

Roof Connections

FS · 3

An information series on residential concrete masonry technology

SUMMARY

Single-family residential roof systems are most often constructed of lumber; however, steel roof systems are also used in certain areas of the country. Concrete roof systems are used in some multifamily construction. Concrete masonry roof systems are relatively new to the market and are being used by some builders in single-family custom homes. All these roof systems are discussed herein.

Connecting a roof system to a concrete masonry wall is similar to connecting a floor system to a concrete masonry foundation wall in that most roof systems bear directly on the walls below.

While many proprietary roof systems are currently available, this fact sheet focuses on common roof systems constructed of standard dimensional lumber, wood trusses, cold-formed steel framing, steel bar joists, concrete block joists, and precast concrete roof systems. In addition, there may be more than one way to connect the roof system to a wall; these connections are grouped into the following three categories:

- ✓ direct-bearing connections;
- ✓ pocket connections; and
- ✓ ledger connections.

The most popular connections are direct-bearing connections. Light-frame builders may not be as familiar with ledger and pocket connections; those connections typically are not used in light-frame construction. Ledger and pocket connections are not, however, new to the building industry. For example, wood roof-to-masonry wall pocket and ledger connections were used in residential masonry homes in the United States during the 1700s, 1800s, and 1900s and continue to perform satisfactorily.

Similarly, residential builders may not be familiar with steel-frame or concrete roof systems. The construction details illustrated herein for steel-frame and concrete flooring systems are similar to those details used in commercial construction.

The details shown herein are “generic” and apply to typical low-wind and seismic areas (less than 110-mph, three-second-gust wind speed and less than Seismic Design Category D). It is suggested that the designer or builder consult the roof manufacturer before construction to determine if these generic details require modification when installing a proprietary roof system. Refer to local building codes and recognized standards for reinforcement and anchorage requirements. For additional requirements that

may apply to special conditions, refer to the Resources section for more information.

Multifamily or attached single-family construction often uses a parapet wall to achieve fire-rated assemblies between dwelling units. (A parapet is the segment of wall that continues beyond the roof level.) However, parapet walls are typically parallel to the span of the roof system; therefore, this fact sheet focuses only on direct-bearing connections.

DIRECT-BEARING CONNECTION

A direct-bearing connection is used in instances where the wall below does not continue beyond the roof level (i.e., no parapet). It is also used when the wall below provides a ledge with sufficient bearing area for the roof to bear on directly. The direct-bearing connection is the simplest and most common connection in the home building industry. The course of block on which the roof system bears typically is often a horizontal bond beam that ties together the walls in the story below.

WOOD-FRAME ROOFS

Wood-frame roofs most often bear directly on the concrete masonry walls below. Wood that is in direct contact with concrete masonry can potentially absorb moisture that may be present in the concrete masonry. To prevent decay, a moisture barrier (i.e., polyethylene sheet, sill sealer, felt, and galvanized sheet metal flashing) should be placed between the wood and the masonry. In lieu of using a moisture barrier, wood in direct contact with masonry must be either preservative-treated or of a durable species to prevent decay.

Standard Dimensional Lumber

The recommended methods for connecting wood-frame roofs to concrete masonry walls by direct-bearing connections are identical to those for wood truss connections; refer to Figure 3-1. Standard dimensional lumber used for residential roof systems is most often nominal 2 x 6s, 2 x 8s, 2 x 10s depending on span and loading conditions.

In high-wind (i.e., greater than 110 mph, three-second-gust) or high seismic areas (i.e., Seismic Design Category D), additional metal connectors are often necessary.

Wood Trusses

Wood trusses, also known as metal plate-connected wood trusses, are popular for roof construction because of their competitive price, reduced labor requirements for roof framing, and ability to span long distances. Wood trusses are most often fabricated of nominal 2-inch standard dimensional lumber and designed by the truss manufacturer for given span and loading conditions.

Figure 3-1 illustrates some recommended methods for connecting wood roof trusses to concrete masonry walls by using direct-bearing connections. In high-wind (i.e., greater than 110 mph, three-second-gust) or high seismic areas (i.e., Seismic Design Category D), an extra metal connector is often necessary.

