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INSULATING CONCRETE MASONRY WALLS

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INTRODUCTION

The variety of concrete masonry wall constructions provides for a number of insulating strategies. These insulating strategies include: interior insulation, insulated cavities, insulation inserts, foamed-in-place insulation, granular fills in block core spaces, and exterior insulation systems. Each masonry wall design has different advantages and limitations with regard to each of these insulation strategies. The choice of insulation will depend on the desired thermal properties, climate conditions, ease of construction, cost, and other design criteria.

MASONRY THERMAL PERFORMANCE

The thermal performance of a masonry wall depends on its thermal resistance (R-value) as well as the thermal mass characteristics of the wall. The R-value is determined by the size and type of masonry unit, type and location of insulation, finish materials, and density of masonry. Lower density concretes result in higher R-values than higher density concretes.

Thermal mass describes the ability of materials to store heat. Because of its comparatively high density and specific heat, masonry provides very effective thermal storage. Masonry walls remain warm or cool long after the heat or air-conditioning has shut off. This, in turn, effectively reduces heating and cooling loads, moderates indoor temperature swings, and shifts heating and cooling loads to off-peak hours.

The effectiveness of thermal mass varies with factors such as climate, building design and insulation position. Thermal mass is most effective when insulation is placed on the exterior of masonry. This insulation strategy keeps masonry directly in contact with interior conditioned air.

Integral insulation refers to insulation placed within the wall, usually in the cores of concrete masonry units. Integral insulation strategies also result in excellent thermal mass benefits.

Interior insulation, such as furring and insulation on the interior side of masonry, moderates the effect of exterior temperature swings on the building's interior.

INTERIOR INSULATION

Interior insulation typically consists of insulation installed between studs, as shown in Figure 1. The insulation may be fibrous batt, rigid board (polystyrene or polyisocyanurate), cellular glass, or fibrous blown-in insulation. As an alternative to studs, systems have been developed to attach insulation using specially designed clips and channels. The interior wall surface is usually finished with gypsum wallboard, panelling, or lath and plaster.

Typically, non-structural wood or metal studs are installed on the interior of the masonry, and attached at the floor and ceiling. The size of the stud is determined by the type of insulation chosen and the R-value required.

As an alternative, studs may be held away from the face of the masonry with spacers. In this case, the insulation should be stapled, or otherwise attached to the studs to prevent the insulation from becoming dislodged. The space created by the spacers provides moisture protection, as well as a convenient and economical location for additional insulation, wiring or pipes.

Because the studs penetrate the insulation, the properties of the stud should be considered in analyzing the wall's thermal performance. Metal stud penetrations through insulation significantly affect the thermal resistance by conducting heat from one side of the insulation to the other. Wood stud penetrations also affect the thermal performance. Though not as conductive as metal, the thermal resistance of

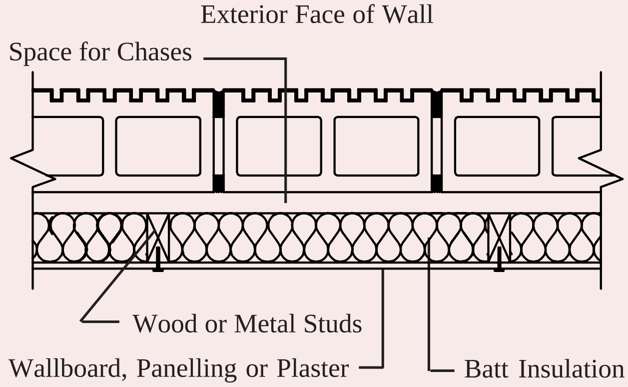

Figure 1—Typical Interior Insulation

the wood and the cross-sectional area of the stud penetration should be taken into account.

When using interior insulation, concrete masonry can accommodate both vertical and horizontal reinforcement with partial or full grouting without interrupting the insulation layer.

The durability, weather resistance, and impact resistance of the exterior of a wall remain unchanged with the addition of interior insulation. Impact resistance on the interior surface is determined by the interior finish.

