# Design and Performance of

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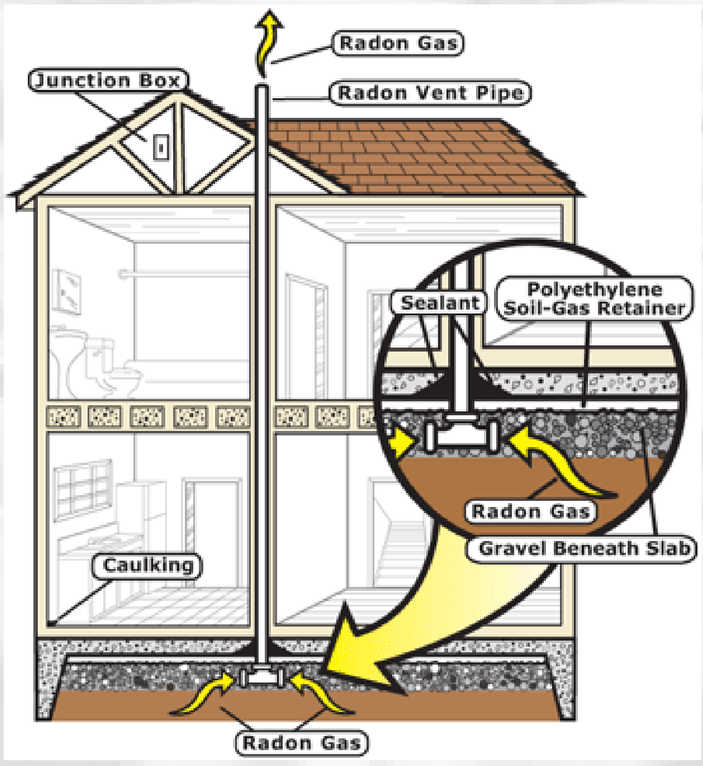
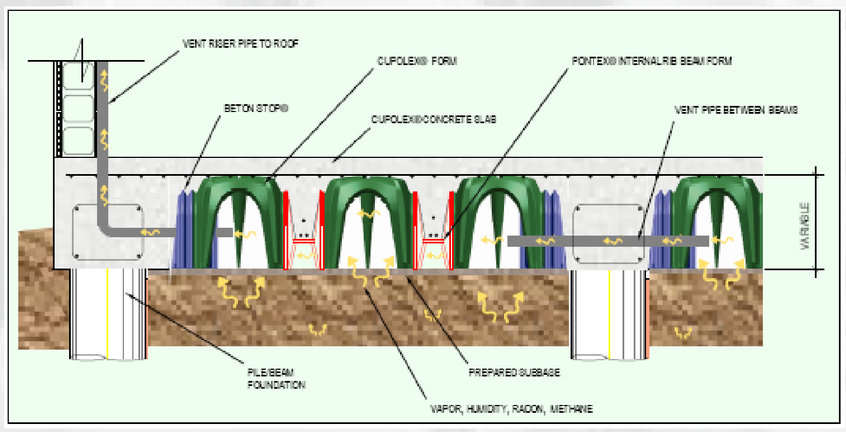
**Abstract:** Aerated floor systems were incorporated into the design of several newly constructed buildings, including two homes in the Southwest and a community center in the Rocky Mountain region, to provide an under-slab void network that could be vented for vapor intrusion control. Compared to a conventional slab on grade liner and granular venting layer designs, the aerated floor system was selected to allow more efficient movement of ventilation air, increasing the potential for passive air flows to adequately dilute sub-slab gas concentrations and protect indoor air. Passive mitigation avoids electrical and other operation and maintenance costs associated with electric fans (active systems), resulting in a more sustainable and "green" remediation system. Air flow and pressure measurements were taken at these sites to determine how well the aerated flooring system performed under normal and wind pressure gradients, induced gradients using whirlybird fans, solar powered fans and using traditional radon blowers. Based on the data collected, wind-driven gradients can provide sufficient ventilation to dilute moderate sub-slab concentrations to predictable and acceptable levels with a reasonable number of riser pipes. The addition of a radon fan allowed depressurization of the under-slab void network and conversion to a mitigation system that could address higher concentration conditions.

