

Economical High R-Value Brick Walls for Housing

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ABSTRACT In some instances, high R-values are desirable for residential wall constructions, but the means of achieving a high R-value in exterior wall construction is often costly. One method of obtaining a high R-value with a brick veneer wall system for low-rise residential construction is discussed in this paper, and information is provided regarding its thermal performance, design considerations, and construction procedures.

INTRODUCTION

In some instances, it is desirable to have the exterior building envelope constructed with walls that have more thermal resistance than typical wall systems, usually because of specific climatic conditions or design requirements. For most applications, walls with a moderate amount of insulation, thermal resistances of 13 to 20 hr. °F.ft²/Btu (2.289 to 3.346 K.m²/W) provide adequate thermal performance.¹ However, in climates where the exterior temperature stays well below the interior design temperature (or, for more accurate analysis, the balance point temperature) for an extended period of time, heavily insulated walls may be desired. The high R-value is necessary in this type of situation because the thermal performance of the wall is very similar to steady-state heat flow, and increased thermal resistance is the only practical means of reducing heat loss through the walls of the building while maintaining comfortable interior conditions.

In addition to climatic conditions, the design of the building itself may require the use of wall construction that has a high thermal resistivity. In some passive solar building designs, such walls may be necessary to retain the heat provided by solar gains through glazed apertures. In other designs, trade-offs may be used to meet building code requirements. Using walls with a high thermal resistance may permit the use of other building components with low thermal resistance. For example, using a wall system with a high thermal resistance, R-30 (R-5.283), may permit the use of double-glazed windows instead of triple-glazed windows, thus resulting in a more economical building. The thermal performance of the wall and its performance as a part of the entire building envelope should be a consideration of every building design.

There are many ways of obtaining high thermal resistance with masonry construction. The most common method is the use of a brick-and-block insulated cavity wall. Such a system may be constructed of nominal 4-in (100 mm) brick and nominal 4-in or 8-in (100 mm or 200 mm) concrete masonry units with a nominal 2-in to 4-in (50 mm to 100 mm) cavity between the two wythes. This wall system permits the cavity to be filled with moisture-resistant loose-fill insulation or 2 in to 4 in (50 mm to 100 mm) of rigid board insulation, and R-values of well over 24 hr. °F.ft²/Btu (4.403 K.m²/W) are easily and relatively economical to achieve. This type of wall usually has an interior finish that consists of furring and wallboard, which permits the use of additional insulation to result in an even higher R-value.

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Although meeting the design requirements for any building wall, this wall system is limited mostly to commercial buildings for three reasons:

1. The cost of the wall is much higher than the cost of wood-frame walls used in most low-rise residential buildings.
2. The wall thickness, 11.5 in to 17.5 in (292 mm to 495 mm) is much larger than normal residential construction, which is 5 in to 10 in (127 mm to 254 mm). The increased wall thickness may require a thicker foundation, which is an additional cost, and may, in some instances, because of subdividing lots, require a reduction in the usable floor area of the building.
3. The weight of the wall is greater, usually more than twice the weight of a brick veneer wall, which may also increase the cost of the foundation construction.

These are the drawbacks of using cavity walls in low-rise residential applications, when the intent is to achieve a high level of thermal resistance. The cavity wall is the best type of masonry wall construction. It provides load-bearing capacity and interior and exterior thermal mass, permits the cost-effective use of moderate levels of thermal resistance insulation, such as R-13 to R-19 (R-2.289 to R-3.346), and provides moisture resistance by performing as a drainage-type wall. It also provides fire resistance, sound penetration resistance, and a durable facade that is virtually maintenance-free. But, as previously mentioned, when constructed with a large amount of thermal resistance insulation, such as R-30 (R-5.283), it may not economically compete with other available wall systems. The brick veneer wall system is another drainage-type wall, which may be more economically constructed to achieve high values of thermal resistance.

BRICK VENEER WALL SYSTEMS

Brick veneer wall systems are selected as components of buildings because they provide beauty, freedom from maintenance, fire resistance, weather resistance, and good thermal performance, among other attributes, and are a common type of construction in low-rise residential buildings. The brick veneer wall systems discussed here are limited to brick veneer over wood-frame construction for low-rise residential buildings.

Five ways in which they are constructed to achieve different levels of thermal performance are discussed with regard to all the properties that should be considered when selecting a building wall. The major difference between the various wall systems described in Figs. 1 through 5 is the amount and type of thermal resistance insulation installed.

Structural Capabilities

Factors affecting the strength of brick veneer are the height of the brick veneer, the stiffness of the backup, the tie system, and the foundation. Brick veneer over wood-frame construction for low-rise residential application is designed using empirical requirements. The height limitations are provided in Tab. 1.

In addition to its own weight, the only load that the brick veneer should carry is a proportionate share of the lateral load. Due to the relatively low stiffness achieved in most wood-frame backup systems, the brick veneer usually carries the majority of any lateral load, even though it is not designed to carry lateral loads. Thus, the tie system between the brick veneer and the backup should be as rigid as possible to permit the maximum possible transfer of lateral load to the backup and still provide for differential movements between the veneer and the backup.

The ties most frequently used are corrosion-resistant, corrugated metal, at least 22 gage, 7/8 in (22 mm) wide and 6 in (150 mm) long. These ties normally provide adequate lateral support for wall systems such as those shown in Figs. 1 and 2 when anchored through the exterior sheathing to the wood frame. For the

wall systems shown in Figs. 3 and 4, the rigid board insulating sheathing may not provide sufficient stiffness to prevent movement of the tie. Positive loads may cause the tie to compress the sheathing, thus requiring the brick veneer to withstand all lateral loads by itself. The ties should thus be anchored directly to the wood frame or through only about 1 in (25 mm) of the rigid board insulating sheathing to provide an adequate connection. This method of attachment requires that rigid board insulating sheathing must be installed between the metal ties attached to the frame wall assembly, which is more expensive than attaching the ties to the surface of the sheathing already in place. In addition to the increased installation cost, the distance of the unsupported span of the tie is increased, thus reducing the capability of transferring lateral loads. Alternate two-piece corrosion-resistant metal wire ties may be used to overcome this reduction in stiffness, but these ties are more expensive and most costly to install. The wall systems shown in Figs. 3 and 4 provide less structural capability than the wall systems shown in Figs. 1 and 2, when the same type of tie is used.

The innovative wall system shown in Fig. 5 provides adequate transfer of lateral loads by requiring a special tie system. The ties used are corrosion-resistant, 9-gage metal wire Z-ties, which are 9 in (225 mm) long, with minimum 2 in (50 mm) long horizontal legs. The ties are attached to the wood studs by being inserted into pre-drilled holes at 24 in (600 mm) on center vertically, so that the tie extends approximately 1.5 in (38 mm) beyond the exterior face of the wood stud. The ties are rotated vertically into the final position as the brick masonry veneer is constructed and are embedded a minimum of 2 in (50 mm) into the bed joints of the brick veneer. The ties are of sufficient stiffness so that they may be driven into the wood studs, thus eliminating the step of providing pre-drilled holes.

The structural capability of the brick veneer is also affected by the element supporting the vertical load of the veneer itself. The foundation or the foundation wall supporting the brick veneer wall assembly should be at least as thick as the total thickness of the brick veneer. Many building codes permit a nominal 8 in (200 mm) foundation wall under single-family dwellings constructed using brick veneer, provided the top of the foundation is corbeled to provide adequate bearing. The total projection of the corbel in this application should not exceed 2 in (50 mm) with individual corbels not exceeding one-half the height of the corbeled unit nor one-third its width.

Wall #1, the conventional brick veneer wall, is 9.75 in (248 mm) wide and thus requires a 10-in (250 mm) foundation wall, or a 8-in (200 mm) foundation wall with a 2-in (50 mm) corbel. Wall #2, the alternate brick veneer wall system, is 11.75 in (298 mm) thick and requires a greater foundation wall thickness. The foundation wall for Wall #2 must be 12 in (300 mm) thick or 10 in (250 mm) thick with a 2-in (50 mm) corbel. Wall #3, Type I of the high R-value, conventionally constructed brick veneer wall systems, is 10.75 in (273 mm) wide, thus requiring a 12-in (300 mm) foundation wall or a corbeled 10-in (250 mm) foundation wall. Type II of the conventional high R-value brick veneer wall system, Wall #4, requires a corbeled 12-in (300 mm) foundation wall to support its 12.75-in (324 mm) thickness.

The cost of the increased thickness of the foundation wall may eliminate the selection of Walls #2 through #4 as economical alternatives to reduce heat loss through the wall. This is especially true for Wall #4, which requires at least a 12 in (300 mm) thick foundation wall.