INTEGRAL INSULATION

Figure 2 illustrates typical integral insulations in single-wythe masonry walls. Integral insulations are typically molded polystyrene inserts, expanded perlite or vermiculite granular fills, or foams. As for the studs used for interior insulation, the thermal resistance of the concrete masonry webs, and any grouted cores, should be accounted for when determining the thermal performance of the wall. When using integral insulation, the insulation should occupy all ungrouted core spaces.

Granular fills are placed in the masonry as the wall is laid up. Usually, the fills are poured directly from bags into the cores. A small amount of settlement usually occurs, but has a relatively insignificant effect on overall performance. Granular fills tend to flow out of any holes in the wall system. Therefore, weep holes should have noncorrosive screens on the interior, or wicks, to contain the fill while allowing water drainage.

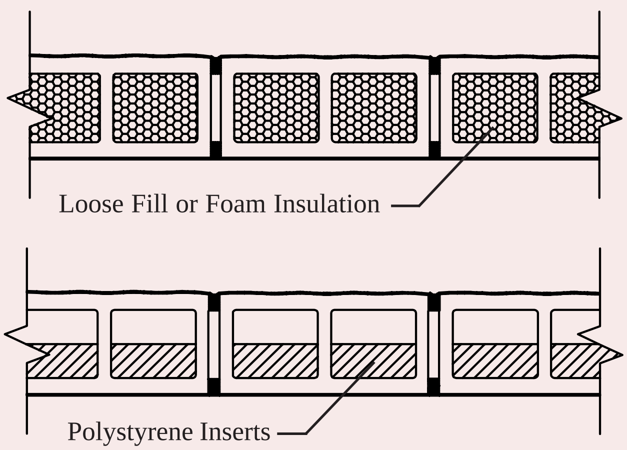

Figure 2—Typical Integral Insulation

Bee holes or other gaps in the mortar joints should be filled. In addition, drilled-in anchors placed after the insulation has been installed will require special installation procedures to prevent loss of the granular fill.

Foamed-in-place insulation is installed after the wall is completed. The installer will either fill the cores from the top of the wall, or drill small holes in the masonry and pump the foam through those holes. Foams may be sensitive to temperature, mixing conditions, or other factors. Therefore, manufacturers' instructions should be carefully followed to avoid excessive shrinkage due to improper mixing or placing of the foam.

Polystyrene inserts may be placed in the cores of conventional masonry units, or they may be used in specially designed concrete masonry units. Inserts are available in many shapes and sizes, to provide a range of R-values and accommodate various construction conditions. In pre-insulated masonry, the inserts are installed in the cores of the units at the time of manufacture. Inserts are also available which are installed at the construction site.

Specially designed concrete masonry units may incorporate reduced-height webs to accommodate inserts. Such webs also reduce thermal bridging through masonry, since the reduced web area provides a smaller cross-sectional area for heat flow through a wall. To further reduce thermal bridging, some manufacturers have developed concrete masonry units with two cross webs rather than three.

Vertical and horizontal reinforcement grouted into the cores of the units may be required for structural performance. Cores to be grouted are isolated from cores to be insulated by placing mortar on the webs to confine the grout. Granular or foam insulation is placed in the ungrouted spaces within the wall. Thermal resistance is then determined based on the average R-value of the wall area. Most rigid inserts are configured to accommodate reinforcing steel and grout, to provide both thermal protection and structural performance. When inserts are used in grouted construction, the minimum dimensions of the grout space contained in Table 1[2] should be met.

