

Healthy and Affordable Housing: Practical Recommendations for Building, Renovating and Maintaining Housing

**READ
THIS**

**BEFORE YOU DESIGN,
BUILD OR RENOVATE**



Asthma Regional Coordinating Council
of New England

U.S. Department of Energy
Building
AMERICA  
Program Partner

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The Building Connection

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The Building Connection

Housing and Asthma

Asthma is a serious disease that affects millions of Americans, particularly children. Asthma is also increasing at an alarming rate. Many air contaminants are found at higher levels indoors than outdoors. Among them are the most common asthma triggers: particles from molds, dust mites, mice, rats, roaches and pets.

Indoor air contains other contaminants such as carbon monoxide, volatile organic compounds (chemicals released from materials), nitrogen dioxide, sulfur dioxide, radon and other particles that can also affect individuals.

Some indoor air contaminants come from outside (e.g. ozone, sulfur dioxide, carbon monoxide, pollens and other particles) and can also affect individuals' health.

The design, construction, renovation, maintenance and operation of homes can have significant effects on the control of asthma triggers and other indoor and outdoor contaminants.

Before You Design, Build or Renovate

The principles for a healthy home are the same for all types of construction: rehabilitation, new construction, low rise, high rise, single family or multifamily.

The design and construction options for rehabilitation are limited by the conditions of the salvaged building and equipment and the extent of the rehabilitation. Despite the limitations, the same principles apply to whatever work is done as part of the rehabilitation.

Systems Approach Can Save Money

Applying the principles for a healthy home to design, construction and renovation does not have to result in significant cost increases. By understanding the interactions between building systems we can identify cost saving trade-offs that improve building performance.

The Whole is Greater than the Sum of the Parts

—	
Cost Saving Trade-Offs	
Improve Building Envelope	Costs More (+)
Downsize Mechanical System	Costs Less (-)
<hr style="width: 20%; margin-left: auto; margin-right: 0;"/>	
Cost Remains the Same	

BEFORE YOU DESIGN, BUILD OR RENOVATE

READ THIS

The Seven Steps to a Healthy Home

There are seven steps to a healthy home. A healthy home is:

- Dry
- Clean
- Well Ventilated
- Combustion Product Free
- Pest Free
- Toxic Chemical Free
- Comfortable

Dry and Clean

Water, clutter and dust permit or encourage the growth of mold, insects, rodents and mites. Keeping a home dry controls mold and pests.

Well Ventilated

Ventilation provides a mechanism to remove contaminants

Combustion Product Free

Combustion products such as carbon monoxide should not be present in a healthy home.

Pest Free

Pests lead to allergic reactions and pests lead to pesticides. Food and water lead to pests.

Toxic Chemical Free

Toxic cleaning compounds, pesticides, oil- or alkyd-based paints and solvents can lead to problems. Many of the containers these products are stored in slowly release the chemicals into the indoor air.

Comfortable

Uncomfortable homes can make people take action that makes a home unhealthy. A lack of comfort can lead to a lack of ventilation and over-humidification. If people are cold they won't ventilate their home. If people can't afford to heat their home they won't ventilate their home. In the summertime, some people need to keep their windows closed because of outdoor pollutants such as pollen. If people are hot they'll open their windows. If they open their windows they can't filter the air. If they can't filter the air they can't keep out the pollen. If people are dry they'll humidify. When they humidify they over-humidify. When they over humidify they get mold.

Factors That Must be Controlled for a Healthy Home

In order to address the seven steps to a healthy home the design, construction and renovation must control the following factors:

Water

- Rain
- Ground Water
- Plumbing Leaks
- Drying

Dust

- Entry Control
- Cleanable Surfaces
- Filtration

Air

- Big Holes
- Cold Surfaces
- Indoor Humidity
- Airborne Contaminants
- Pressures

Creatures

- Keeping Them Out
- Reducing Food and Water

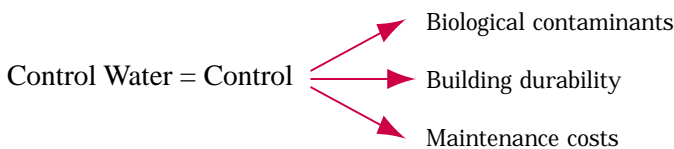
Combustion

- Combustion Appliances
- Garages
- Smoke

Recommendations

Water

Water is a precondition for mold, insects, rodents, dust mites and is arguably the single most important factor in the design and construction of a healthy home. Water is also the most important factor affecting the durability of a home and the most important factor affecting maintenance costs.



The three most important sources of water requiring control are:

- Rain
- Ground Water
- Plumbing Leaks

One of the key elements of water control is the concept of drying. It is common sense to accept that things will get wet. Especially buildings. Especially buildings under construction. Since all things will get wet, they should be designed and built to dry.

The problem is not that something gets wet. It's how long it stays wet and does it ever dry? Buildings should be designed to dry.

Rain

The fundamental principle of rain control is to shed water by layering materials in such a way that water is directed downwards and outwards from the building or away from the building. It applies to assemblies such as walls, roofs and foundations, as well as to the components that can be found in walls, roofs and foundations such as windows, doors and skylights. It also applies to assemblies that connect to walls, roofs and foundations such as balconies, decks, railings and dormers.

Layering materials to shed water applies to the building as a whole. Overhangs can be used to keep water away from walls. Canopies can be used to keep water away from windows, and site grading can be used to keep water away from foundation perimeters.

Flash, Flash and Re-Flash

Problem:

Windows Leak
All Windows Leak
Windows that Don't Leak Today Will Leak Tomorrow
As Windows Age They Leak

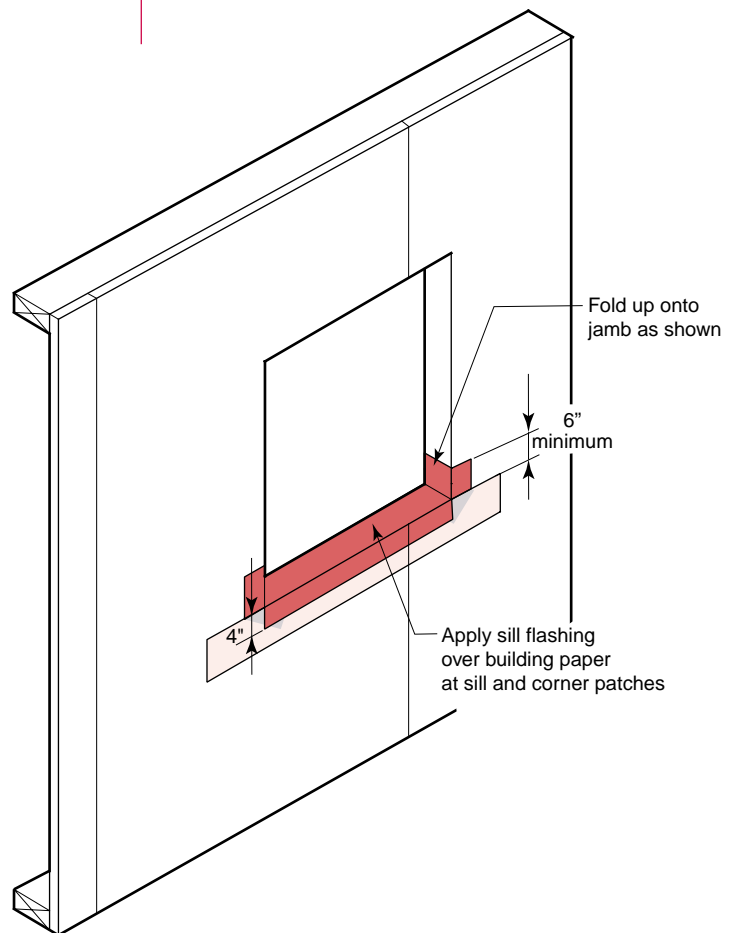
Doors Leak
All Doors Leak
Doors that Don't Leak Today Will Leak Tomorrow
As Doors Age They Leak

Solution:

All Windows and Doors Require Pan Flashing
(See Figures 1 and 2)
Pan Flashing is Under Window and
Door Gutter

Figure 1
Pan Flashing

- Can use adhesive bituminous membranes as sill flashing only with asphalt impregnated felts, coated papers or foam sheathing; do not use adhesive bitumen-based membranes or butyl flashings with plastic housewraps due to chemical incompatibilities
- Use building paper as sill flashing with plastic housewraps



Drain the Rain on The Plane

Problem:

Claddings Leak
All Claddings Leak
Brick Leaks, Vinyl Siding Leaks, Everything Leaks

Solution:

All Claddings Require Drainage Planes

Reservoirs on the outside of buildings are a problem. What are reservoirs? Materials that store rain water – sponges that get wet when it rains. Once the reservoirs get wet, the stored water can migrate elsewhere and cause problems. Common reservoirs are brick veneers, stuccos, wood siding, wood trim and fiber cement cladding.

How to handle reservoirs? Easy. Get rid of them or disconnect them from the building. Backpriming (painting all surfaces, back, front, edges and ends of wood siding, cement siding and all wood trim) gets rid of the moisture storage issue with these materials. No reservoir, no problem.