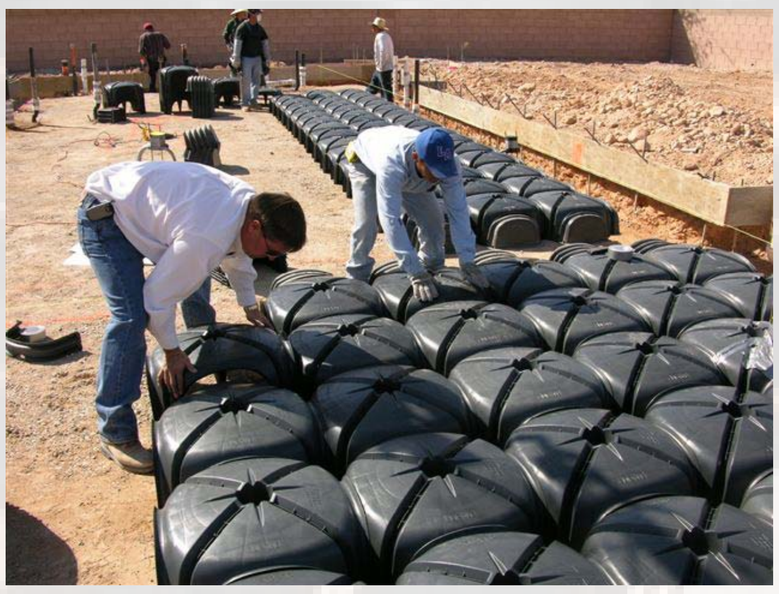


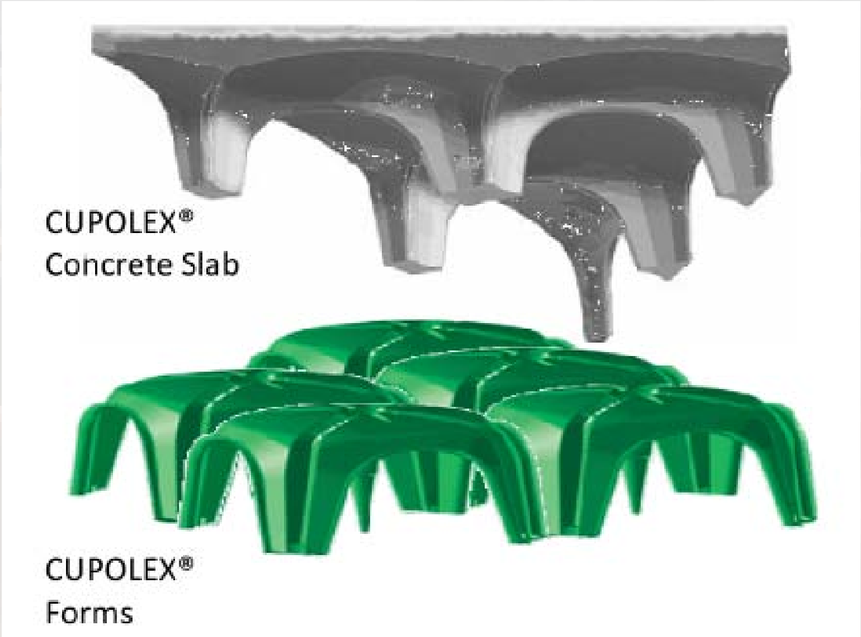




**TRADITIONAL VENTING** **vs.** **AERATED FLOOR**

- No Cupolex forms
- 4" compacted sub-base
- 6-8" washed gravel for venting layer
- Collection piping in venting layer
- Vent pipes (2x-3x)
- 4" concrete
- Rebar or welded wire with chairs
- Power Screed Finish