Wall #5, the innovative high R-value wall, has a total wall thickness of 13.25 in (337 mm) and requires at least a 12 in (300 mm) thick corbeled foundation wall. However, other material cost savings as compared to Wall #4 do result in this wall system being more economical. The cost of supporting the brick veneer wall system is directly proportional to the increased wall thickness as a result of adding resistive insulation. The cost of supporting the wall assemblies may be a negligible cost factor where slab-on-grade construction is used.

An additional deviation from these five wall systems and traditional brick veneer construction is the structural capability of the wood-frame backup system. Even the wall systems, such as Walls #1, #3, and #4, which have rigid board insulating sheathing, do not have sufficient strength to resist racking without special

provisions. Thus, all the wall systems, with the possible exception of Wall #2, require some type of diagonal corner bracing to prevent racking. If Wall #2 is constructed with sufficiently rigid sheathing materials, such as ½-in (13 mm) plywood, the sheathing may provide adequate resistance to racking.

Acoustical Properties

Brick veneer wall assemblies reduce sound transmission by two means: The mass of the brick veneer absorbs the energy of sound vibrations, and the discontinuity of construction prevents vibrations of the exterior brick wythe from directly vibrating the rest of the wall assembly, thereby retarding sound transmission to the interior. Although no specific data are available on the sound transmission characteristics of the five wall systems discussed here,² each is estimated to have a sound transmission classification (STC) of 40 to 47.

Fire Resistance

All of the brick veneer wall systems discussed have at least a one hour fire rating. The wall systems as shown have not actually been tested, but a 4-in (100 mm) brick wall alone has a fire rating of one hour.³ A two hour fire rating may be expected with most brick veneer wall assemblies.

Durability and Maintenance

In addition to their beauty and prestige, brick veneer wall assemblies are selected for buildings because they provide a durable, virtually maintenance-free facade, attributes that are dependent upon proper design, proper detailing, selection of appropriate materials, and good workmanship.⁴ These factors are similar for all five brick veneer wall assemblies discussed here, except that Wall #5 permits additional quality control during and after construction of the brick veneer. The innovative, high R-value brick veneer wall system does not have a sheathing material between the brick veneer and the wood-frame backup, which permits inspection of the brick veneer construction, not only from the exterior, but from the interior as well. This lack of sheathing and the installation of the building felt and insulation after the brick veneer is constructed provide this added feature.

Moisture Penetration Resistance

Brick veneer wall assemblies are drainage-type walls and thus have excellent resistance to moisture penetration. Any water that may penetrate the brick veneer flows down the interior face of the veneer to the base of the wall, where it is collected on flashing and channeled to the exterior through weepholes. Although moisture penetration is not nearly as critical in low-rise residential applications as in other applications, because the walls are usually protected by overhangs, moisture penetration should always be a consideration in selecting a building wall. Walls #1 through #4 are constructed so that there is a nominal 1-in (25 mm) airspace between the interior face of the brick veneer and the exterior face of the sheathing over the wood frame. Maintaining this airspace ensures proper drainage of the wall and prevents saturation of the insulation, which could reduce the R-value of the insulation or have other deleterious effects on it. The exterior sheathing often is covered with building felt as an added precaution, which is a necessity if the exterior sheathing material is not water-resistant.

Wall #5, the innovative, high R-value wall system, is not constructed to ensure the existence of the nominal 1-in (25 mm) airspace, and alternate provisions are necessary to ensure proper drainage. In Wall #5, the use of 15-lb (0.93 Kg/m³) asphalt-impregnated building felt is used to prevent moisture that may penetrate the brick veneer from entering the insulation. The building felt is installed between the metal ties, which occur at 24 in (600 mm) on center vertically, after the brick veneer is constructed. The felt should be pre-cut and slotted so that it overlaps the metal ties, which are at 16 in (400 mm) on center horizontally, and the previously placed piece of felt. The felt may be attached to the exterior brick masonry with mastic until the 6-in (150 mm) batt insulation is installed between the brick veneer and the wood studs. The placing of the insulation will hold the building felt in place. To ensure good resistance to water penetration,

the joints of the lapped building felt should be sealed with a durable sealer or tape. The best way to ensure resistance to moisture penetration in any brick masonry wall is not to permit water to enter the wall. For brick veneer wall systems, this is achieved by proper detailing and construction and by sealing the tops of walls, jambs, and sills. The best moisture penetration resistance of the masonry itself is obtained when Type N, portland cement-lime mortars are used.

Thermal Performance

The major difference between the five brick veneer walls shown in Figs. 1 through 5 is in their thermal resistivity. Thermal performance is a major consideration in selecting a brick wall, but it should never be the sole criteria. Nor should thermal performance of a wall be evaluated without proper consideration of the thermal performance of the rest of the building envelope. In most buildings, the wall accounts for only 2% to 15% of the fuel consumption as a result of heating or cooling the building to maintain comfortable interior temperatures. Thus, any variations from conventional building wall systems should only be considered with proper attention to the economics of incorporating that wall into the building envelope.

The thermal resistance of the five wall sections varies from minimum building code requirements of 19 hr.°F.ft²/Btu (3.346 K.m²/W) to 34 hr.°F.ft²/Btu (6.021 K.m²/W). The weights of the walls are all approximately the same, ranging from about 52 lb/ft² (254 Kg/m²) to 56 lb/ft² (273 Kg/m²). Thus, all the wall systems are in Wall Group A or B when considering the Cooling Load Temperature Differences (CLTD)⁵. The thermal resistance and average CLTD of the wall systems are shown in Tab. 2, along with the other criteria for selecting a building wall.

The thermal resistances and thermal conductances of the various brick veneer wall assemblies do not consider the effect of the wood frame. Fig. 6 shows the thermal resistances of the wall assemblies when framing is considered. Walls #1, #3, and #5 have 2 in by 4 in (50 mm by 100 mm) wood frame with studs at 16 in (400 mm) on center. Walls #2 and #4 have 2 in by 6 in (50 mm by 150 mm) wood frame with the stud spacing increased to 24 in (600 mm) on center. The values shown in Fig. 6 are only for the framing of the wall assembly itself, without consideration of window and door framing, and toe and top plates. Consideration of the additional framing even further reduces the thermal resistances of the wall sections.

The increases in thermal conductance in Btu/hr.°F.ft² (W/K.m²) of the wall assemblies, without consideration of the additional framing are:

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|----------|----------------------------------|---|------------------------|
| Wall #1: | 0.050 (0.2848) to 0.053 (0.3000) | = | 0.003 (0.0152) or 5.3% |
| Wall #2: | 0.043 (0.2468) to 0.046 (0.2640) | = | 0.003 (0.0172) or 7.0% |
| Wall #3: | 0.038 (0.2168) to 0.039 (0.2246) | = | 0.001 (0.0078) or 3.6% |
| Wall #4: | 0.029 (0.1661) to 0.030 (0.1718) | = | 0.001 (0.0057) or 3.4% |
| Wall #5: | 0.031 (0.1788) to 0.032 (0.1838) | = | 0.001 (0.0050) or 2.8% |

This demonstrates that the insulation on the exterior of the wood frame reduces the effect of the nonmetallic thermal bridges, i.e., the wood studs.

Each wall system also contains metal ties, which are metallic thermal bridges, in the wall assembly. The effect of the metal ties may be estimated by using the Zone Method.⁶ In Walls #1 through #4, the metal tie simply extends from the brick veneer across an airspace to the exterior surface of the sheathing material. The metal tie spanning the airspace has a negligible effect on the overall thermal conductance of the wall system, usually less than an 0.5% reduction in the thermal conductance.⁷ In Wall #5, the innovative brick veneer wall system, the metal ties penetrate the batt insulation and thus, have a more substantial effect on the thermal conductivity of the brick veneer wall system. Fig. 7 shows the zone of the wall affected by the metal ties. This zone has two paths within it: the path through the wood frame and the path through the insulation, both of which also exist for the portion of the wall not affected by the metal ties. The analysis of the effect of the metal ties is shown in Fig. 8. The calculations show that the effects of the metal tie and the wood studs increase the thermal conductance from 0.031 Btu/hr.°F.ft² (0.1788 W/K.m²) without consideration of the studs and ties to

0.034 Btu/hr.°F.ft² (0.1936 W/K.m²), a difference of 0.003 Btu/hr.°F.ft² (0.148 W/K.m²), or about a 9.5% increase in thermal conductivity. This wall system does provide a much lower thermal conductivity than Walls #1 and #2. The innovative wall provides a thermal conductivity similar to that obtained with Walls #3 and #4, but the criteria presented in Tab. 2 demonstrate that Wall #5 is the more practical selection when a high R-value is required.