Back venting brick veneers and installing them over foam sheathings disconnects the brick veneer moisture reservoir from the building. Installing stuccos over two layers of building paper or over an appropriate capillary break such as foam sheathing similarly addresses stucco reservoirs.

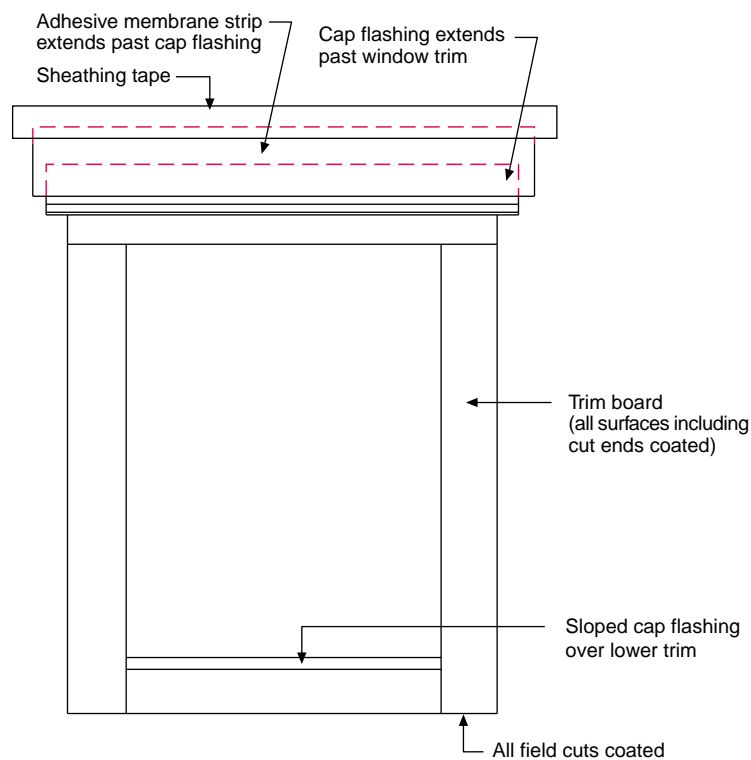


Figure 2
Flashing Over and Under Window Trim

Ground Water

The fundamental principles of ground water control are to keep rainwater away from the foundation wall perimeter and to drain groundwater with sub-grade perimeter drains before it gets to the foundation wall (see Figure 5).

Concrete and masonry are water sponges – they can wick water due to capillarity (see Figure 3). This is the main reason that damp-proofing (the black tar-like coating) is applied to exterior foundation walls. The damp-proofing fills in the pores in the concrete and masonry to reduce ground water absorption. The damp-proofing is a capillary break. Under concrete floor slabs, the stone layer serves a similar function (it is also a capillary break). Unfortunately, the capillary rise through footings is typically ignored. This can be a major problem if foundation perimeter walls are finished or insulated.

In new construction a capillary break should be installed on the top of the footing between the footing and the perimeter foundation wall (see Figure 4). This can be done by damp-proofing the top of the footing or by installing a membrane at this location.

In new construction and particularly in renovations the interior insulation and finishing approach must take into account the moisture load provided by the capillary water migrating up through the footing. This is best accomplished by installing semi-permeable rigid foam insulation on the interior of the assembly to protect the interior finishes and to release the capillary water to the interior in a controlled manner – at a rate that does not damage interior finishes or lead to mold.

Figure 3
Capillary rise through concrete footing

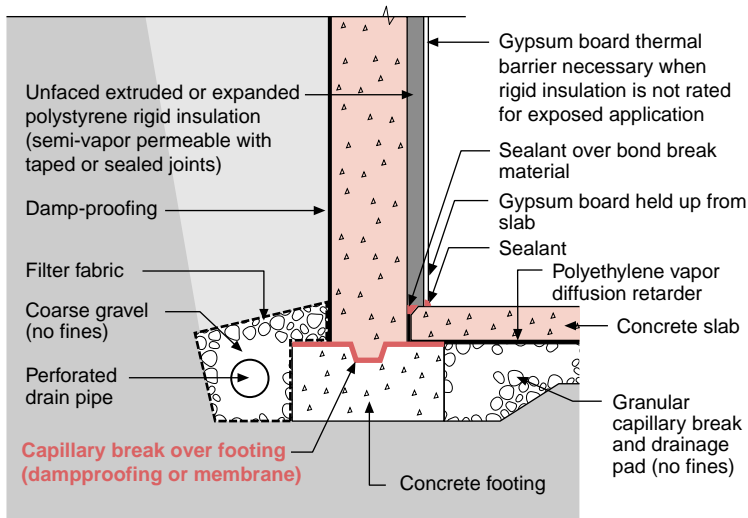
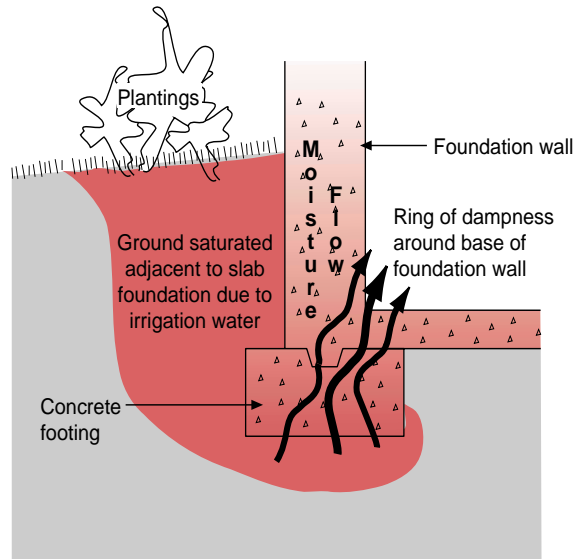


Figure 4
Capillary break over footing

- Concrete wall cold, can only dry to the interior if interior assemblies are semi-vapor permeable; mold possible if interior assemblies do not permit drying
- Cold concrete wall must be protected from interior moisture-laden air in winter and in summer
- Basement floor slab can dry to the interior

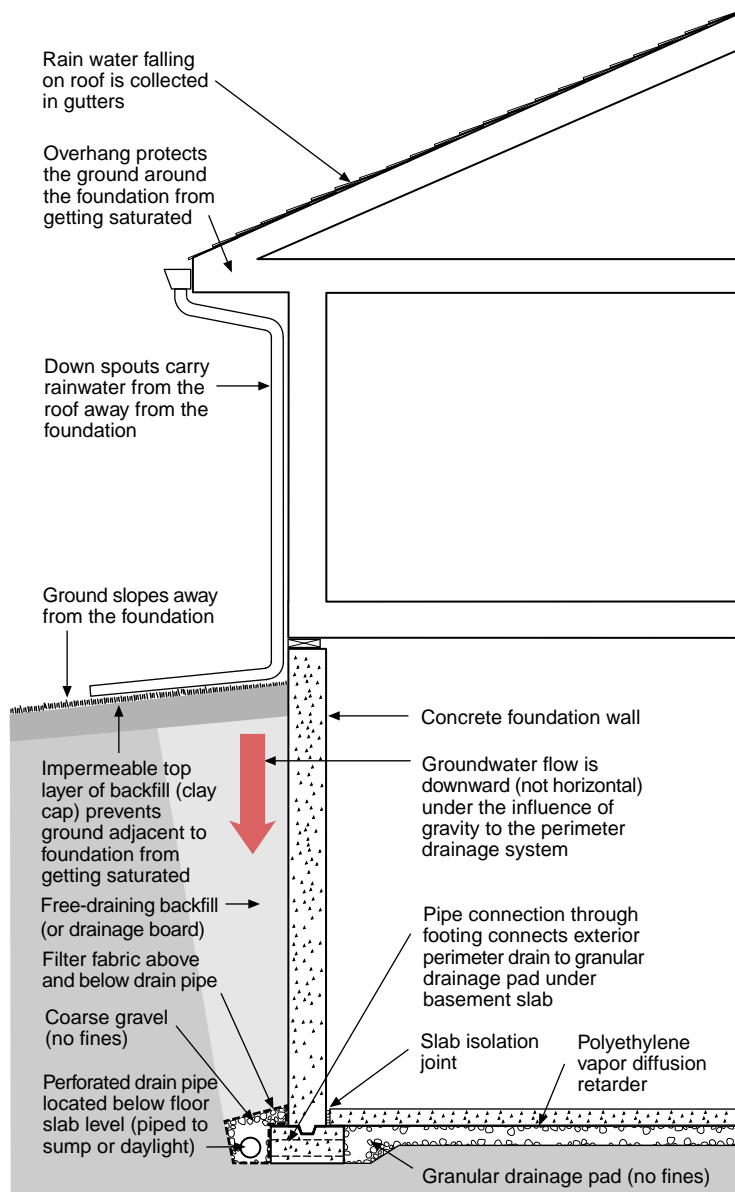


Figure 5
Water Managed Foundations

- Keep rainwater away from the foundation wall perimeter
- Drain groundwater away in sub-grade perimeter footing drains before it gets to the foundation wall

Plumbing Leaks

Don't put plumbing in exterior walls. Don't put plumbing in exterior walls. Not any kind. Not cold or hot water supply pipes, not drains, not anything. Not steam lines, not hydronic heat pipes, not anything that carries water.

