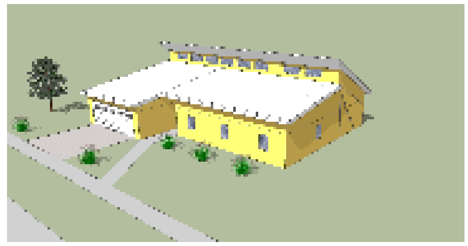
Equinox House Project

Topic 6 Foundations

Ty Newell – April 10, 2010



I successfully made it through Valentines Day this year by getting a card and gift in a timely manner to my wonderful spouse, Deb. I screw up on these card things periodically, and it takes a few months to get out of that hole (as it should….my ability to do anything is totally dependent on her).

What does Valentine's Day have to do with this note? In the below left picture, taken on February 15 (reasonably close to VD, but not close enough in terms of Hallmark cards), you can see a squirrel attacking our bird feeder. It was bitter cold outside. The pictures on the right show the temperature of the ceiling in our lab (upper photo) and the temperature of our uninsulated concrete slab floor in the lab. Summer or winter, the ceiling and the concrete floor track each other within 1 to 2F of each other. If you ask someone the temperature difference between the ceiling and floor, they will tell you the floor is 10 to 20F colder, because heat "rises".

In this topic we will be discussing heat transfer through a concrete floor slab as we have installed in Equinox House. A popular feature of high performance homes these days is insulation added under the foundation. Sometimes, insulation more than a foot thick is being placed below a slab or basement floor. Insulation under a foundation can be a reasonable idea, however, there are situations when it is not. As in our other discussion topics, we will give some quantitative information so you can understand the impact of design decisions encountered when specifying a floor.

First, let's dispel a myth that an uninsulated slab floor is cold. Yes, concrete has a cold "feel", but it is not cold. The accompanying pictures taken with the attached outdoor picture, shows a picture with a ceiling temperature measurement (top picture) and a picture showing the concrete floor temperature. A two degree difference between the floor and ceiling in either direction, summer or winter, is typical. The ceiling in our lab is very well insulated (about 2 feet of chopped fiberglass). Radiative thermal communication between the floor and ceiling is very high, keeping them together in a tag team fashion. Convective heat "rises" due to buoyancy effects of air (well, actually not in ice water with a density inversion, causing heat to "sink"), but radiative heat transfer moves in any direction from surface to surface. That's how the sun keeps us warm. And, it is very significant. You can feel cold in a room with 72F air temperature when cold surfaces, such as too many windows, surround you.

At night in the winter, the ceiling will cool below the floor temperature, and during the day, increased roof temperature increases the ceiling to temperatures as shown in the photos. The temperatures shown above are quite cold because we keep the thermostat low in the lab. These results are true regardless of the thermostat setting. Our lab building is a simple Morton Building without any special precautions taken to superinsulate the concrete slab floor in any manner. As you move toward the external walls, the floor cools to 58F, indicating a heat loss to the outside. In Equinox, with the excellent insulation barrier provided by the ICF foundation, the perimeter will not drop significantly in temperature.

Determination of the temperature effects of a foundation requires sophisticated "transient, three-dimensional" heat transfer computer simulation modeling. One needs to chop the floor and ground under and around the house into small, interconnected regions transferring heat from one place to another. How many "little regions" (called cells) are needed? In our model, we use 500,000 cells. The system of cells represent the dirt extending about 15 feet below the slab and approximately 15 feet beyond the foundation perimeter. The house foundation undergoes a day-by-day calculation that varies the weather, and the cell temperatures and heat flows are calculated. Approximately 3 weather years of simulation are needed for the house ground temperatures to reach a steady cyclical temperature variation. The 3 year time period is also indicative of the time it will take the actual ground and foundation to reach a steady variation pattern, although the impact of the early time period is not a significant energy performance factor. Altogether, about 182,000,000 calculations are performed to solve this problem. Fortunately, that's what computers are good at doing.