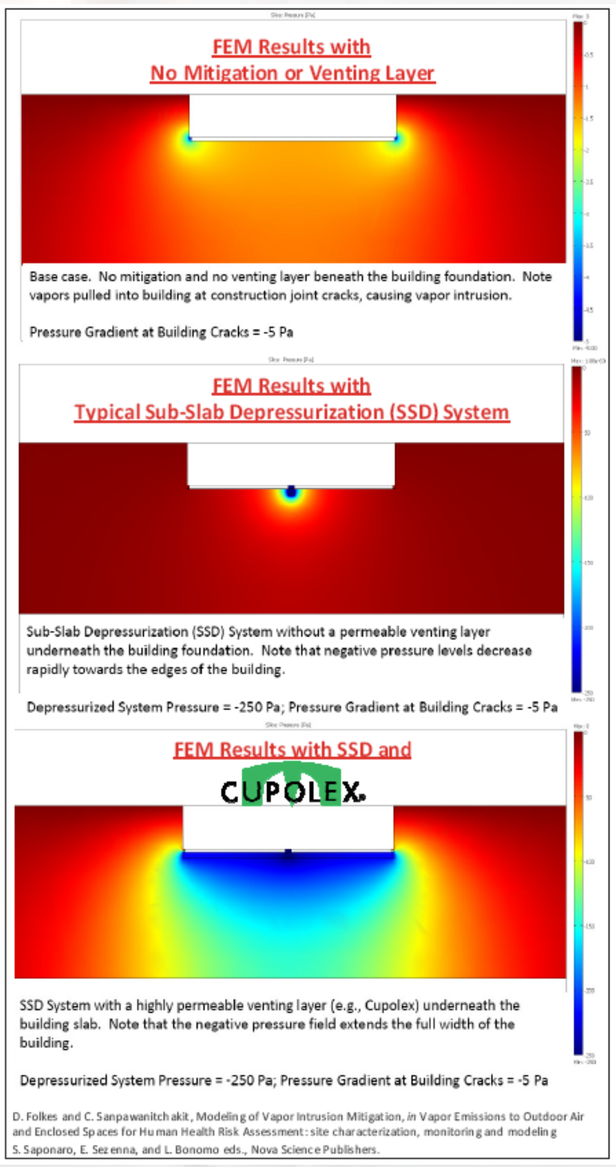
- 10" Cupolex
- 2" compacted sub-base (if needed)
- Vent piping
- 2" concrete
- 6"x6" 4/4 welded wire
- Hand Screed Finish






**Green building** (also known as **green construction** or **sustainable building**) is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort.