Put plumbing in interior walls or in floors (see Figure 6) so when the plumbing leaks, and make no mistake about it, plumbing will leak, we can see the leak and fix it. Leaking plumbing that is installed in exterior walls, particularly insulated walls, is a major source of mold and water damage. Especially when we don't see it. It's easier to see leaks when they are inside.

Since plumbing leaks and since we have lots of plumbing in bathrooms we'll probably have leaks in bathrooms – particularly in the “wet areas”. Don't use paper faced gypsum board products in wet areas such as tub and shower enclosures. Don't use the “green board” either. It's just paper with a green color. It's best to use cement board or fiber cement board or do it the old-fashioned way with cement plaster. Where you use gypsum board keep the gypsum board up off of floors everywhere at baseboard locations – because when the inevitable leak happens we don't want the gypsum board to suck water upwards.

Clothes washers leak, especially the rubber hose connections. Reinforced hose connectors should be used. Clothes washers should also be installed in rooms with drains and floor systems that drain to the drain with floor coverings that are not water sensitive.

Hot water heaters leak, especially when they get old. Hot water heaters should also be installed in rooms with drains and floor systems that drain to the drain with floor coverings that are not water sensitive.

Because clothes washers leak and hot water heaters leak, shut off valves that can be used to isolate these devices should be provided. These shut off valves should be easily accessible and visible. Don't hide them behind the clothes washer or hot water heater.

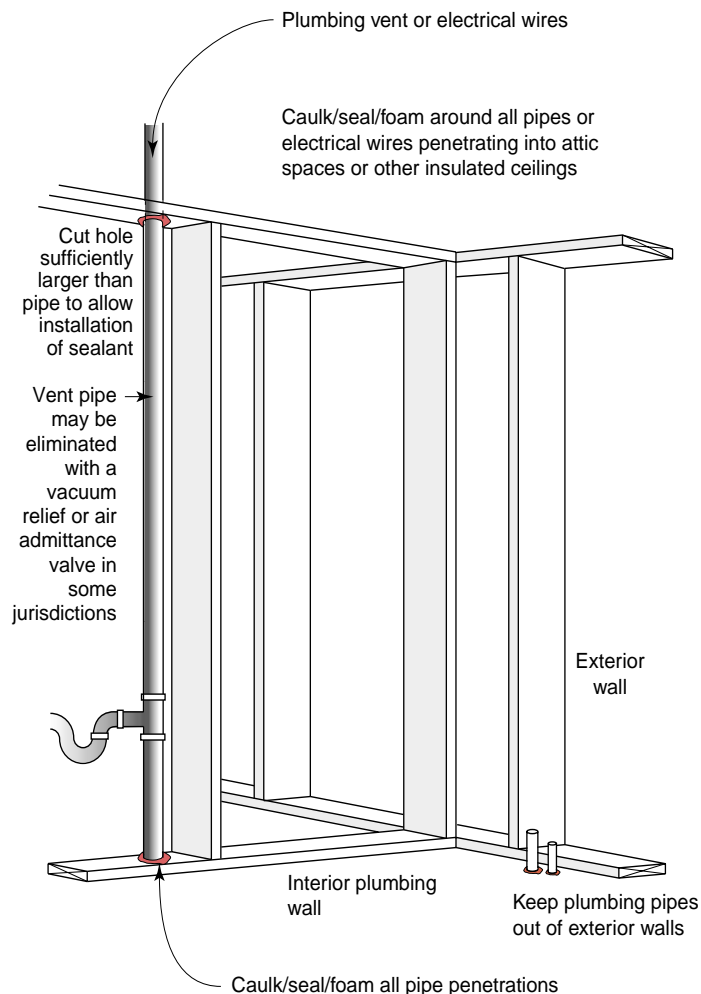


Figure 6
Locating Plumbing Pipes

- Sealants should be flexible, non-hardening

Drying

Walls should be designed to dry to both the exterior and the interior (see Figures 7 through 10). Basements should be designed to dry to the interior. These principles are often in conflict with some common misapplied energy conservation and moisture control practices – for example the use of sheet polyethylene as an interior vapor barrier.

Sheet polyethylene is an almost “perfect” vapor barrier because it does not allow any moisture in the vapor form to pass through it. This is a great feature during cold winters but a terrible feature during summers.

Paper-faced cavity insulation can and should be used in place of plastic interior vapor barriers. Alternatively, cellulose cavity insulation can be used in conjunction with 2 coats of interior latex paint on gypsum board.

Installing interior polyethylene as a vapor barrier should be limited to severe cold climates (8,000 heating degree days or greater). Sheet polyethylene should never be installed on the interior of basement or below grade wall assemblies in any climate as it prevents drying to the interior.

Impermeable interior finishes should also be avoided such as vinyl wall coverings or oil based paints. In a similar vein, vinyl floor coverings should be avoided on basement floor slabs or on slab-on-grade construction unless a low water-to-cement ratio concrete is used (less than 0.45) installed directly over a polyethylene vapor barrier.

Roofs should be designed to dry. That means they should be ventilated. It is possible to design and construct unvented roofs, but this should be done only with professional design and analysis.

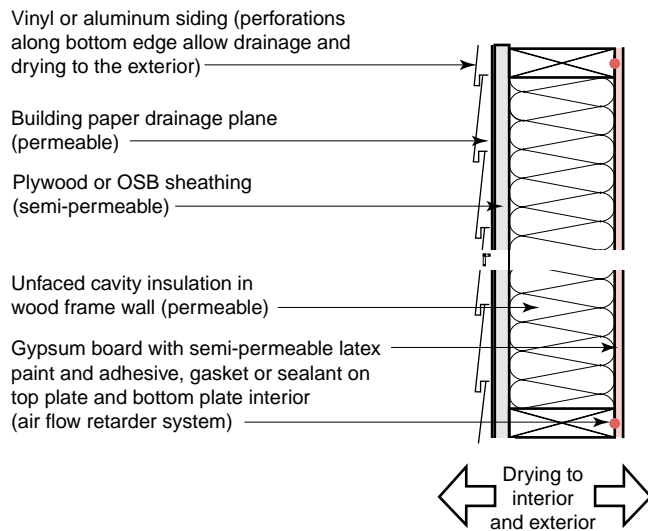


Figure 7
Classic Flow-Through Wall Assembly

- Permeable interior surface and finish and semi-permeable exterior sheathing and permeable building paper drainage plane
- Ventilation provides air change (dilution) and also limits the interior moisture levels during heating
- Air conditioning/dehumidification limits the interior moisture levels during cooling

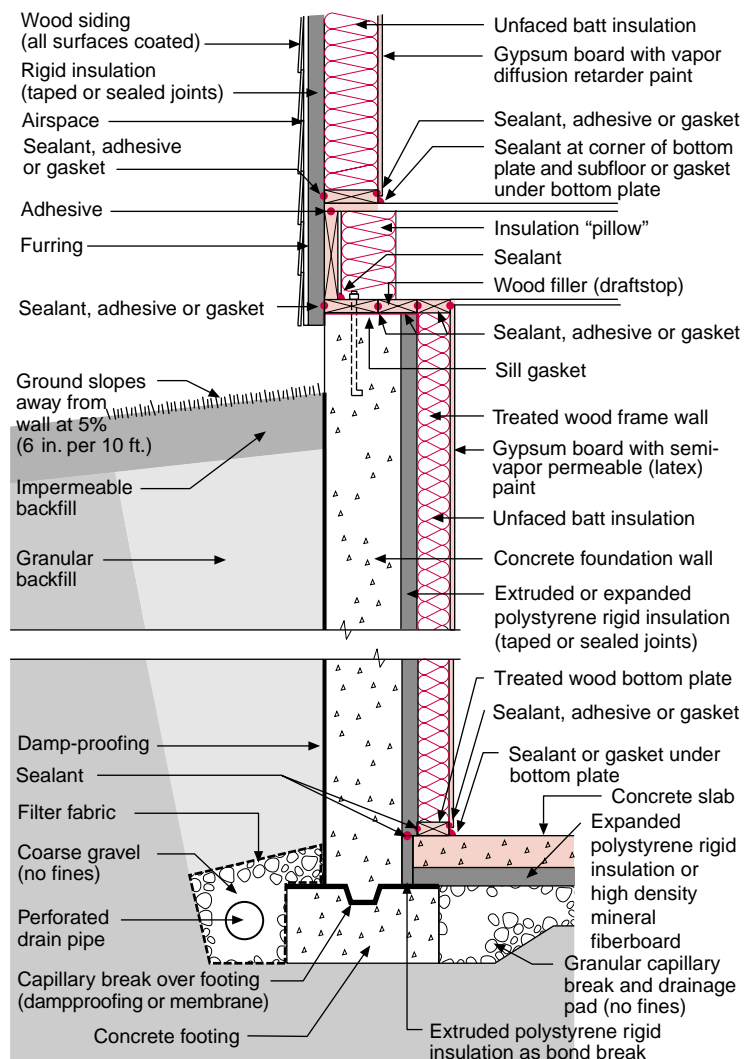


Figure 8
Internally Insulated Concrete Basement with Wood Siding

- Concrete wall cold; can only dry to the interior if interior assemblies are semi-vapor permeable; low likelihood of mold
- Cold concrete wall must be protected from interior moisture-laden air in winter and in summer
- Basement floor slab is warm, can dry to the ground (since there is no under slab vapor diffusion retarder) as well as to the interior; lowest likelihood of mold

Air

Air transports contaminants. In order to control contaminant movement you must first control air. But in order to control air you must enclose air. That means getting rid of the big holes. Once we get rid of the big holes (and get an “enclosure”), we can control the air movement within a home and between the home and the outside.