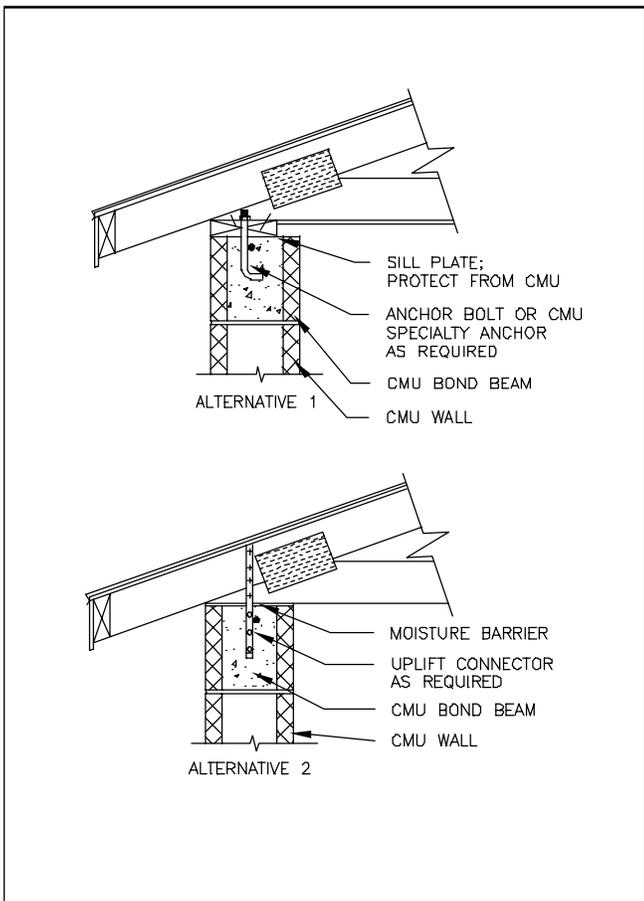


Figure 3-1: Wood Roof Truss (or Rafter) Direct-Bearing Connection

Wood I-Joists

Wood I-joists are also popular because of their consistent quality and ability to span relatively long distances. Wood I-joists resemble steel I-beams and are typically manufactured using plywood or oriented strand board for the web and solid sawn lumber for the flanges.

The recommended methods for connecting wood I-joists to concrete masonry walls are similar to those for standard dimensional lumber; refer to Figure 3-1. Consult the I-joist manufacturer for other possible methods of connecting wood I-joists to concrete masonry walls. In high-wind (i.e., greater than 110 mph, three-second-gust) or high seismic areas (i.e., Seismic Design Category D), an additional metal connector is often necessary.

STEEL

Steel-frame roofs are common in commercial structures. Steel-frame roofs are also used in multifamily construction involving long spans or in heavily infested termite areas.

Steel roofs most often bear directly on the walls below, although pocket and ledger connections may also be used. This section focuses on the direct-bearing connection, which is the most common connection in residential construction.

Cold-Formed Steel Framing

Cold-formed steel framing is typically truss-built from C-shaped members, with width and depth dimensions similar to solid sawn lumber. The framing members are placed at 16 or 24 inches on center.

Figure 3-2 illustrates one recommended method for connecting cold-formed steel-frame roof systems to concrete masonry walls by using direct-bearing connections. In high-wind (i.e., greater than 110 mph, three-second-gust) or high seismic areas (i.e., Seismic Design Category D), an additional metal connector is often necessary.

Cold-formed steel trusses are also available from manufacturers and are shipped to the site already assembled much like wood trusses; however, most steel trusses are built on site. Figure 3-2 is also applicable to cold-formed steel trusses.

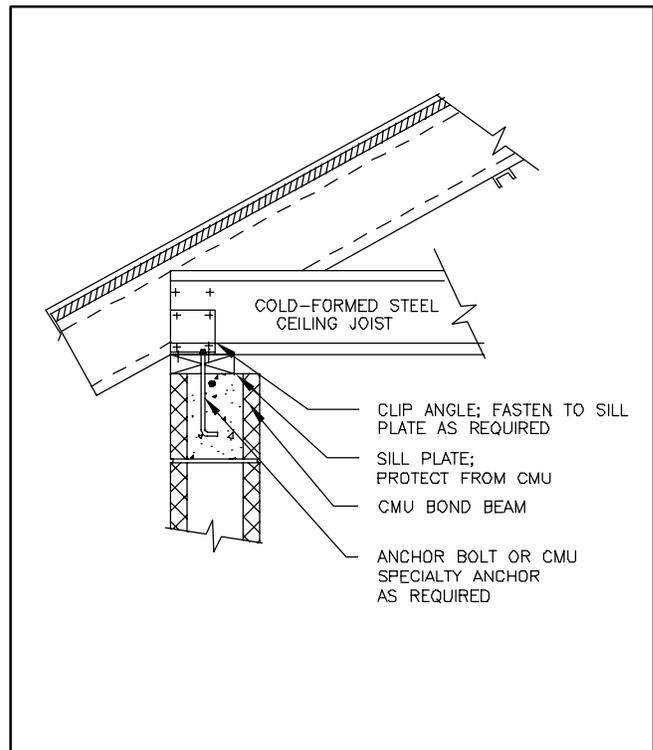


Figure 3-2: Cold-Formed Steel Roof Direct-Bearing Connection

Steel Bar Joists

Steel bar joists are open web joists that are capable of long spans. They are designed to bear directly on or to be pocketed into concrete masonry walls. In some areas, a steel ledger angle is bolted to the masonry wall such that the steel bar joists bear on the steel angle. The steel angle ledger connection is sometimes used to eliminate the need for

