Energy Savings with Radiant Barriers

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Typical residential brick veneer walls contain an airspace to provide drainage inside the wall. In addition to drainage, the airspace provides thermal benefits to the wall system. The presence of the air space makes the heat transfer through the wall more complex. From both experimental testing and computational fluid dynamic modeling, it was found that the majority of the heat transfer across the air space was due to radiative heat transfer from the brick to the house wrap. A cutaway of a typical residential brick veneer wall is shown in Figure 1. By modifying the wall assembly to reduce the heat transfer across the air space, it is possible to significantly improve the thermal performance of the assembly.

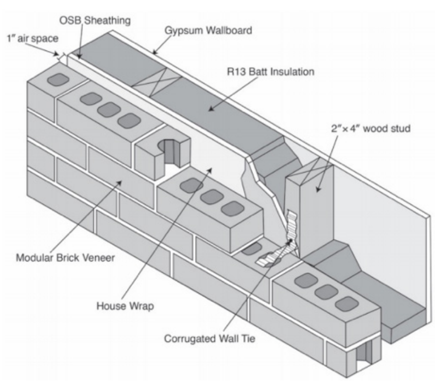

Figure 1 – Typical Residential Brick Veneer Wall

One of the ways this can be done is by using a radiant barrier to further reduce heat flow across the air space. A radiant barrier is a thin metallic foil whose surface properties are engineered to reflect approximately 95% of all thermal radiation. Radiant barriers are most commonly used inside attic spaces to improve the R-value of the roof but have not seen as much adoption in vertical walls. Large scale hot box testing of a residential brick veneer wall, done at the NBRC, has demonstrated the effectiveness of radiant barriers in improving the thermal performance of brick veneer. In this study, a brick veneer wall that incorporated a perforated radiant barrier instead of a traditional house wrap was found to have an additional 7.5% and 14.9% improvement in steady-state and dynamic thermal performance, respectively. Experimental results for theses wall system are shown in Table 1.

> "...a brick veneer wall that incorporated a perforated radiant barrier instead of a traditional house wrap was found to have an ***additional 7.5% and 14.9% improvement...***"

Although this was a significant increase in performance, it was not quite as large as simple calculations suggested. The expected increase in performance was closer to 25% improvement in steady-state

Table 1: Experimental Results

Wall System	R-Value $[ft^2\ hr\ °F/BTU]$	Dynamic Energy Usage $[kWhr/m^2 day]$
Wood Stud Wall	12.0	107
Brick Veneer	13.5	52.3
Brick Veneer with Radiant Barrier	14.5	44.5

performance. The reason for the less-than-expected performance is that the calculation assumes that the air cavity behind the brick veneer wall is a perfect 1-inch cavity. That is, the back face of the brick veneer is perfectly flat, there is no mortar or mortar protrusions in the cavity, there are no wall ties, and the cavity is exactly 1-inch wide. Small-scale testing, where these factors could be more easily controlled, did find the expected level of improvement, however. Modeling the performance of wall systems with a radiant barrier is only possible if the internal radiation is included in the model explicitly, rather than the effective properties of the air space adjacent to the radiant barrier. This type of modeling is much more complex than what is generally done. By properly modeling the wall systems, small changes to the geometry can be made, and