Then we can concentrate on the cold surfaces (get rid of them by insulating them) or make sure that the indoor air or the outdoor air never gets to the cold surfaces. Why do we not want air seeing cold surfaces? Because we do not want condensation. Condensation, especially the kind we don’t see, causes mold and destroys buildings.

Finally, we can limit indoor humidity and airborne contaminants by controlling air change between the interior and exterior. Dilution is the solution to indoor pollution that cannot otherwise be prevented or removed near the source.

But none of this is possible until we first get rid of the big holes.

Big Holes

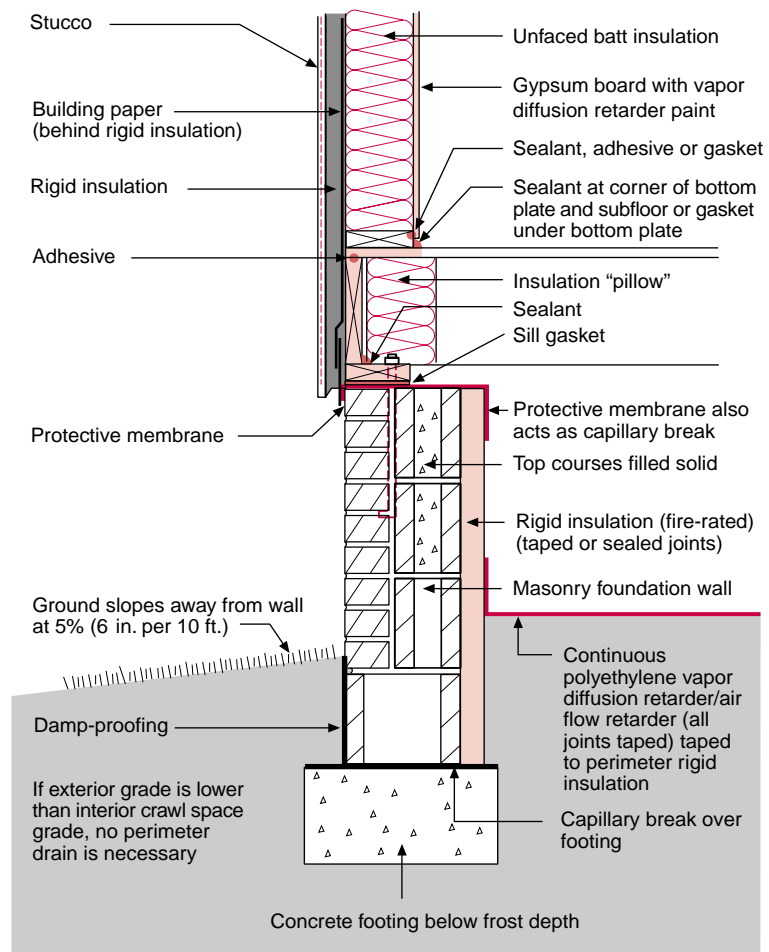
The biggest holes in buildings often occur between basements, crawl spaces and living areas. Other major holes include bathtubs on exterior walls, ductwork in attic spaces or exterior walls, soffits, recessed lights, plumbing chases and chimneys.

Basements and crawlspace are part of a home – despite repeated attempts over the years to disconnect them. They should be designed and constructed to be dry and conditioned. This is particularly important for basements because mechanical systems are always located in basements. It's pretty silly to install mechanical systems outside of a home in unconditioned space. People also store stuff in basements and people also live in basements. Yes, basements are a part of a home – they must be part of the conditioned part of a home – therefore they must be dry.

Basements should be insulated on their perimeters – they should not be insulated between floors. Ceiling basement insulation is a bad idea. Especially, if the basement is wet. If the basement is wet, make the basement dry. Don't try to disconnect the basement from the home – you won't be successful. Especially if you put mechanical equipment in the basement. The mechanical equipment connects the basement to the house.

Figure 9
Internally Insulated Concrete Basement with Stucco Wall Above

- Masonry wall cold; can dry to exterior; low likelihood of mold
- Protective membrane acts as termite barrier
- Rigid insulation must be fire-rated if it is left exposed on the interior
- Building paper installed shingle fashion acts as drainage plane located behind rigid insulation



BEFORE YOU DESIGN, BUILD OR RENOVATE
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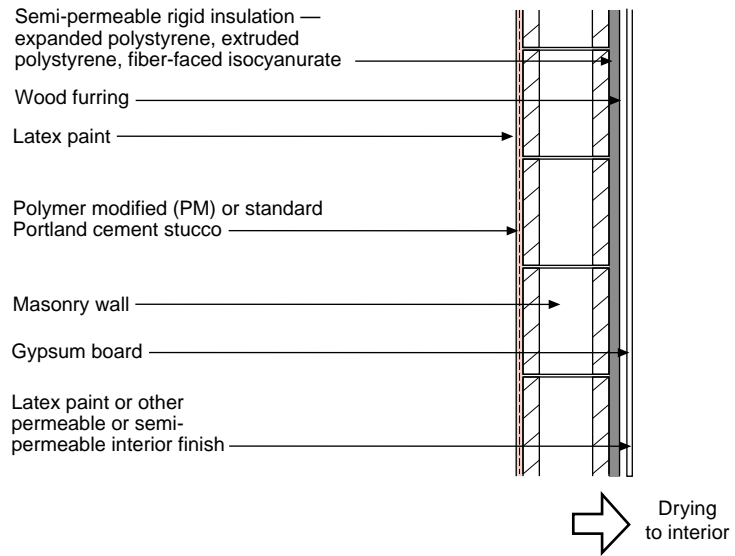


Figure 10
Masonry Wall with Interior Rigid Insulation and Stucco

- The semi-vapor permeable rigid insulation and interior latex paint permit drying to the interior
- Semi-vapor permeable rigid insulation used on the interior should be unfaced or faced with permeable skins; foil facings and polypropylene skins should be avoided
- Avoid use of metal furring or “hat” channels due to thermal bridging and impermeability; use only wood furring
- Wood furring should be installed over rigid insulation; rigid insulation should not be installed between wood furring, but should be installed directly on interior of masonry

Crawlspaces should be designed and constructed as mini-basements. They should be dry and conditioned. They should not be vented to the exterior. They should be insulated on their perimeters and should have a continuous sealed ground cover such as taped polyethylene. They should have perimeter drainage just like a basement.

Another major big hole are utility walls where they intersect exterior walls and ceilings or where exterior walls are padded out to provide space for utilities (see Figure 11).

Bathtubs and shower enclosures are rarely draftstopped (air sealed) with rigid materials such as sheathing or gypsum board (see Figures 12 through 14). Most people forget that cavity insulation is just a filter or a screen for air. Just leaving insulation behind a tub is like leaving your front door open – for thirty years.

Finally we have duct work and air handlers in attics – they leak. Don’t put them there. While we are at it, don’t put ductwork in exterior walls. Leaky ducts and air handlers located in attics are one of the major sources of ice-damming problems.

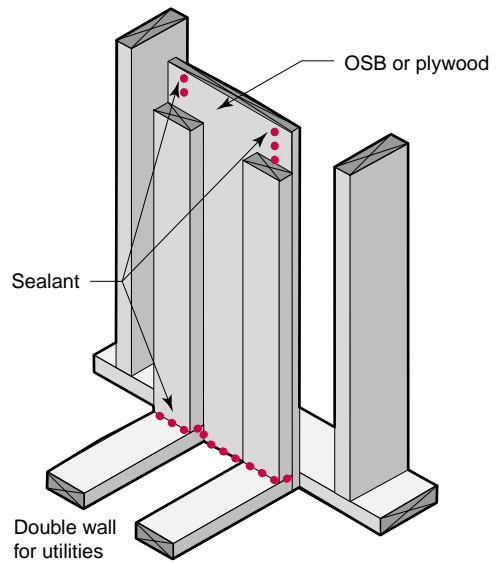
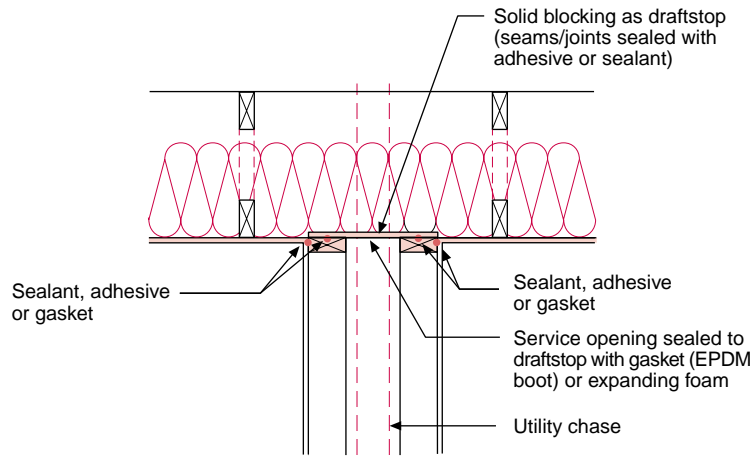


