History of Insulation with Masonry

HIGHER ENERGY COSTS AND CODES DEMAND GREATER EFFICIENCY

There is a story of a young architect today analyzing a building constructed in the 1950s with solid masonry walls and single paned glass used on the exterior of the structure. That young architect referred to the building as an "old, masonry, energy inefficient building." In the present context of the 21st century, it is not energy efficient using today's standards. But, when it was built, as with most other buildings at that time, very little insulation was used because energy was a cheap commodity and architects and owners did not require use of insulation in their building envelopes.

Insulation and other techniques for energy conservation are coming to the fore today. Therefore, masonry buildings and other building types have been upgraded with different types of insulations. The use (in the 1950s and 1960s) of zonolite, vermiculite and perlite was used initially in the cores of concrete masonry units and wall cavity's to increase the masonry's marginal thermal performance. This satisfied the increased energy demands. In the earlier part of the 20th century, some insulation materials utilized on the inside of ice houses built in Chicago were horse hair and cork

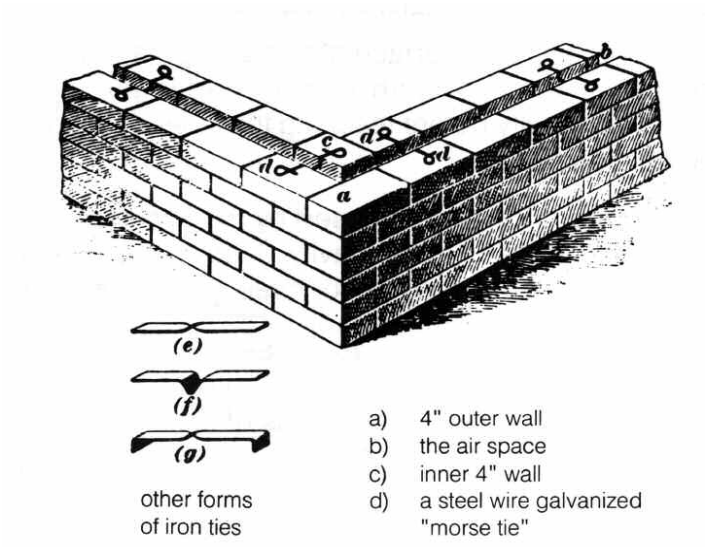

Figure 1. Cavity wall from, "Masonry-Carpentry-Joinery, The Art of Architecture, Engineering and Construction 1899

CAVITY WALL HISTORY: 200 YEARS

Cavity walls are not new, they have been observed in ancient Greek and Roman structures. At the Greco-Roman town of Pergamum, on the hills overlooking the Turkish town of Bergama, a stone wall of cavity type construction still exists.

Sometime in the early part of the 19th century, the cavity wall was rediscovered by the British. Plans dating as early as 1805 suggest a type of cavity wall construction. It featured two leaves (wythes) of brick, bonded by brick headers, spanning across a 6" cavity. An early British publication (dated 1821) suggests the use of cavity walls as a means of protection against moisture penetration. The use of metal ties was introduced in Southern England sometime after 1850. These original ties were made of wrought iron.

Cavity walls were first built in the United States late in the 19th century. Figure 1 illustrates an alternate type of cavity wall system originally featured in an 1899 text book assembled for people engaged in the engineering professions and construction trades. However, it was not until 1937 that this type of construction gained official acceptance by any building or construction agency in the United States. Since then, interest in and use of cavity walls in this country has rapidly increased. This has resulted in extensive testing to determine cavity wall properties and performance.

IN THE EARLIER PART OF THE 20TH CENTURY, SOME INSULATION MATERIALS UTILIZED ON THE INSIDE OF ICE HOUSES BUILT IN CHICAGO WERE HORSE HAIR AND CORK.

Batt Insulation

Unfaced thermal batt insulation complies with ASTM C665, Type I and ASTM E136. Kraft-faced thermal batt insulation complies with ASTM C665, Type II, Class C. Foil-faced thermal batt insulation complies with ASTM C665, Type III, Class B and C.