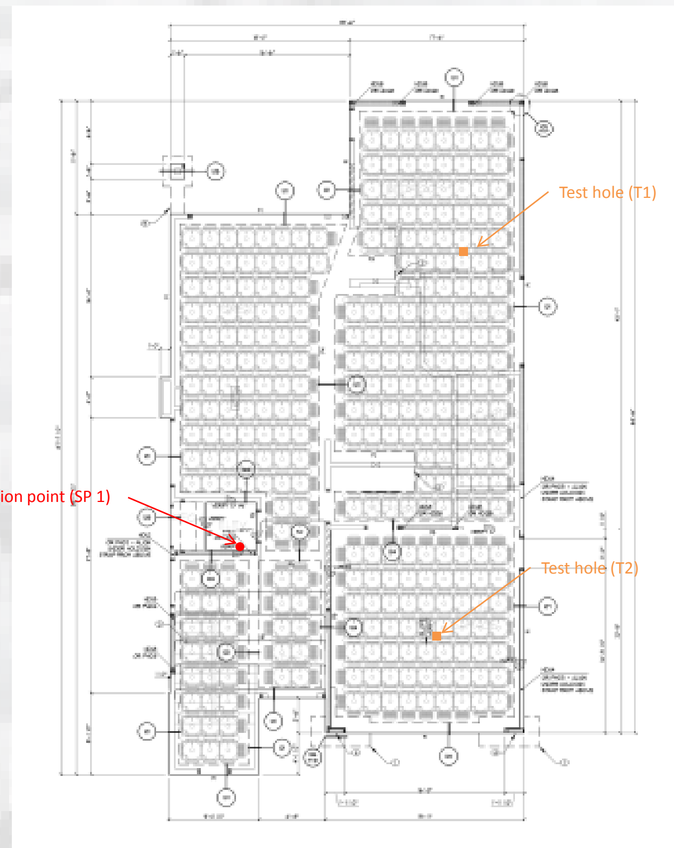
# an Aerated Floor System for




| Cupolex Form Height (inches) | Void Space Under Form (inches) | Concrete Consumption on Form ($yd^3$/sq. ft.) |
|---|---|---|
| 2 | 1.57 | 0.001 |
| 4 | 2.76 | 0.0017 |
| 5 | 4.33 | 0.0036 |
| 8 | 6.69 | 0.0043 |
| 10 | 8.66 | 0.0055 |
| 12 | 10.24 | 0.0051 |
| 14 | 12.2 | 0.0055 |
| 16 | 13.39 | 0.0073 |
| 18 | 15.35 | 0.0078 |
| 20 | 17.32 | 0.0079 |
| 22 | 19.29 | 0.008 |
| 24 | 20.87 | 0.0085 |
| 26 | 22.83 | 0.009 |
| 28 | 24.8 | 0.0095 |

The table above demonstrates the amount of concrete used over standard Cupolex forms compared to a 4” thick slab which consumes 0.1111 $yd^3/ft^2$ and a 6” thick slab consumes 0.1667 $yd^3/ft^2$.

Modeling results of an aerated floor, which were consistent with the measured performance characteristics found at home built with an aerated floor (see below).



