WT - Indoor Environmental Quality

“Compact form and good insulation: All components of the exterior shell of the house are insulated to achieve a U-factor that does not exceed 0.15 W/(m^2K) (0.026 Btu/h/ft^2/°F). Heating and cooling buildings contributes to more energy usage than any other aspect of a buildings. One of WT project main objectives is creating buildings well insulated to reduce the energy costs of heating (and cooling) looking to the materials section. We consider different methods to keep the buildings environment comfortable while minimizing energy input including: roof ponds, thermal mass walls, solar chimneys, solar rooms and green roofs. As a result of the lack of energy input these methods require, they are often called passive heating and cooling. All methods of passive heating and cooling rely directly on the sun for energy input. Due to this reliance on the sun one of the first aspects that we consider is the solar orientation of the building. A building that is shaped like a rectangle (with side lengths having the ratio of 1.6 to 1, the golden ratio, being ideal) and elongated in the east-west direction is the optimum shape in all climates.

Roof ponds are a particularly effective method of keeping a buildings temperature constant. To create a roof pond, water is stored in bags inside the actual roof structure. Because of water’s high specific heat capacity, water can store hot or cold temperatures better than most materials. During the summer, the bags of water are covered during the day and uncovered during the night. During the night, the water is cooled down by nighttime temperatures and during the day the cool water keeps the house cool. During the winter the exact opposite approach is taken. The daytime heat is soaked up with the water bags uncovered and during the night this heat is released into the building when the bags are covered up. This set up has the potential to keep temperatures nearly constant in even extreme temperatures.

Building envelope air-tightness: Air leakage through unsealed joints must be less than 0.6 times the house volume per hour. Passive preheating of fresh air: Fresh air may be brought into the house through underground ducts that exchange heat with the soil. This preheats fresh air to a temperature above 5°C (41°F), even on cold winter days. Highly efficient heat recovery from exhaust air using an air-to-air heat exchanger: Most of the perceptible heat in the exhaust air is transferred to the incoming fresh air (heat recovery rate over 80%).
Hot water supply using regenerative energy sources: Solar collectors or heat pumps provide energy for hot water.

Another option is to take advantage of the greenhouse effect:glass allows solar energy waves (visible light) to pass through it but does not allow heat (infrared) to escape. To take advantage of this fact, we often create a glass enclosed room containing a material (usually the floor or a trombe wall) with low reflectivity and high specific heat. When light hits this material, the energy becomes heat and is not allowed to escape from the room. Also, because the material has a high specific heat, it is able to store energy and release it over a longer period. Energy-efficient window glazing and frames: Windows (glazing and frames, combined) should have Ufactors not exceeding 0.80 W/(m^2K) (0.14 Btu/h/ft^2/°F), with solar heat-gain coefficients around 50%. Just like the roof ponds,we suggest to selectively cover the windows during different times of day and temperatures to control the space’s temperature. Large cement blocks, rocks, and different types of containers filled with water can act as excellent materials for this application.

A growing concern in urban areas today is something called the urban heat island effect. Many may not have heard of this term, however they invariably feel its effects. The urban heat island effect describes why urban environments are often several degrees hotter than the areas surrounding them. This is caused largely by "the lack of vegetation in urban areas, which inhibits cooling by evapotranspiration" and the prevalence of massive, darkly colored surfaces, mainly pavement and the roofs of buildings, which absorb rather than reflect heat. Of course the way to decrease this effect is to increase vegetation, which brings us to our next method for controlling the temperature in buildings: green roofs. To implement a green roof one simply plants a building's roof with vegetation. The advantage green roofs offer is mitigation of storm water run-off (as the plants and soil absorb much of a heavy rainfall), evapotranspiration to reduce the urban heat island effect, as well as a place to grow food and other plants. Aesthetically, green roofs are often more attractive as well.

Cooling a space in the summer can be very difficult to accomplish, however even in the summer, shaded areas with cool air can be found. Near building examples can be: under a porch, in a cellar or in an underground parking garage. Fans can be an effective method of drawing this cool air into a building and blowing out hot air, but more energy efficient methods exist. Solar chimneys can often be an effective and natural "fan" that can aid in passive cooling. A painted black chimney will heat up during the summer, hotter than the air below it. This hot air rises and creates suction on the space below. Having an opening somewhere at the bottom of the building that opens up to a cool space (like the parking garage mentioned) creates a convection current that brings cool air from the bottom through the building and the hot air out the top through the solar chimney.

Light is a very important aspect of human life; our bodies use it to create vitamin D. Studies have shown that laboratory mice living under a restricted spectrum of light become ill and develop antisocial behaviors. Lighting affects us on a psychological and physiological level (Day 193). Thus it is very important to have good lighting in built spaces. As humans have evolved in daylight conditions, it follows that the human body is best adapted for the varied lighting conditions that are present in natural lighting. Therefore, we consider Lighting a space with natural lighting is the best option. Of course caveats exist to placing as many windows in the building as possible. First of all, every window put into a building creates a hole in the building envelope, lowering the overall insulation value of the building. Also, lighting in space should be diffuse; glare from daylight or the sun, reflected or direct, can cause headaches and annoy people in a space. Lighting levels that are too low can cause eye strain. Emulating natural lighting by having light from multiple sources is important; light comes from all directions outdoors. One excellent option for lighting spaces is to use polycarbonate. Polycarbonate is cheaper and insulates better than windows. While light transmission is slightly lower than glass, polycarbonate is a good option for windows that are above eye level and solely for lighting a space. Another option for daylighting a space that has no access to the outside is fiber optics. Fiber optics allow natural light to be passed through a small, fibrous, glass tube. While this option is currently very expensive and it would be better to design spaces that have direct access to natural light through a window, fiber optics are becoming more affordable and are sometimes the only option for daylighting a space. Light tubes, essentially sky lights with mirrors in them that allow one to control the direction of daylight, are oftentimes a more affordable option.