NOMINAL FRAMING DEPTH AND SPACING	"LABELED" BATT INSULATION R-VALUE (BETWEEN STEEL STUDS)	"EFFECTIVE" R-VALUE WITH BATT INSULATION AND STEEL STUDS	WALL THERMAL EFFICIENCY (1)
4" @ 16" oc	R-11	5.5	50%
	R-13	6.0	46%
	R-15	6.4	43%
4" @ 24" oc	R-11	6.6	60%
	R-13	7.2	55%
	R-15	7.8	52%
6" @ 16" oc	R-19	7.1	37%
	R-21	7.4	35%
6" @ 24" oc	R-19	8.6	45%
	R-21	9.0	43%

(1) — Data Source: ASHRAE/EIS Standard 90.1 — 1999, Appendix A.

Thermal batts are flexible, fiberglass insulation. It is made in R-values from 11 to 38. The product is manufactured in thicknesses from 3 1/2" to 12". The batts must be kept dry to maintain the stated R –values. Insulation that has become wet should be inspected for evidence of residual moisture and contamination, and any insulation that is contaminated should be promptly removed and replaced. Batt insulation's R-value is adversely affected by the presence of moisture. Due to thermal bridging, with just batt insulation between steel studs, a wall's thermal efficiency is lowered 50% to 65%.

The early use of cavity walls in this country was limited primarily to exterior load-bearing walls in low rise construction. In the 1940s, designers began to recognize the advantages of cavity walls in high-rise buildings. Today, masonry cavity walls are the preferred wall system and are used extensively throughout the United States in all types of buildings. The primary reasons for their popularity are: superior resistance to rain penetration, excellent thermal properties, excellent resistance to sound transmission and high resistance to fire.

At the first North American Masonry Conference (1978), at the University of Colorado Boulder, masonry design professionals and research professors gathered from around the world for paper presentations and discussion. Water penetration and solid masonry walls were being discussed along with the now more accepted insulated cavity wall currently being designed and constructed in America.

Timber West, an elder scholar from England, who had an Albert Einstein white head of hair and a white handle bar mustache, addressed the crowd. He cleared his throat and said, "When are you bloody Colonialists going to learn that if you want to build brick masonry walls that won't leak, you have to build a cavity wall. We (British) have been doing it for the last 200 years…" He silenced the audience.

MODERN ERA OF INSULATED MASONRY WALLS

The insulation used in masonry buildings changed drastically in the mid 70s due to the Arab oil embargo. Long lines of cars waiting to get gas along with increased energy demands promulgated new energy codes – this phenomenon changed the design world. Requirements for minimum R-values for various types of construction came into being. Masonry, concrete and precast industries were given credit for their mass in tempering the exterior temperature fluctuation. To meet these needs, a variety of insulations were used.

- BATT INSULATION
- EXPANDED POLYSTYRENE
- EXTRUDED POLYSTYRENE
- PHENOLIC FOAM
- POLYISOCYNAURATE INSULATION

PHENOLIC FOAM:
Introduced in the 70s and early 80s, it had a high R-value of 8.33/1". Unfortunately, it also caused steel corrosion upon contact with water. It was withdrawn from roofing and wall construction in the mid-1980s.

DESIGN CHALLENGES

The need for higher R-valued walls presented a design problem for architects. Traditionally architects designed buildings for commercial, industrial and residential applications. The most economical wall system in the past was solid masonry walls composed of three wythes (or layers) of brick and/or one wythe of brick tied into an 8" concrete masonry back up. The only place you could put rigid insulation in solid walls was on the inside of the building. This gave rise to the use of cavity walls composed of an exterior 4" brick wythe of masonry, a cavity consisting of an air space and closed cell rigid insulation and an interior wythe of the 8" concrete masonry. (Figure 2)