The innovative brick veneer wall system permits the use of additional thermal resistance insulation if 2 in by 4 in (50 mm by 150 mm) wood framing at 24 in (600 mm) on center is used with R-19 (R-3.46) batt insulation. The thermal resistance of the wall assembly without considering the metal ties, or wood studs is increased from 31.76 hr.°F.ft²/Btu (5.593 K.m²/W) to 39.76 hr.°F.ft²/Btu (7.902 K.m²/W). Projecting an increase in thermal conductivity similar to that present in the previously analyzed wall system (9.5% for metal ties and wood studs) the thermal conductivity of the wall system with 2 in by 6 in (50 mm by 150 mm) insulated wood frame would be 0.028 Btu/hr.°F.ft² (0.154 W/K.m²/W). However, this wall system would probably not be practical because of the further increase in foundation wall thickness and head, jamb, and sill extensions.

COST

Cost of a brick veneer wall system varies with the type of backup, the tie system, the brick, local construction costs, the type of foundation or foundation wall, and many other factors, so it is difficult to discuss specific costs of building walls. The costs of the various types of veneer, as compared to the conventional brick veneer wall system are:

Wall #1: Conventional Brick Veneer Wall System R-19.94 (R-3.512)

- Cost of brick veneer
- Cost of 10-in (250 mm) foundation wall
- Cost of rigid board insulating sheathing
- Cost of conventional metal ties
- Cost of flashing and weepholes
- Cost of 2 in by 4 in (50 mm by 100 mm) wood frame construction
- Cost of standard heads, jambs, and sills for windows and doors
- Cost of R-11 (R-1.937) batt insulation
- Cost of interior gypsum wallboard and finish
- Cost of corner bracing.

Wall #2: Alternate Brick Veneer Wall System R-23.01 (R-4.042)

- Cost of Conventional Brick Veneer Wall System (Wall #1)
- Plus: The cost of 2 in by 6 in (50 mm by 150 mm) wood frame construction (minor cost)
- Plus: The cost of R-19 (R-3.346) batt insulation vs. R-11 (R-1.937) batt insulation (minor cost)
- Plus: The cost of 12-in (300 mm) foundation wall vs 10-in (250 mm) foundation wall (major cost)
- Plus: The cost of 2 in (50 mm) extension of heads, jambs, and sills for windows and doors (major cost)
- Minus: The savings of wood frame at 24 in (600 mm) o.c. vs. 16 in (400 mm) o.c. (minor cost)
- Minus: The savings of fiberboard sheathing vs. rigid board insulating sheathing (minor cost).

Wall #3: High R-Value Brick Veneer Wall System, Type I R-26.21 (R-4.612)

- Cost of Conventional Brick Veneer Wall System (Wall #1)
- Plus: The cost of an additional 1 in (25 mm) of rigid board insulation (major cost)
- Plus: The cost of longer metal ties (minor cost)
- Plus: The cost of installing the rigid board insulation between metal ties rather than directly to wood frame backup (major cost)

- Plus: The cost of a 12-in (300 mm) foundation wall vs a 10-in (250 mm) foundation wall (major cost)
- Plus: The cost of the 2-in extension of heads, jambs, and sills for windows and doors (major cost)

Wall #4: High R-Value Brick Veneer Wall System, Type II R-34.19 (R-6.021)

Cost of Conventional Brick Veneer Wall System (Wall #1)

- Plus: The cost of additional 1 in (25 mm) rigid board insulation (major cost)
- Plus: The cost of longer metal ties (minor cost)
- Plus: The cost of installing rigid board insulation between metal ties rather than directly to wood frame backup (major cost)
- Plus: The cost of installing 16 in (400 mm) wide rigid board insulation rather than 24 in (600 mm) wide insulation (minor cost)
- Plus: The cost of a 14-in (350 mm) foundation wall vs a 10-in (250 mm) foundation wall (major cost)
- Plus: The cost of the 4 in (100 mm) extension of heads, jambs, and sills for windows and doors (major cost)
- Plus: The cost of 2 in by 6 in (50 mm by 150 mm) wood frame construction (minor cost)
- Minus: The savings of wood frame at 24 in (600 mm) on center vs. 16 in (400 mm) on center.

Wall #5: Innovative Brick Veneer Wall System R-31.76 (R-5.953)

Cost of the Conventional Brick Veneer Wall System (Wall #1)

- Plus: The material and installation of special ties (minor cost)
- Plus: The cost of installing overlapping building felt that is slotted to fit metal ties (moderate cost)
- Plus: The cost of R-19 (R-3.346) batt insulation
- Plus: The cost of 4 in (100 mm) extensions of heads, jambs, and sills for windows and doors (major cost)
- Plus: The cost of a 12-in (300 mm) foundation wall vs. a 10-in (250 mm) foundation wall (major cost)
- Minus: The savings of sheathing, which is not used in this system (minor cost).

The cost of the thicker foundation and the extended heads, jambs, and sills requires for Wall #2, the alternate brick veneer wall system, rarely would be justified for the energy savings from an increase in thermal resistance of 3.07 hr.°F.ft²/Btu (0.541 K.m²/W) as compared to Wall #1, the conventional brick veneer wall system. Wall #3, Type I of the high R-value brick veneer wall systems, has a 6.25 hr.°F.ft²/Btu (1.101 K.m²/W) increase in thermal resistance as compared to Wall #1. This wall system may be economical in some instances, but life-cycle costing would demonstrate that this wall will rarely provide energy savings that will recover the costs of the thicker foundation and extended heads, jambs, and sills, plus the material and installation costs of the rigid board insulating sheathing. Wall #4, Type II of the high R-value brick veneer wall systems, although the most energy-conserving, R-34 (R-6.021) is probably never justifiable economically. The cost of the 14-in (350 mm) foundation and 4-in (100 mm) head, jamb, and sill extensions, combined with the material and installation costs of the rigid board insulation, essentially eliminates the selection of this wall as a practical wall for low-rise residential construction.

Walls #2 through #4 do not readily offer enough energy savings to offset the increased costs of the walls, as compared to Wall #1. In areas where slab-on-grade construction is common or as the price of heating fuels rises, these wall systems may become more viable selections. The innovative brick veneer wall system, Wall #5, provides the greatest increase in thermal resistance, 11.82 hr.°F.ft²/Btu (2.082 K.m²/W) for the least proportional amount of construction costs. The major costs for this wall are a special tie system, special provisions for resistance to moisture penetration, a 12-in (300 mm) thick foundation wall, and 4-in (100 mm) extensions to heads, jambs, and sills. This wall system is more expensive than the conventional brick veneer wall system, but if a high R-value

is required, this wall system will offer it more economically than any other brick veneer wall system. In fact, this wall system probably provides an R-30 (R-5.283) wall more economically than can be achieved with a double-envelope or any other wall system.

DEMONSTRATION PROJECT

The use of the innovative high R-value wall system has been demonstrated in a single-family residence at Deep Creek Lake, near Garrett City, MD, by James G. Gross, P.E. The finished project and the project under construction are shown in Figs. 9 through 12. Garrett City averages 5975 (3319) heating degree-days and 300 (167) cooling degree-days per year.

Architectural Design

A brick facade was chosen to give an appearance that would be aesthetically appealing to the surrounding area. An off-white, hand-molded, oversized, $4\frac{1}{2}$ by 2- $\frac{3}{4}$ by 9 in (114 mm by 70 mm by 229 mm) face brick unit was selected. The exterior brick wall was constructed in a running bond pattern with Type S portland cement-masonry cement mortar. In this manner, a rustic appearance permitted this single-family house to blend into the forested surroundings of Deep Creek Lake.

Structural Design

The super-insulated brick veneer walls were designed using empirical requirements, although special consideration was given to the tie-spacing requirements for the greater thickness of the wall assembly. The final choice was an exterior facade consisting of 5-in (125 mm) nominal brick, with 15-lb (0.92 Kg/m²) asphalt-impregnated building felt attached directly against the interior face of the brick wall. A nominal, 6-in (150 mm) space was provided between the brick wall and the 2 in. by 4 in (50 mm by 100 mm) loadbearing wood-stud framing. This space was filled with R-19 (R-3.346) batt insulation. R-11 (R.1.937) batt insulation was positioned against the insulation previously installed and located between the wood stud framing. A moisture barrier, or roofing felt, was installed on the interior face of the wood framing only in the bathroom areas with a pine board interior finish.