Figure 11
Utility Chase

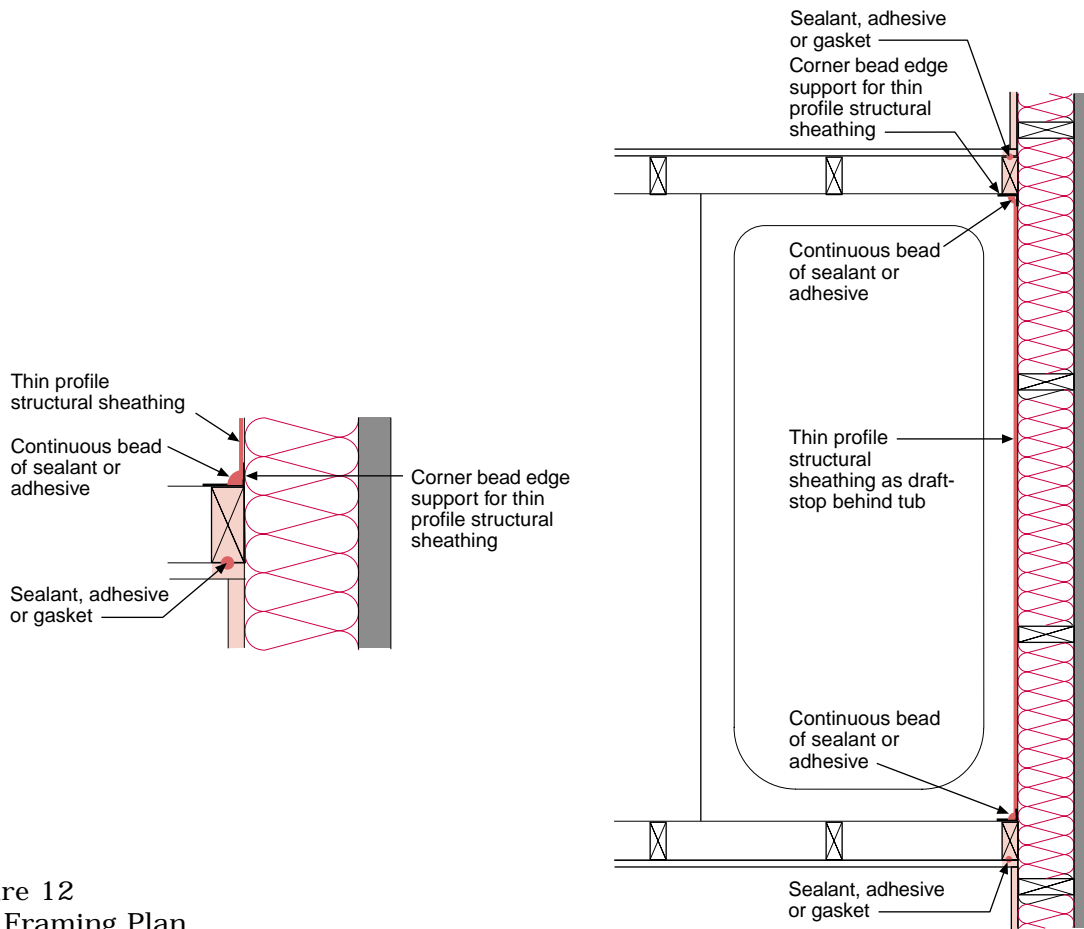


Figure 12
Tub Framing Plan

Figure 13
Tub Framing
Interior Elevation

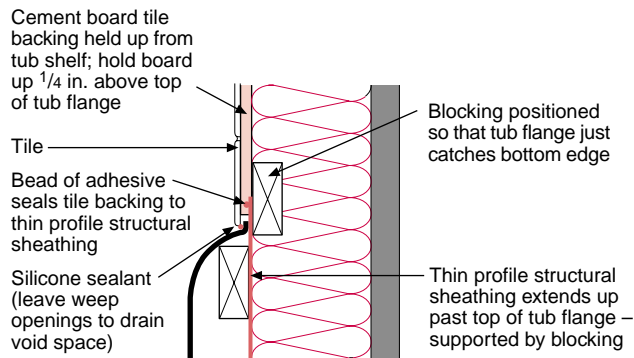
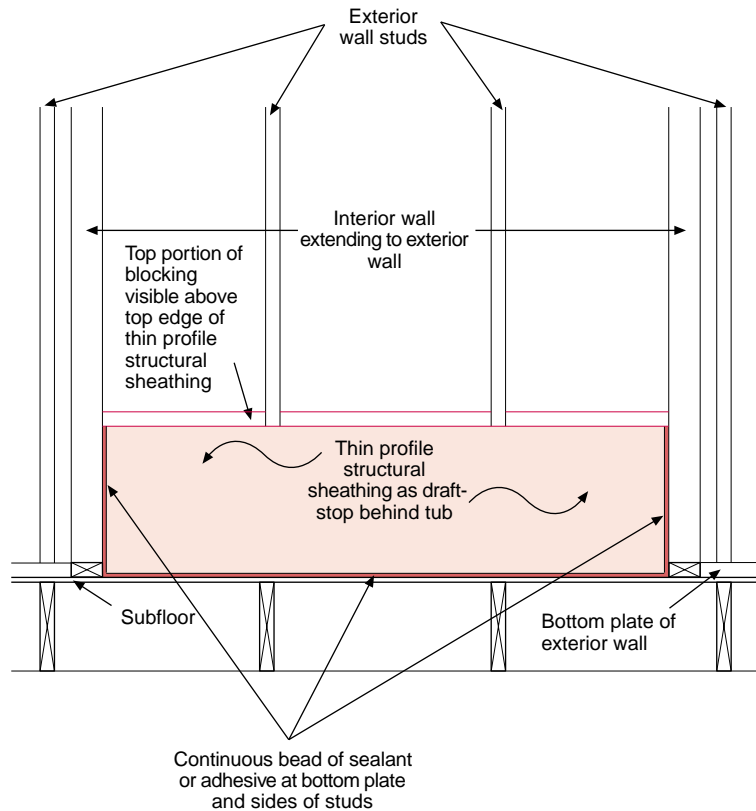
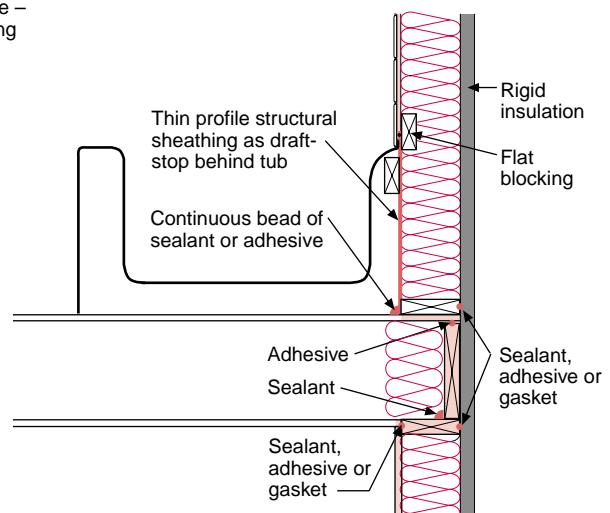


Figure 14
Tub Framing Section

- Flat blocking allows cavity insulation to be installed behind tub draftstop
- Cement board tile backing is recommended in place of “green board”. However, if green board is used, it is critical that the factory edge be used at the top of the tub flange; alternatively, if a cut edge is used at this location it must be sealed with mastic to prevent wicking of water upwards.



Cold Surfaces

Condensation happens on cold surfaces. One of the best techniques for controlling condensation is to eliminate cold surfaces. The coldest surfaces in homes are windows. Windows should never have condensation on them. That means they must be warm. That means at a minimum windows must be double glazed with non-thermally conductive frames. Avoid aluminum extrusion windows. Window frames should be constructed from wood, vinyl or fiberglass. Wood windows can be clad with vinyl or aluminum for maintenance reasons.

In severe cold climates window glazing should be low E. In all other climates window glazing should be spectrally selective (low SHGC, low U-value). The increased cost of such glazing is readily offset by a reduction in the size of the mechanical conditioning system.

Metal studs are 300 times more conductive than wood studs. They are prone to condensation and ghosting. Metal studs should never be used with cavity insulation because it makes them even colder. If metal studs are used they should be limited to interior walls or to the interior of rigid insulation assemblies. Metal studs should never be used below grade unless they are separated from slabs with thermal breaks and separated from foundation perimeters with rigid insulation.

Below grade walls are cold. The main problem with below grade walls comes during the summer when warm moist air comes in contact with basement cold surfaces. Basement walls should be insulated with non-water sensitive insulation that prevents interior air from contacting cold basement surfaces. The best insulations to use are foam based and semi-vapor permeable. Semi-vapor permeable materials allow the basement wall assemblies to dry to the interior. No interior vapor barriers should be installed in basements – ever — because they trap moisture inside the assemblies.