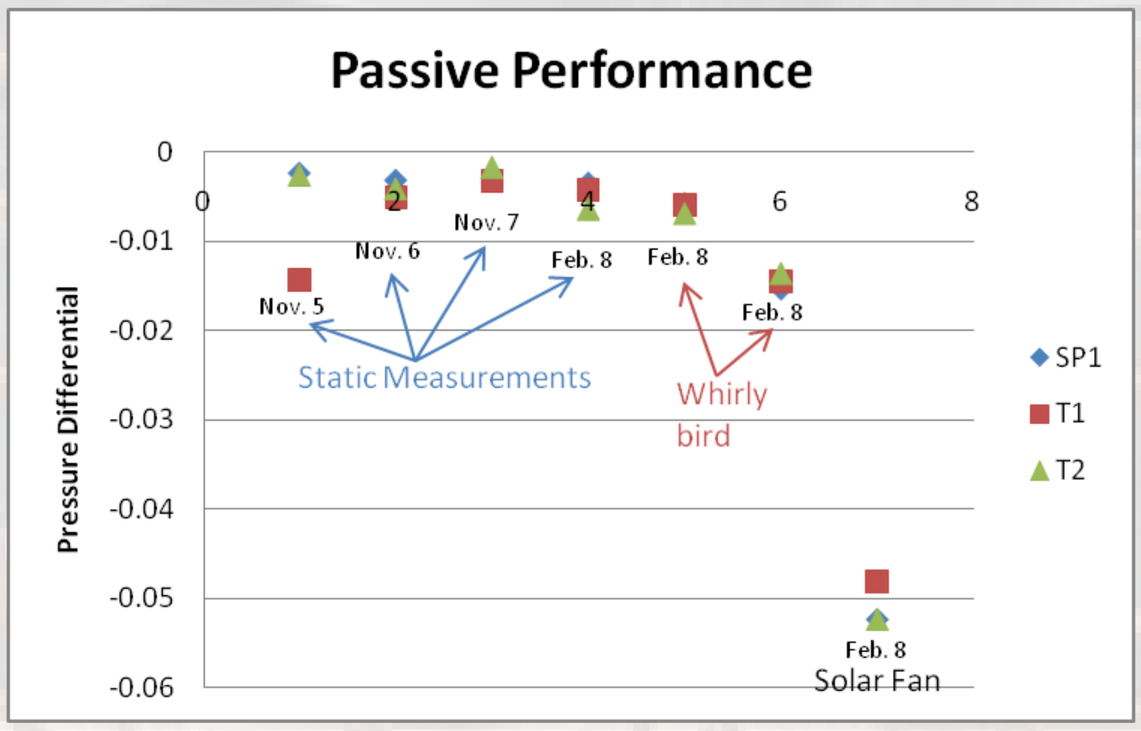

## 2000 sq. ft. Residence in Las Vegas

Extreme Makeover Home Aerated Floor System Results

| | | SP1 | T1 | T2 |
|---|---|---|---|---|
| 5-Nov | Static | -0.0023 | -0.0143 | -0.0026 |
| 6-Nov | Static | -0.0031 | -0.0051 | -0.0041 |
| 7-Nov | Static | -0.0029 | -0.0032 | -0.0017 |
| 7-Nov | Radon fan | -1.385 | -1.178 | -1.233 |
| 8-Feb | Static | -0.0034 | -0.0042 | -0.0064 |
| 8-Feb | Whirlybird @ 3 mph wind speed | -0.0057 | -0.0059 | -0.0069 |
| 8-Feb | Whirlybird @ 12 mph wind speed | -0.0153 | -0.0145 | -0.0136 |
| 8-Feb | Solar fan | -0.0524 | -0.0481 | -0.0524 |
| 8-Feb | Radon fan (RP 145) | -1.609 | -1.571 | -1.591 |

1. Measurements made in inches of water column
2. Radon measurements showed > two orders of magnitude reduction for sub-slab concentration to indoor concentration
3. Home is 2000 sq. feet and has only one 4 inch riser pipe