With a 13- $\frac{3}{4}$ in (349 mm) wide wall assembly, the foundation became an important consideration. It was designed according to the wall loads that would bear on the foundation wall. To satisfy the loading requirements, the foundation wall consisted of 8-in (200 mm) exterior concrete block, 2 in (50 mm) of styrofoam insulation, and 4-in (100 mm) interior concrete block. This provided a 14-in (356 mm) wide foundation wall to support a 13- $\frac{3}{4}$ in (349 mm) thick wall assembly.

One of the primary considerations of the design was the anchorage of the brick veneer to the wood stud framing. The 2-in by 4-in (50 mm by 100 mm) wood studs were located 16 in (400 mm) on center, horizontally. Corrosion-resistant metal wire ties, $\frac{3}{16}$ in (4.8 mm) in diameter, and 10 in (254 mm) long, were used and spaced 16 in (400 mm) on center horizontally and 29 in (737 mm) on center vertically. Metal wire Z-ties were selected because they provide a stronger stiffness for lateral support of the wall assembly than would corrugated metal ties. They also would be more capable of resisting tension and compressive stresses resulting from forces acting on the greater thickness of the wall and would also permit slight differential movement of the building envelope.

Sloping brick sills were designed into the wall system, specified to be set in mortar, so added support had to be provided because of the increased wall thickness. For this specific house, 4-in by 4-in (100 mm by 100 mm) brick pilasters were selected to give this needed support under all window openings. They were the same height as the brick wythe at the sill interruption and positioned under each window jamb.

Moisture Resistance Design

With the R-19 (R-3.346) batt insulation to be positioned directly against the interior face of the brick wythe, moisture had to be prevented from reaching the insulation, which could decrease the overall thermal performance; the possibility

also existed for wood decay if moisture soaked through the insulation. The most practical solution to this potential problem was to install a moisture barrier to the interior face of the brick wythe, which was accomplished in the design by specifying 15-lb (0.92 Kg/m²) asphalt-impregnated building felt. The purpose of the building felt was to cause any moisture that penetrated the brick wythe to flow downward between the moisture barrier and the brick wall and to be collected on the flashing and channeled to the exterior through weepholes. This provision prevents the chance of moisture harming the interior wall assembly.

Quality Control

The brick used for the project is a face brick, conforming to ASTM C 216, Grade SW, and Type S mortar was used to construct the walls. The mortar mix consisted of one part portland cement, one part masonry cement, and six parts sand, and all mortar was batched on site. By using let-in corner bracing at the first two levels, inspection was provided to ensure that the house was being constructed using excellent workmanship, which was critical to the successful performance of the wall assembly.

Construction

This unique wall system required construction techniques not usually associated with brick veneer construction. The entire wood framing, plus the wood-truss roof, was erected first; then the brick wythe was constructed to its specified height. Next, the moisture barrier was installed to the entire height of the interior brick face, and after this was completed, the R-19 (R-3.346) batt insulation was installed in the space between the brick veneer and the wood frame. Finally, the insulation was installed between the wood studs, and the interior finish was applied. Following this sequence, different contractors did not have to be called out at various times throughout the project, which would have added to construction costs.

One of the most important steps in construction was applying the moisture barrier to the interior face of the brick wythe. This deviated from conventional construction techniques in which the moisture barrier is usually fastened to the exterior side of the sheathing prior to the construction of the brick veneer wall. The installation procedure for the moisture barrier was: (1) the brick walls were constructed to their full height; (2) the moisture barrier of 32 in (813 mm) wide sections was notched at 16 in (400 mm) on center horizontally to fit over the metal wire ties; (3) the barrier was placed horizontally so that the bottom of the moisture barrier was parallel to the metal wire ties; (4) placement started at the top of the wall assembly and continued down the face of the brick wythe in an overlapping, shingled fashion in which the higher notched length overlapped the metal wire ties and the sections of building felt previously applied; and (5) the sections were tacked together with roofing cement.

The R-19 (R-3.346) batt insulation was placed directly against the moisture barrier and was placed horizontally between the metal wire ties, which helped prevent it from moving. The R-11 (R-1.937) insulation was then placed between the wood stud spacing in the conventional manner, to result in approximately 9½ in (240 mm) of batt insulation in the wall assembly. Paper-backed insulation was specified to reduce the possibility of condensation occurring within the wall assembly. Roofing felt was fastened to the interior face of the wood stud framing only in the bathroom areas to prevent condensation within the wall. Interior pine board finish was installed to complete the construction of the entire wall assembly.

Economics

During the winter of 1981-1982, the residents occupied the house only on weekends. With mechanical heating by electric baseboards and individual thermostats located on each level, the estimating heating cost was \$100 for the entire winter. This was for outdoor winter temperatures as low as -20°F (226 K). The lower level thermostat was set at 42°F (279 K) and comfortable interior temperatures were maintained on the other levels. These low energy costs could be attributed to several factors:

1. The south-facing glazing, which permits sun from the warmest part of the day to heat the inside. To form a direct-gain passive solar feature, the fireplace was positioned near the glazing, and the benefit of sunshine being absorbed by the mass of the fireplace provided radiant heat even after sunset,
2. Using the fireplace for supplemental heating also produced savings in the heating requirement of mechanical systems,
3. The heavily insulated wall envelope helped to reduce the heat flow through the wall assembly.

It should be noted that the 6 in (150 mm) of R-19 (R-3.346) batt insulation cost only \$0.02 per square foot (\$0.22 per square meter) of wall area more than is associated with conventional brick veneer construction. This was estimated based on sheathing not being used in construction of the wall system, the cost of longer metal ties for the anchorage requirements of the wall system, and the cost of the insulation and its installation in the increased thickness of the wall. This cost does not include the cost of the increased foundation wall thickness.

SUMMARY

The innovative, high R-value brick veneer wall system may be used to economically obtain high thermal resistance in a building wall. The wall itself cost an estimated \$0.02 per square foot (\$0.22 per square meter) more than a conventional brick veneer wall system. The wall is an economical selection when this additional cost, plus the costs of the increased foundation wall thickness and the extensions of the heads, jambs, and sills for windows and doors are less per square foot (per square meter) of the brick veneer wall system than the savings due to reduced energy consumption over the lifetime of the building.

The information provided here is by no means conclusive. It does, however, provide a good insight for the designer to select an economical building wall and particularly an economical high R-value brick veneer wall system. The available information regarding the high R-value brick veneer wall system is limited and further research is required. Four areas which should be addressed are:

1. Accurate cost/savings data need to be developed for this wall type for low-rise residential buildings.
2. Moisture penetration through the wall may cause considerable deleterious effects. Alternate methods, which more positively prevent moisture penetration, may be necessary.
3. Moisture due to condensation may have similar effects. Potential condensation problems need to be considered and, as necessary, appropriate alterations in the design and construction of the wall system need to be developed.
4. Data suggest that this wall system is practical for low-rise residential buildings. Research is needed to determine if this type of system may be useful for other types of buildings and for different types of backup systems.

The last of these considerations needs only to be considered if the first three are favorably resolved; however, it could provide the means by which heat loss and heat gain through other opaque wall systems may be greatly reduced. The calculations contained here demonstrate that this insulating system greatly reduces the effect of thermal bridges within a wall assembly. For example, with brick veneer/metal stud wall systems, the metallic thermal bridges may increase the thermal conductance of the wall system by over 80%, as demonstrated by the Zone Method Calculations.^{6,7} Any significant reduction in the effects of thermal bridges could greatly improve the thermal performance of the brick veneer/metal stud wall system and any other similar building envelope component.

The high R-value brick veneer wall system will hopefully be a wall system considered by designers when a wall with a high value of thermal resistance is

desired. More importantly, however, it is hoped that this information will result in continued efforts by members of the building community to improve the system and apply these concepts to result in more economical, energy-conserving building envelope components and systems.

NOMENCLATURE

A = Area in ft^2 (m^2)

R = Thermal resistance in $\text{hr.}^\circ\text{F.ft}^2/\text{Btu}$ ($\text{K.m}^2/\text{W}$)

U = Design coefficient of thermal transmission in $\text{Btu/hr.}^\circ\text{F.ft}^2$ (W/K.m^2)

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ACKNOWLEDGEMENTS

The authors would like to acknowledge the helpful contributions of Mr. James G. Gross, P.E. His design of the demonstration project in Garrett City, MD, and the information he provided have contributed to making this a more useful and accurate report.

