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Cob and Thermal Comfort

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When it comes to cob, there is a big elephant in the room. Cob's u-value is about 3 times worse than the current u-value requirements. This is cob's biggest stumbling block as a viable contemporary building material. Although its u-value is not good, cob has many other qualities in its favour, none of which are recognised by the current set of calculations for compliance with the building regulation energy conservation requirements. This article examines some of these qualities and looks at how cob could be brought under the umbrella of mainstream compliance in the future.

Cob and Humidity Regulation

Cob can regulate indoor humidity levels. 600mm wide cob walls are essentially a huge reservoir of earth, which can absorb and release moisture from the atmosphere, leading to stable, even and optimum moisture levels in our rooms. Surprisingly, temperature is not the greatest influence on our perception of thermal comfort (do we feel too hot, too cold or just right). Humidity is.

An example I often give is of a friend from New York who came to stay one Christmas. In New York, it had been -4°C and snowing. We headed off to Italy on a snow holiday. It was -17°C. We then spent a week in Ireland, where it was 5°C (that's ***plus*** 5°C, mind you!). Where did our friend feel the coldest? In Ireland. Why? Because our humidity levels were probably permanently above 85%. He never could get warm and felt the damp creep into his bones, where it stayed.

When humidity levels are between 40-60%, they are optimum for human comfort and we can feel more comfortable at lower temperatures. Think of the impact this could have on your heating bills.

Cob and Indoor Air Quality

There is another important issue associated with optimum humidity levels in a building. The nasty things, such as bacteria, mites, fungi, mites, allergy and asthma triggers, respiratory infections and chemical interactions like to live outside the 40-60% zone. As your indoor environment gets drier or damper, all of these nasties multiply. This issue is largely ignored by the building regulations, despite indoor air quality being critical to human health.

Earth and cob has the ability to bind toxins and odours out of the air. This could have the knock-on effect of needing less ventilation to provide good quality indoor air. The excessive moisture problem, normally dealt with by ventilation, is also minimised by using earth as the structure of the building. While the need for ventilation would not be completely eliminated, the amount of ventilation required could be significantly reduced. The less air that needs to move in and out of a building, the more heat gets to stay in that building.

Cob and Air-Tightness

Speaking of air movement, cob is inherently airtight. Why is this important? We want to control the air that enters and leaves a building. We do not want leaks. Moving air takes heat with it.

Layered forms of construction have many layers that could fail. If one layer fails, all of the rest are compromised. What am I talking about? Let’s take the example of a timber frame wall.

A well-designed wall will have plasterboard (or clay-board or some other form of board), an airtight membrane behind that, possibly a layer of insulation board, timber studs with insulation infill, racking board, another layer of insulation board, an external wind-tight membrane, possibly a cavity, cladding and possibly render.

If there are tears in the airtight membrane, the wall will not perform to its calculated u-value. A tear of 1mm over 1 metre has been shown to reduce the u-value of a timber frame wall by a factor of 5, i.e. the thermal performance of the wall was 5 times worse than expected. When you consider all of the trades (electricians, carpenters, specialist insulation contractors, plumbers, window installers) who could be working on that wall, it is not hard to imagine that the airtight membrane could be torn in a few places.

What about the insulation? If insulation boards are used, they may not butt up tightly to each other, creating multiple air-gaps or leaks. Insulation batts can sag or slump over time, or they may not fit tightly against the timber studs. Even blown insulations can eventually settle with gravity, leaving gaps at the tops of walls.

Cob does not consist of layers of potentially flawed construction. It is monolithic. There are no voids or gaps or changes in material. So while its calculated u-value is not "good", monolithic walls have been proven to surpass their expected u-value. With hemp-lime walls, they have exceeded their calculated thermal performance by a factor 2.5 to 3 in some cases. I accept that cob needs a certain level of insulation to limit the energy use of a house. I am a fan of applying hemp-lime externally. However, I do not accept that cob performs as "badly" as its u-value would suggest.

What are U-Values?

What are these u-values? U-value (W/m^2K) tells you how much energy or heat (Watts or W) is passing through $1m^2$ of construction when there is a 1°C temperature difference between inside and outside (1°C is 1 Kelvin or K).

So think that the average house is heated to 21°C, the u-value will assume that outside it is 20°C. There is a relationship between the thickness of the construction too. On a very basic level, the more material there is for the heat to pass through, the longer it will take, the lower the u-value.

Low u-values are desirable, heading towards 0.1 W/m^2K for Passivehaus standard. 0.21 W/m^2K is the upper limit for walls under the current building regulations. A 600mm wide cob wall has a calculated u-value of 0.65 W/m^2K, obviously way off target.

But there is a fundamental flaw with u-value measurements. They are laboratory measurements. They assume that the temperatures both inside and outside the building never fluctuate. This is not true at all in the real world.

Temperatures fluctuate between night and day and even from hour to hour. This has an effect on how heat passes through construction and, with materials such as cob, can really slow down this passage of heat through the wall. In a 600mm wide cob wall, it takes 8 to 9 hours for heat to pass through. This is not recognised by the current building regulation calculations.