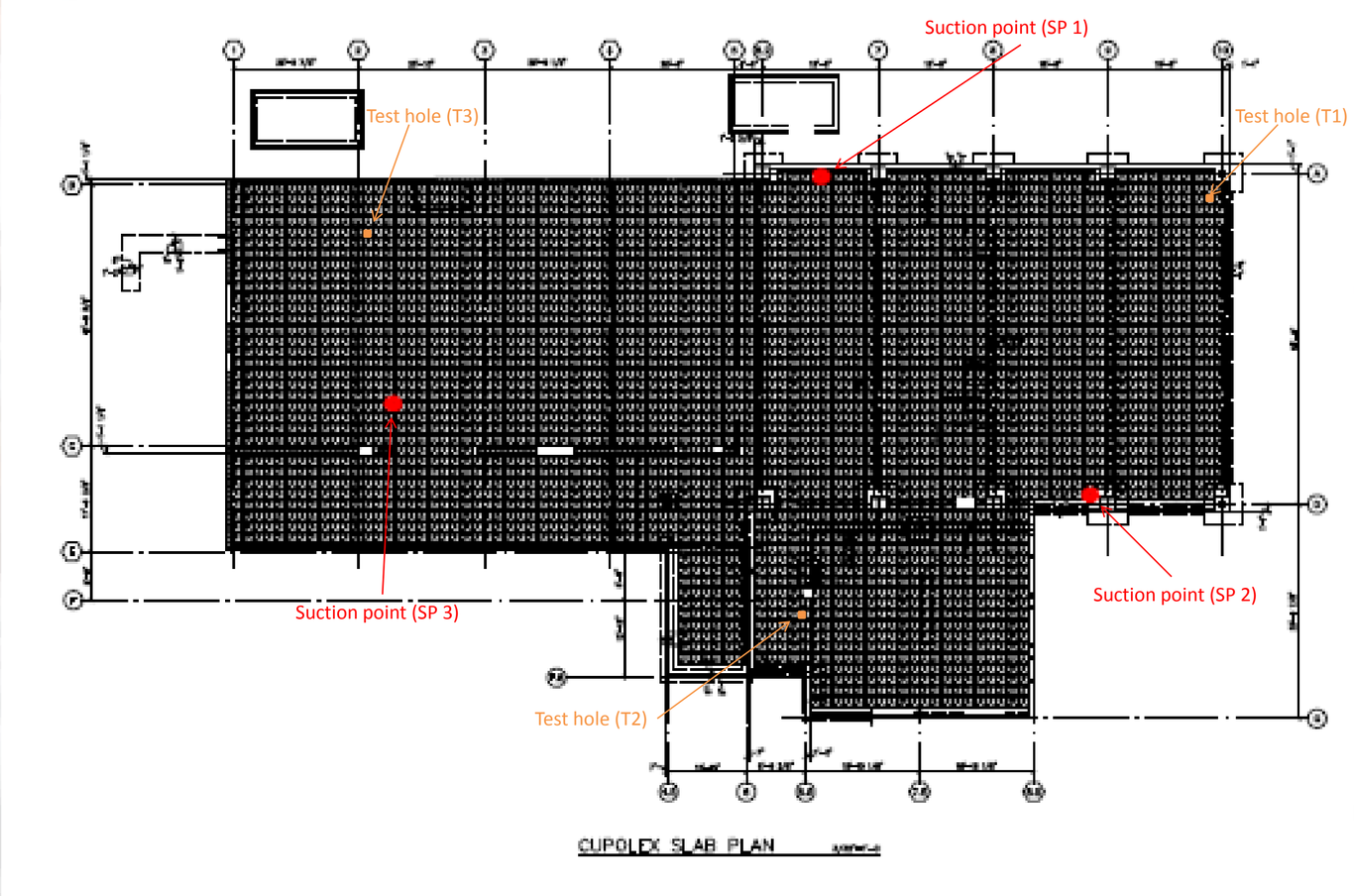
RP 145 radon fan from RadonAway




*Active radon fan data excluded from graph

**Sustainable** - The word sustainability is derived from the Latin *sustinere* (*tenere*, to hold; *sus*, up). Dictionaries provide more than ten meanings for *sustain*, the main ones being to “maintain", "support", or "endure”. However, since the 1980s *sustainability* has been used more in the sense of human sustainability on planet Earth and this has resulted in the most widely quoted definition of sustainability and sustainable development.

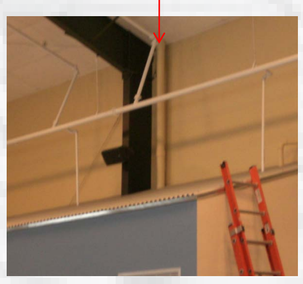
# Vapor Intrusion Mitigation



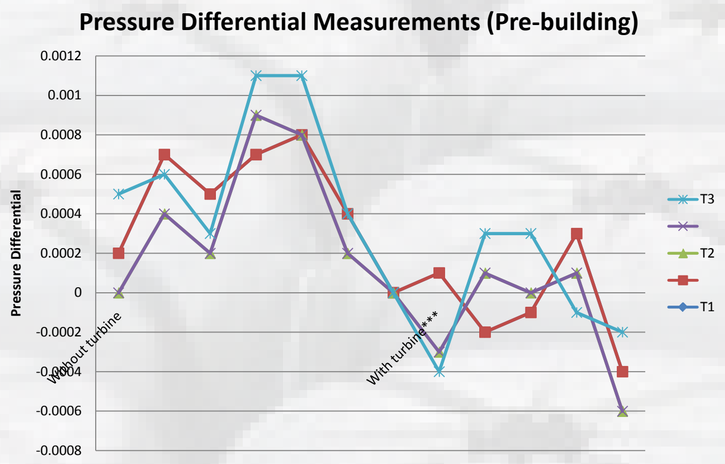

Example of a Cupolex layout plan for a new building.

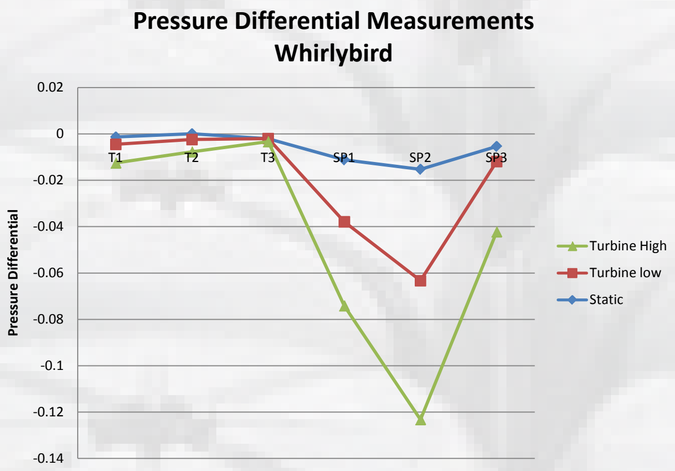
Venting plan consisted of three 4 inch PVC vent pipes terminating above the roof line.

