Energy Efficient Family Homes: New Constructions in Stone or Wood? Notes about the Design of Highly Energy Efficient Masonry Single-Family Homes

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In today's new energy efficient homes wood is the predominant material for walls. At the moment, thick masonry walls play a more minor role, although over centuries this building method was regarded as progressive compared to the previously popular methods for building with wood. In this essay, I will demonstrate that family homes can be built in an equally energy efficient way with mineral building materials.

Years ago, brick manufacturers came under increased pressure concerning insulation and labor costs. As a result, they changed their products toward larger bricks with a higher percentage of air and cavities. They continued to further enhance the design, for example by using vertically perforated bricks. A negative side effect of this design was the weakening of the outer walls. Butt joints get no mortar at all, and are poorly stabilized. External walls´ air tightness is decreased significantly and achieved only by interior and exterior plaster, stucco or similar covering. Sound absorption, which depends on mass, is also diminished. The ability of these walls to store heat is far lower than with the older solid walls, a very negative factor for the sometimes rapid and extreme temperature changes in parts of the world.

Looking at the above arguments, timber construction seems to be the logical conclusion. On the other hand, the arguments only show how the conventional solutions of the brick industry for energy efficient exterior walls have not gone far enough. They have not been competitive solutions for today's demands concerning thermal insulation. It looks like a dead end for the brick and mortar industry. The industry objects to that argument and has been offering new and enhanced – but also expensive – products, such as Thermoplan, which contains mineral wool fillings in larger holes. The most advanced products had an unacceptably high rate of damage during transportation from factory to construction site. A heavy earthquake may also demonstrate in a very undesirable way how weak these "airy" walls really are. I am convinced that from today onward multilayer exterior walls including a crucial heat-insulating layer cannot be avoided. They have the added benefit of high weight in the inner part of the exterior wall which is known to improve the living quality inside the house.

In this kind of construction the weight-bearing wall should be inside the heat insulating layer. Also, the weight-bearing wall should consist of massive, mineral material, because only mineral material has the noise absorbing and heat storing properties desired. It is also not subject to any adverse aging process or other biological wear and tear by parasites, such as carpenter ants or termites. It is also completely stabile and does not change with humidity and heat. As an added benefit it is fire retardant and more secure against burglary.

With this set of arguments, the conventional bricks without cavities or even natural stones are an option for the construction industry again. Of course mortar and manpower requirements are higher than with the use of 10DF standardized bricks. Building houses however is, like any construction of complicated structures, a compromise after the evaluation of possible options. If minimal energy consumption is the only focus of a potential home owner, then his house should be built according to that foolish preference. However, the house will probably not be ideal for the overall requirements because other important factors such as cost of construction and maintenance as well as the resale value of the home are not considered properly. In the same way, a toilet designed with the sole goal of minimal water usage will never be an acceptable product.

Unfortunately, the fact remains that most modern solid homes need more heating energy than properly built timber constructions. That is surprising, because the same windows and outside doors can be installed as well as insulation layers. The same air tightness can be reached, the same home technology can be used and the same ventilation. So what is the reason for the discrepancy?

The reason is the so-called cold bridges. In this case, the problem is not the well known cold bridges such as balconies, verandas, attached garages, pre-walls, walls at and in unheated gables, chimney walls conducting heat from the heated rooms to cold parts, concrete bridges to patios, etc. The cold bridge in question here is very frequently overlooked. The cold bridge in question is created where the basement walls attach to the basement ceiling (which is also the floor of the first floor). This area is the non-insulated part of the lowest heated concrete slab. The heat of he home is conducted into the floor and works its way through the concrete slab into the cold basement walls. In the same way the carrying exterior walls transport heat down into the concrete slab and further into the basement walls. The heat flow created here is not insignificant.

The dimensions of the heat flow can be calculated with the example of a comparatively small, ground level single family home of about 150 m^2 (app. 1600 sq. feet) living space. The external dimensions are 12 x 14 m (app. 40 x 46 feet). The basement wall thickness is 20 cm (8 inches). According to these measurements the exterior walls of this home are over 50 m (160 feet) long, so this results in a cross section of 10 m^2 (108 sq. feet) through which heat is conducted to the ground. Heat transportation is directly and positively correlated to the heat conductivity of the material, the temperature difference and the physical distance between the temperatures. Therefore, the better the heat conductivity, the bigger the cross-section, the bigger the temperature difference and the shorter the distance, the more heat is lost. In our example, temperature differences in winter can easily reach 20 degrees Celsius (36 degrees Fahrenheit). Also, the distance is short because the home's heat output is usually close to the exterior wall and also the basement ceiling (concrete slab) and does heat both. The distance between the home's heat output and outside ground level is often 1 m (3 feet) or less. The concrete and brick materials also conduct heat very well.