The history of cavity walls goes back many hundreds of years, but the greatest

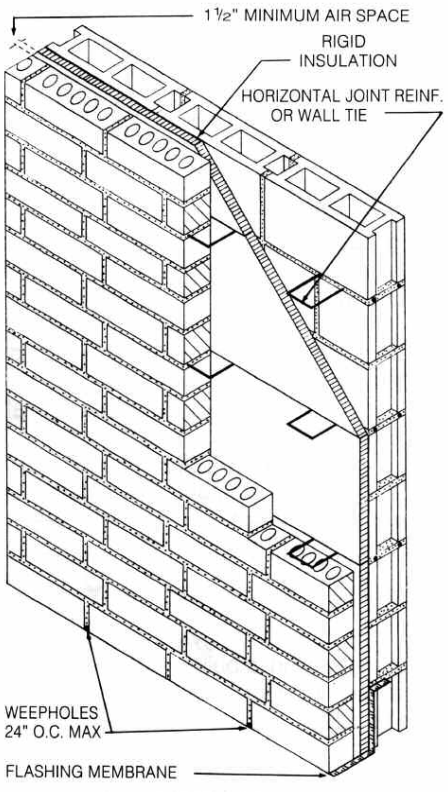

Figure 2. Typical cavity wall with insulation

Expanded Polystyrene (EPS)

ASTM C578 Standard Specification for Preformed Cellular Polystyrene Thermal Insulation – Expanded Polystyrene.

TYPE	XI	I	VIII	II	IX
R-VALUE / IN @ 75° F	3.1	3.6	3.8	4.0	4.2
DENSITY, MIN PCF	0.7	0.9	1.15	1.35	1.8
WATER ABSORPTION MAX, % BY VOL.	4	4	3	3	2
COMPRESSIVE STRENGTH MIN, PSI	5	10	13	15	25

Must be protected with ½" drywall. (15 minutes of fire protection or greater.)

Extruded Polystyrene (XPS)

ASTM C578 Standard Specification for Preformed Cellular Polystyrene Thermal Insulation – Extruded Polystyrene.

TYPE	X	IV	VI	VII	V
DENSITY, MIN.,PCF	1.35	1.60	1.80	2.20	3.00
R-VALUE/INCH @75°F, MIN.	5.00	5.00	5.00	5.00	5.00
COMPRESSIVE STRENGTH, MIN.,PSI	15	25	40	60	100
WVP,MAX.PERM FOR 1"	1.1	1.1	1.1	1.1	1.1
WATER ABSORBTION, MAX.,%/VOL.	0.3	0.3	0.3	0.3	0.3

Must be protected with ½" drywall. (15 minutes of fire protection or greater.)

Most cavity applications use Type X or Type IV. All roof and interior wall systems incorporating extruded polystyrene insulation must consider adequate fire protection. Coverings such as 15 minute thermal barriers (1/2" drywall) or other alternatives based on building code diversified tests are regarded as acceptable in most applications.

Insulation Myths & Deceptive Truths:

Several years ago, a large manufacturer of batt insulation produced television commercials comparing the insulative R-value of 6" of batt insulation to 15" of wood and to 84" of brick masonry. This was a deceptively true statement. However, neither wood nor masonry is marketed as an insulation material. The comparison of R-values of batt insulation to other types of insulation materials (2½" of polyisocyanurate, or 3½" of extruded polystyrene, or 4¼" of expanded polystyrene) was not made because the comparison would not favor the batt insulation manufacturer in the general public's perception. If the masonry industry had responded using the same illogic, you would have seen commercials on TV with the three little pigs building a brick house, and one little pig would be saying to his brother, "Do you realize it takes one half square mile of 6" batt insulation to have the same compressive strength of one square inch of brick masonry?"... After a five second pause, the other brother, with a questioning look on his face, would say "Did you have some bad beer last night?"...

Masonry is a structural and/or architectural material. You don't build buildings with just insulation. In the Midwest climate, the Masonry Advisory Council encourages the use of insulation with masonry. The masonry industry needs insulation with its product, with the exception of masonry used as a passive solar heat storage medium.

Fax your wall cross section and questions to Chuck Ostrander at 847-297-8373.

