How to Build a House

Comfort + Efficiency

Have you ever wondered why your house feels cold in the winter and hot in the summer, even though the temperature might be a constant 70°? When it's very cold outside, you're probably more comfortable with the thermostat set at 74°, and when it's 100° outside you might want to cranked the AC down to 64°. Why such a big difference in temperature to be comfortable?

It turns out that your comfort has more to do with the temperature of the walls in your home than the temperature of the air. The walls radiate infrared heat, which has a much greater influence on your comfort than the conductive heat you receive from the air. In fact, the difference is about four to one - a four degree change in air temperature feels like a one degree change in wall temperature.

You want another example? Radiant energy in the form of infrared heat from the sun can warm you up even on freezing winter days. It could be 40°, yet if you're in the sun, it feels pretty good. But a 60° day that's cloudy will feel cold.

In your home, when the outside air is 20°, the inside of the exterior walls has cooled to 60° or so. This will make you feel cold even if the air temperature is over 70°. In the summer when the outside air reaches 100°, your exterior walls are probably around 80°, and you feel hot with a 70° air temperature. So for the greatest comfort, control the temperature of the walls and not the air.

Radiant heat energy is constantly streaming out of every object or piece of matter warmer than absolute zero. The energy is either reflected or absorbed by every other object in its field of view. The absorbed energy is then re-radiated back to the other objects. This process never stops. Objects that are colder will retain more heat energy and objects that are warmer lose energy until everything in view is at the same temperature. Radiant heating relies on this temperature balance. If the walls are warmer than the objects in the building, then more heat energy will transfer to the objects, and vice versa.

The air that fills your home isn't heated directly by the radiant energy from the walls. Air is made up of 78 percent nitrogen and 21 percent oxygen. Nitrogen N_2 and oxygen O_2 do not absorb infrared radiation. The other one percent of the air is made up of trace gases, which do absorb and emit the infrared energy. Most of the air will warm up or cool down by conduction through direct contact between the objects and the air.

The perfect house, or building, would have walls at a constant 70°. It would be even better if the ceiling and floors were also at 70°. Any deviation in the air temperature by plus or minus 10° would go mostly unnoticed. If people were performing physical labor, a wall temperature of 65° would be even more comfortable.

So how do you get your walls to maintain a constant temperature? It's done with thermal mass, which is any material that can store a lot of thermal energy, or heat. The walls are heated or cooled, as the case may be, and then they either warm or cool the occupants and objects. Due to the construction materials in the vast majority of homes, there is very little thermal mass in the exterior walls. They fluctuate in temperature throughout the day as the exterior temperatures change and the heating or cooling system operates. Since the walls lack the thermal mass to maintain the desired temperatures, the air will be heated or cooled with a forced air furnace or a baseboard heater.

The perfect home would be build with concrete walls. Although they are more expensive, they will be more comfortable, use less purchased energy and are safer. Many of the homes in Florida are being built with concrete to withstand the hurricanes. A properly built concrete home is also fire proof and wind proof. Wood framed homes happened to be more common purely due to cost and the experience of the trades.

Warmth

Where should the energy come from to heat your home? Solar and geothermal is the most environmentally friendly and lowest cost over the long term. Solar can supply all of your energy needs if you have a means to store it. With a concrete structure, the heat gained from insolation (solar energy) can be stored for many days. A mistake made in many passive solar homes of the past was to use wood framing instead of concrete, and the houses would overheat by collecting too much energy for the very limited thermal mass. Without a place to store the excess heat, the temperature will rise excessively.

The azimuth alignment of the home and its eves, windows and overhangs should be set to capture as much winter insolation as possible. Probably the best

system to capture winter insolation energy is a Trombe wall. These are thermal mass walls placed behind an equator-facing glass panel and painted flat black. The interior side of the Trombe wall should face the living space, and be able to store the energy for several days. With an open floor plan, infrared radiation from the inside side to the Trombe wall would also be absorbed by the other thermally massive walls on the other three sides of the living space. It might be a challenge to get the thermal energy into separate rooms of the house if the interior walls are opaque to infrared radiation. This calls for some creativity in the design of the interior partitions and materials.

The size and placement of the Trombe walls will depend on your local climate, although going a bit larger would be better. It will be easier to lower the interior temperatures if you gain too much versus trying to gather more energy from a too small of a system. Even on a perfectly sized Trombe wall there will be some days or weeks when there is too much gain, and in those situations increasing the ventilation would achieve the desired cooling, and the enjoyment of crisp, fresh air.