TABLE I
Empirical Height Limitations for Brick Veneer

| Nominal Thickness of the Brick Veneer, in (mm) | Stories | Empirical Height Limitations | | | |
|---|---------|------------------------------|--------|-----------------|---------|
| | | Height at Plate | | Height at Gable | |
| | | ft | (m) | ft | (m) |
| 3 (75) | 2 | 20 | (6.10) | 28 | (8.53) |
| 4 (100) | 3 | 30 | (9.14) | 38 | (11.58) |

TABLE 2
Properties of Brick Veneer Wall Systems

| Properties | Type of Brick Veneer Wall ^a | | | | |
|---|--|------------------------------|------------------------------|------------------------------|------------------------------|
| | Wall #1 | Wall #2 | Wall #3 | Wall #4 | Wall #5 |
| General Properties | | | | | |
| Wall Weight, lb/ft ² (Kg/m ²) | 52 (254) | 56 (273) | 54 (254) | 56 (273) | 52 (254) |
| Wall Thickness, in. (mm) | 9.75 (248) | 11.75 (298) | 10.75 (273) | 12.75 (324) | 13.25 (337) |
| Use of Exterior Sheathing | Yes | Yes | Yes | Yes | No |
| Use of Building Felt | Optional | Optional | Optional | Optional | Yes |
| Type of Insulation | Rigid Board Batt and Batt | Rigid Board Batt and Batt | Rigid Board Batt and Batt | Rigid Board Batt and Batt | Rigid Board Batt and Batt |
| Difficulty of Construction | Low | Low | High | High | High |
| Sill, Jamb, and Head Extensions in. (mm) | None | 2 (50) | 2 (50) | 4 (100) | 4 (100) |
| Wood Frame Backup, in. (mm) | 2 x 4 (50 x 100) | 2 x 6 (50 x 150) | 2 x 4 (50 x 100) | 2 x 6 (50 x 150) | 2 x 4 (50 x 100) |
| Spacing of Wood Studs in. (mm) | 16 (400) | 24 (600) | 16 (400) | 24 (600) | 16 (400) |
| Structural Properties | | | | | |
| Type of Metal Tie | Corrugated | Corrugated | Corrugated | Corrugated | Wire |
| Min. Tie Length, in. (mm) | 6 (150) | 6 (150) | 7 (175) | 7 (175) | 9 (225) |
| Tie Stiffness | Adequate | Adequate | Low | Low | Adequate |
| Bracing of Backup | Diagonal | Diagonal or Sheathing | Diagonal | Diagonal | Diagonal |
| Minimum Foundation Wall Thickness, in. (mm) | 8 (200) | 10 (250) | 10 (250) | 12 (300) | 12 (300) |
| Height Limitations | Table 1 | Table 1 | Table 1 | Table 1 | Table 1 |

| Properties | Type of Brick Veneer Wall ^a | | | | |
|--|--|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| | Wall #1 | Wall #2 | Wall #3 | Wall #4 | Wall #5 |
| <u>Thermal Properties</u> | | | | | |
| Thermal Resistance hr. °F.ft ² /Btu (K.m ² .W) | 19.94 (3.512) | 23.01 (4.052) | 26.19 (4.612) | 34.19 (6.021) | 31.79 (5.593) |
| Thermal Conductance Btu/hr. °F.ft ² (W/K.m ²) | 0.050 (0.285) | 0.043 (0.247) | 0.038 (0.217) | 0.029 (0.166) | 0.031 (0.179) |
| %Increase in R over Wall #1 | -- | 15.4 | 31.3 | 71.5 | 60.3 |
| Wall Group | B | B | A | A | A |
| Avg. CLTD at hr 16, 40°N Latitude, July 21 N,E,S,W °F (°C) | 16.25 9.25 | 16.25 9.25 | 16.50 9.25 | 16.50 9.25 | 16.50 9.25 |
| <u>Fire Resistance</u> | | | | | |
| Estimated Fire Rating (hr) | 1-2 | 1-2 | 1-2 | 1-2 | 1-2 |
| <u>Sound Penetration Resistance</u> | | | | | |
| Estimated STC | 40-47 | 40-47 | 40-47 | 40-47 | 40-47 |
| Maintenance | Low | Low | Low | Low | Low |
| Durability | Excellent | Excellent | Excellent | Excellent | Excellent |
| Moisture Penetration Resistance | Drainage Type Wall Excellent | Drainage Type Wall Excellent | Drainage Type Wall Excellent | Drainage Type Wall Excellent | Drainage Type Wall Excellent |

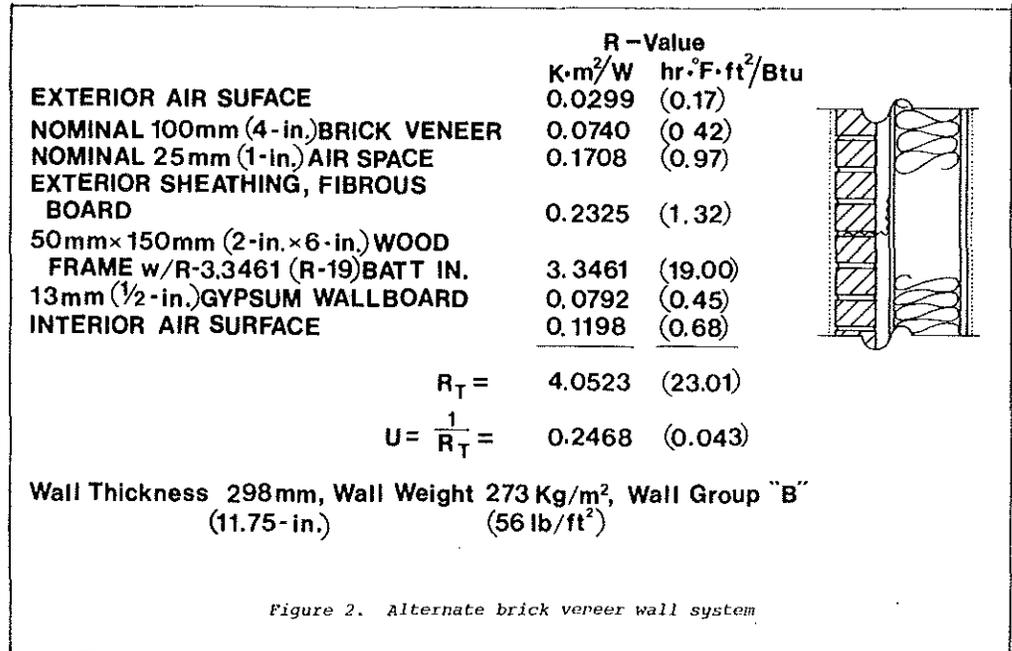
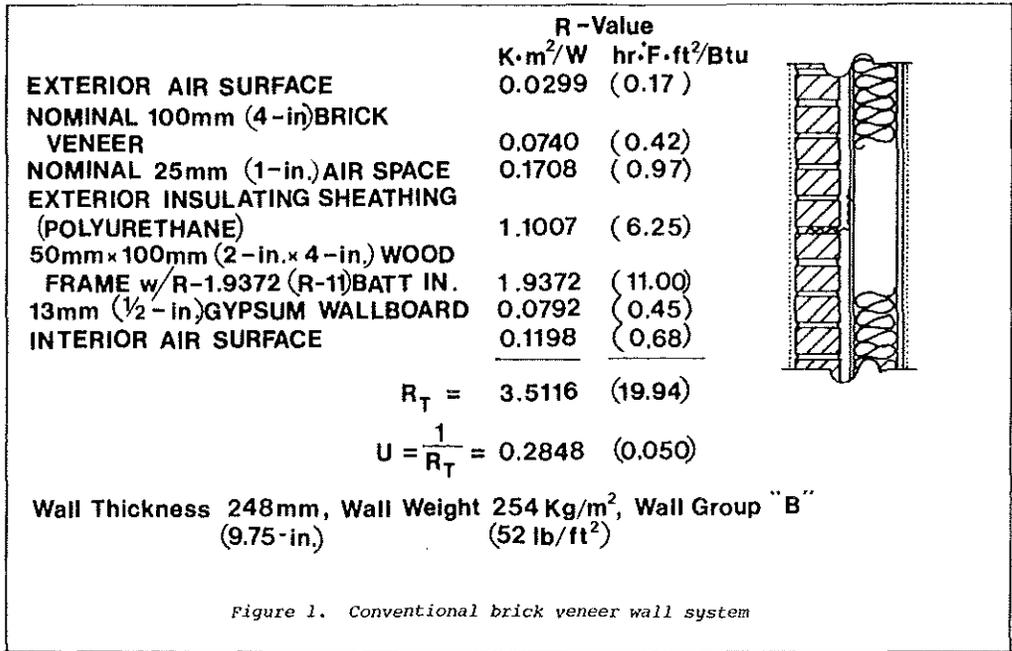
^aWall #1: Conventional brick veneer wall system, see Fig. 1.

