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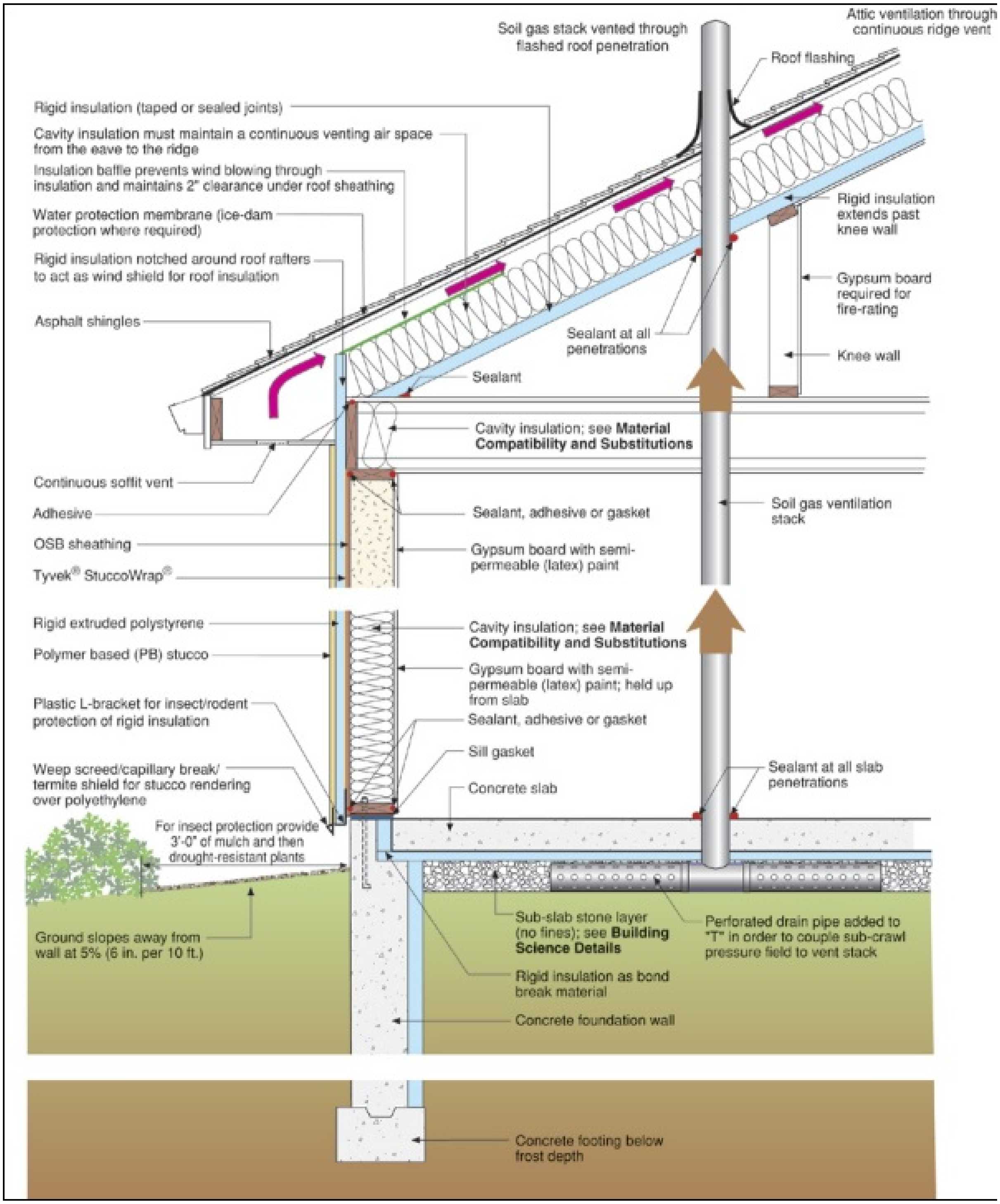
Designs that Work: Cold Climate - Minneapolis Profile

Cross Section



Construction Recommendations

- **Foundation:** Slab-on-grade
- **Above Grade Walls:** Wood frame
- **Cladding:** Stucco
- **Attic:** Vented cathedral ceiling
- **Roof:** Asphalt shingles