masons to form pockets in the wall, thereby reducing the cost of constructing concrete masonry walls. Steel bar joists may be used to construct either a flat or slightly sloped roof system.

Figures 3-3 and 3-4 illustrate some recommended methods for connecting the steel bar joist to a concrete masonry wall. Steel bar joists typically require 3 to 4 inches of bearing and should be fastened to the wall to provide anchorage for uplift and lateral forces.

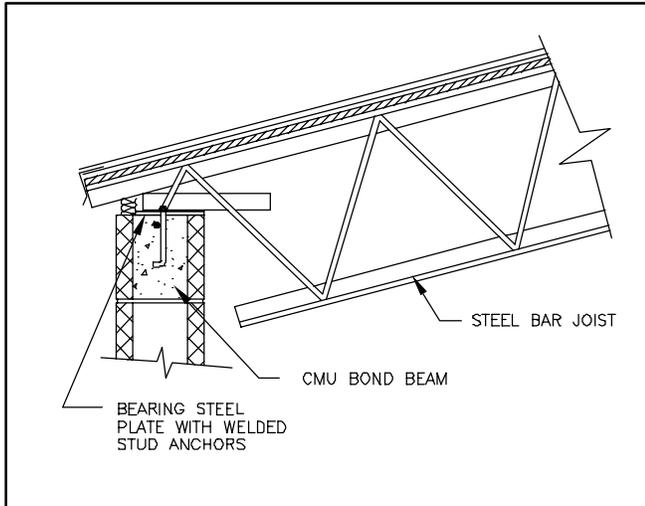


Figure 3-3: Steel Bar Joist Roof Direct-Bearing Connection

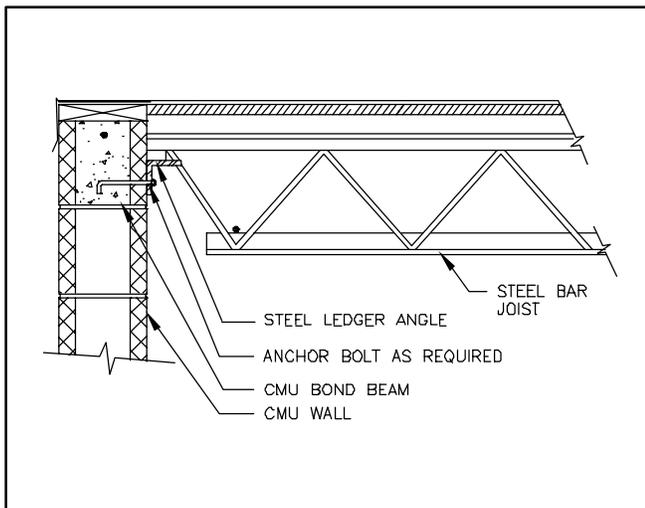


Figure 3-4: Steel Bar Joist Roof Ledger Connection

CONCRETE MASONRY

A few currently available roof systems use concrete masonry while some rely on precast concrete joists or steel bar joists; however, other materials may be used in conjunction with the concrete masonry. One system currently available is the Block Joist® System, which relies on steel bar joists for support. The Block Joist® System is a composite system that is constructed with concrete blocks placed side by side on patented steel bar joists. The bar joists rest on a ledge within the wall. Figure 3-5 illustrates how the block and steel bar joists interlock to form the finished roof deck. Some builders are using this type of roof system for patio roof deck applications where strength is

desired. Refer to the Resources section to obtain manufacturer information and installation instructions.