Rigid insulation can be installed in basements above concrete floor slabs and coupled with a floating floor

One of the worst assemblies for basement walls from the perspective of mold and moisture problems is a foundation wall that is internally framed and insulated with fiberglass cavity insulation and covered with a plastic vapor barrier. The only thing to make this wall even worse is to construct it from metal studs. Air gets in behind the framing and condenses on the cold surfaces. Alternatively, moisture from the foundation enters the internal framing. The moisture is trapped within the foundation assembly by the vapor barrier and deterioration occurs.

All bottom plates of below grade frame walls should be thermally isolated from basement floor slabs with thermal breaks.

If basement spaces or below grade spaces (garden apartments) are designed and constructed to be occupied, continuous rigid insulation should be installed under concrete floor slabs to raise the temperature of floor coverings to control mold and dust mites. Alternatively, rigid insulation can be installed above concrete floor slabs and coupled with a floating floor.

All cold water pipes should be insulated to control summer condensation.

Wood framing details, particularly in corners, should be constructed “open” in order to allow the installation of insulation and reduce thermal bridging (see Figures 15 and 17). Headers should be designed to accept insulation as shown in Figure 16.

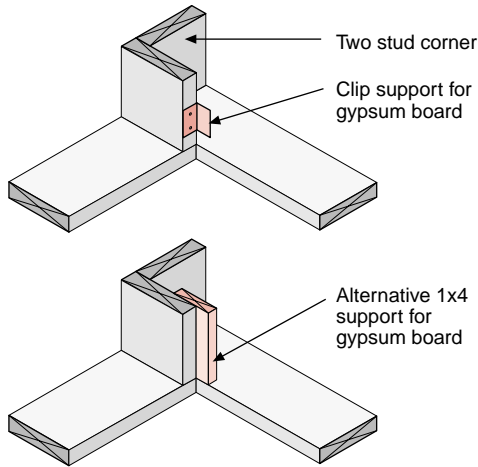


Figure 15
Corner Framing

- Open to interior to allow insulation installation

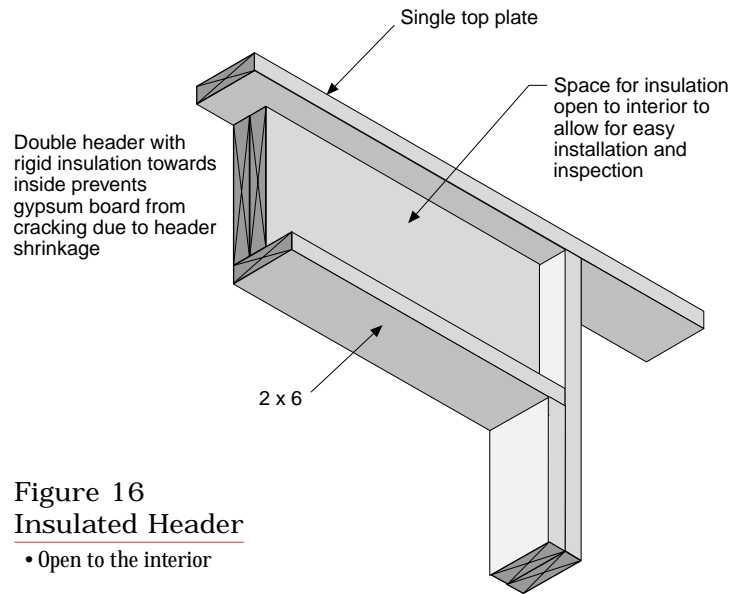


Figure 16
Insulated Header

- Open to the interior

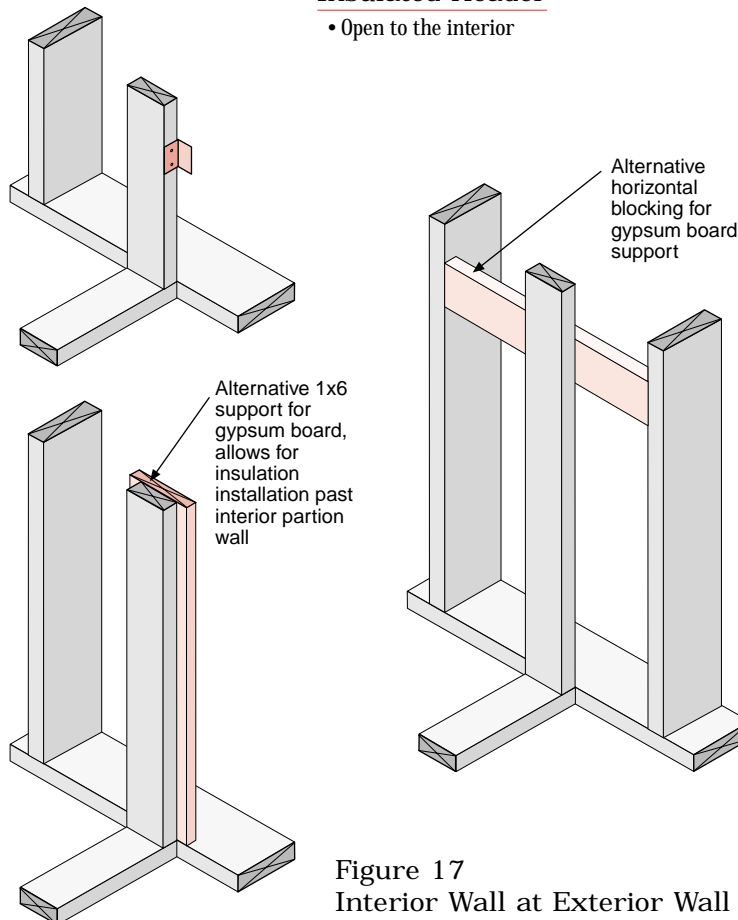


Figure 17
Interior Wall at Exterior Wall

Loose attic insulation (fiberglass, cellulose) at exterior walls should be protected from wind wash by placement of a wind baffle (see Figure 18).

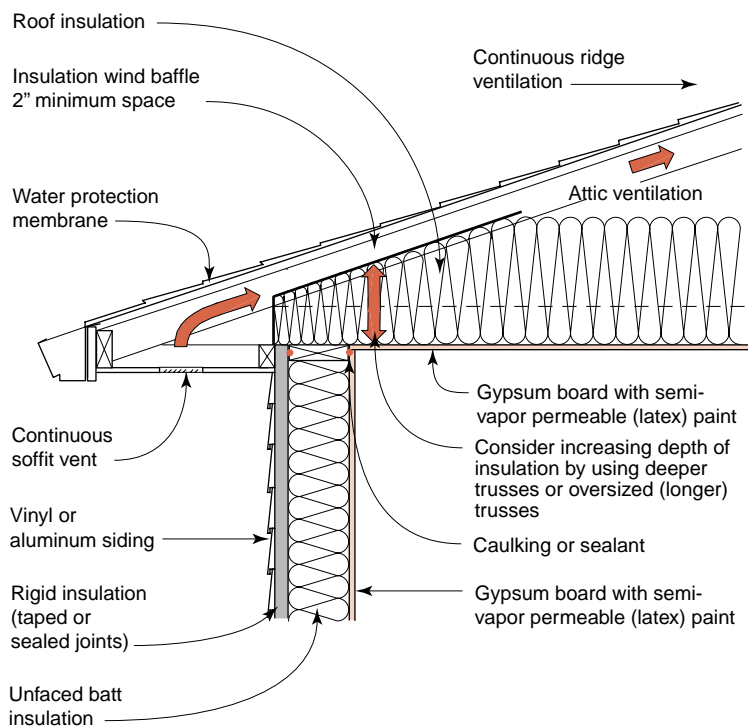


Figure 18
Baffle Installation

- Roof insulation thermal resistance (depth) at truss heel (roof perimeter) should be equal or greater to thermal resistance of exterior wall

Indoor Humidity and Airborne Contaminants

Indoor humidity and airborne contaminants are both controlled by ventilation. There are two kinds of ventilation: spot ventilation and dilution ventilation. Both are necessary in a healthy home. Spot ventilation deals with point sources of contamination such as bathrooms and kitchens (see Figure 19). Dilution ventilation deals with low level contamination throughout the home.

Every home requires exhaust from bathrooms and from kitchens. In kitchens, recirculating fans should be avoided because they become breeding grounds for biologicals, a major source of odors, and in all cases allow grease vapors to coat surfaces throughout the home. Kitchen range hoods must be exhausted to the outside to remove moisture, odors and other contaminants.

All bathrooms require exhaust fans to the exterior – even bathrooms with operable windows. No exceptions. Low speed fans (less than 3 sones) are recommended because they are quiet and more durable.

Dilution ventilation can be provided three ways: exhaust, supply or balanced (see Figure 20). In all cases it should be continuous and fan powered.

To reduce emissions from particle board surfaces, reduce the amount of particle board. Use wire shelving in closets. Wire shelving is easy to clean and permits air circulation. With kitchen and bathroom cabinets constructed from particle board, the exposed particle board surfaces can be sealed with 100% acrylic paint.