So why is this rather substantial heat loss path mostly ignored? The main reason is that in the calculation of heat utilization this gigantic loss path is not explicitly calculated. It is rather lumped in with the usually considered and calculated loss paths (i.e., vertically through the walls, floors and ceilings). This, however, does not get taken into consideration when, for example, increased insulation of the walls and ceilings of an existing building is considered. Only when the average result over many years is analyzed does it become obvious that the benefit of the increased insulation is far less than was expected according to the heat consumption calculation. Also, especially in the past, these calculations often led to the installation of boilers that were unnecessarily big. The second, replacement boiler then was often much smaller, not only because today the hot water consumption is omitted in the calculation. As a result, the German Federal Government was surprised that the federal subsidies for home insulation did not show the desired effect in the national primary energy cost calculation. The reason was not that the recipients received subsidies without implementing the measures, but that the expectation was too high because of the simplified calculation of the heat energy consumption.

This effect can be seen in the most pronounced way in bungalows (single level homes, also called “ranches” in the US). The more levels a house has, the less influence this effect really has overall. Only the residents of the first level have more often cold feet while paying more for heat than those in the other levels. When after big snowfall the snow has evaporated in a one-meter (3 feet) square around the house, it did not happen because of an act of God, but rather it is paid for in the oil bill. Heat of melting plus heat of evaporation – that gets expensive!

When asking a specialist for ways to avoid this particular heat loss the offered solutions are rather unsatisfactory: use special concrete in the basement and foundation, insulate all basement walls, etc. Sometimes the answer is just: “well, the house has to be set on the ground in some way”.

However, there is a way to nearly completely avoid the loss; it is explained in the following part of this article.

Let’s assume the house to be built is to have a basement. The first floor (the floor concrete slab) does not necessarily need to be resting on top of the basement walls. It can rather be placed on concrete or brick pillars which are resting on small foundations inside the basement. Their quantity and diameter can be calculated according to the laws of static. The concrete slab is then insulated from below, as it is common practice. The pillars also get insulated all the way around. The basement walls would end about 10 cm (4 inches) underneath the concrete slab so it can be insulated completely. The weight-bearing outside walls of the first floor are of course insulated from the outside.

A thin surface layer may be applied directly onto that insulation layer or, better and more expensive, a separate and solid outer wall on top of the basement wall may be erected. If this is done the foundation walls cannot be directly underneath the bearing walls, but have to be slightly off-set to the outside. This results in a wall that is constructed out of three or even four parts: inside the thick, bearing mineral wall, then insulation layer, a space filled with air, and outside the non-bearing wall you see when you look at that house.