The two figures below show the results from this simulation model. Figure 1 shows the surface temperature of the floor in the Equinox House at some time during the year. What time of year? Well, it doesn't change much through the year, so take your pick. Actually, the figure shows June, and the green boundary around the outside edge of the plot is the outside ground surface temperature (about 17 to 18 C, or about 65F). January doesn't look much different, however, because the surface temperature of the floor doesn't vary much. When a house is super-insulated and super sealed, the thermal communication within the house interior keeps all surfaces quite close in temperature all the time. The region in the plot where colors (temperature) change is the insulated foundation. Within the house, the floor surface temperature variation is very small. Our temperature measurements inside

Equinox through the past winter bear this out, however, we will continue reporting on this as the house becomes conditioned so you non-believers will believe.

Figure 2 shows the heat flux variation over the floor surface. This variation also stays about the same through the year with an average heat flux of about 2 watts per square meter. For the house as a whole, this amounts to a heat loss of about 400 watts through the year. Near the edges of the foundation, the heat flux increases to 4 to 5 watts per square meter, which is quite small.

The big question is whether insulation should be added under the floor, and as usual, the answer is that it “depends”. If you are up north (eg, Minneapolis), then some insulation would be reasonable (not a lot, certainly, not as much as you add to walls and roof). And if you are further south (eg, Mobile), insulation under a slab most likely will cost you twice; once for the cost of the insulation and again for the loss of cooling effect. The “depends”, however, also requires consideration of the house design. A heavily south windowed house would be less likely to require insulation under the slab than a house without windows.

Illinois is a region where the house could be winter dominated or summer dominated depending on the house design. In our case for the Equinox House, we found that the summer cooling benefit offsets the winter heating deficit of an uninsulated floor. In addition, but too much detail to add here because most likely your metabolism is about to drop in half, we found that the summer-winter temperature variation of the house thermostat (setting the thermostat to 76F in the summer and 72F in the winter), results in an enhanced effect due to the ground’s significant energy storage. That is, the slightly warmer ground from the summer provides some winter heating, and vice versa as one moves from winter to summer.

Keeping the slab coupled to the ground also makes your house freeze proof. With all of our indoor plumbing in conditioned space, and having good ground coupling, our analyses for a house in a “float” condition (no active heating or cooling of the house) shows that the ground protect the interior from ever reaching a freezing condition….assuming no one leaves the door open for a month.

So, insulating a slab floor is not necessarily a good thing to do. It may result in higher capital cost, more energy consumption, and loss of interior freeze protection. But, that all depends…. Sorry, it would be nice to give you one answer, but let’s leave some flexibility for people to create.