Building Science Notes

- **Cathedralized roof** – This roof assembly has continuous back-venting from eave to ridge of the structural roof deck, providing higher drying potential of the assembly to the exterior. This, in combination with the low vapor permeability of the rigid insulation on the interior of the assembly that keeps interior moisture out of the roof assembly, makes for a robust, cold-climate, cathedralized system.
- **Ducts in conditioned space** — This building profile is designed to accommodate HVAC equipment and ducts in the living space. HVAC ducts should not be run in exterior walls or in the slab where an increased potential for condensation exists.
- **Air sealing details at transitions** – Air sealing can be particularly difficult, but no less important, at assembly transitions such as band joists, and between attached garages and living spaces. These are discussed below because they have proven to be a consistent challenge for builders.
    - **Band joists** – Continuity of an exterior air barrier can be maintained at the band joist with sealed or taped housewrap or rigid foam insulation. Continuity of an interior air barrier can be maintained through a combination of cut foam blocks and sealant/caulk, rigid draftstopping material (wood blocking) and sealant/caulk, or spray foam. Note that neither nor fiberglass (batt or blown) can be used for the air barrier. The air barrier detail on second-story band joists is important because it is inaccessible (covered by structural/finish floor and ceiling finish) after construction. Note that while fiberglass batts fulfill the requirement for protection from ignition in the open band joists, fiberglass batt material by itself cannot maintain the air barrier.

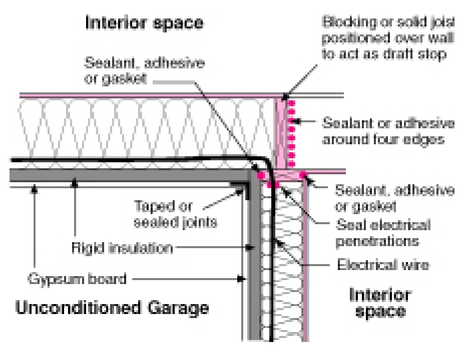


Figure 17

    - **Attached garages** – The building enclosure surfaces shared between conditioned space and an unconditioned garage must have a continuous air barrier. See *Figure 17* for details in terms of using sealants and rigid insulation to create a continuous air barrier between the attached garage and living space. See Air Sealing / Air Drywall Approach Details.
- **Drying mechanisms** – In any climate, vapor control is based on the relationships among the following: the permeability of wall components, the type of cladding (reservoir or non-reservoir), the presence/lack/nature of an air space, and the magnitude/duration of the vapor drive (based on the relationship between the exterior and interior moisture content and temperature differences). The type of sheathing and housewrap used in any wall assembly must be based on an understanding of these inter-relationships. See "Insulations, Sheathings, and Vapor Diffusion Retarders" for more information.

In cold climates, the moisture load in the winter months is primarily from the interior, so roof and wall assemblies are generally designed to dry primarily to the exterior. Wintertime condensation control can be facilitated by elevating the temperature of the first condensing surface (the back side of the exterior sheathing) via the use of insulating sheathing. When XPS (with relatively low permeability) is used, then only slow drying is available to the exterior. Accordingly, the majority of drying occurs to the interior during the summer months. Therefore, interior vapor barriers should not be installed. Note that there is a difference between an interior vapor barrier and an interior vapor retarder (see “Insulations, Sheathings, and Vapor Diffusion Retarders”). Particular care must be taken to prevent the entry of bulk water (i.e., leaks) and to control interior relative humidity in the coldest months. See Material Compatibility and Substitutions.

- **Drainage plane, air barrier, vapor control** – The drainage plane on this stucco-clad wall assembly is the building paper (in this case, StuccoWrap®).

  This building profile has a continuous air barrier on the interior (see Airtight Drywall Approach on ceiling and walls) and on the exterior walls (sealed rigid insulation). Note that framing of the second story knee wall after the rigid insulation is installed makes for a continuous air barrier at the roof line.

  In cold climates, walls are generally designed to dry to the exterior, with the vapor permeability of the exterior of the wall being 5 times more permeable than the interior; or, they are designed with insulating sheathing in order to control the temperature of the condensing surfaces. The thickness of the insulating sheathing is determined by calculation based on the severity of the climate (see “Insulations, Sheathings, and Vapor Diffusion Retarders”. Walls constructed with XPS insulating sheathing are designed to dry to the interior during the summer months. Latex paint or some other vapor retarder (i.e. the kraft facing on fiberglass batts or CertainTeed’s MemBrain™ Smart Vapor Retarder) acts to slow moisture entry in to the framed assembly from the interior. Ideally, the more vapor permeable EPS rigid insulation works well as the thickness of insulation goes beyond 1 inch, but see Field Experience Notes for more discussion.