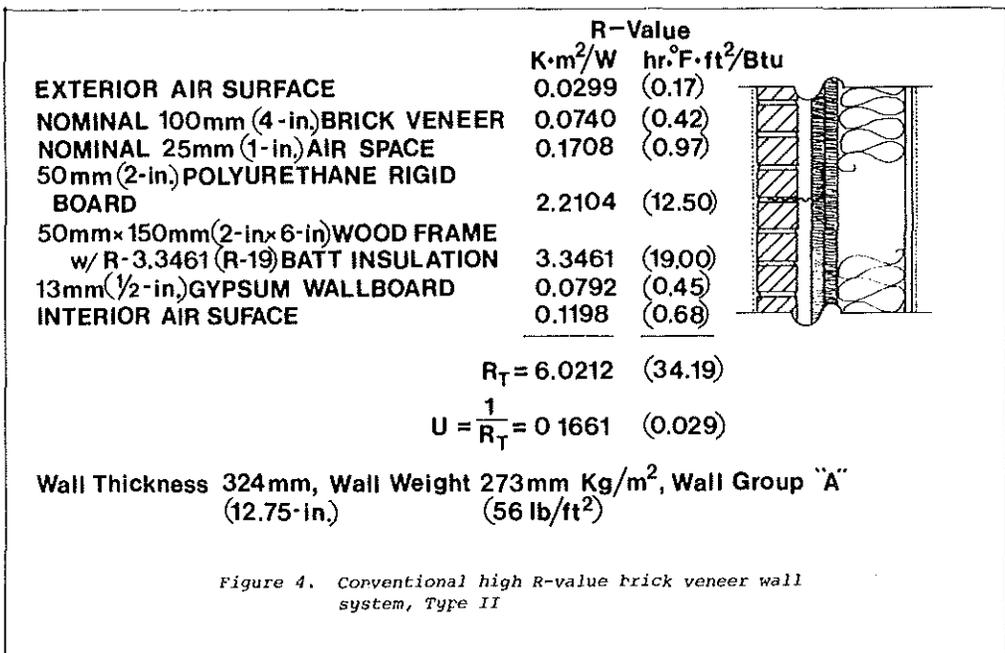
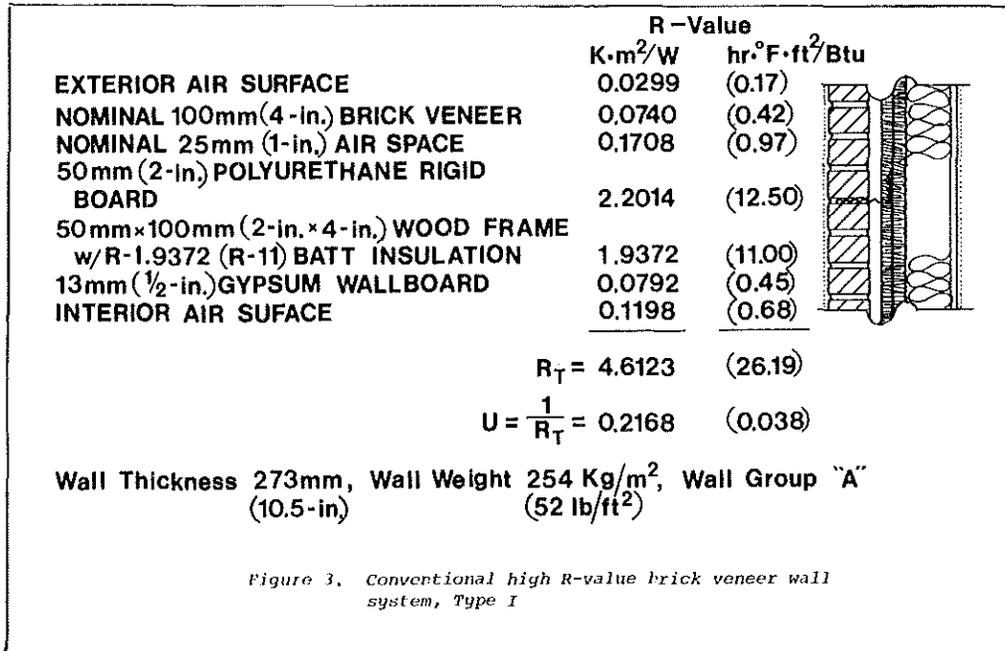
Wall #2: Alternate brick veneer wall system, see Fig. 2.

Wall #3: Conventional high R-value brick veneer wall system, see Fig. 3.

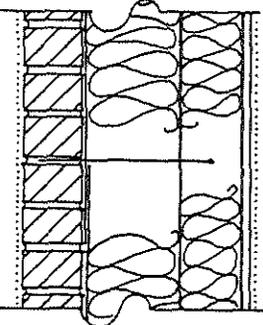
Wall #4: Conventional high R-value brick veneer wall system, see Fig. 4.

Wall #5: Innovative high R-value brick veneer wall system, see Fig. 5.





| | R-Value | |
|---|-----------------|------------------------------------|
| | $K \cdot m^2/W$ | $hr \cdot ^\circ F \cdot ft^2/Btu$ |
| EXTERIOR AIR SURFACE | 0.0299 | (0.17) |
| NOMINAL 100mm (4-in.) BRICK VENEER | 0.0740 | (0.42) |
| 0.93 Kg/m^3 (15 lb) BUILDING FELT | 0.0070 | (0.04) |
| R-33461 (R-19) BATT INSULATION | 3.3461 | (19.00) |
| 50mm x 100mm 2-in. x 4-in. WOOD FRAME w/ R-1.9372 (R-11) BATT INSULATION | 1.9372 | (11.00) |
| 13mm ($1/2$ -in.) GYPSUM WALLBOARD | 0.0792 | (0.45) |
| INTERIOR AIR SURFACE | 0.1198 | (0.68) |



$$R_T = 5.5932 \quad (31.76)$$

$$U = \frac{1}{R_T} = 0.1788 \quad (0.031)$$

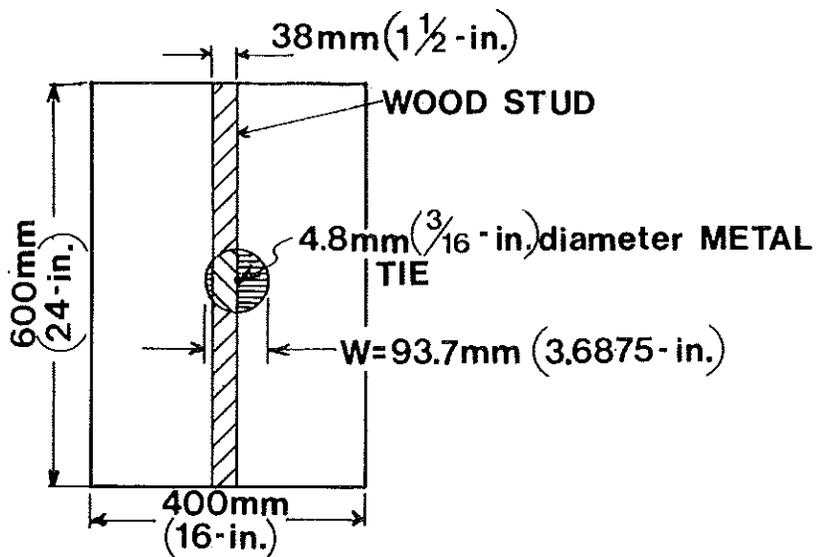
Wall Thickness 337mm, Wall Weight 254 Kg/m^2 , Wall Group "A"
 (13.25-in.) (52 lb/ft²)

