

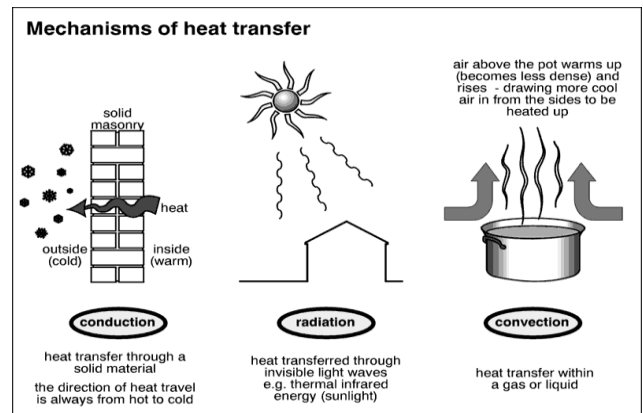
## 8 Rules of Building Performance

Select the following links to learn more about the 8 Rules of Building Performance, a concept developed by [Building Knowledge Inc.](#) and subscribed to by Prescott Green Builders.

1. [Heat flows from warm to cold](#)
2. [Moisture moves from warm to cold](#)
3. [Moisture moves from more to less](#)
4. [Air out equals air in](#)
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### Rule #1: Heat flows from warm to cold

- Heat flows by conduction, convection, or radiation
  - On a hot summer day when a wall is exposed to direct sunlight, the heat flow direction will be from the exterior to the interior.
  - In winter, when the reverse situation applies, the heat flow direction is from the interior to the exterior.
  - If the interior temperature is the same as the exterior temperature, there is no directional heat transfer.
- **How does this building performance rule affect the home occupant?**
  - Heat flow into or out of the home means that the home can be too warm or too cold (depending on the season) for [personal comfort levels](#)
  - Maintaining the comfort level in a home with high heat flow means that mechanical systems will be used more and energy costs to run these systems will be higher.
  - Mean radiant temperature (MRT) is the average of the surface temperature of the surroundings with which the body can exchange heat by radiant transfer. Radiant heat transfer to and from the body is quite apparent when sitting near a fireplace (high MRT) or large cold window area (low MRT), thus MRT significantly affects comfort level.
- **How is this building rule incorporated into a high-performance home?**
  - All surfaces of the building envelope must be air sealed and properly insulated to control heat flow.
  - [Prescott's climate zone](#) (Mixed Dry climate zone 4) determines the minimum insulation levels in the walls, ceiling, and floor (see [Energy Efficiency and Insulation](#) for more information)
  - Evenly distribute conditioned air to maintain a comfortable mean radiant temperature
  - Use [high-quality, energy efficient windows](#) with low E coatings to reflect heat out in summer and in during the winter



## Rule #2: Moisture moves from warm to cold

- As heat moves from warm to cold temperatures (via conduction, convection, or radiation)
  - it has the potential to carry moisture vapor along with it through a mechanism called vapor diffusion
  - As the [moisture vapor moves into wall cavities](#), it has the potential to condense into liquid water on surfaces which are cold enough to be at dew point temperature

- **How does this building performance rule affect the home occupant?**

- Moisture that condenses and accumulates in walls has several negative effects:
  - Insulation becomes wet and reduces its effectiveness at reducing heat flow, meaning that interior temperatures could be too warm or too cold depending on the season
  - Wood becomes wet and results in dry rot that reduces the durability of the structure; eventually the homeowner will need spend maintenance dollars to replace the degraded wood structure.
  - Wet wood also has the potential to [grow mold](#) and attract insect pests which have potentially negative health effects on home occupants.

- **How is this building rule incorporated into a high-performance home?**

- In Prescott's "mixed-dry" climate zone, select materials and wall systems that allow vapor to pass through them (i.e., vapor permeable) thus allowing the wall to dry in both directions e.g., to the interior and the exterior
- Insulate the exterior wall so that the wall cavity temperature does not cool to the dew point temperature i.e., vapor will not condense



Water vapor condenses into liquid water on cold surfaces ... including wood

## Rule #3: Moisture moves from more to less

- Moisture (liquid or vapor) will move from areas which are wet to areas which are dry
  - Mechanisms of moisture movement is termed vapor diffusion and capillarity
  - [Moisture in the home's interior](#) is derived from a variety of sources including plumbing leaks, internal sources (people, pets, cooking, etc), and the soil.
- How does this building performance rule affect the home occupant?
  - Durability issues, health issues, see discussion under [Rule #2](#)
- How is this rule incorporated into a high-performance home?
  - See discussion under [Rule #2](#)
  - Properly seal all penetrations through the building envelope to limit the easy pathways for moisture-laden air to flow. Penetrations can include those made in through exterior walls for plumbing, those made through stud walls for plumbing or electrical wiring
  - In the case of masonry stemwalls, a [foundation drain and damp proofing materials](#) are used on the on the below-grade portion of the foundation and perimeter drains are used to capture and direct water away from the structure
  - A [subslab vapor barrier \(polyethylene plastic\) and capillary break \(4" of gravel\)](#) will effectively limit the amount of water vapor that pass through the slab and into the home's interior