- **Rough opening flashing** – Because the drainage plane is the StuccoWrap, flashing details must occur at this point in the wall assembly. See the EEBA Water Management Guide at the EEBA Bookstore for flashing details.

- **Advanced framing** – Although roof trusses that accommodate second floor half-stories are available, solid sawn framing may be more practical and cost-effective and must be used with the thermal barrier details shown in this assembly. 24-inch on center spacing, single top plate, and in-line framing are strongly recommended in this assembly in this climate because of the clear thermal performance and reduced drywall cracking benefits. See Advanced Framing Details for details.

- **Framing on slabs** – Installing a capillary break between the sill plate and a concrete slab on all walls—exterior, interior, partition—is good practice. A closed cell foam sill sealer or gasket works well. Alternatively, a strip of sheet polyethylene can be used. This isolates the framing from any source of moisture that may be either in or on the concrete slab (and using sill sealer on all walls maintains wall height exactly the same).

- **Soil gas ventilation** – The sub-slab to roof vent system handles conditions that are difficult, if not impossible, to assess prior to completion of the structure—resultant confined concentrations of air-borne radon, soil treatments (termiticides, pesticides) methane, etc. The cost of this “ounce” of prevention is well balanced against the cost of the “pound” of cure.

- **Thermal barrier** – Cavity-warming exterior rigid insulation is important in this climate where the average monthly temperature for the coldest month of the year goes below 45°F (see Unvented Roof Systems for more information). The heat loss through the basement walls is significant enough to warrant 1-1/2 to 2 inches of rigid insulation. Note that the insulation must either comply with local codes for protection against ignition or be covered with material such as gypsum wallboard.

Climate Specific Details

- **Below-grade insulation** – The combination of stem wall and slab insulation is an important element in reducing heat loss and preventing condensation. Note the thermal break provided by the rigid insulation separating the slab from the concrete stem wall.

- **Above-grade insulation** – Homes in this climate benefit from exterior insulation that warms whatever structural material is to its interior, protecting it from the moisture degradation that can occur as the result of condensation.

- **Ice dam protection** – The combination of sufficient roof pitch, adequate insulation just above the exterior wall, and air sealing at the wall-roof assemblies transition are all essential to prevent ice dams. But ice dams can occur even in properly detailed roof assemblies from differential solar snow melt. A water protection membrane at the eave is recommended on all roof assemblies in this climate.

- **Stucco cladding** - This polymer-modified stucco wall assembly is water-managed as a drain-screen system. For more information on water management strategies for different building assemblies in different climates and levels of precipitation, see the appropriate Builder's Guide at Building Science Press.

- **HVAC configuration** –
  *For homes **with** central forced air distribution system:*
  Intermittent central-fan-integrated supply, designed to ASHRAE 62.2P rate, with fan cycling control set to operate the central air handler as much as 33% of the time, but not less than 25% of the time, occurring within at least every three hours to provide ventilation air distribution and whole-house averaging of air quality and comfort conditions ($125 to $150). Outside air fraction is designed to keep mixed air temperature at furnace heat exchanger above 50°F, usually not more than a 10% outside air fraction. Optionally include a normally closed motorized damper in the outside air duct (+$50 to $60). See Figure 18.

  In very cold climates ventilation can also be accomplished using a continuous single-point exhaust system, designed to ASHRAE 62.2P rate, pulling from the principal living area ($150).

