THERMAL PERFORMANCE IN BLUE PLANET BUILDING PANELS & THE "R" SYSTEM

This is a very superficial treatment of this subject and is not intended to offer technical information. Rather, it is intended to offer a general overview of the subject and answer some frequently asked questions and, hopefully, clear up some common misunderstandings.

In general, the "R" system of rating building materials, in lay terms, is a system designed to provide an objective method of determining the relative performance of different materials in resisting heat moving through them. Materials are rated through testing and given an "R" rating, indicating their resistance to heat passing through them.

The following is quoted from a discussion by John I. Yellott, P.E., College of Architecture, Arizona State University, as published in the Architectural Graphic Standards, Seventh Edition. This is an excellent reference volume, prepared by the AIA committee on Architectural Graphic Standards and published by John Wiley & Sons, New York, and highly recommended for a more complete discussion of the subject.

"Problems in the performance of building construction materials and assemblies are frequently associated with undesirable flow of heat, moisture, or both. The heat transfer characteristics of most building materials are published in standard references such as the ASHRAE Handbook of Fundamentals. While the published data are subject to manufacturing and testing tolerances and judgment must be used in applying them, they may generally be used with confidence for design purposes.

Heat transmission coefficients are generally expressed as conductivities, k, for which the thickness unit is 1 in., or in conductance, C, for a specified thickness. The resistance to heat flow through a material, R, is the reciprocal of the conductance. For a homogeneous material of thickness L in., the thermal resistance R=L/k."

In conventional construction (studs, fiberglass batt insulation, gypsum wallboard and wood sheathing) the general rule of thumb is that the thicker the wall and the thicker the insulation, the higher the "R: rating, and the better the insulation.

A second issue in thermal performance is air infiltration / exfiltration in a building, or in other words, how much air gets into or out of the building. This happens intentionally, when we open the windows, for example. It also happens as a function of use and occupancy, such as opening doors as we go in and out of the building. Lastly, it happens unintentionally as a function of the "tightness" of the construction. In other words, the building "leaks". We experience this in strong winds when we feel air blowing into the building around door and window frames and through electrical outlets, or other penetrations though the building envelope.

This "leaking" of the building is conventionally mitigated by "wrapping" the building with a membrane such as Tyvek™ and by caulking and sealing joints and door and window frames and applying weather stripping. This is also the reason for building entry vestibules or using storm doors and windows.

Another aspect of thermal performance in a building that we will address here is "passive "heating and cooling. When we have the air conditioner or heater running in a building we are "actively" cooling and heating the building. When we have the sum streaming through the windows and heating up the air and contents of the building we are experiencing "passive" heating. Likewise, when we lay out on the pool deck on a hot, sunny day and get warmed by the concrete, we are experiencing "passive" heating. When we walk on a cold concrete or tile floor and our feet get chilled we are experiencing "passive" cooling. Again, this is not a technical presentation and not technically accurate (as it is technically that the heat is leaving the body and being absorbed by the floor) but is conveys the idea in an easily grasped way.

We rarely deal with "passive" heating or cooling in conventional construction because the materials that get heated or cooled have little "thermal mass" (they do not weigh much) or are covered with materials that insulate them (the carpet on the concrete floor slab).

Now let's look at a Blue Planet Panel building in relationship to each of the three above aspects of thermal performance: 1) insulation or "R's", 2) air infiltration / exfiltration or "leaking" and, 3) passive heating / cooling and thermal mass.

A Blue Planet Panel building is built of panels typically fabricated with a plastic foam core made of EPS foam with a density of 1#/cubic foot. This material is generally given an R rating around 3.5 to 4, which means that every inch of foam adds about R-4 insulation. The panel is then covered in cement plaster, or shotcrete. This material does not offer much insulation value and is generally rated at about 0.2.

Adding up the material in a Blue Planet Panel then, we arrive at an R rating of about R-16. However, anyone who has ever lived in a Blue Planet Panel building knows that this just does not make sense, because Blue Planet Panel buildings are "so much better insulated" than conventional buildings. Why the discrepancy?

This is where the other two items come into play and end up offering a greater "R Performance" vs. an "R Rating". In other words, a Blue Planet Panel building has additional thermal performance attributes that allow it to behave far better than would be expected from adding up the R's of the foam and concrete skins. This is why we always talk about the "R Performance" of Blue Planet Panel buildings and not their "R Ratings". As will be explained below, combining the Thermal Mass and the Monolithic and Isolated Skins of a Blue Planet Panel building makes them so thermally efficient that a building made of conventional materials would need to be build to an R-40 standard, at least, to behave thermally as well, or to be as well insulated, as a Blue Planet Panel building.

First let's discuss the monolithic skins. Because Blue Planet Panel buildings have two concrete skins that are unbroken, that is, they have no joints; there is no way for air to get through the Blue Planet Panel panels. Additionally, since the mortar is typically shot on after the door and window frames are in place, the mortar ends up tightly sealing the frames. On top of all this, there is a closed cell plastic foam core, further ensuring that air is not going to get through the panels.