The construction of your home could use insulated concrete forms (ICF), which are styrofoam forms into which concrete is poured to produce an insulated clad concrete wall. Although there is plenty of thermal mass in an ICF wall, it is insulated from the interior living space. The heat energy held in the concrete would not radiate into the living space so you would still be left with heating the interior air mass. The true benefit of an ICF home is the somewhat air-tight structure and the insulation value.

The preferred construction procedure would be to pour the concrete walls and then adhere rigid foam to the exterior. You could choose the type of foam and the thickness to address your local winter extremes. At about 40° latitude, three inches of expanded polystyrene (EPS) or extruded polystyrene (XPS) would provide sufficient insulation. The foam would be covered and protected with a stucco or other solid material. In some cases the interior concrete wall can be painted or left bare, depending on the owner's tastes. If a wall covering material is desired, the material should be highly thermally conductive, with little insulation value. In all cases the interior surface should not be glossy or otherwise reflective. Flat paints or materials are best.

Using poured concrete walls with exterior rigid foam provides an opportunity to incorporate the Trombe wall directly into the structure. The equator facing wall could be constructed with a number of openings for direct insolation into the living space. Glazing could then be fixed into the rigid foam a small distance proud of the concrete wall. The glazing could span a much larger area than the openings in the walls. The concrete behind the glazing would be painted flat

black to capture the insolation directly into the concrete. The energy captured in the concrete would warm the wall and continue to radiate into the living space after the sun has set. This is an economical way to incorporate the energy storage right in the building's structure. In this manner, the concrete and the Trombe wall can be completely hidden behind whatever style or appearance the owner desires.

Cool

The nice thing about a concrete structure is its connectedness with the earth. In most habitable zones, the earth is about 54°F at a meter deep. This provides a very accessible heat sink for the hot summer air and excessive solar gain. The concrete walls and floor are cooled through conduction into the earth. (During the heating season this doesn't matter much since the earth is warmer than the outside air.) As the walls cool they will accept more radiant energy generated by your body, and not radiate back as much as when they were warm. The net energy balance will transfer the heat from you to the walls and floor and into the ground.

It is also important for summer cooling to limit the summer insolation. You might have noticed in the northern hemisphere that the summer sun rises east-northeast and sets west-northwest. The sun will come into the north facing windows and the east facing windows right after sunrise. To limit the insolation, extended overhangs on the east and west sides of the house will shade those walls and windows without obscuring the view. Many of the western homes of centuries past had large, wraparound, fully-covered porches that would limit sun exposure during the summer months.

Cooling chimneys are another method for passively cooling a home, and are very popular in some of the hottest places on earth. If the air inside a home does get too hot, the chimney will allow it to rise and escape. It is best if it works at night and the hot air is replaced by cooler night air.

Retrofits

What can be done to increase the comfort of your home with radiant heating if you don't live in a concrete house? If you have forced air or baseboard heating in a low thermal mass structure, you could install radiant wall panels. Many of the radiant panels use exceptional printed images or mirrors on their viewable sides. There are hundreds of images to choose from. Usually, the panels are about a meter by a half meter in size and are hung on the wall like a picture. They can be controlled by a thermostat, a light switch or a motion detector switch.

For existing structures with concrete, brick or other heavy masonry exterior walls, adding three to six inches of rigid foam insulation will have a significant reduction on the cost of energy used for heating and cooling. The rigid insulation can be finished in stucco or other forms of siding. The quick solution would be an acrylic stucco finish that can be shot on. In addition to reducing purchased energy costs, this approach would give the structure a completely new look. With the proper placement of glazing in the new insulation and modification to the interior walls, Trombe wall could be retrofitted to increase the insolation gain.

The most efficient, add-on system for winter heating is a hot air panel. Similar to solar thermal panels, these panels use air as the energy transfer medium and heat recirculated or fresh air to be piped into the house. It only takes a small fan, which can be powered from a small PV panel. No sophisticated controls are required - when the insolation is sufficient to heat the air in the panel, the PV panel will have enough charge to start up the fan.

Conclusion

Follow these principles for a comfortable and efficient house or building:

1. Incorporate radiant heating and cooling.
2. Use a large thermal mass to store solar energy.
3. Insulate the exterior of the thermal mass.
4. Incorporate direct solar energy collection in a Trombe wall.
5. Use high emissivity interior surfaces on the energy storage walls.
6. Orient the structure to maximize solar gain.
7. Limit summer solar gain with overhangs and porch roofs.
8. Add insulation to the exterior of existing structures that have concrete or other thermal massive exteriors.

For more energy saving tips visit EnergySense.com