LightweightSteelFraming

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Technical BULLETIN

Report on:

Thermal Performance of Lightweight Steel Framed Homes

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Energy Efficiency of Steel Framed Homes Confirmed

One of the more common concerns amongst homebuyers and building officials when it comes to steel framed homes is their energy efficiency. Builders framing their homes with lightweight steel desire to achieve the required level of insulation as a wood framed home while using the same insulating materials. Apart from thermal performance, the National Building Code of Canada (NBCC) requires building assemblies (wood or steel) to resist condensation on interior surfaces, which has implications not only on the structural integrity of the building materials but also on the health of the occupants due to biological growth and staining.

R-value and Energy Efficiency

There is a difference between the insulating value in walls and ceilings and the thermal performance or energy efficiency of a home. Energy efficiency depends on the entire home acting as a system, from the basement to the attic including the space conditioning equipment. Most of the energy lost in a home is due to air infiltration. The majority of heat loss is attributed to air leakage through the building envelope. Within a home approximately 30% of heat is lost through the basement. The walls and ceilings and their insulating value are one small component, which contribute to the overall energy performance of a home. Combined only 25% of the heat in a home is lost through these areas.

Thermal Resistance

Wall and ceiling areas are constructed to reduce heat flow by adding insulating materials. The thermal resistance of the wall is therefore made-up of all the elements that build the wall. This is known as the effective thermal resistance. The framing member regardless of material acts as a thermal short circuit between the heated and unheated space, through the insulation in a wall. The degree of the short is determined in part by the conductivity of the material. Another important parameter is the physical dimensions of the member, which along with the material conductivity determines its thermal resistance.

Construction details in wall and ceiling assemblies are also important considerations when discussing thermal performance. In lightweight steel construction, the members typically are 0.84 to 1.22 mm (.033 to .048") thick and spaced at 400 mm (16") o.c. in the walls. This means that less than 0.5% of the wall area is taken up by the framing leaving >99% for insulation. For walls framed with traditional materials the wall area consumed by the framing is approximately 10%.

Since walls have openings for windows and doors, the framing details around them are also important when considering the thermal resistance of the assembly. Lightweight steel framing has the advantage of being slender and can therefore be better insulated. Due to steel's uniformity and stability in dimension, there are fewer gaps and less chance for gaps to form as a result of shrinking or warping. This will reduce the likelihood of air infiltration the biggest contributor to heat loss.

Since framing materials act to bridge heat from the heated space to the unheated space, applying insulating materials to the exterior of these members is an effective way of creating a break to significantly reduce the path for heat transfer. Application of exterior insulation is a good idea regardless of the framing material used. For lightweight steel framing, an exterior insulating sheathing, with an R-value of at least 5, is normally applied to the outside of lightweight steel frame construction to mitigate the effects of thermal bridging through the steel studs. This is the same procedure that is used in 2x4 wood frame construction.

Performance

Several studies have been performed to characterize heat transfer in steel framed wall assemblies. However, the majority of the laboratory studies have been performed on opaque walls (i.e. walls without openings). This work has contributed to developing analytical methods for estimating the effective thermal resistance of various assemblies, but does little to predict the actual field energy performance of the house.

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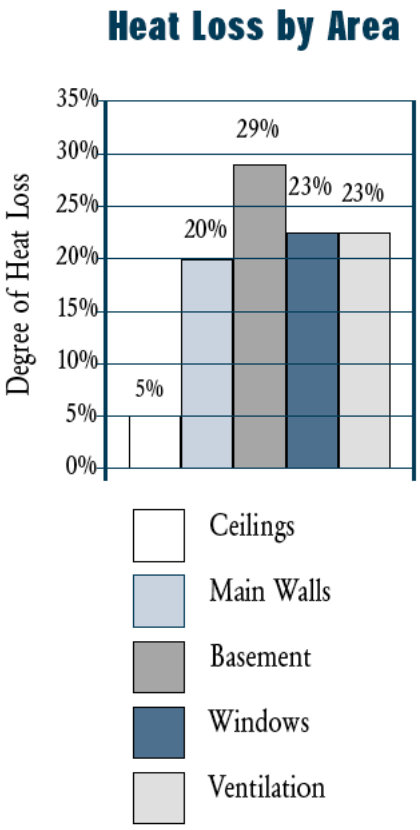

Source: CMHC for a conventional house.

One approach of obtaining a more accurate representation of the actual energy performance of steel framed homes requires field testing by monitoring energy consumed for heating and cooling. This has been done for a number of homes in North America, situated in a variety of climatic zones.

In one case, a builder constructing R-2000 homes north of Toronto (4000 degree days) monitored the natural gas consumption of 6 R-2000 homes, 3 of which were framed with lightweight steel. The houses were all built by the same builder, located in the same subdivision, tested and certified to the requirements of R-2000 using the same nominal insulating R-value and were all bungalows of approximately the same size. The natural gas consumed for the heating season was obtained from the gas utility and showed that the average gas consumption for the 3 steel framed homes was 7% less than for the 3 wood framed homes. Another project conducted by the Consortium for Advanced Residential Buildings (CARB) analyzed the energy use in 3 different townhouse units located within a 5 unit block in Frederick, Maryland. The control house was typical 2x4 wood frame construction with R-13 batt insulation in the wall cavities and R-30 in the ceilings, the next unit was steel frame using nominal 2x4" steel studs with R-13 full width batt insulation and 1/2" rigid insulation R-2 on the exterior and a steel framed roof with R-30 insulation. The third home was constructed with structural insulated panels R-20. The homes were monitored for the cooling period June 1 to September 30 1997. The results showed that the steel framed home consumed 33% less energy than the control house.

These case studies show that lightweight steel framing is an effective means of constructing a building envelope for a house system with the energy efficiency expected from traditionally framed homes.

Full Scale Testing

Another approach for gathering information on the actual thermal performance of steel framed homes is to conduct full scale testing in controlled environments. Such a test of complete floor, wall and roof assemblies was conducted recently. The assemblies contained a variety of typical construction details and were framed in both lightweight steel and wood. The construction specifications were identical apart from the framing material. Testing was conducted in an environmental chamber with accurate control of inside and outside temperatures. Heat transfer characteristics were determined by measuring surface temperatures and temperatures within the wall cavity using contact thermocouples.

The most interesting result was the through wall temperature distribution as measured on the wall framing stud. In the case of the wood framing member, the temperature at the mid-point of the stud i.e. mid-way through the thickness of the wall, was below the dew point temperature. This indicates there is significant potential for condensation or ice buildup when coupled with moisture flow. This moisture then increases the potential for mold and mildew growth. On the other hand the temperature across the steel stud was more uniform and above the dew point temperature. This indicates that the dew point in the direction of steel framing member resides outside of the building envelope.

All of the assemblies tested contained exterior rigid insulation. The fact that the dew point temperature resides outside of the building envelope indicates that at normal indoor humidity levels (RH = 30-40%) condensation with not form on the interior surfaces over the steel framing member.

There are other small scale studies being performed to investigate the thermal performance of steel framed assemblies. This type of work will eventually lead to better predictive methods for determining the thermal performance of homes.

In summary, there is sufficient evidence to show that steel framed homes, when built to the requirements of the NBC perform as well as and in some cases better than traditionally framed homes. More research on a system approach is required to quantify this in detail.

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