



BUILDING SCIENCE BASICS
Your Home is Alive and Breathing

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IT HIDES BENEATH YOUR FLOOR

It's always down there under the floor. Most of the time it's quiet and leaves you alone, but every once in a while, especially if you've ignored it for a long time, it may seek a way to remind you that hey! It needs a little occasional attention!
It's that word "occasion" that gets to most of us, because it's often not a happy occasion, that reason which forces us to go down into... the crawlspace.

Since solutions to crawlspace problems vary according to location, rather than try to provide one explanation which will apply to all crawlspaces, we'll discuss the forces that effect crawlspaces and through them... the living space.

Your goal in approaching the subject of crawlspace conditions is to manipulate moisture, temperature and environmental hazards to create a safe, comfortable home environment.

1. MOISTURE

Two Kinds of Moisture

This article is concerned with moisture in its *liquid* and *vapor* forms. Vapor is very tiny droplets of water suspended in air. The amount of water vapor in the air is measured as *relative humidity*. High humidity means lots of water in the air.

Even in dry climates it's not uncommon for 10 gallons of water a day to enter a crawlspace through evaporation from the soil. This amount can be far higher if the homesite is in a wet climate, above a spring, an underground stream or has a high water table. Moisture intrusion of the crawlspace may be seasonal or may only be a problem when annual rainfall is unusually high.

WHY MOISTURE IS A PROBLEM

Mold

Mold is actually a fungus. There are many different kinds of mold fungi and they're found everywhere on earth, in almost every environment, including inside our bodies. In many situations they are not only harmless, but *necessary* for life to proceed normally.

When moisture levels in a material approach 20%, fungi begin to become active. The more moisture available, the more active fungi will be and the faster fungal colonies will grow.

As moisture levels drop, fungal activity slows and when moisture levels drop below about 20%, activity stops.

Here are the two main ways in which fungal activity is a problem...

1. High spore concentrations in indoor air: Fungi reproduce by releasing spores. Spores are like microscopic seeds which produce new fungi. With moisture intrusion, spore concentrations in indoor air can reach levels unhealthy for those with weak immune systems, allergies, asthma or lung disease.
2. Decay fungus. Some types of fungus consume material in wood cells, deteriorating these cells and producing what we call wood decay or rot.

Erosion

In some cases, especially in situations in which the surfaces around the home slope toward the foundation, surface runoff may wash soil from beneath the foundation. This can result in excessive stress being placed on the affected areas.

Foundation Damage

Moisture may cause soil beneath the foundation to expand and contract. This can exert tremendous force and can actually crack or break a foundation. It can do this in two ways...

1. Freezing: Because water expands when it freezes, soil containing a high percentage of moisture may expand enough to damage home foundations.
2. Swelling: some kinds of soil contain clay particles which expand to many times their original size as they absorb moisture. Soils with a high percentage of these particles can expand enough to damage foundations. They're called "expansive soils".

SOURCES OF MOISTURE INTRUSION

Because moisture can move through concrete, soil, air and many other materials, it's very good at getting into your crawlspace...

- From *outside* the home
 - *Surface runoff*: Rain or snowmelt is moved by gravity down through the soil until it meets a layer through which it can't pass. It then begins to move laterally. It can enter the crawlspace...
 - Through the foundation walls (called *diffusion*)
 - Under the foundation walls (called *seepage*)
- From *beneath* the home
 - *Rising groundwater*: Groundwater is underground water that is always there. It often rises and falls seasonally. The top surface of groundwater is called the "water table".
- From leaking pipes

- Crawlspace are full of water pipes which eventually leak. Until leaks are noticed and fixed, this water will probably live in your crawlspace... unless it decides to move around... and it *can* move around.

CONTROLLING MOISTURE INTRUSION

Moisture entry into crawlspaces can be controlled in a number of ways...