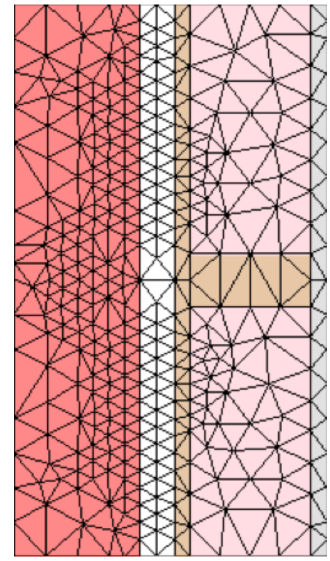

Figure 2 – Finite Element Model Mesh for 2x4 Residential Brick Veneer

effects on the overall performance studied. Several wall systems were modeled under both steady-state and yearly climate conditions to evaluate the R-value of the system as well as the yearly expected energy usage. Comparisons of wall systems using just R-value results in underperformance of brick veneer due to the thermal mass not being taken into account. By modeling using measured climate data, a more realistic comparison can be performed. This modeling tool, which was created by the NBRC, was verified against hot box testing, and utilizes measured climate data from many cities which allows for determining the expected yearly energy usage in a particular city. Starting with a residential brick veneer wall assembly with no continuous insulation and a 2x4 wood stud wall with R-13 batt insulation, the performance with and without a radiant barrier was modeled. The finite element mesh used for this model is shown in Figure 1. The radiant barrier is applied at the boundary between the air space and the OSB on the stud wall.

The results from this model closely matched what was measured experimentally in the hot box.

Table 2: Modeling Results for a 2x4 Residential Brick Veneer Wall

Wall System	R-Value $[ft^2\ hr\ °F/BTU]$	Yearly Energy Usage $[kWhr/m^2]$
Brick Veneer	13.4	27.8
Brick Veneer with Radiant Barrier	14.7	25.4
Improvement from Radiant Barrier	9.7%	8.6%

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These results are shown in Table 2. For the yearly simulation, the climate data used was from Atlanta, GA corresponding to climate zone three. The yearly energy usage numbers correspond to the amount of thermal energy required to maintain a constant indoor air temperature. This would be the thermal load on the building's HVAC system. The inclusion of the radiant barrier alone reduced the energy load from the wall by 8.6%. These comparisons are looking at the thermal performance of just the wall assembly. This is not a whole-house or building simulation. These models are designed to show the performance of the wall only.

The second wall assembly that was modeled was a residential brick veneer wall with 1-inch of

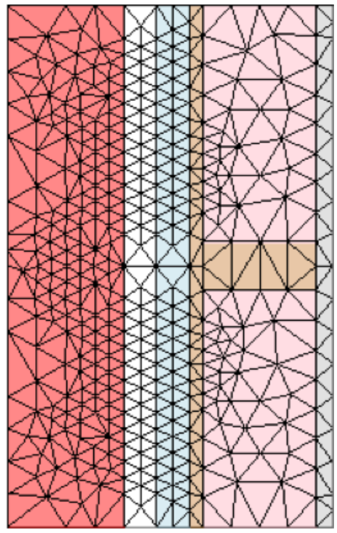

Figure 3 – Finite Element Model Mesh for 2x4 Residential Brick Veneer Wall with 1-inch XPS Insulation

XPS continuous insulation and a 2x4 wood stud wall with R-13 batt insulation. The finite element mesh used for this model is shown in Figure 3. A cutaway showing the layers of the wall assembly is shown in Figure 4. This wall also looked at how including a radiant barrier would impact the thermal performance. In this model, instead of the radiant barrier being attached to the sheathing, it is instead used on the surface of the XPS insulation. This represents

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using continuous insulation with the radiant barrier directly incorporated to its surface. The radiant barrier is not placed against the sheathing in the case since it would be subsequently covered by the insulation. A radiant barrier only gives additional thermal performance if installed facing an air space.

Comparing the results of the brick veneer wall with and without continuous insulation, the modeled results show that the inclusion of 1-inch of XPS (which has an R-value of approximately R-5) results in the assembly increasing its R-Value of approximately R-5. Looking at the improvement gained by the radiant barrier, there was the same level of increase in R-value. The radiant barrier was found to increase the R-value of the assembly the same amount (R-1.3). For the brick veneer wall with continuous insulation, the percent improvement appears smaller since there is more R-value already present. This data is given in Table 3.