Most wall applications use Type I, class I or class II. Type II is used primarily in roofing applications. Thermax insulation by Dow can be installed exposed to the building interior, without a thermal barrier, in many applications. Foil – faced polyisocyanurate insulations may also provide an additional reflective R-Value of 2.8 when installed adjacent to a clean dead air space, per ASHRAE standards. (A non-reflective dead air space has a R-Value of 0.97).

impetus for its use is for a more rain resistant type of wall system compared to solid masonry. In addition, it was more energy efficient as a corollary. Below are various wall cross sections and the R-value of the total wall system including the insulation selected. It is hoped this is of assistance to you in designing energy efficient walls in the future. ME

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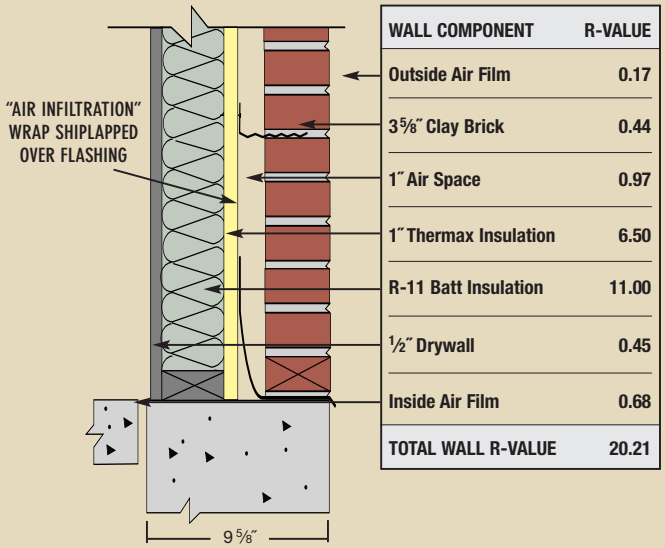
Polyisocyanurate (ISO)

ASTM C1289-2001 ***Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board.***

TYPE CLASS FACER	I I FOIL/FOIL	I II FOIL/FOIL	II I FELT OR GLASS	II II POLYMER BONDED
R-VALUE/INCH@75°	6.5	6.5	5.6	5.3
COMPRESSIVE STRENGTH,MIN.PSI GRADE I GRADE II GRADE III	20	20	 20 20 25	20
WVP, MAX.PERM FOR 1"	0.3	0.3	1.0	4.0
WATER ABSORPTION MAX.%/VOL	1.0	1.0	1.5	1.5

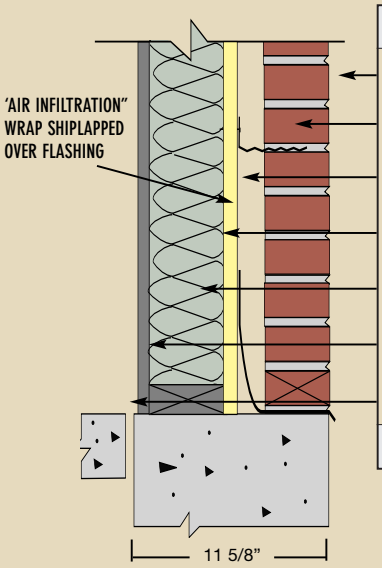
R-VALUE OF VARIOUS WALL CROSS SECTIONS OF

BRICK VENEER OVER 4″ WOOD FRAME CONSTRUCTION



WALL COMPONENT	R-VALUE
Outside Air Film	0.17
3⅝″ Clay Brick	0.44
1″ Air Space	0.97
1″ Thermax Insulation	6.50
R-11 Batt Insulation	11.00
½″ Drywall	0.45
Inside Air Film	0.68
TOTAL WALL R-VALUE	20.21

BRICK VENEER OVER 6″ WOOD FRAME CONSTRUCTION

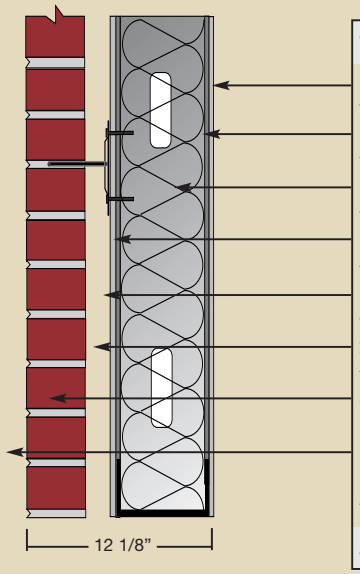


WALL COMPONENT	R-VALUE
Outside Air Film	0.17
3⅝″ Clay Brick	0.44
1″ Air Space	0.97
1″ Thermax Insulation	6.50
R-19 Batt Insulation	19.00
½″ Drywall	0.45
Inside Air Film	0.68
Total Wall R-Value	28.21