- **Evaporation:**
A vapor barrier is a waterproof membrane such as plastic which is spread out across the soil to help prevent moisture in the soil from evaporating into the crawlspace air. This waterproof membrane is also called a "soil cover" or "ground cloth".
- **Groundwater**
A sump pump is a float-activated water pump which is installed in a pit dug into the floor of the crawlspace. As groundwater enters the pit, the pump is activated automatically and water is pumped through pipes to the outside of the home. More than one pump may be installed.
- **Ventilating Crawlspaces**

Passive Ventilation...

- Passive vents are simply ventilation holes installed in a crawlspace. Passive ventilation depends upon natural air movement to move moisture-laden air out of the crawlspace.

Advantages to installing passive vents are...

- The system is simple and requires no electricity or maintenance.
- Air movement can carry off hot air during the summer.
- Disadvantage to ventilating crawlspaces
 - In moist climates, warm moist air entering the cool crawlspace will condense and the resulting moisture will be absorbed by wood framing and insulation. Under certain conditions materials may absorb enough moisture for fungi (mold) to become active.

Mechanical ventilation...

- A humidistat is a device similar to a thermostat, except that it monitors humidity levels and activates a fan when moisture levels in the air exceed the humidistat setting.

The fan pushes crawlspace air to the outside. This air must be replaced, and replacement air must come either from the great outdoors, from inside the home or from out of the soil.

Pulling replacement air from inside the home can create a whole new set of problems such as...

- Negative pressure- Low pressure in the living space can suck toxic combustion gasses from water heater and furnace vents into the living space. Sounds nasty!
- Air temperature- Replacement air coming into the living space may need to be heated, cooled, humidified or de-humidified depending on the climate and time of year.
- Damp-proofing
 - Damp-proofing is the application of an asphalt-based water-resistant coating to the exterior of the foundation walls which will be underground after the home is complete. This is typically applied before the excavation is backfilled. There is some disagreement about the advisability of applying damp-proofing to the interior of the foundation walls.
- Perimeter drain
 - Perimeter drains are underground drains that extend around the outside perimeter of a structure's foundation. They are designed to catch and drain away underground moisture before it reaches the foundation wall and enters the crawlspace.

Crawlspace Recommendations

- Insulate heating ducts- You can lose up to 35% of the heat from uninsulated heating ducts in an unheated crawlspace.
- Insulate water supply pipes- Insulating pipes helps keep them from freezing in especially cold weather and helps save money on your hot water heating bill.
- Plastic soil cover- helps prevent moisture from evaporating out of the soil into crawlspace air.
- Insulate crawlspace walls rather than the home floor- This will help prevent damage from pipes freezing. The idea is that conditions in the crawlspace will be easier to control if the crawlspace is treated as indoor space.

Moisture in the Living Space

Moisture enters the home living space from various sources...

- Moisture (humidity) levels inside the home are raised by...
 - Water-using appliances such as clothes and dishwashers.
 - Plumbing fixtures such as showers.
 - Moisture in its liquid form comes as a result of leakage from plumbing fixtures and pipes and from the roof.
 - Living space air lost through ventilation, leakage and combustion is replaced by moist crawlspace air.
 - Human respiration is a major source of interior moisture.

2. TEMPERATURE

When it's cold outside, your mission is to prevent as little heat as possible from leaving your home, because anytime it leaves, you have to pay to replace it. The price you pay is reflected in your monthly heating bill.

There are two physical laws which affect how well your home hangs onto its heat...

1. *Temperature Gradient*- Heat moves from warm areas to cold areas.
2. *Pressure Gradient*- Warm air moves from high pressure to low pressure.

HOW HEAT LEAVES YOUR HOME

Thermal Bridging

The living space is warm and it's cold outside. Materials that conduct heat will try to radiate warmth from inside the home to the outside, just like... a radiator!