Regulatory calculations and building codes address thermal performance of buildings. Typically there is a built-in assumption for air infiltration / exfiltration in the building. These regulations affect on how much heating or air conditioning capacity is required for a building, or how much glass surface is permitted, etc. This built-in assumption on "leaking" can be as high as 70%. With a Blue Planet Panel building this leaking is virtually eliminated. All that is left is intentional or usage air movement\, which we can readily control.

A brief note should be made here about a potential problem with a building built as tightly as a Blue Planet Panel building is. There is the possibility of the negative effect of "indoor air pollution" because there is so little "leaking". Consequently we always specify and encourage air-to-air exchangers or similar equipment, so that fresh air can be intentionally brought into the building and stale air taken out. With air-to-air exchangers, this changing of the building air can be done without wasting the heated or cooled air.

Lastly, let us discuss the passive heating and cooling of the interior skins. Because the foam core and the isolated exterior skin protect the interior skin from the outdoor temperatures, the inside skin can now act as a "thermal flywheel". When a heavy material is at a certain temperature, is takes a lot of energy to change that temperature. For example, when we try to heat up water, which weighs about 60 pounds per cubic foot, it takes quite a while to get a bunch of it hot. Think about heating up a swimming pool, for example. In other words it can absorb a great deal of energy. Shotcrete weighs about 140 pounds per cubic foot, more than twice as much as water. Consequently, it takes a lot more energy to heat it up.

What this means for a building constructed of Blue Planet Panels is a lot of thermal mass. For example, in a 2500 square foot house, with walls and roof of Blue Planet Panels, there would be about 50 tons of concrete on the inside of the house. This concrete is exposed to the room in the walls and ceiling and can absorb energy readily. This means that once we get all this mass to the desired temperature, is will stay at that temperature; it will not change its temperature quickly. This is also sometimes called the thermal flywheel effect. A quick rule of thumb is that in a well insulated conventionally built building, if there is 1 sq. ft. of thermal mass concrete for each square foot of floor area, the result will be a pretty efficient passive heating / cooling performance. In a Blue Planet Panel built room there are four walls and a ceiling surface of thermal mass, or more than twice as much thermal mass area as floor area! This translates into a very efficient passive heating / cooling performance!

A final item to be addressed in the thermal performance of Blue Planet Panels is the concept of "thermal bridging". By this we are referring to the ability of heat to move through the materials that are connecting the two faces of a structure. For example, the ability of heat to move through a metal stud in an outside wall and consequently transfer the heat from the stucco on the outside to the gypsum wallboard on the inside. This aspect can be important because, even though the wall is well insulated, thermal bridging could cause "hot spots" or "cold spots" at each stud location. With Blue Planet Panels the question comes up because of the wire trusses connecting the inside and outside skins of the panels.

The short answer to this issue is: "There is no significant thermal bridging in Blue Planet Panels through the truss wires." The short explanation for this is that the truss wires are too skinny to carry enough heat across them to heat up the concrete on the other side. Remember that the wires are only about 1/8" in diameter and there is about a 6" x 6" square of concrete that each wire would need to heat up. A quick "what if" might also help; what if you held a block of concrete 6" x 6" and 1" thick in your hand with a 1/8" diameter wire sticking out of it. If a plumbers torch were held to the free end of the wire, how long would it take before you would feel the concrete block heating up? If the concrete did heat up, it would be hours and hours. When we consider that the plumbers torch is applying a heat of over 1000 degrees (delta T) to the wire and the sun is only going to be applying less than 100 degrees (delta T) it is understandable that thermal bridging, because of the narrow truss wire size and large concrete mass, is simply not a problem in Blue Planet Panel buildings.

In conclusion, when all three aspects of the thermal performance of a building, insulation, leaking and thermal mass are considered, Blue Planet Building Panels are superior to conventional buildings. In fact, they are superior to almost any other type of construction. The insulation and the exterior concrete skin isolate the interior skin from the effects of the outdoor temperature. The two monolithic, joint free, skins and the foam core stop almost all leaking. The large amount of exposed interior thermal mass creates a huge thermal flywheel. Taken together, it can now be readily seen why Blue Planet Panel buildings can rightly claim such high levels of thermal efficiency. It should now be better understood why Blue Planet Panel buildings can claim “R-40 performance”; meaning that a conventionally constructed building would need to be built to an R-40 rating standard to match the performance of a Blue Planet Panel building.

This R-40 performance translates into cost savings for the owner / operator of a building; it also presents design opportunities not otherwise available. The owner / operator of the structure can look forward to energy savings in heating and cooling a Blue Planet Panel building from 40 to 60% over a conventional building. There is also the initial savings of being able to achieve these energy savings without the costs of trying to achieve them with conventional construction. This savings can be found in the direct cost of Blue Planet Panel construction compared to conventional construction. We have available several cost comparison sheets proving this. Additionally, the heating and cooling equipment can be much smaller because the loads will be much lighter. Lastly, a designer can now design more glass surfaces in the building and still conform to energy efficiency regulations and requirements. All in all, building with Blue Planet Panels is simply a better, more thermally efficient way to build, and all this for a cost savings, too! Build with Blue Planet Panels and you can gain all the benefits and skip any extra costs to do so!