THE TOTAL WALL SYSTEM INCLUDING INSULATION

BRICK VENEER OVER STEEL STUDS WITH BATT INSULATION

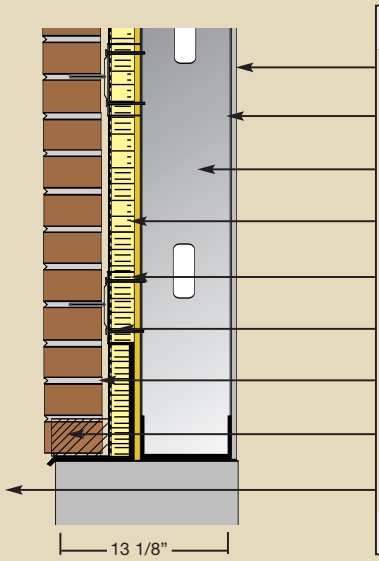
*TAKING INTO ACCOUNT STEEL STUD THERMAL SHORTING AND ASHRAE 90.1 CORRECTION FACTORS



WALL COMPONENT	R-VALUE
Interior Air Film	0.68
1/2″ Drywall	0.45
R-19 Batt Insulation	19.00
½″ Dens-Glass Gold	0.56
15# Felt	0.01
2″ Airspace	1.36
3⅝″ Clay Brick	0.44
Outside Air Film	0.17
Apparent R-Value	22.67
ACTUAL R-VALUE*	11.27

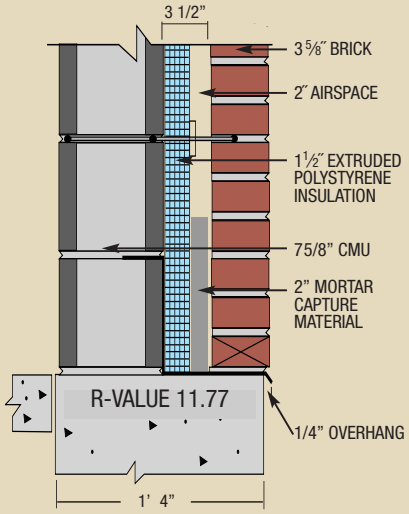
BRICK VENEER OVER STEEL STUDS WITH EXTERIOR RIGID INSULATION

*TAKING INTO ACCOUNT STEEL STUD THERMAL SHORTING AND ASHRAE 90.1 CORRECTION FACTORS

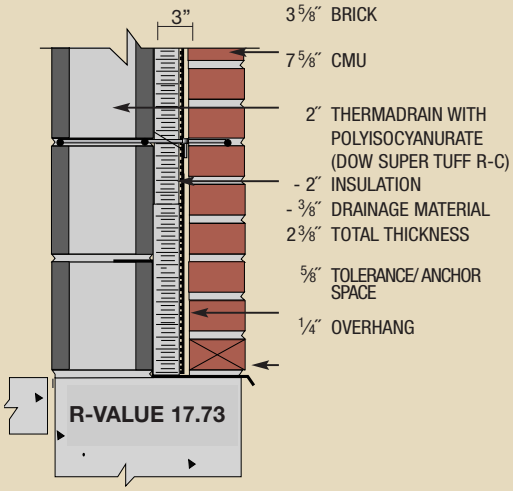


WALL COMPONENT	R-VALUE
Interior Air Film	0.68
1/2" Drywall	0.45
Wall Air Space	1.62
1/2" Dens-Glass Gold	0.56
Air Infiltration Barrier	-
2" Thermax Insulation	13.00
Air Space	.97
3 5/8" Clay Brick	0.44
Exterior Air Film	0.17
TOTAL WALL R-VALUE*	17.89