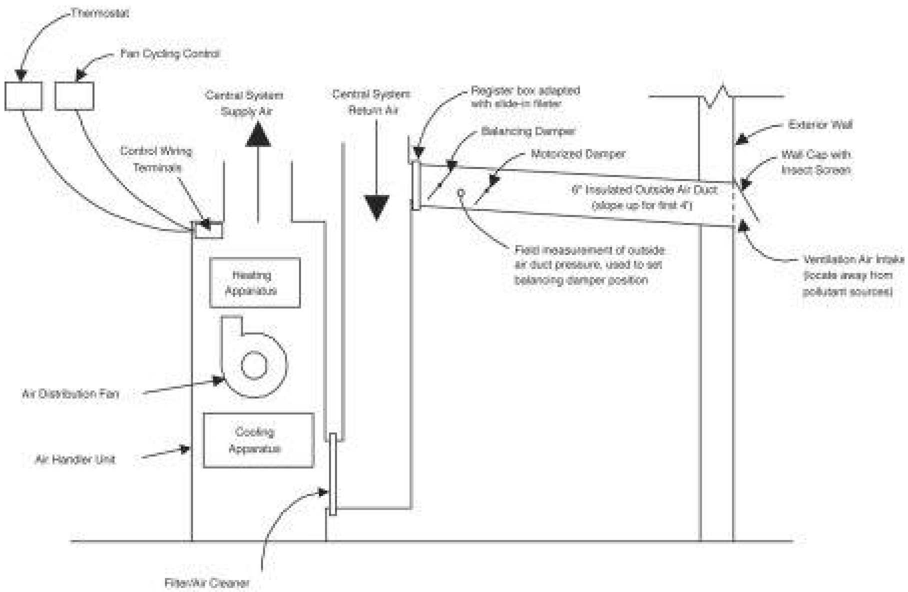


Figure 18 - HVAC Configuration

*For homes **without** central forced air distribution system:*
Continuous multi-point exhaust, designed to ASHRAE 62.2P rate, pulling from each bedroom, unless the bedroom has a bathroom. Then it will pull from the bathroom and from at least one location in the principal living area. Any combustion appliances must be direct-vented sealed combustion.

- **Supplemental dehumidification** - Although high performance homes in this climate rarely require supplemental dehumidification, it is:
  ... one of three strategies appropriate for conditioned crawlspaces (see Building Science Notes),
  ... may be desired in homes with full basement foundations, and,
  ... is strongly recommended when occupants require humidity control (and high-efficiency air filtration) for asthma trigger control.

  There are a number of different ways to accomplish supplemental dehumidification with varying costs and performance advantages (for a detailed discussion of supplemental dehumidification see Conditioning Air). Described below is one low-cost yet effective approach and one more costly but higher performance/systems-engineered approach:

  1. Ducted stand-alone dehumidifier: This system is a "site-constructed" one consisting of an off-the-shelf standard dehumidifier ducted in the attic and controlled by a dehumidistat located in the living space. This arrangement of individual components has proven to be an effective and economical system for the production home building setting. The installed cost ranges from approximately $350 to $550. The system is comprised of a GE dehumidifier model AHG40FCG1 (dehumidifier located in attic in an insulated enclosure and ducted to living space), Honeywell dehumidistat model H8808C located in living space, and Honeywell switching relay (with transformer) model RA89A 1074. See Figure 18a. The selection of the dehumidifier is based largely on the fact that it has a blower wheel rather than paddle fan that moves air more efficiently in its ducted box configuration.

Note: The following manufacturers make Energy Star-qualified blower wheel stand-alone dehumidifiers:

- LG Electronics (all models)
- Haier America (all models)
- Heat Controller (all BHD models use a turbo-impeller with turned blades)
- Or you can check the EPA Energy Star website for dehumidifiers from these manufacturers.

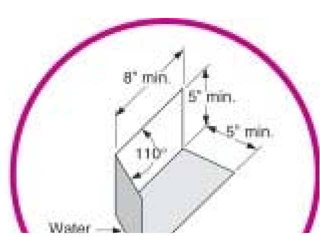
2. Aprilaire 1700: This is a truly engineered, coherently manufactured, supplemental dehumidification system with built-in air filtration, ducted design, and a controls package that integrates central blower cycling for distribution, dehumidification and intermittent introduction of outside air ventilation. The system is also designed for flexibility-it can be connected to the conditioned space directly or to the central air distribution system in a number of configurations. It's also compact and lightweight enough to be set on or hung from most framing. The product cost for this system is currently about $1,100. For more information, see: http://www.aprilaire.com/category.asp?id=F63D255EB0054BBF811DBB024BF068FA.

For more information on other high performance supplemental dehumidification systems, see: http://www.thermastor.com/DesktopDefault.aspx.