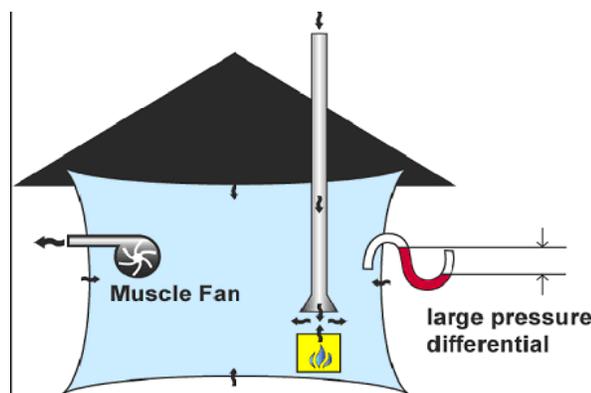
Solid materials like concrete and wood are better radiators than materials like insulation, which is filled with tiny air pockets. Solid materials offer better *thermal bridging*, allowing heat to move more easily from the warm inside to the cold outside, except in this case, better is worse.

Building methods which minimize thermal bridging help save on heating costs.

You Change the Air Pressure

When you turn on a fan in a bathroom, above a stove or in a laundry room, you are pushing warm air out of the home through the fan vent. Whenever anything in your home burns fuel such as wood, propane or natural gas, combustion takes place. Since the products of combustion are poisonous gasses (and moisture), those gasses are vented to the outside, along with warm air from the home.

Low air pressure is created in a home when air is removed either by using a fan or by creating a strong draft using the combustion process. Since the air pressure is lower in the warm house, air will come in to replace it... cold air.



Nature Changes the Air Pressure

Blowing wind will create areas of high and low pressure around your home, pushing and sucking the warm air out and replacing it with... cold air.

Stack Effect

As cold air enters the home and is heated, the warm air rises and leaves the home through vents in bathrooms and laundry rooms and through cracks and airspaces in and around ceilings. This rising heat loss is called *stack effect*.

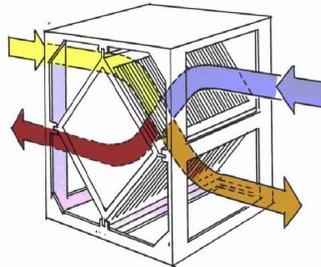
As warm air leaves the home through stack effect, it's replaced by... cold air.

INDOOR AIR QUALITY

A Tight Home

It's usually considered an advantage to have a tight home; limiting air movement through the building envelope means you don't lose the air you've paid to heat, right? But what about all those sweaty, smelly bodies, human and dog, especially *wet dog*? Easy answer! Just take a shower/put him out 'til he's dry, Jeez, some people! But wait... people, showers, dish and clothes washers and cooking put moisture into the air and a number of activities put odors into the air. This means for the home to have clean, comfortable air, stale air must be ventilated to the outside and be replaced with clean air. But I paid to heat that stale air! Too bad.

There are different methods used to recover the heat from the stale home air before it's ventilated to the outside. One way is with a Heat Recovery Ventilator (HRV). Wherever did they get that name? HRV's work by passing outgoing warm air past incoming cold air. A good portion of the heat is transferred to the incoming cold air, which means you heat less air and save more money.



Inadequate number of air exchanges per hour can result in...

- Excessive humidity
- unpleasant odors
- Increase in mold spore concentrations

3. RADON

Radon is a colorless, odorless, radioactive gas that enters the crawlspace (or home) from the soil beneath the home. The EPA calls Radon the second-leading cause of lung cancer in the US.

Where does Radon come from?

Radon is a decay product of uranium. As underground uranium goes through a series of decays, at one point it becomes radon. Being a gas, radon finds its way to

the surface and vents to the atmosphere. If, when it reaches the surface it happens to reach the surface beneath a home, it enters the home.

What's the Danger from Radon?

Because it's a radioactive material, radon will continue to decay. When radon decays, it emits radioactive particles. If radon is inside lungs at the time it decays, these radioactive particles can strike DNA strands in lung cells and cause abnormal lung cell replication, which is lung cancer.

What Happened to Bob?

Bob? Who's Bob? Check out the poster image at the beginning of this article. Bob is out back with a hair dryer and a poodle.