1980s TRADITIONAL CAVITY WALL

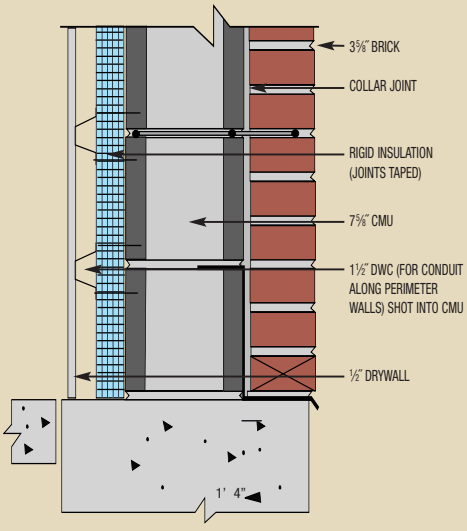


CAVITY WALL R-VALUES WITH VARIOUS INSULATION CONFIGURATIONS



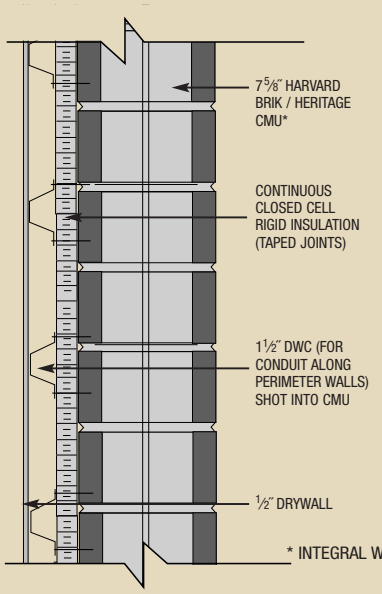
R-Value of wall using Polyisocyanurate
1½"–14.52
2"–17.73
2½"–20.53
R-Value of wall using Extruded Polystyrene
1½"–11.77
2"–14.27
2½"–16.77

SOLID COMPOSITE MASONRY WALL



R-Value of Wall Using Polyisocyanurate	
1½"	15.93
2"	19.13
2½"	21.93
R-Value of Wall Using Extruded Polystyrene	
1½"	11.81
2"	14.31
2½"	16.81
3"	19.31
R-Value of Wall Using Expanded Polystyrene	
1½"	10.31
2"	12.31
2½"	14.31
3"	16.31

SINGLE WYTHE CONCRETE UNITS HARVARD BRICK / HERITAGE BRICK

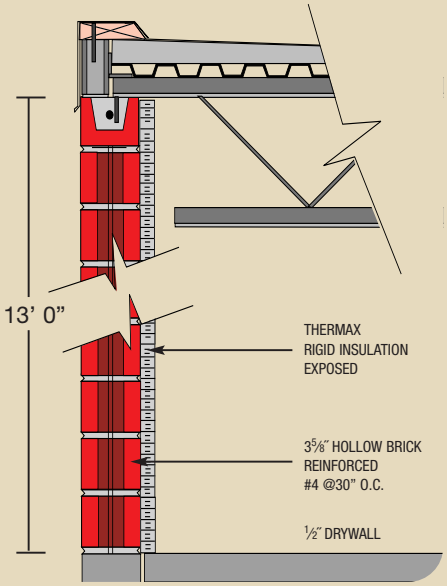


R-Value of Wall Using Polyisocyanurate	
2"	18.7
2 ½"	21.5
R-Value of Wall Using Extruded Polystyrene	
2"	13.87
2 ½"	16.37
3"	18.87

* INTEGRAL WATER REPELLENT IN CMU AND MORTAR

4″ SINGLE WYTHE HOLLOW REINFORCED BRICK

R-Value of Wall Using Thermax	
2″	14.52
2 ½″	17.32



6″ SINGLE WYTHE HOLLOW REINFORCED BRICK

R-Value of Wall Using Thermax	
2″	14.89
2 ½″	17.69