Comparing each of the previously discussed wall systems, the wall with the lowest yearly energy

Table 3: Modeling Results for a 2x4 Residential Brick Veneer Wall with 1-inch XPS Insulation

Wall System	R-Value [$ft^2\ hr\ °F/BTU$]	Yearly Energy Usage [$kWhr/m^2$]
Brick Veneer	18.5	20.0
Brick Veneer with Radiant Barrier	19.7	18.7
Improvement from Radiant Barrier	6.5%	6.3%

usage for Atlanta, GA was the 2x4 residential brick veneer wall with 1-inch continuous insulation and a radiant barrier. In addition to the yearly energy usage, by utilizing the efficiency of the HVAC unit and the electricity cost, a yearly electricity cost can be estimated. This cost for each wall is given in Table 4. Since this simulation does account for thermal mass, two low-mass walls were included for comparison. The equivalent R-value gives the R-value that a low-mass wall would need in order to have the same yearly energy usage as the given wall. For instance, the brick veneer walls show an equivalent R-value that is between R-1.5 and R-2 higher than the steady-state R-value. This means that the thermal mass benefit in this climate has the same impact on the energy usage as an additional R-2 would have.

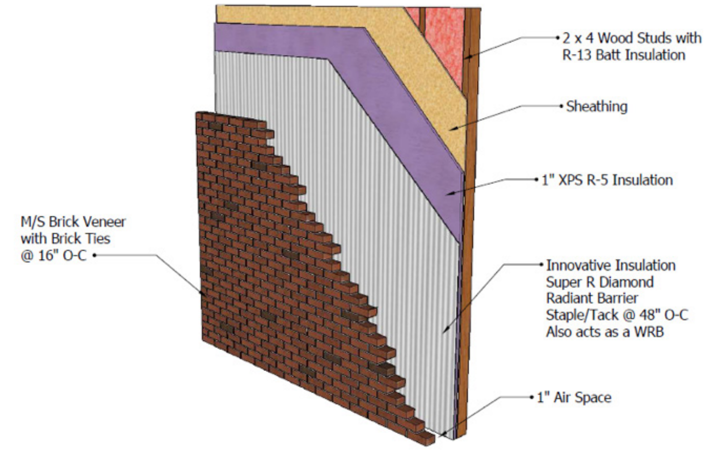

Figure 4– Cutaway of a 2x4 Residential Brick Veneer Wall Assembly with 1-inch XPS Insulation and a Radiant Barrier

Table 4: Comparison of Wall Systems Using Climate Data from Atlanta, GA

Wall System	R-Value $[ft^2\ hr\ °F/BTU]$	Yearly Energy Usage $[kWhr/m^2]$ $(\$/m^2)$	Equivalent R-Value* $[ft^2\ hr\ °F/BTU]$
Brick Veneer	13.4	27.75 ($2.85)	15.0
Brick Veneer with Radiant Barrier	14.7	25.40 ($2.61)	16.3
Brick Veneer with 1-inch XPS	18.5	19.90 ($2.06)	20.5
Brick Veneer with 1-inch XPS and Radiant Barrier	19.7	18.74 ($1.94)	21.7
Vinyl Siding with 1-inch XPS	18.0	22.51 ($2.31)	18.3
Fiber Cement with 1-inch XPS	17.4	23.78 ($2.38)	17.3

The residential brick veneer wall with the 1-inch of XPS insulation was found to have an R-value that was slightly higher than that of either the fiber cement or the vinyl siding walls which also had 1-inch XPS. This higher R-value is attributable to both the air space present, as well as the brick veneer layer. The brick veneer has a higher reduction in yearly energy usage than the R-value would suggest due to the additional thermal mass benefit. A 2x4 brick veneer wall with 1-inch of XPS has a yearly energy usage that is 11.6% and 16.3% lower yearly energy usage than vinyl siding and fiber cement, respectively. By adding a radiant barrier, this can be increased to 16.7% and 21.2%. Including a radiant barrier within a brick veneer wall can add to the thermal performance by increasing the performance of the air space that is already present. ■