Innovative High R-Value Brick Veneer Wall System

Figure 5. Innovative high R-value brick veneer wall system

| | Wall #1 Conventional | | Wall #2 Alternate | | Wall #3 Conventional | | Wall #4 High R-Value | | Wall #5 Innovative | |
|---|-------------------------|-------------------|----------------------|-------------------|-------------------------|-------------------|-------------------------|-------------------|-----------------------|-------------------|
| | Path A | Path B | Path A | Path B | Type I | | Type II | | Path A | Path B |
| | | | | | Path A | Path B | Path A | Path B | | |
| Exterior Air Surface | 0.17 (0.0299) | 0.17 (0.0299) | 0.17 (0.0299) | 0.17 (0.0299) | 0.17 (0.0299) | 0.17 (0.0299) | 0.17 (0.0299) | 0.17 (0.0299) | 0.17 (0.0299) | 0.17 (0.0299) |
| 4 in (100 mm) Brick Veneer | 0.42 (0.0740) | 0.42 (0.0740) | 0.42 (0.0740) | 0.42 (0.0740) | 0.42 (0.0740) | 0.42 (0.0740) | 0.42 (0.0740) | 0.42 (0.0740) | 0.42 (0.0740) | 0.42 (0.0740) |
| 1 in (25 mm) Air Space | 0.97 (0.1708) | 0.97 (0.1708) | 0.97 (0.1708) | 0.97 (0.1708) | 0.97 (0.1708) | 0.97 (0.1708) | 0.97 (0.1708) | 0.97 (0.1708) | | |
| 15# (0.93 Kg/m ³) Building Felt | | | | | | | | | 0.04 (0.0070) | 0.04 (0.0070) |
| Sheathing or Insulation | 6.25 (1.1007) | 6.25 (1.1007) | 1.32 (0.2325) | 1.32 (0.2324) | 12.50 (2.2014) | 12.50 (2.2014) | 12.50 (2.2014) | 12.50 (2.2014) | 19.00 (3.3461) | 19.00 (3.3461) |
| 2 in x 4 in (50 mm x 100 mm) Insulated Wood Frame | 11.00 (1.9372) | 4.38 (0.7714) | -- | -- | 11.00 (1.9372) | 4.38 (0.7714) | -- | -- | 11.00 (1.9372) | 4.38 (0.7714) |
| 2 in x 6 in (50 mm x 150 mm) Insulated Wood Frame | -- | -- | 19.00 (3.3461) | 6.88 (1.2116) | -- | -- | 19.00 (3.3461) | 6.88 (1.2116) | -- | -- |
| Gypsum Wallboard | 0.45 (0.0792) | 0.45 (0.0792) | 0.45 (0.0792) | 0.45 (0.0792) | 0.45 (0.0792) | 0.45 (0.0792) | 0.45 (0.0792) | 0.45 (0.0792) | 0.45 (0.0792) | 0.45 (0.0792) |
| Interior Air Surface | 0.68 (0.1198) | 0.68 (0.1198) | 0.68 (0.1198) | 0.68 (0.1198) | 0.68 (0.1198) | 0.68 (0.1198) | 0.68 (0.1198) | 0.68 (0.1198) | 0.68 (0.1198) | 0.68 (0.1198) |
| Total R-Value | 19.94 (3.5116) | 13.32 (2.3458) | 23.01 (4.0523) | 10.89 (1.9178) | 26.19 (4.6123) | 19.57 (3.4465) | 34.19 (6.0212) | 22.07 (3.8867) | 31.76 (5.5932) | 25.14 (4.4274) |
| U-Value of Path | 0.050 (0.2848) | 0.075 (0.4263) | 0.043 (0.2468) | 0.092 (0.5214) | 0.038 (0.2168) | 0.051 (0.2901) | 0.029 (0.1661) | 0.045 (0.2573) | 0.031 (0.1788) | 0.040 (0.2259) |
| % of Wall Area | 89.33 | 10.67 | 93.75 | 6.25 | 89.33 | 10.67 | 93.75 | 6.25 | 89.33 | 10.67 |
| U _{avg} | 0.053 (0.3000) | | 0.046 (0.2640) | | 0.039 (0.2246) | | 0.030 (0.1718) | | 0.032 (0.1838) | |

Figure 6. Determination of coefficient of thermal transmission by dual path method



$$W = m + 2d = 4.8 \text{ mm} + (2 \times 44.45 \text{ mm}) = 93.7 \text{ mm}$$

$$(0.1875 \text{ -in.} + (2 \times 1.75 \text{ -in.}) = 3.6875 \text{ -in.})$$

where: m = thickness of metal tie
 d = distance from the metal tie to the face of the wall, not to be taken less than 12.7 mm (0.5-in.)

-  Area of Path B_A through insulation not affected by metal tie 166561 mm^2 (258.17-in.²)
-  Area of Path B_B through wood stud not affected by metal tie 12355 mm^2 (19.15-in.²)
-  Area of Zone 1 through insulation affected by metal tie 3761.3 mm^2 (5.83-in.²)
-  Area of Zone 2 through wood stud affected by metal tie 3129.0 mm^2 (4.85-in.²)

Figure 7. Heat flow paths through insulation and wood stud and areas affected by the presence of the metal tie for Wall #5

| | Path A | | | | Path B | | | | |
|----------------------|----------------------|----------------------|----------------------|-----------------------|----------------------|----------------------|--------------------|----------------------|----------------------|
| | R-Value | Zone 1 Area | R/A | Zone 2 Area | R/A | R-value | R/A | R-value | R/A |
| Exterior air Surface | 0.17-- (0.02994) | 0.04049 (0.00376) | 4.199 (7.983) | 0.03368 (0.00313) | 5.068 (9.565) | 0.17-- (0.02994) | 0.045 (0.180) | 0.17-- (0.02994) | 1.278 (2.477) |
| Brick | 0.02-- (0.03522) | 0.04049 (0.00376) | 4.939 (9.367) | 0.03368 (0.00313) | 5.938 (11.257) | 0.42-- (0.07397) | 0.234 (0.444) | 0.42-- (0.07397) | 3.158 (5.967) |
| Brick | 0.22-- (0.03874) | 0.04039 (0.00375) | 9.465 (5.020) | 0.03359 (0.00312) | 11.187 (5.997) | --- | --- | --- | --- |
| Metal Tie | 0.0064 (0.00113) | 0.00010 (0.00001) | (5.020) | 0.00009 (0.00001) | (5.997) | --- | --- | --- | --- |
| Building Felt | 0.04-- (0.00704) | 0.04039 (0.00375) | 1.278 | 0.003359 (0.00312) | 1.443 | 0.04-- (0.00704) | 0.022 (0.042) | 0.04-- (0.00704) | 0.381 (0.579) |
| Metal Tie | 0.0002 (0.00004) | 0.00010 (0.00001) | (0.662) | 0.00009 (0.00001) | (0.775) | --- | --- | --- | --- |
| Insulation | 19.00-- (3.34609) | 0.04039 (0.00375) | 228.966 (127.550) | 0.03359 (0.00312) | 239.281 (144.702) | 19.00-- (3.34609) | 10.598 (20.089) | 19.00-- (3.34609) | 142.872 (270.938) |
| Metal Tie | 0.0175 (0.00308) | 0.00010 (0.00001) | (127.550) | 0.00009 (0.00001) | (144.702) | --- | --- | --- | --- |
| Wood Stud | 1.88-- (0.33109) | --- | --- | 0.03359 (0.00312) | 47.196 | --- | --- | --- | --- |
| Metal Tie | 0.0048 (0.00085) | --- | --- | 0.00009 (0.00001) | (27.310) | --- | --- | --- | --- |
| Wood Stud | 2.50-- (0.44028) | --- | --- | 0.03368 (0.00313) | 74.228 (140.665) | --- | --- | 4.38-- (0.77136) | 32.935 (62.433) |
| Insulation | 4.71-- (0.82948) | 0.04039 (0.00375) | 61.404 | --- | --- | --- | --- | --- | --- |
| Metal Tie | 0.0048 (0.00085) | 0.00010 (0.00001) | (34.004) | --- | --- | --- | --- | --- | --- |
| Insulation | 6.29-- (1.10773) | 0.04049 (0.00376) | 155.347 (294.609) | --- | --- | 11.00-- (1.93721) | 6.135 (11.631) | --- | --- |
| Gypsum Wallboard | 0.45-- (0.07925) | 0.04049 (0.00376) | 11.114 (21.077) | 0.03368 (0.00313) | 13.361 (25.319) | 0.45-- (0.07925) | 0.251 (0.476) | 0.45-- (0.07925) | 3.184 (6.414) |

| | Path A | | | | Path B | | | | |
|--------------------------|---------------------|----------------------|--|---|----------------------|---------------------|--|----------------------|----------------------|
| | R-Value | Zone 1 Area | R/A | Zone 2 Area | R/A | R-value | R/A | R-value | R/A |
| Interior Air Surface | 0.68-- (0.11975) | 0.04049 (0.00376) | 16.794 (31.848) | 0.03368 (0.00313) | 20.190 (38.259) | 0.68-- (0.11975) | 0.379 (0.719) | 0.68-- (0.11975) | 5.113 (9.692) |
| Total R/A | | | 359.629 (665.977) | | 297.549 (524.167) | | 17.714 (33.581) | | 189.041 (358.457) |
| l (R/A) | | | 0.00278 (0.00150) | | 0.00336 (0.00191) | | 0.05645 (0.02978) | | 0.00529 (0.00279) |
| U _{avg} of Path | | | 0.00614 (0.00341) 0.07417 (0.00689) | = 0.0828 (0.4949) | | | 0.06175 (0.03257) 1.92583 (0.17892) | = 0.0321 (0.1820) | |
| U _{avg} of Wall | | | 0.0828 (0.4949) | 0.07417 (0.00689) + 2.00000 (0.18581) | 0.0321 (0.1820) | | 1.92583 (0.17892) + 2.00000 (0.18581) | = 0.0340 (0.1936) | |

