Solar Building Envelopes

Getting the energy of the sun into a building is easy... making good use of it in the building is both an art and a science. One of the key factors in any passive solar design is the building envelope. How are you going to keep the energy in the home for use when you need it without overheating the space when there is more than enough solar gain?

A proper passive solar design starts with a VERY efficient envelope. The envelope is comprised of the Floor, Walls, Roof and Windows, where each part plays a distinct role in achieving the end result. Some of the factors controlling or motivating the design of a solar building include aesthetics in design style as well as exterior and interior finishes. Environmental load requirements are a consideration for both heating and cooling as well as for structural loads of the building such as snow, wind and seismic. And of course cost is a primary controlling factor as well.

For passive solar designs most of the mass needed for storage of the energy can be met simply with a concrete slab floor. With the Northwest's new fascination with radiant heating this is fast becoming the norm and although this is not always true, for our discussion let's assume that is the case. That leaves us with the walls, roof and windows.

Although the earliest solar designs were simply south facing caves, humans progressed slowly through various methods of wall building for their homes depending on their location on the planet and the natural resources that were available in that area. Some of those systems have included earthen or rock walls, timber frames with waddle and cob infill, solid wood walls and currently our "modern" frame building.

As always some innovator said there ought to be a better way to do this. Some of the alternative choices for walls that have come out of that thinking include: Insulated Concrete Forms (ICFs), which are a hollow block that either is foam insulation or has some level of insulation in it. It is reinforced with re-bar and then filled with concrete There are many variations, like AARX® / Reward / Rastra® / Cempo® and Durisol® block. There are also solid block walls like E-Crete® block. Structural Insulated Panels (SIPs), have been around for 40 years and most commonly consist of an OSB sheet on two sides adhered to a foam core. At least one old idea that is seeing a resurgence is straw bale infill between a frame that supports the roof. Other systems have also been designed to make our standard frame wall better; one that holds promise is wood framing with spray soy-foam and an exterior foam wrap which works especially well if combined with advanced framing.

If you break down the basic functions of exterior wall construction, you will find at least these characteristics:

- R-Value -- the resistance to energy movement through a wall.
- Thermal Mass -- the ability of the wall material to absorb energy.
- Infiltration -- air movement through the wall.
- Fire resistance -- code requires 20 minutes in residential construction.
- Moisture resistance -- walls MUST stay dry to be durable and keep mold from growing.
- Sound transmittance coefficient -- the ability to reduce noise.
- Ease of use -- how easy is this product for the builder to use?
- Breath-ability -- the ability of moisture vapor to move through the wall.
- Design Flexibility -- can this system be used with many styles of buildings and can it be remodeled in 30 years when styles change?
- Cost of Material and Labor -- this is always a consideration!

The three big factors for a wall to function well in a solar building are **R-value** or its inverse U-value, **Thermal Mass** and **Infiltration.** Let's take a look at how they work together.

The R-value of the insulation is only part of the whole picture. An R-21 Batt is never an R-21 wall since there are a lot of materials in a wall besides the insulation. In standard wood frame construction a full 1/4 of the wall can be solid wood at a value of R-1 per inch. Code authorities use a system of evaluating R-value called steady state R-value where the various parts that make up an assembled wall are added together. This may still be only part of the picture because they only add where the insulation is. To better test how wall systems work Oak Ridge National Laboratory (ORNL) has done extensive testing of whole wall assemblies which include a corner a window and a door. This allows them to see how "whole walls" perform in relationship to R-value. See the web site at the end or the article for more information.

Thermal Mass, heavy materials like concrete and rock have the ability to absorb more energy than light objects. In the winter, mass absorbs heat during the day and release it during the night as temperatures drop. An interior mass performs much better than an exterior wall for this function that is why concrete slabs and interior mass walls have been used in passive solar designs. If you insulate the exterior walls, keeping the mass inside, it is protected from outside temperature extremes. For further study on wall mass, see the web site below

Infiltration can best be understood by thinking of the building as a box with wind blowing on one side. The wind creates a high pressure on that side and a low pressure on the opposite side almost like a vacuum. If walls leak they allow the warm or cool air to be sucked through the building. In standard stud construction it is very hard to control all the places it might leak. Almost any solid wall system will perform well in this category however any penetration of the wall can contribute to this leakage in either direction. Windows and doors can be large contributors to this leakage because of the many linear feet of gap around them. These penetrations must be sealed properly to get the best performance from any wall system. If wind is allowed to ventilate a building, it will be very hard to control the interior environment. Yes you still need to ventilate a building for the health of the occupants as well as the building; this can be done in a variety of ways, from opening a window to installing an efficient heat recovery ventilator. Current thinking indicates 1/3 of an air change per hour to be a good goal for residential construction.

So which wall is the best wall? It depends. Make a list of the characteristics that are most important to you and then compare wall systems that you think would work. If you know, for example, that you want an earthen clay for your interior wall finish or stucco for the exterior finish, perhaps Rastra® or Durisol® might be your best choice, because you can apply it directly to the block. If you decide that speed of construction or high R-value is the most important factor, then having large SIP panels with pre-installed lumber delivered to the building site might be a good choice. On the other hand if you own a wheat ranch and you want to use timbers from an old barn nearby, then straw bale might win out over some of the other options. Do you have a design that has extremely high shear wall requirements? Then take a good look at ICF construction. Do your research, ask plenty of questions and get independent third party answers. There are no perfect building materials; each product is only right for your set of parameters.

No matter which wall system you use roof options are fewer, you still need to think of the envelope as a whole system. Many of the criteria that apply to walls also apply to an efficient solar roofs. High R-value, low air leakage, Ease of use and cost.

Research indicates that putting the insulation in the roof plane as opposed to in the attic is a much better energy saving strategy. If you can keep the heat and cold out of the building in the first place it is much easier to control the interior temperature. There are a couple of strategies that can allow you to move the insulation to the roof plane. Timber framers and log home builders have used some of these for years. Timber or log Framed rafters with 2x6 white wood ceiling boards and a built-up urethane foam roof is one option. Another is SIPs with a supporting system of logs, timbers, glulams or trusses.

Depending on the roof design trusses or hand framing may be the only option. At the very least you will want to use factory trusses with an energy heel so you can get full depth insulation all the way out to your wall.

Windows and glazing are an article by themselves but with today's window technology it is possible to "tune" the windows to the direction they face. On south facing windows where you want solar gain clear glass low-e windows allow solar radiation in yet block it from escaping. On west walls where you want to block the afternoon sun a glazing with a solar filter built in would be a better choice.

With the emphasis on Green Building today, which includes much more than energy conservation or renewable energy you will want to have an over arching view of your whole construction process as a sustainable process.

SIPs	http://sipweb.com/
ICF	http://www.icfweb.com/
Rastra Block	http://www.rastra.com/
E-Crete block	http://www.e-crete.com/
Durisol Block	http://www.durisolbuild.com/
Straw infill with a Frame	http://www.ironstraw.org/
Oak Ridge National Lab	http://www.ornl.gov/sci/roofs+walls/
Thermal Mass	http://www.buildinggreen.com/features/tm/thermal.cfm.

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