability Of HDPE/ PVC Under Buildings