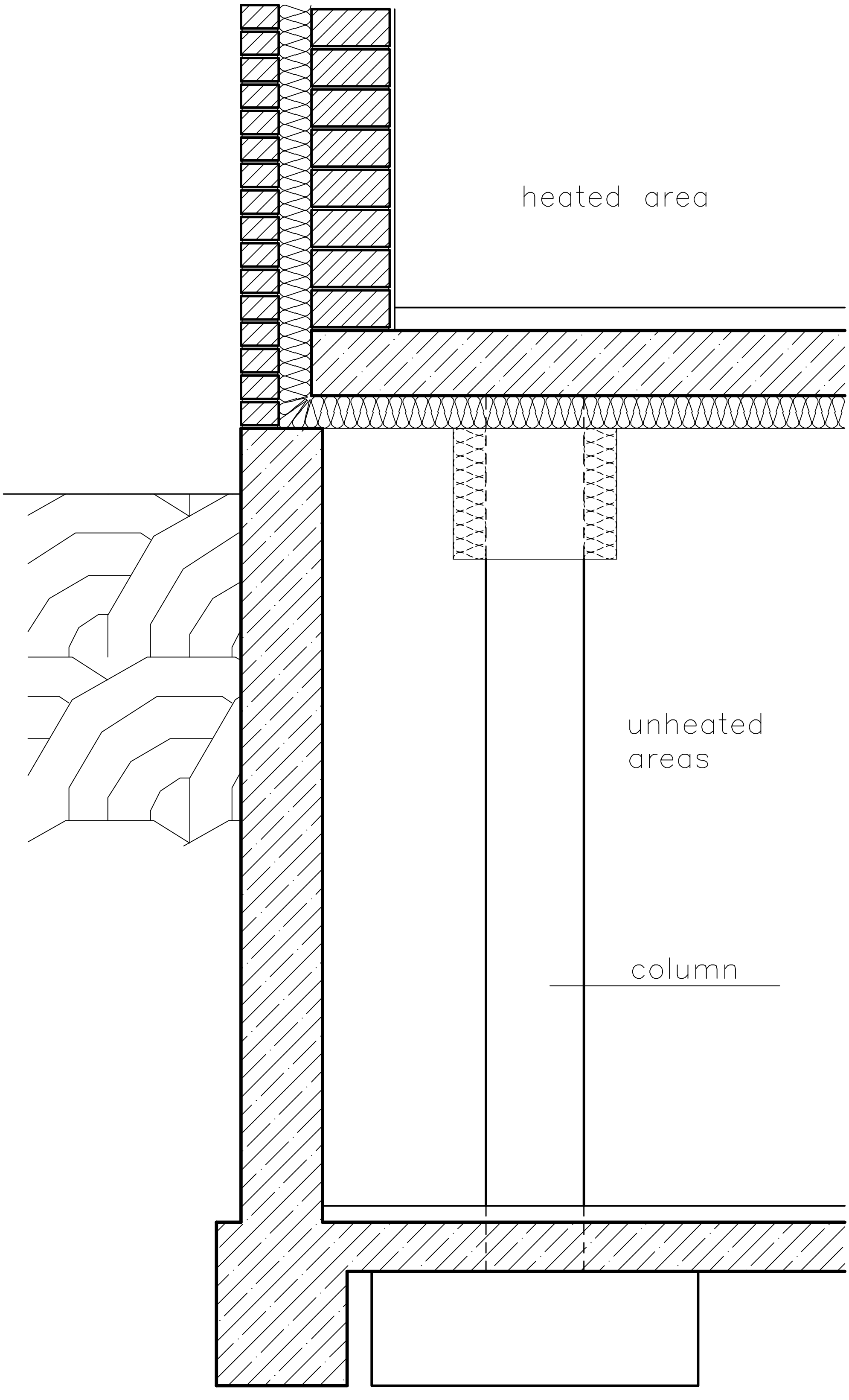
With these measures the heat conducting cross section is reduced to 10-15% of the area assumed earlier. The distance has grown to about 2.5 m (8 feet). This will reduce the heat loss further in comparison to the 1 m (3 feet) used previously by over 50%. The temperature difference is also reduced by around 50%, because the temperature below the basement floor does not go below 12 degrees Celsius (54 degrees Fahrenheit), even in winter. As a total result, the heat loss is now a mere 3% of the normal loss – it is virtually eliminated. The additional cost is not very high, most modern office buildings are actually already planned this way: concrete slab, concrete pillars, next concrete slab, etc. These buildings have been designed with cost savings in mind.

There is one more point concerning the outer wall. Insulation today is much better than a few decades ago. As a result of this, humidity of rain, snow and fog remains on the outer walls longer than previously. This is especially true on the sides that do not get any sun in winter (North West, North, and North East). This often leads to a higher inhabitance by algae, bacteria and fungi. This leads to the outer walls looking worn and not in good shape. The effect is not as pronounced on natural stone and brick. It is most pronounced on wood or other thin organic sidings.