There are architects and engineers who deal with monolithic construction, such as cob or hemp-lime, who feel that u-values are a completely irrelevant way to measure the performance of these types of construction.

Cob and Thermal Storage

Cob acts as a thermal store. It absorbs available heat, from the sun, from the heating system and stores it within the walls. Later, as the internal temperatures drop, this stored heat starts to flow back into the room. It acts like a huge storage heater. We really feel this effect in our house, where the walls and floor physically radiate heat in the evening after a bright afternoon. It need not be warm outside at all, just bright for a period.

The first winter we lived in the house, we had the big freeze. So although the temperatures were sub-zero for weeks, the house was comfortable with relatively little heating because we benefited from storing so much free heat through passive solar gain. Last winter, although the temperatures did not drop so low, it was a very grey winter. We had long periods without clear skies or a bit of brightness. We probably used as much fuel as the year before.

We heat the house with off-cuts from Colin's carpentry. A small stove handles 10 radiators and our hot water in the winter (we have solar panels for our summer hot water). One comment we regularly get from visitors is how even the heat feels throughout the house. This is largely thanks to cob's ability to even out humidity and temperature fluctuations.

Cob and CO_2 Emissions

The calculations for energy conservation in the building regulations are concerned with minimising CO_2 emissions. A building which minimises its energy use throughout its lifetime will obviously help to reduce CO_2 emissions. However, if the building has been made from materials such as concrete and insulated with materials such as foam insulations, then the materials themselves are responsible for dumping a load of CO_2 into the atmosphere. Cob does not contribute to CO_2 emissions ***at all***. There is no mining, quarrying or extracting; there is no heavy processing; there is no transportation to site. This fact should be given some form of credit, but it isn't.

Credits for Being a Truly Sustainable Building Material

The building regulations insist that our heating appliances must be 90% efficient. That is proper. The more efficient the appliances are, the more heat we get out of our fuel, the less we have to burn.

However, there is an exception and that is for people who grow their own fuel. They are allowed to have less efficient heating appliances (77%) in recognition of the fact that the fuel source is so sustainable. A similar approach should be applied to materials such as cob, where its transformation into a building material has zero negative impact on the environment.

Monitoring the Mud and Wood House

We find that our home is very comfortable. We certainly heat it less than one would expect for a house with walls with a u-value of only 0.65 W/m²K. We intend to start monitoring the house this winter. We will monitor indoor air temperature, outdoor air temperature, indoor humidity levels, outdoor humidity levels, indoor wall surface temperature, outdoor wall surface temperature, and the weight and moisture content of all fuel we burn.

Except, before we start this, we have to sort out some air leakage problems we discovered. Where were they? In our thermally "awful" cob walls? No - in our allegedly super-dooper insulated timber frame walls - a perfect example of where layered construction can go wrong.

The Role of the Building Regulations

Recently, I was at a conference in Scotland about thermal mass. Thermal mass slows down the transfer of heat through materials such as cob. Thermal mass allows cob to act like a storage heater.

The issue of building regulations was a hot topic. A representative of the Scottish building regulations government office was there. So were some much esteemed architects and engineers, designers of multi-storey, multi-million pound buildings in places like Singapore. Yet they were facing a similar problem to me, albeit at a very different scale and from a different perspective.

They were exploring thermal mass and even the use of earth to prevent overheating in these huge commercial buildings. They carry out a lot of dynamic computer modelling in this regard. This looks at how materials will perform in the real world, with fluctuating temperatures and humidity levels in "real" local weather conditions. We had the exact same modelling done for the Mud and Wood House during the design phase. It was expensive, but it was worth it. Our results were very encouraging.

The problem for these high-hitters and me was that the building regulations do not accept these calculations. The "big boys" with their multi-million pound projects said that they could not justify charging their clients to run the project through two sets of calculations. Their buildings, although cutting edge and proving to be vastly energy-saving, could not comply with the Scottish building regulations because the scope of the required calculations is now too narrow.

The regulations were originally brought in to pull the lowest common denominator up by the boot straps. Unintentionally, what seems to be happening now is that at the other end of the spectrum, innovation is being stifled because clients do not want to or cannot afford to face the difficulties of non-compliance.

Another very interesting point raised at the conference was that the calculations are based on computer models of how buildings and materials will behave (in a steady state world where temperatures do not fluctuate). However, when these models were examined against data from real-life buildings, some models proved to be off the mark, sometimes significantly. To be forced to assemble a building in a particular way, just because this is what the computer dictates, when it may not even be the reality, is a hard pill to swallow.

The consensus was that the tail (energy-related building regulations) has begun to wag the dog (innovation in the reduction of CO_2 emissions associated with the built environment) and that certain elements may need re-thinking. The Scottish building regulation representative seemed quite open to exploring this further.

The Irish regulations will be up for review in the next few years, as we move ever closer to carbon neutral buildings. Until then, cob builders may need to rely on the open-mindedness of their local building control officer and apply for a Relaxation of a Requirement of the Building Regulations.