Table 1—Minimum Grout Space Dimensions

Specified grout type	Maximum grout pour height, ft (m)	Minimum[a] grout space dimensions for cells of hollow units, in. x in.
Fine	1 (0.3)	1½ x 2 (38 x 51)
Fine	5 (1.5)	2 x 3 (51 x 76)
Fine	12 (3.7)	2½ x 3 (64 x 76)
Fine	24 (7.3)	3 x 3 (76 x 76)
Coarse	1 (0.3)	1½ x 3 (38 x 76)
Coarse	5 (1.5)	2½ x 3 (64 x 76)
Coarse	12 (3.7)	3 x 3 (76 x 76)
Coarse	24 (7.3)	3 x 4 (76 x 102)

[a] Grout space dimension equals grout space width minus horizontal reinforcing bar diameter.

EXTERIOR INSULATION

Exterior insulated masonry walls are walls that have insulation outside of the thermal mass. These walls require a protective finish on the exterior to maintain the durability, integrity, and effectiveness of the insulation. In these walls, continuous exterior insulation envelopes the masonry, minimizing the effect of thermal bridges. This places the mass inside the insulation layer and the maximum heat storage is achieved. Exterior insulation also reduces heat loss due to air infiltration.

Exterior insulated masonry walls may be either multi-

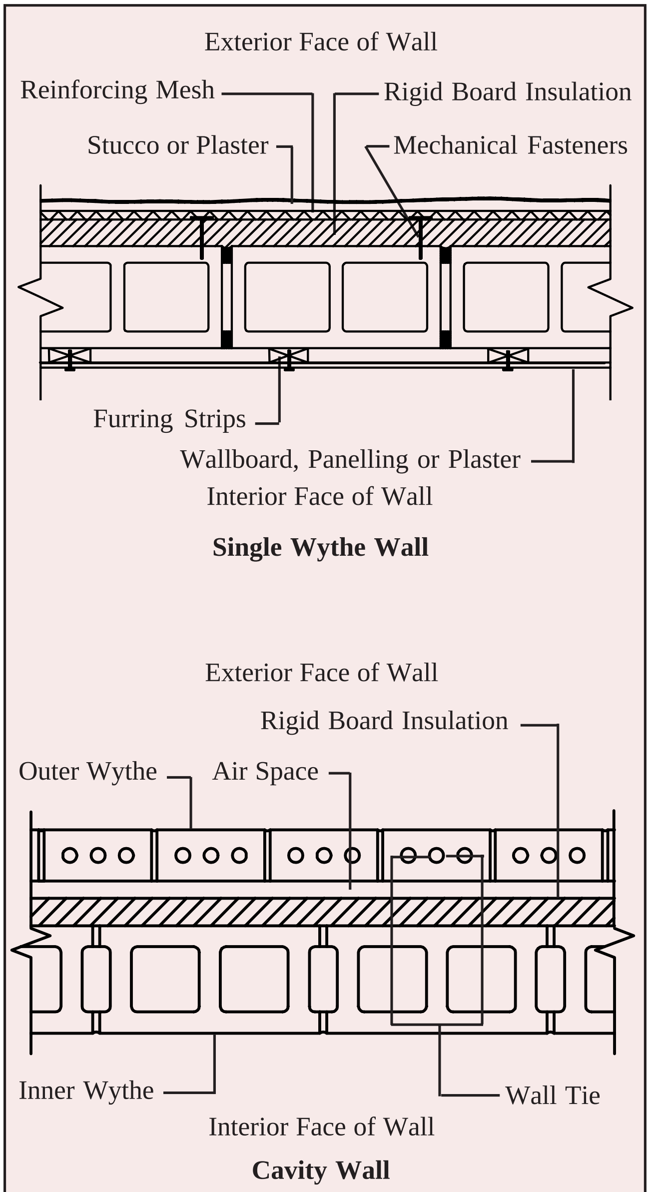

Figure 3—Typical Exterior Insulation

wythe or single-wythe construction. Multi-wythe cavity walls contain insulation between the two wythes of masonry. The cavity width can be varied to achieve a wide range of R-values. Rigid board, granular fill, or foam insulation may be used in the cavity. To further increase the thermal performance, the backup wythe, if hollow, may be integrally insulated.