During the coldest part of the winter, indoor relative humidity should not exceed 30%. During the summer months, indoor relative humidity should not exceed 60%. Most individuals are comfortable where relative humidity is in the 30% to 60% range.

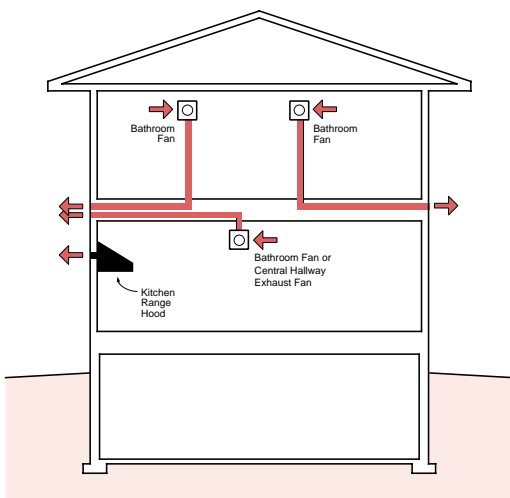


Figure 19
Exhaust Ventilation System with Point Source Exhaust

- Individual exhaust fans pull interior air out of bathrooms. One of these fans is selected to also serve as the exhaust ventilation fan for the entire building that operates continuously. Alternatively, an additional centrally located (hallway) exhaust fan can be installed.
- Replacement air is drawn into bathrooms from hallways and bedrooms providing circulation and inducing controlled infiltration of outside air.
- Kitchen range hood provides point source exhaust as needed.

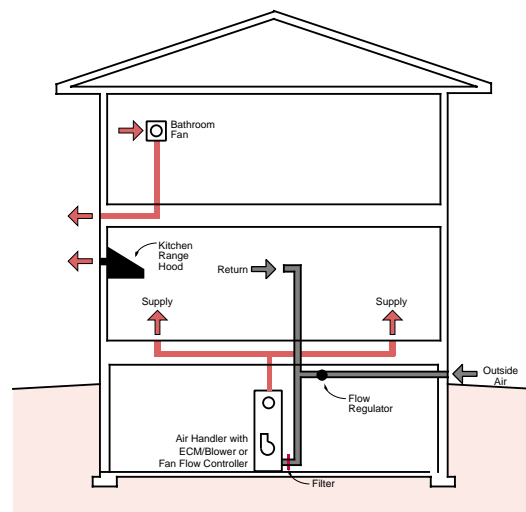


Figure 20
Supply Ventilation System Integrated with Heating and Air Conditioning

- Air handler with electrically commutated motor (ECM)/blower runs continuously (or operated based on time of occupancy) pulling outside air into the return system
- A flow regulator provides fixed outside air supply quantities independent of air handler blower speed
- House forced air duct system provides circulation and tempering
- Point source exhaust is provided by individual bathroom fans and a kitchen range hood
- In supply ventilation systems, and with heat recovery ventilation, pre-filtration is recommended as debris can affect duct and fan performance reducing air supply
- Outside air duct should be insulated and positioned so that there is a fall/slope toward the outside to control any potential interior condensation. Avoid using long lengths of flex duct that may have a dip that could create a reservoir for condensation
- Mixed return air temperatures (return air plus outside air) should not be allowed to drop below 50° Fahrenheit at the design temperature in order to control condensation of combustion gases on heat exchanger surfaces

Pressures

Air pressure differences cause air to move. That is both good and bad. Air change is good when it causes dirty air to be replaced with clean air. Air change is bad when dirty air is brought into a home. The bad air change is commonly associated with high negative air pressures (suction) in homes. High negative pressures can draw contaminants (such as radon and soil gas) into homes from below grade. High negative pressures can also cause problems with furnaces, boilers and water heaters. Additionally, high negative pressures can cause smoke and odors to be drawn from neighboring units.

High negative pressures can be avoided several ways. The first is to seal forced air ductwork, particularly on the return (or suction) side (see Figure 21). The second is to provide air pressure balancing between rooms (transfer grilles) when forced air systems are used (see Figure 22). The third is to compartmentalize (isolate) multifamily units and high rises to limit air flow between floors.

An effective way to use air pressure differences to capture and vent contaminants is through a sub-slab ventilation system (see Figure 22). All floor slabs, both below grade and on grade, should be constructed with sub-slab ventilation.

Combustion

When something is burned it produces products of combustion, particularly carbon monoxide and particulates that are unhealthy. Products of combustion should never be found in the indoor air of a healthy home.

Combustion Appliances

Gas cook tops and gas ovens produce products of combustion. They should only be used in conjunction with exhaust ventilation. Even with exhaust ventilation some individuals with asthma and other respiratory diseases can be adversely affected. Electric ranges and ovens coupled with exhaust ventilation may be the only option with these individuals. All cook tops and ovens should be installed in conjunction with range fans that are exhausted to the exterior.

Gas furnace, gas boiler and gas water heater vent systems should not communicate with occupied spaces. They should always be sealed combustion power vented devices (see Figure 21).

Fireplaces must be vented to the exterior.

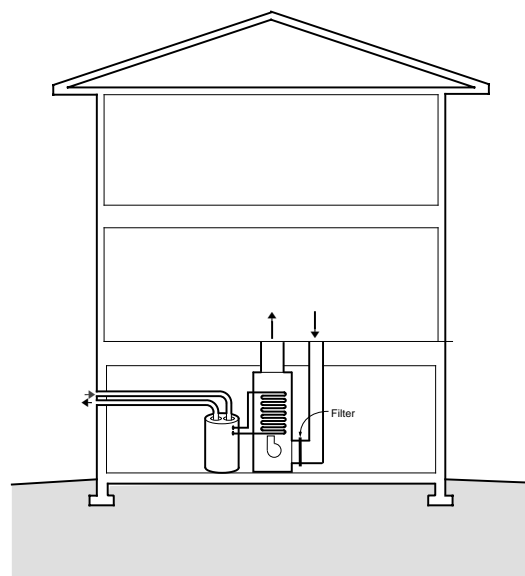


Figure 21
Sealed Combustion Power Vented Gas Water Heater

- Water heater flue gases exhausted to exterior using a fan; combustion air supplied directly to water heater from exterior via duct
- No furnace; heat provided by hot water pumped through a water-to-air heat exchanger (fan-coil)

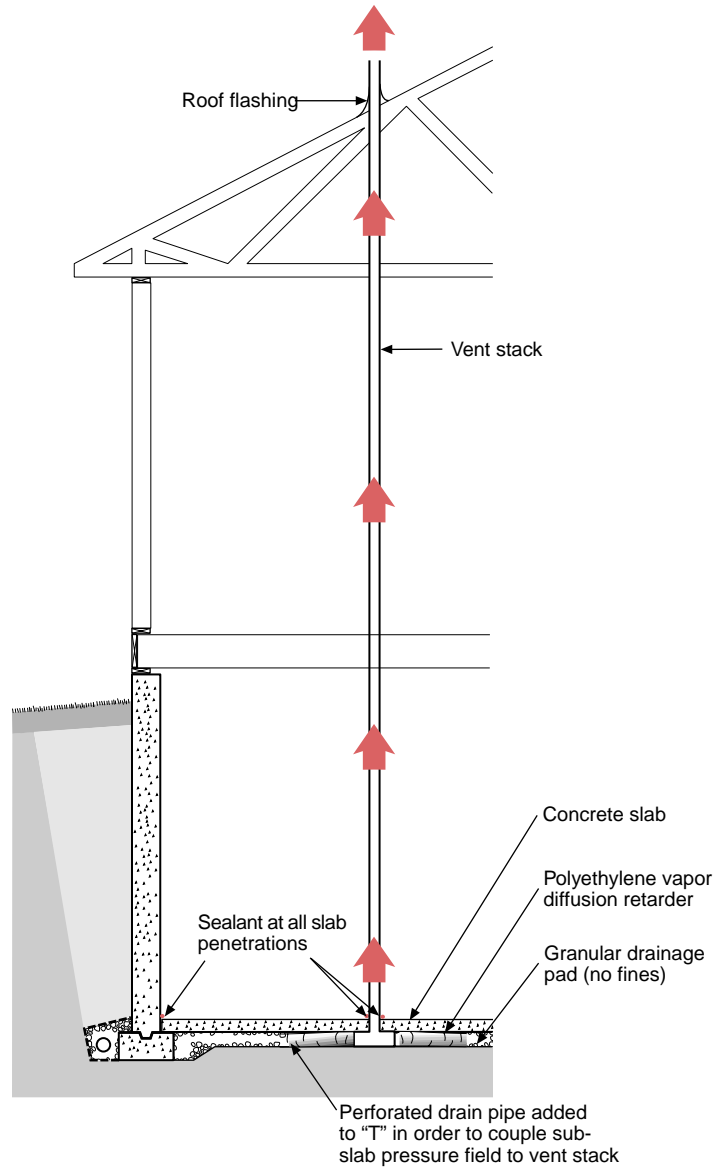


Figure 22
Soil Gas Ventilation System — Basement Construction

- Granular drainage pad depressurized by passive stack action of warm vent stack located inside heated space
- Avoid offsets or elbows in vent stack to maximize air flow

Good duct layout and proper placement of air handlers provides thermal comfort and avoid the introduction of contaminated air into the system (see Figure 23).