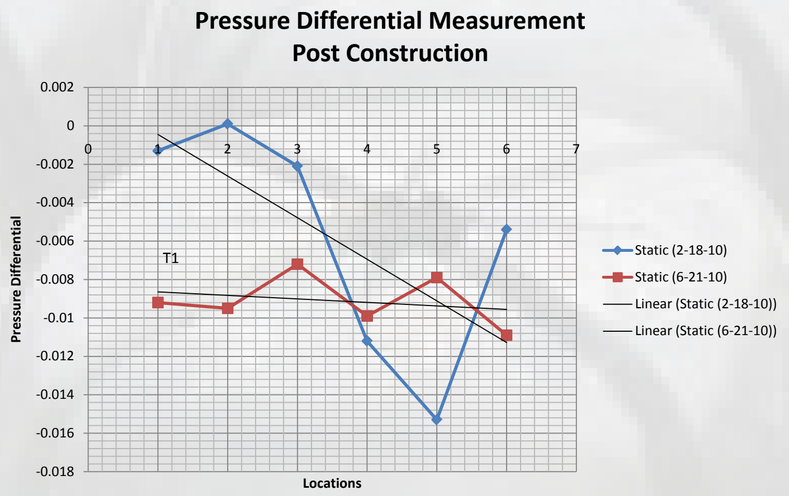
Vent pipes are located inside the building envelope to increase the thermal effect.

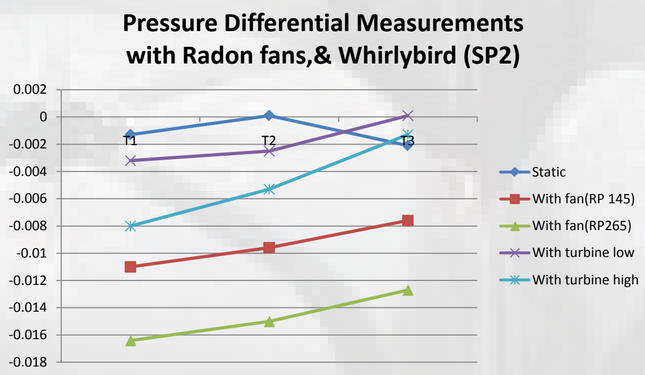


9000+ sq. ft. Commercial building in Cheyenne, WY



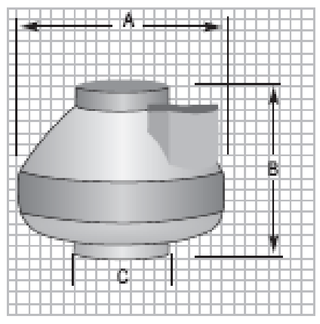



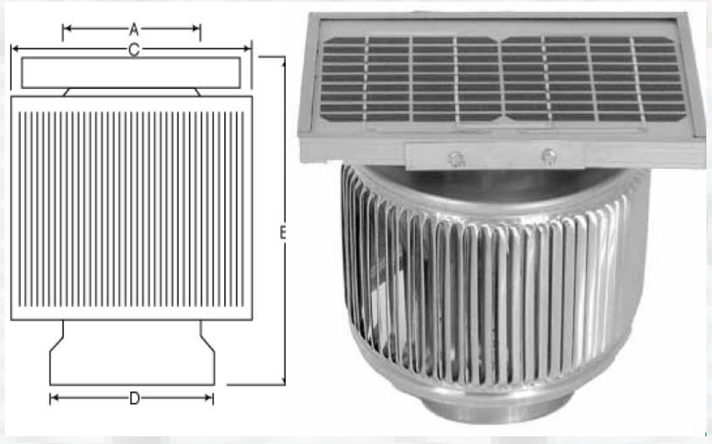

Pressure differential measurements vary and can be easily overcome with a wind driven whirlybird vent, a solar powered vent or by adding an electrical radon fan. The addition of an electric fan would not meet the passive design criteria but may be necessary if the sub-slab concentration are too high or the slab seals into the building create a preferential pathway. Nevertheless, much smaller and fewer fans can be used to mitigate an aerated floor void, compared to traditional sand and gravel venting layers. A number of slab seals were required at the above referenced building (for reasons not related to the aerated floor system) , but any leakage may have had a positive effect by providing additional dilution air, reducing the sub-slab concentrations to low levels compared to the expected concentrations , which were in the several thousand micrograms per cubic meter range (based on groundwater concentrations).