- **Insect management** – In cold climates, insect pressure (termites and carpenter ants) is less pronounced than in warmer climates, but important nonetheless. A three-pronged approach deals with the three things insects need—cover, moisture, and food (wood or paper):
  - **Reduced cover** – Keep plantings 3 feet away from the building perimeter, thin the ground cover (wood mulch or pea stone) to no more than two inches depth for the first 18 inches around the building, and maintain any termite inspection zone on the foundation.
  - **Control moisture** – Maintain slope away from building as shown, carry roof load of water at least three feet away from building, and make sure that irrigation is directed away from the building.
  - **Chemical treatment** – Use an environmentally-appropriate building materials treatment (such as Bora-Care®) for insect-prone, near-grade wood materials.
  - **Inter-relationship of first three points** – Since a builder and a homeowner's ability to employ or stick to each of the three strategies above will vary, make sure that an inability to fully employ one strategy is compensated for by complete rigor with others. For example, if for some reason, chemical treatment of soil or building materials is not an option, then complete rigor in moisture control and ground cover is required.

Field Experience Notes

- **Selection of rigid insulation** – Most builders select rigid insulation based on costs and handling properties. Although the vapor permeability of both EPS and rigid fiberglass insulation can make



them particularly well suited to cold climate envelope assemblies, their availability or their user-friendliness (or both) generally make XPS insulation the builder choice. For these reasons, we recommend 1-inch or thicker XPS in most wall assemblies. But remember, the type of sheathing to use is always a question that should be asked in the context of:

- the given cladding; and
- the level of control that can be expected over interior relative humidity via mechanical ventilation. See “Insulations, Sheathings, and Vapor Diffusion Retarders” for more information.

- **Joint treatment in rigid insulation** – Shiplapped rigid foam insulation has proven to be available in only very limited areas. Mastic works as a water sealant but its long term performance is not known but appears promising. The flexible flashing with polyethylene film is straightforward and creates a natural weatherlap and therefore is the preferred approach.

Kick-out Flashing

- **Stucco flashing detail** – Where a roof intersects an exterior wall (for example, on a garage attached to a gable end), the flashing detail for the stucco should look *Figure 19* and employ a kick-out flashing.
- **Advanced framing** – For a technical resource that may help with resistance to advanced framing methods from local code officials, see the *Building Safety Journal* article written by Peter Yost of BSC.
- **Energy trusses** –There are a number of different truss configurations that yield greater depth at the heel, but they vary quite a bit in cost. The truss shown in *Figure 20* (sometimes called a “slider” truss) has proven to be among the most cost-competitive. And of course, the pitch of the roof affects just how much insulation you can get at this location, regardless of the type of truss.

Figure 20

Material Compatibility and Substitutions

- **Slab foundation** – A monolithic slab with rigid insulation extending out below grade horizontally (shallow frost-protected foundation) can be used in this climate for slab-on-grade foundations. See *Figure 21* and the American Society of Civil Engineers standard, "Design and Construction of Frost-Protected Shallow Foundations.”

- **Flooring** – Many finished flooring materials — either because of their impermeability (sheet vinyl, for example) or sensitivity to moisture (wood strip flooring, for example) — should only be installed over a slab with a low w/c ratio (≈0.45 or less) or a slab allowed to dry (< 0.3 grams/24hrs/ft2) prior to installation of flooring. In general, sheet vinyl flooring should be avoided.

- **Interior latex paint** - The substitution of low permeability interior finishes (vinyl wall paper, oil-based paints) for latex paint should be considered in the context of severely limiting or eliminating any drying potential that the wall assembly has to the interior. These interior treatments should be avoided.

- **Cavity insulation materials** – Acceptable cavity insulation includes any that have a relatively high vapor permeability—cellulose, fiberglass, foam (as long as air sealing is accomplished by a separate component or system when cellulose or fiberglass is used). User discretion can be based on properties other than building science.

- **Slab insulation** – A polyethylene vapor barrier is not necessary with this design due to the moisture control properties of the rigid insulation. If a polyethylene vapor barrier is installed with the rigid insulation, it must be installed on top of the rigid insulation in direct contact with the concrete. A sand layer should not be placed between the polyethylene or rigid insulation and the concrete slab. The polyethylene should never be installed under the rigid insulation. See "Why Sand Layers Should Not Be Placed Under Slabs".

- **Gypsum wallboard** –Areas of potentially high moisture, such as bathrooms, basements, kitchens, are excellent candidates for non-paper faced wallboard systems (e.g. James Hardie's Hardibacker®, GP's DensArmor®, USG's Fiberock®). In addition, paper-faced gypsum board should never be used as interior sheathing or backer for tub or shower surrounds where ceramic tile or marble (any material with joints or grout lines) is used as the finish.