Figure 8. Determination of coefficient of thermal transmission by the zone method for Wall #5

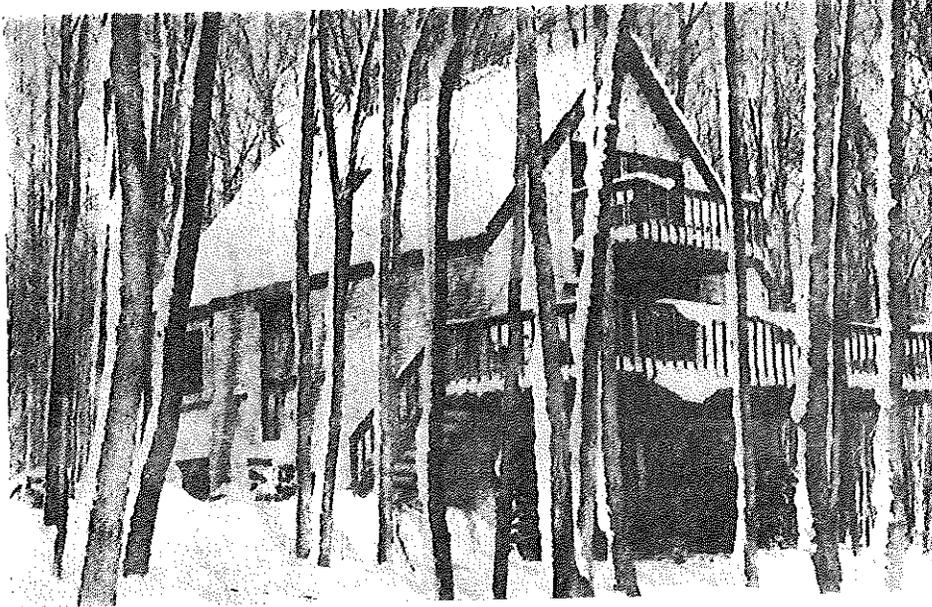


Figure 9. Completed demonstration project

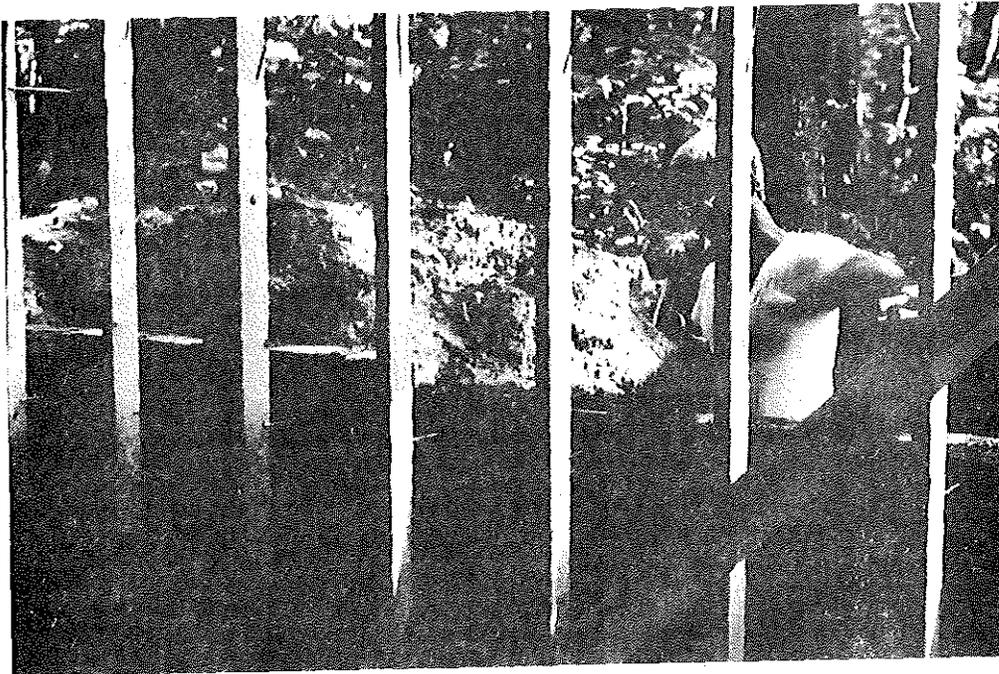


Figure 10. Brick masonry under construction showing installed Z ties

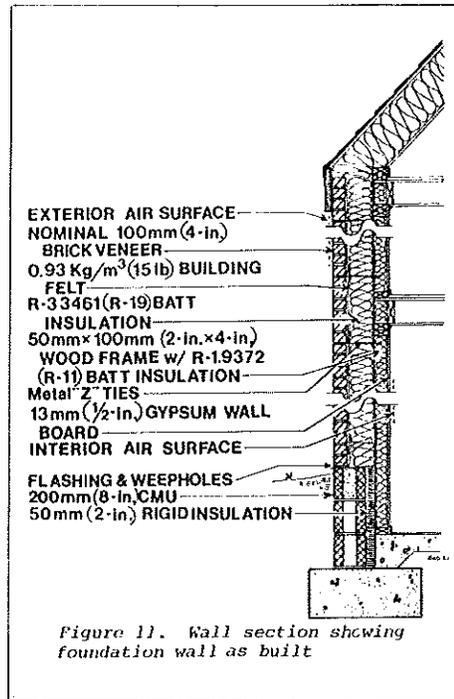


Figure 12. Interior view of wall after completion of brick masonry

Discussion

D.R. Robertson, New Mexico Energy Research and Development, Albuquerque: What are the advantages of brick in this wall, as opposed to some other sheathing?

S.S. Szoke: There are many advantages of using brick in this wall system as opposed to other forms of sheathing. The paper discussed the considerations that should be used when selecting a building wall. The high R-value brick veneer wall system provides structural integrity, moisture penetration resistance, mass to reduce sound penetration, mass to reduce cooling loads, ample thermal resistive insulation, fire resistance, durability, and low maintenance, in addition to aesthetics. It is difficult to construct an exterior building facade that provides all of these factors as well as brick masonry does.

D.E. Welker, Forster-Morrell Engineering, Colorado Springs: Is the increase in footing and foundation thickness to accommodate the increased insulation thickness cost-effective? Would it be better to install rigid insulation with a higher R-value per inch instead of the batt insulation, which would result in decreased foundation thickness?

Szoke: The increased foundation thickness is a major cost for the high R-value brick veneer wall system. This cost, combined with the increased sill, jamb, and head thicknesses, may result in this wall not being an economical choice as a building wall. Several examples of using rigid board insulation are discussed in the paper. These systems still require an increased foundation wall thickness, but not as great as the super-insulated brick veneer wall. If alternate insulation materials can be installed more economically than those used in the high R-value brick veneer wall, increasing the foundation wall system, then rigid insulation is a viable option.

The only concern that exists is the installation of the rigid board insulation. Rigid board insulation has to be installed between the metal ties as the brick veneer is constructed. This may increase the installation costs and will eliminate the opportunity to inspect the completed brick veneer from the interior. However, in most applications where quality workmanship is typical, inspection is not a necessity, and alternate insulation materials used to increase the R-value or decrease the wall thickness may be used.

R.F. Jones, Brookhaven National Lab., Upton, NY: A paper by the Research Institute at Lund in Sweden indicated that in retrofit construction, adding insulation to existing brick walls on the interior surface could reduce the internal temperature of the masonry wall below freezing and create deterioration of the wall. What would be the solution to this problem?

Szoke: The additional insulation in the wall system will thermally isolate the brick veneer and subject it to temperatures that will essentially be the same as ambient temperatures. Temperatures below freezing should not have any deleterious effects on properly constructed and detailed brick veneer. If the wall is not detailed and constructed to prevent water penetration, moisture present in the brick veneer during freezing temperatures may cause deterioration of the brickwork. The high R-value brick veneer wall system with the 6-in. cavity is very easy to construct and thus, with the use of some portland cement-lime mortar, penetration through the brick veneer should not be a problem. The use of proper flashing at the sills and a roof overhang at the eaves and gable should prevent any water from entering the brick veneer. Without saturation by water, Grade SW brick, conforming to the ASTM Standards will provide successful performance and resistance to freeze/thaw deterioration.