# Projects

| Model | Watts | Max. Pressure "WC | Typical CFM vs. Static Pressure WC 0" | .5" | 1.0" | 1.5" | 2.0" | A" | B" | C" |
|---|---|---|---|---|---|---|---|---|---|---|
| RP140 | 14-20 | 0.8 | 134 | 68 | - | - | - | 9.7 | 7.9 | 4 |
| RP145 | 37-71 | 2.1 | 173 | 132 | 94 | 55 | 11 | 9.7 | 7.9 | 4 |
| RP260 | 52-72 | 1.8 | 275 | 180 | 105 | 20 | - | 11.8 | 9.9 | 6 |
| RP265 | 86-140 | 2.5 | 327 | 260 | 207 | 139 | 57 | 11.8 | 9.9 | 6 |
| RP380 | 103-156 | 2.3 | 510 | 393 | 268 | 165 | 35 | 13.41 | 10.53 | 8 |

Choice of model is dependent on building characteristics including sub-slab materials and should be made by a radon professional.



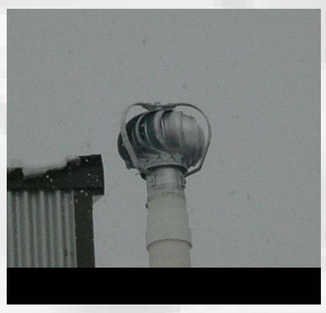




| 4" Diameter for a 4" PVC Pipe (includes adapter to fit over pipe) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Inside Dia. (A) | Height of Head (B) | Outside Dia. (C) | Bottom Dia. (D) | Weight (lbs) | Max. Pitch Capacity | Net Free Vent Area (in.) | Net Free Vent Area (feet) | Application per sq. ft. |
| 4 | 8.75 | 7 | 4.5 | 1 | 4/12 | 12 | .09 | 52 |

| Fan Rating with Solar Power On | | | | | |
|---|---|---|---|---|---|
| Solar Module | Voltage | Motor Wattage | # of Fans | Total Fan Watts | Total CFM |
| 2.5 W | 12 V | 1.8 | 1 | 1.8 | 21 |

| CFM Performance Testing using wind only | | | | |
|---|---|---|---|---|
| 4 mph | 5.2 mph | 7.4 mph | 9.8 mph | 11 mph |
| 26 | 38 | 51 | 59 | 62 |

Operating specifications of radon fans used in the testing of these two buildings. The smaller structure indicates a much tight slab as you can see the vacuum applied at the vent is distributed to the entire slab with very little loss as compared to the larger building where it was difficult to generate a vacuum, however, the vacuum that was generated was also distributed to the entire slab with little reduction. The flows for the radon fans were much higher for the larger slab with less of a surface seal.



Wind powered Whirlybird pipe vent

Solar / wind powered pipe vent

## Conclusions

- Passive venting of aerated floor venting systems is achievable.
- Air moves efficiently through aerated floor systems, allowing dilution of sub-slab gases.
- Aerated floor systems have the ability to transfer pressure differentials across the slab with little to no reduction of vacuum level.
- Slab penetrations may not have a significant adverse impact on aerated floor systems due to efficient air movement and dilution.
- For sustainable and green buildings an aerated floor using the Cupolex can reduce the carbon footprint of a building.
- When electric fans are needed for high concentrations of vapors, large areas of aerated floor systems can be depressurized with small fans, reducing the number of suction points, riser pipes, and electrical costs.

EnviroGroup Limited
Vapor Intrusion Solutions