Figure 23
Air Handler and Duct Layout

- Air handler centrally located to minimize duct runs
- No ductwork in exterior walls or attic
- No returns in basement
- Return high in hallway of upper floor
- Return low in hallway of main level
- Only fully “hard” ducted returns when connected directly to air handler; no panned floor joist returns; no stud cavity returns
- Either return ducts in bedrooms or transfer grilles

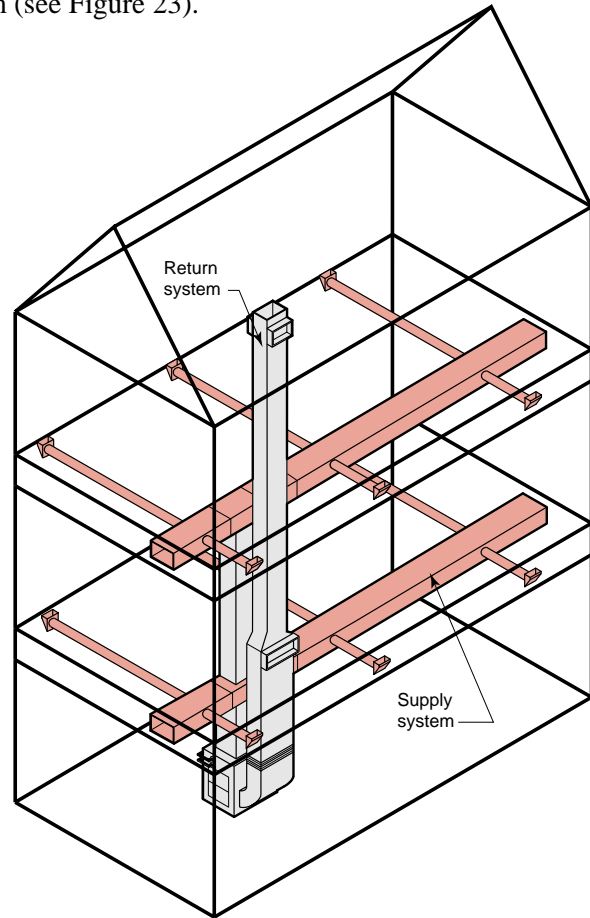


Figure 24

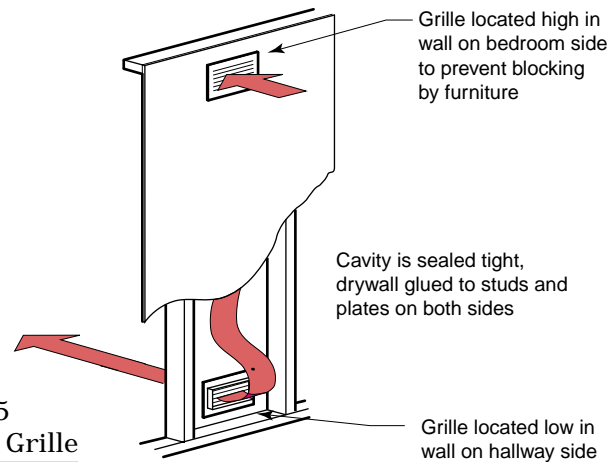
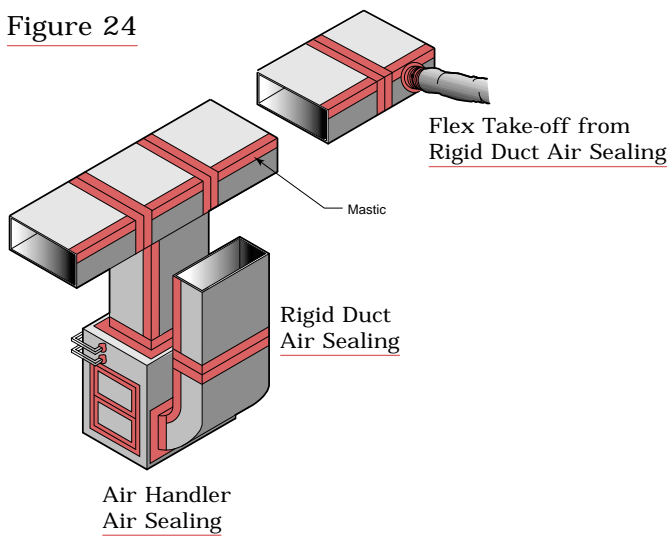


Figure 25
Transfer Grille

Garages

Ideally, garages should not be connected to a healthy home. Discrete, separate garages constructed away from homes are preferred. If garages are connected to a home, they should be ventilated to the exterior with a passive vent stack. Air handling devices such as furnaces or air conditioners should never be located in garages. Nor should forced air ductwork. Weatherstrip the door between the garage and the home and air seal the common wall.

Smoking

Smoking should not occur in healthy homes.

Dust

Stop the dust at the door. Vacuum and filter the rest away. And make it easy to clean.

Over two thirds of dust in houses originates outdoors, and is tracked in on feet. House dust is known to contain many hazardous materials. House dust is an asthma trigger.

Entry Control

Pave exterior walks. Use exterior grate track off, interior carpet mat and hard surface floors. Design entries so that there is room to remove and store coats, shoes and boots.

Use a three part track-off approach:

1. Permeable, rugged outdoor mat that collects gritty materials or a grate over a collection hole is an alternative approach;
2. Rugged indoor mat that collects grit and water; and
3. A hard surface, easily mopped floor to collect very fine particles left by drying foot prints.

Cleanable Surfaces

Whenever possible, replace carpets with washable flooring. Use window treatments such as blinds or shades that can be easily wiped. Use hard surfaces rather than textiles. Use semi-gloss paints instead of flat or matte finishes. Such surfaces are easier to clean using mild soaps.

Filtration

Construct a tight building enclosure to keep out outside dust and provide filtration. Filters should be MERV 6 – 8 (35 percent or better ASHRAE dust spot efficiency).

Creatures

Infestations of cockroaches, dust mites, mice and rats can all cause allergic reactions. Even after the pests are gone, their skin, hair and feces can remain and cause allergies.

Making a home pest resistant produces a healthier home two ways: it reduces exposure to allergens and asthma triggers released by the pests and it can reduce the amount of pesticides used by the occupants.

Design and construct the building so it's easy for people to keep pests from colonizing. Do these things:

- Make it hard for them to get in by sealing the walls, ceilings, roofs and foundations
- If they do get in make it hard for them to move around unseen by sealing passages through interior floors, walls and ceilings, kick spaces
- Make it hard for them to find water by keeping out the liquid water, making plumbing easy to inspect and mend and by keeping plumbing pipes warm (above dewpoint temperatures) by insulating them
- Make it hard for them to find food using tight food storage and by keeping paper and wood products away from potential moisture sources, and pest-resistant materials
- Make directed use of low toxicity pesticides in neighborhoods that are heavily infested with problem creatures.

To Know the Critter is to Control The Critter

To actually do the things on the list, you must know the creature. The simplest, safest and most elegant controls are those that work with the creatures natural urges. Creatures that get eaten a lot don't like open spaces. Give them open spaces. No closed-in kick spaces, strips around buildings free of shrubs and organic mulch. Seal around pipes and wires to keep them out of walls.

Keeping Them Out

Keep them out by changing the surrounding landscape and block pest entries and passages. Reduce food and water availability.

Keep bushes and trees at least 3 feet from homes. Bushes and trees near a home provide food, a living place and sheltered passage for pests such as rats, mice, bats, birds, roaches and ants.

Seal utility openings and joints between materials. Use corrosion proof materials such as copper or stainless steel mesh. Rodents can chew through many materials and squeeze through tiny openings.

Reducing Food and Water

Provide places to store food that are dry and ventilated. Provide a place to store trash and to facilitate recycling.

Design and construct the home to be dry and to dry if and when it gets wet. Absolutely no installed carpet in areas prone to get wet: bathrooms, laundry rooms, kitchens, entryways and damp basements.

In the Northeast, dust mites do not generally colonize buildings because buildings are too dry for much of the year. They colonize bedding, stuffed animals and favorite chairs because we humidify these things with our bodies. Control is by washing these items in hot water (greater than 130° Fahrenheit), which kills the mites and washes away allergens.

Pesticides

In the design and construction of new buildings, pesticides have a very limited and targeted role to play. In a neighborhood infested with a difficult species, like roaches or termites, use a limited amount of low toxicity pesticide in targeted locations. In high risk termite areas, exclusion and inspection detailing, plus a combination of treated wooden materials and soil treatment is useful. For roaches, dusting with boric acid in areas that would be hard to treat later is an effective, low risk strategy. For example, dust inside the kick space beneath sink, then seal the kick space as completely as possible.

To assess risk factors associated with a pesticide, look at:

- Registration, classification, use, mode of action
- Specificity, effectiveness, repellency
- Toxicity to humans
- Cautions on label, data gaps
- Toxicity in the environment
- Resistant populations

Look especially for products like insect growth hormone regulators, which are species specific, effective and have low toxicity for the applicators, occupants and the environment.

Don't spray pesticides; apply them directly to surfaces to be treated.



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