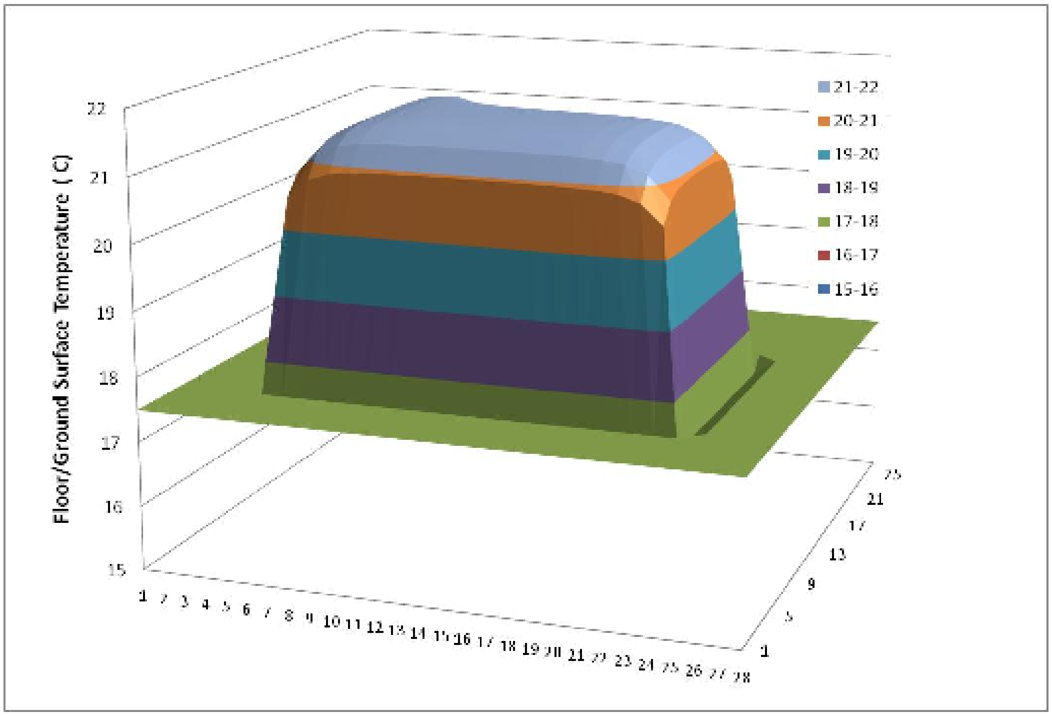


Figure 1 Sample floor surface temperature results from Newell Instruments 3-dimensional, transient floor, foundation and ground heat transfer simulation model.

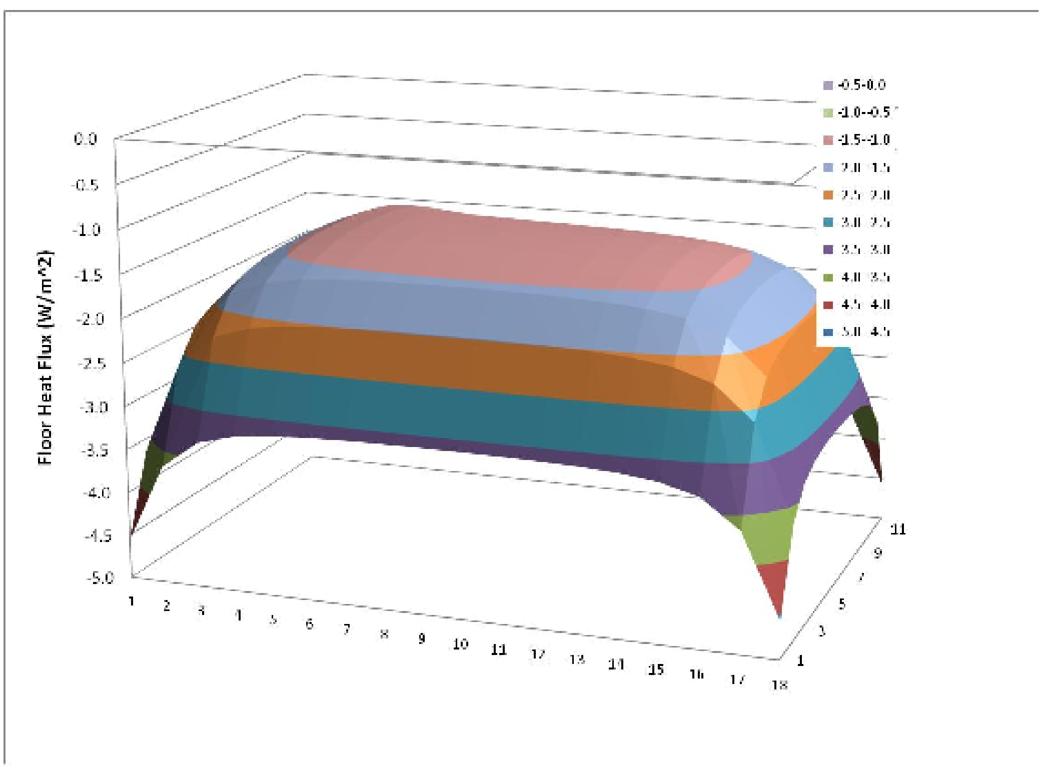


Figure 2 Sample floor heat flux results from Newell Instruments 3-dimensional, transient floor, foundation and ground heat transfer simulation model.