LogBuilding NEWS

Thermal Properties of Log Homes

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In the last few years, as I became more involved with ILBA, I noticed an increased number of requests for reliable technical information on the thermal performance of log homes.

As I studied this topic I came across various reports and articles that said everything from "log homes are very energy efficient" to "log homes are energy inefficient." So, what is the truth? Are log homes energy efficient or not?

While there is no definitive answer to such a general question (considering the number of various log building systems), I will bring up some points to help you understand the basics and the complexity of the problem.

The energy efficiency of a home is determined by so-called R-values (resistance to thermal flow) of building segments such as walls, floors, roof, windows, etc., and by the air tightness of the building envelope. In log homes (and other heavy structures) there is also the heat mass that influences the heat-holding ability of the structure, thus influencing heating bills.

Let's start with the basics. Log homes are made of wood (well, parts of the walls are anyway). The cross section of the log under the microscope appears like a bundle of straws. Those "straws" are filled with air when the moisture content of the wood is lower than so-called fiber saturation point (somewhere around 28 percent).

It is common knowledge that air is a very good thermal insulator, and the more layers of air in the system, the better its insulating properties. Therefore, wood seems like an ideal material to separate the warm and cozy interior of your house from the freezing winter conditions outside, right? Bigger is not always better except in log

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walls, where the thicker wall provides better thermal performance. At least the R-value (thermal resistance) of the wall will be higher. By the way, even in this case the larger the number, the better the wall should perform. I am using should because it is only one of the features needed to achieve energy efficiency.

Thermal resistivity of different softwood species varies, but not significantly. Generally speaking, the higher the wood density, the lower the thermal resistivity. In the following table, please compare the R-values of common wood species used in log construction. Values in this table are approximate and should be used with caution; actual conductivities may vary by as much as 20 percent.. Note that the resistivity increases with decreasing moisture content. The specific gravities also may not represent species averages.

Comparing thermal resistivity of 1" of wood (ranging approximately between 1-1.5) with 0.00067 for aluminum, 0.0032 for steel, 0.167 for concrete, or 0.143 for glass indicates that wood is not doing all that badly. Even when comparing wood to mineral wool insulation with a resistivity of approximately 4, the wood is still quite competitive.

It is apparent that the logs used for log homes are only as large as is practical for a log builder. In my experience the majority of companies use logs averaging between 12-16 inches in diameter at midrange. That, combined with the average width of the lateral groove between ranging between 2-4 inches, almost predetermines the maximum R-value one can expect from such a log wall.

The National Research Council of Canada (NRC) conducted a study[1] on R-values of log walls for the National Energy Code in 1996. To facilitate the calculation of the R-value for log walls using a simple hand calculation, the NRC introduced an adjustment factor called "profile factor" to accommodate the profile of scribed log wall (thickness of the wall at the joints is less than the diameter of the logs). The profile factor for scribed fit log walls was found to be dependent on

the log diameter and the wall joint detail and to range between 0.7 and 0.84. The air close to the wall (Interior and exterior) contributes to the total R-value of the wall by approximately 0.88.

The R-value of a round scribed wall can be then calculated by using following equation: R-value = [(mean log diameter x wood resistivity) + resistivity of air films] x profile factor.

It is important to understand that this very simple calculation is based on numerous simplifications and assumptions (e.g. disregards the contribution of the mineral insulation in the lateral groove). Therefore, the results should be used with caution.

Here I want to share a story with you. Once I was approached to provide technical information to a builder who was "questioned" by the building official regarding the R-values of log walls. The builder sent me a slick computer-generated picture of a log house that I would put in the category of a "glass structure with a log infill." Beautiful home, but what kind of R-values are we talking about here? One half of the house was made of material (windows) that has thermal properties equivalent to 2" thick cedar blank. In that case, the importance of R-values of log homes was overestimated.