When rigid board insulation is used in the cavity, the inner masonry wythe is typically completed first. The insulation is then cut into strips the same width as the vertical spacing of the wall ties. Then, the insulation can easily be installed without interfering with the ties. The board insulation is typically attached with an adhesive or mechanical fasteners. Tight joints between the insulation boards will maximize the thermal performance and reduce air infiltration. In some cases, the joints between boards are caulked or taped to ensure an effective air barrier.

In single-wythe construction, rigid board insulation is typically adhered to the exterior of concrete masonry walls. With rigid board insulation, an adhesive is used to temporarily hold the insulation in place while mechanical fasteners and protective finish are applied.

A reinforcing mesh is applied to reinforce the finish coating, improving the crack and impact resistance. Fiberglass mesh or corrosion resistant woven wire mesh are used for this purpose.

After the mesh is installed, mechanical fasteners are placed through the insulation, to anchor securely into the concrete masonry. Mechanical fasteners can be either metal or nylon. Nylon fasteners will limit the heat loss through the fasteners.

After the insulation and reinforcing mesh are mechanically fastened to the masonry, a cementitious finish coating is troweled onto the surface. This surface gives the wall its final color and texture, as well as providing weather and impact resistance.

BELOW GRADE APPLICATIONS

Below grade masonry walls typically use single-wythe wall construction, which can accommodate interior, integral, or exterior insulation.

Exterior or integral insulation is effective in moderating interior temperatures and in shifting peak loads. The typical framing used for interior insulation (Figure 1) provides a place to run electric and plumbing lines, as well as being convenient for installing drywall, or other interior finishes.

When using exterior or integral insulation strategies, architectural concrete masonry units provide a finished surface on the interior. By using smooth molded units at the base of a wall, screeding the slab is facilitated, and the space may be used to install an electric race as a molding strip.

The remainder of the wall may be constructed of smooth, split-face, split ribbed, ground faced, scored or other architectural concrete masonry units.

Insulation on the exterior of below grade portions of the wall is temporarily held in place by adhesives until the backfill is placed. That portion of the rigid board which extends above grade should be mechanically attached and protected.

SUMMARY

The wide variety of insulation strategies for concrete masonry walls provides many opportunities for a designer to provide thermal mass benefits, high R-value, and economy. Table 2 lists examples of walls with corresponding R-values which can be achieved using the insulation strategies discussed.

Table 2—Representative R-Values for 8 in. (203 mm) Normal Weight Concrete Masonry Units

	r_{insul} (a) hr·ft^2·°F/Btu·in. (m·K/W)	R_{wall} (b) hr·ft^2·°F/Btu (m^2·K/W)
Single wythe, 3½ in. (89 mm) batt	3.1 (22)	---
Wood furring	---	11.2 2.0)
Metal furring	---	7.7 (1.4)
Single wythe, 1½ in. (38 mm) rigid	5.4 (37)	10.3 (1.8)
Granular fill in CMU	---	13.2 (2.3)
Single wythe, granular fill	3.1 (22)	---
Unreinforced	---	5.1 (0.9)
Reinforced(c)	---	3.9 (0.7)
Single wythe, foamed	5.9 (41)	---
Unreinforced	---	5.4 (1.0)
Reinforced(c)	---	4.1 (0.7)
Single wythe, inserts(d)	4.4 (31)	---
Unreinforced	---	5.4 (1.0)
Reinforced(c)	---	5.3 (0.9)
Cavity wall, granular fill	3.1 (22)	15.6 (2.7)
Cavity wall, 3 in. (76 mm) rigid board	5.4 (37)	16.1 (2.8)
Granular fill in backup wythe	---	22.1 (3.9)

(a) Thermal resistivity of the insulation.
(b) Thermal resistance of the wall. Based on 125 pcf (2002 kg/m^3) concrete density. Listed R-value includes surface air film resistances.
(c) Based on vertical reinforcement at 32 in. (813 mm) on center.
(d) Based on 2.5 in. (64 mm) thick inserts, and half-height webs of concrete masonry units to accommodate the insulation insert.

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