Foundation drain along the below-grade portion of the damp-proofed stemwall captures water before it can enter the foundation



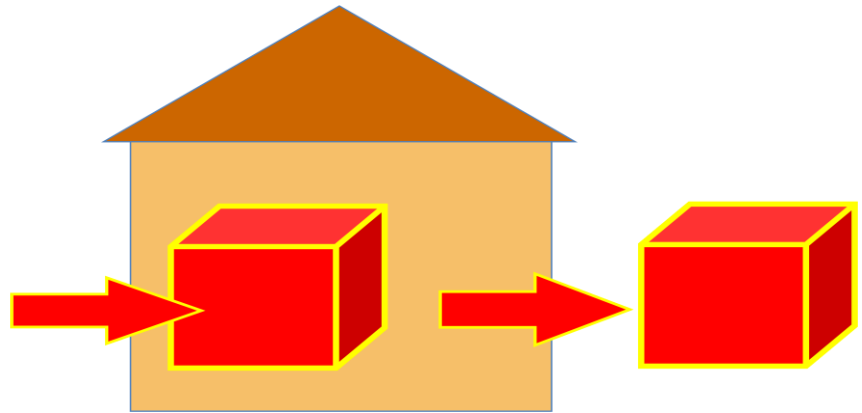
A polyethylene plastic vapor barrier over a 4" gravel layer will effectively limit moisture wicking into the overlying concrete slab



Soil moisture seeping through a stemwall damages materials and increases interior moisture levels

## Rule #4: Air out = Air in

- For each volume of air that leaves the building envelope, there is an equal amount that enters
  - Air leaves the building through exfiltration, exhaust fans (e.g., kitchen and bathroom), or appliances such as clothes dryers
  - With the building envelope depressurized, air enters the home through any crack or penetration to the exterior



*Air out equals air in concept*

- **How does this building performance rule affect the home occupant?**
  - [High-performance houses are built to limit air leakage i.e., they are tight](#)
  - If combustion appliances (e.g., gas dryer, gas fireplace, gas water heater) are used in a tight home, there is the potential that health-hazardous combustion gasses can be drawn into the home's interior through the chimneys of those devices
  - If there are no combustion appliances, then unconditioned air may be being drawn in from the attic or exterior through any type of penetration. The unconditioned air can create comfort issues if it is too hot, cold, or humid; or health issues created if it is air drawn in is dusty or includes pollen
- **How is this rule incorporated into a high-performance home?**
  - "Build it tight, ventilate it right" means that every effort is made to create an air-tight house, then it is equipped with a [balanced ventilation system](#) that expels stale interior air and brings in filtered, fresh exterior air. These units typically include a heat exchanger to buffer the temperature of the incoming air.
  - [Sealed-combustion appliances](#) are specified so that there is no opportunity to backdraft combustion gasses into the home interior
  - A source of make-up air, such as a dampered vent to the exterior, is provided for large exhausting appliances such as clothes dryers

## Rule #5: Air behaves like a fluid

- Air in ducts must be controlled with as much attention as water is in plumbing pipes .... both will leak if joints are not sealed
  - Air is like water in that it flows from high pressure to low pressure
- **How does this building performance rule affect the home occupant?**
  - Ducts which leak conditioned air into unconditioned spaces (e.g., attic) are a primary source of energy loss which translate into higher energy bills for the homeowner in order to maintain a certain comfort level
  - Duct leakage results in depressurization of the home interior, which then results in unconditioned air being drawn in from the exterior, crawl space or the attic. Unconditioned air may carry with it dust, pollen, soil gasses (including termite control sprays), and water vapor. These elements may cause health issues for the occupants and/or structural durability issues in the home.
- **How is this rule incorporated into a high-performance home?**
  - Ideally, locate [ductwork within the conditioned or semi-conditioned space](#). Ducts could run through drop soffits in the home interior or be located in a [unventilated, semi-conditioned attic](#) or crawlspace.
  - Seal all joints on ductwork and all seams on the HVAC air-handler with mastic
  - Have a third-party testing company perform a [duct-leakage test](#) also known as a duct blaster test. If the test shows deficiencies that are still above recognized standards, re-seal the ducts and test again.
  - Use sealed, ducted return-air ducts... do not use wall cavities for air return.