According to research studies conducted in Canada and the US,[2, 3] the heat loss through handcrafted log walls represents approximately 17 percent of total loss for the structure. On the other hand, the air infiltration/leakage can account for up to 50 percent of all heating losses in a handcrafted, chinkless log home. Although the reports are not conclusive, the pattern for a large population of homes is quite clear.

The lateral joints were not identified as the main pathways for the air infiltration/leakage but, rather, each of the following items were shown to account for larger portions of the total heat loss :
• the ridge area of vaulted ceilings
• the joint between the plate log and the roof
• the protrusions of logs through the exterior walls (both frame and log)
• the connections between the floor and a sill log
• the connection of the log wall with the

Table 1 Thermal Resistivity of Various Softwood Species Used in Log Construction

Wood Species	Specific Gravity	Thermal Resistivity (h·ft2·°F/Btu·in)	
		Oven dry	At 12% MC
Western Red Cedar	0.33	1.7	1.5
White Spruce	0.37	1.6	1.3
Eastern White Pine	0.37	1.6	1.3
Western White Pine	0.40	1.5	1.2
Lodgepole Pine	0.43	1.4	1.2
Eastern Red Cedar	0.48	1.3	1.1
Red Pine	0.46	1.3	1.1
Douglas Fir	0.51	1.2	1

(Source: Wood Handbook-Wood as an Engineering Material, USDA, 1999)

frame wall
• the window/door–to-wall log interfaces
• the log-corner interface.

It is very important to pay attention to these structural details during design and construction, as they make a large difference in overall energy efficiency of a log structure. It was shown that gasketed walls with tightened through-bolts perform better than those just using fiberglass, and that exterior/interior chinking reduces air infiltration even further.

Last, is the issue of thermal mass; a difficult subject to address.

While it is a relatively simple exercise to calculate the thermal mass (heat storing capacity) of a log wall, it is rather difficult to estimate how this affects the overall energy consumption of a particular building. Nevertheless, the effect of heat mass was confirmed by long-term testing in a study[4] conducted by the US Department of Commerce.

In the 28 week-long test, the test house with nominal R-10 log walls "consumed" the same amount of energy as a light frame building of the same size and shape

with walls rated R-12. It was determined that the log wall performed 17 percent better than its calculated rating and it was concluded that the relatively large thermal mass of log wall is an energy-conserving feature.

The Model Energy Code (CABO 1992) gives log walls thermal mass credits but these credits are dependent on the site specifics and regional climatic conditions, including Heating-Degree-Days (HDD).

According to the Model Energy Code, a building in a climate that has a 6600 HDD (for example Buffalo, NY, falls into the category of 6500-8000 HDD) must have walls with a combined U-value of 0.12.[5] The combined U-value is reciprocal to summation of the R-values of each component in the walls—doors and windows included. This means that the required combined R-value for a house in that particular region is R-8.3. For buildings with a significant amount of mass (at least 20 lb. per square foot of the wall) the combined R-value in these climactic conditions (6500-8000 HDD) can be lowered to R-7.7. This means that the log walls are given the thermal mass credit of about 8 percent.

In reality, it means that the R-value of the log wall is granted a credit of 8 percent to acknowledge the effect of thermal mass. For example, in the climactic region with only 2000 HDD, the thermal mass credit would be as high as 42 percent.

The idea of combined R-value for the wall including the windows and doors

seems very logical to ensure conservative estimation of heat consumption in a particular environment. However, it can also be a cause of the problem that many log builders have experienced. If the house has half of the wall area filled with high efficiency windows (R-3 would be a very good window) the rest of the wall has to be "beefed up" to bring the overall combined R-value to the required level.

As you can see, this whole issue of thermal properties of log homes is quite complicated due primarily to the influence of many factors. Additional research is clearly needed in order to better understand these complex relationships between materials and construction methods.

ILBA is currently pursuing several initiatives to address the technical issues of the log building industry and Thermal Performance will definitely be one of them.

References

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4 A Field Study of the Effect on Wall Mass on the Heating and Cooling Loads of Residential Buildings, National Bureau of Standards, 1982.

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