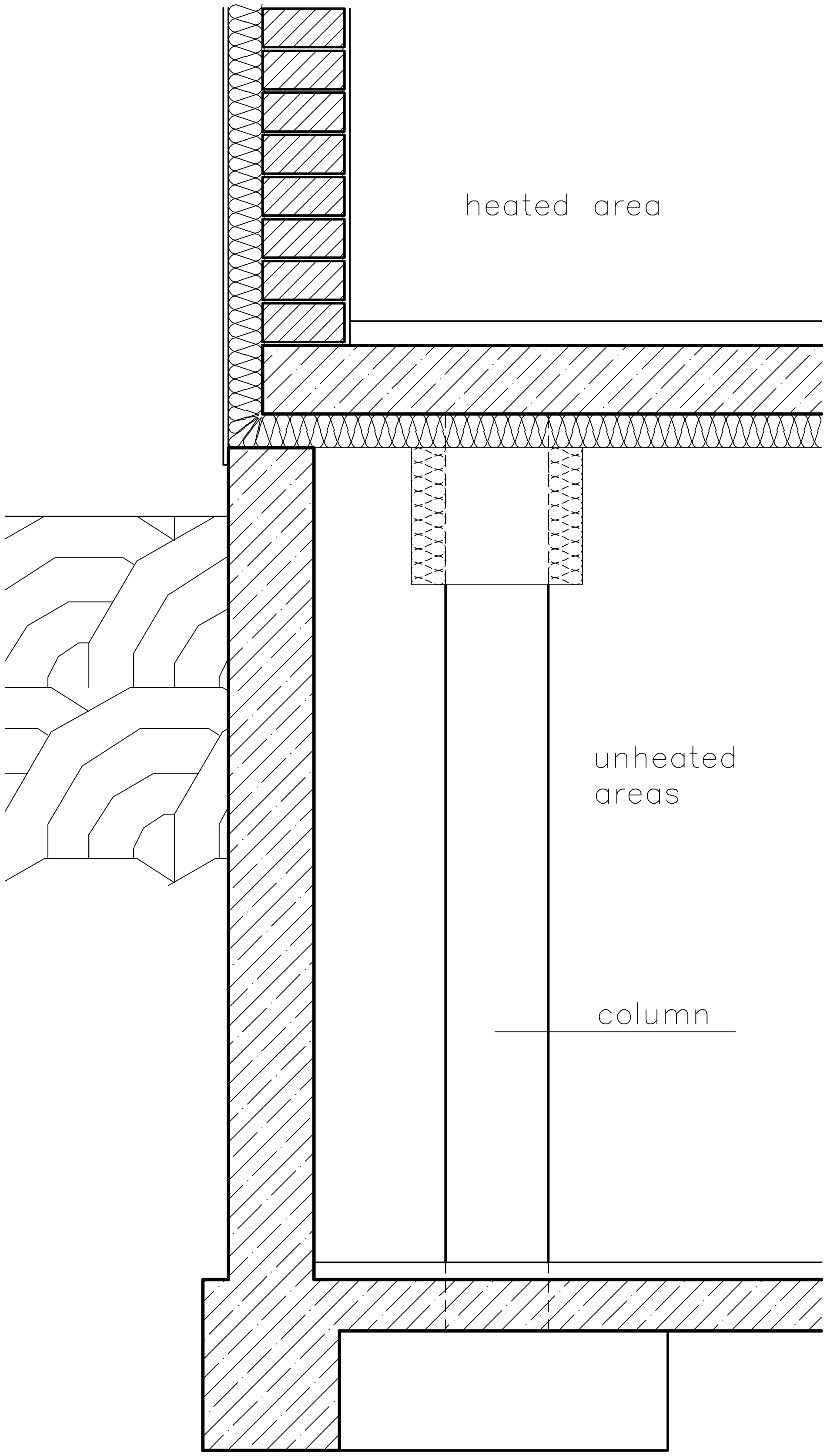
Even frequent painting does not help in the long run, because organic material is used. It would be best to use silicate coatings; however, they are not an option when an organic coating has already been applied. Spraying of the affected walls with a diluted silver nitrate solution in demineralized water may lead to an improvement, because silver ions are very toxic, especially to algae. The walls need to be cleaned thoroughly before this. Also, it should be tried first on a small portion on the house, because a solution too concentrated may darken the appearance of the wall. The investment into a real three-layer wall (bearing wall, insulation, non-bearing outside wall) may be expensive at first, but will pay off due to lower maintenance costs. Also, it will not be a problem attaching a lamp to it or bouncing balls off it as these will not cause any damage – as it will when attempting it on a “glued-on” façade.

As an added benefit, the construction with pillars under the actual living space may increase the house’s stability during an earthquake. To achieve this, the pillars should not be fixed by concrete on the upper and lower end, but should be resting on steel plates which in turn are in the concrete. The pillars will temporarily tilt during the earthquake, but will protect the house against the horizontal earth quake movements. The vertical movements are not as dangerous. However, in order to achieve the additionally needed stability, the pillars need to have strong end pieces on both ends. These can for example be round shoes of cast iron with flat round surfaces for the pillar ends. They also need loosely fitting "steel nuts" (nut-shaped parts) situated in central holes in the pillar end pieces, as well as the steel plates on both ends of every column to keep them in position during earthquake.

To the best of my knowledge, this solution is not presented in any literature about earthquake safe home building – I could not find it despite extensive searching. However, I cannot take the credit for this invention. Years ago, I visited the Mezquita in Cordoba, Spain and saw its many, relatively thin pillars. The guide claimed that this old building has survived some strong earthquakes virtually intact, because the Moorish builders inserted a lead plate above and underneath each pillar.



Recommended architecture
with basement (optional)
and solid facing brickwork
design



Alternative architecture
with basement (optional)
and low price lightweight
siding design