Ductwork sealed with mastic and located in a unventilated, semi-conditioned crawlspace that is part of the home's "pressure envelope"

## Rule #6: Rain follows gravity

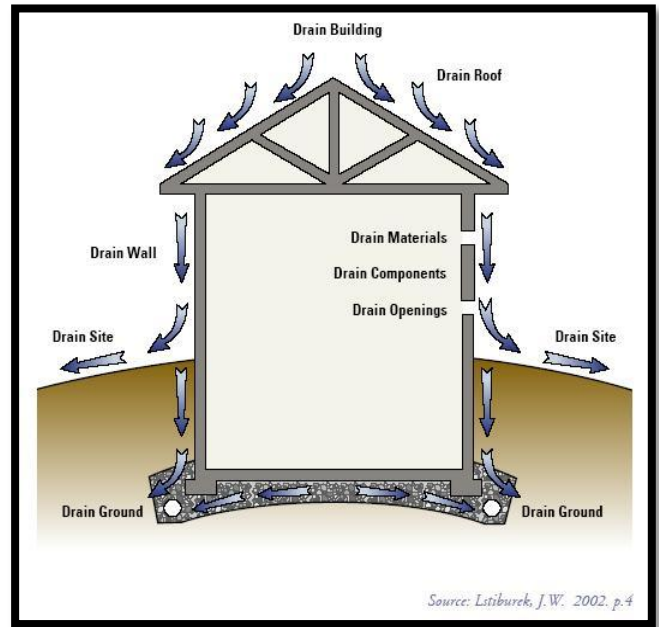
- Rain is the typically the largest source of moisture for an above-grade building enclosure.
  - Rain follows gravity flowing from high points to low points
  - [Three things destroy wood](#) – water, heat, and ultraviolet radiation – and water is by far the most damaging of these factors

- **How does this building performance rule affect the home occupant?**

- Wet wood building materials, if not allowed to dry, leads to [rot and mold](#)
- Wood rot results in a structural durability issue and repair/replacement costs
- Mold growth results in a occupant health issue

- **How is this rule incorporated into a high-performance home?**

- Properly site the home on a building lot to avoid areas of water flow e.g., flood plains, at the bottom of topography
- Properly lap and use “shingle effect” to drain water off of the structure. This applies to housewrap, flashing, and roofing materials
- Use materials and concepts consistent with the concept of [3 Ds: Deflection, Drainage, Drying](#) in the construction process



Draining water off of and away from the structure is critical

## Rule #7: Everything gets wet ... let it dry

- Building materials and assemblies perform optimally when they are dry. However, in the construction process and during the life of the home these materials inevitably get wet through several ways:
  - [Building materials not stored or covered during rain or snow](#)
  - Driving rain against a wall
  - Moisture accumulation in walls through plumbing leaks or condensation
- **How does this building performance rule affect the home occupant?**
  - Wet wood building materials, if not allowed to dry, leads to [rot and mold](#)
  - Wood rot results in a structural durability issue and accrue repair/replacement expenses to the homeowner
  - Mold growth results in occupant health issues
- **How is this rule incorporated into a high-performance home?**
  - Cover or store materials at the jobsite to protect them from rain, snow and ultraviolet radiation. Remember that [three things destroy wood](#) – water, heat, and ultraviolet radiation
  - Construct building assemblies using semi-vapor permeable materials that allow drying to either the interior or exterior:
    - Typical vapor permeable materials include plywood and OSB, sheet rock, housewrap, stucco, fiberglass insulation
    - Typical vapor impermeable materials include polyethylene plastic, oil-based paint
  - Porous materials (e.g., wood, siding) can wick water from soil or concrete and therefore should not come in contact unless the material has been treated or is otherwise suitable for damp conditions.



An example of how not to store building materials at the jobsite

## Rule #8: It all happens at the surfaces and the connections

- Building components should be compatible with each other and their environment to limit cracks, air leakage, and water leakage
- **How does this building performance rule affect the home occupant?**
  - Windows not properly flashed allows water from a driving rain storm to enter the wall system
    - [wet wood building materials](#), if not allowed to dry, leads to rot and structural issues;
    - mold may develop, leading to health issues
  - Incompatible materials leads to cracking
    - cement stucco placed directly over OSB or plywood has a high likelihood of cracking as a result of differing material expansion rates
    - cracks allow water entry into the structure
    - wet wood building materials, if not allowed to dry, leads to rot and structural issues;
    - mold may develop, leading to health issues
  - If wooden materials are not properly stored they can be damaged by UV radiation; [paint on these damaged materials](#) will not adhere as long and maintenance costs will be incurred more frequently
- **How is this rule incorporated into a high-performance home?**
  - Home designs should be carefully reviewed to determine if there are any potential problem areas with water drainage, window or chimney placement
  - Different materials have different coefficients of expansion and should be considered when joining them
  - [Properly flash all windows and doors](#) to shed water that may get behind the siding or exterior cladding; reduce the potential of wet insulation, trapped moisture, and mold; become part of the air barrier system to reduce air leakage.
  - Exterior wood materials are stored properly to protect from rain and UV; paint further protects these materials from damage