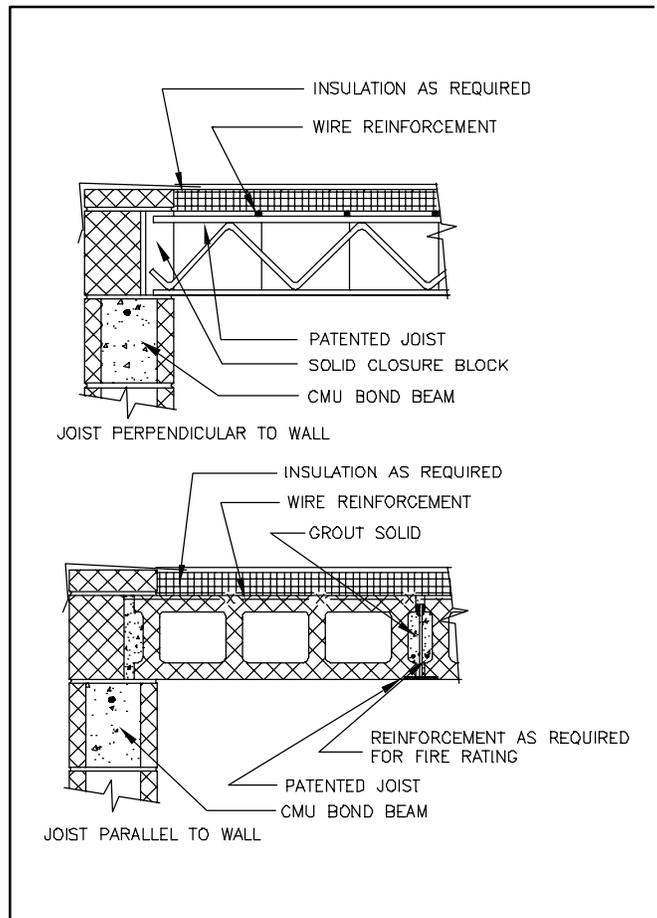


Figure 3-5: Block Joist® Roof System

CONCRETE

Concrete roofs are not common in single-family residential construction, but they are used in multifamily residential construction.

Precast or poured-in-place concrete is typically used in commercial construction because it is capable of spanning long distances and is resistant to rot and termite attack.

Precast Concrete

Precast concrete roof systems come in concrete segments in a variety of widths, thicknesses, and lengths depending on clear span and design loading conditions. In residential construction, roof segments are most often 8-inch-thick hollow core panels, 4 or 8 feet wide.

Precast concrete segments are usually installed on continuous ledges in a concrete masonry wall that provides minimum bearing.

Figure 3-6 illustrates some recommended methods for connecting the precast concrete roof segments to a concrete masonry wall by using direct-bearing connections. Pocket connections are not practical and ledger connections are not common; therefore, pocket and ledger connections are not discussed herein.

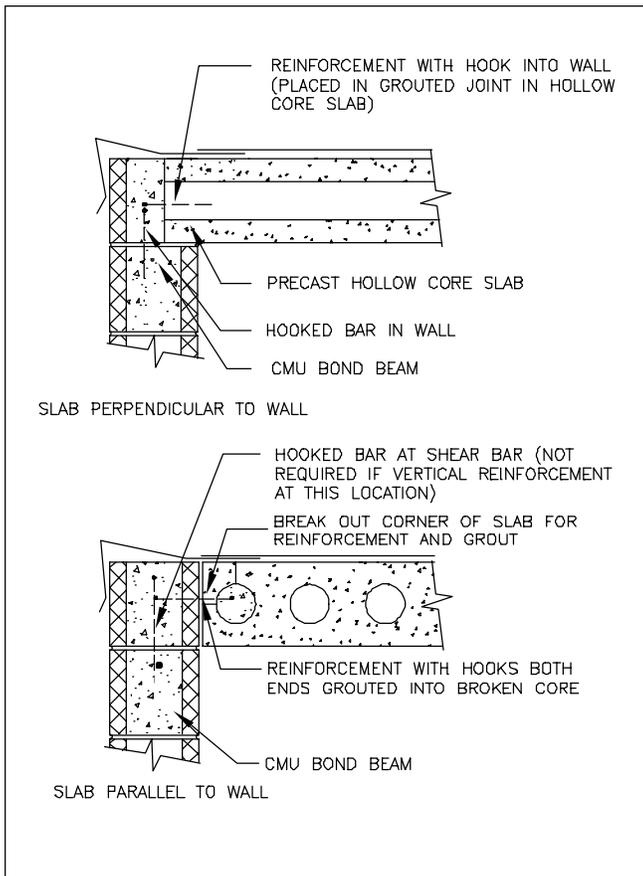


Figure 3-6: Precast Concrete Roof System

CONCLUSIONS

Good construction details are vital to the satisfactory performance of residential structures. Several roof systems are available in today's market.

The foregoing construction details are a compilation of recommended practices intended to ensure that residences resist structural forces and loads. They also address movement and other related issues that compromise the integrity of a well-constructed home. These recommended practices focus on some of the more common roof connections used in single- and multi-family construction.

RESOURCES

American Forest and Paper Association (AF&PA)

1111 19th St., NW, Suite 800
Washington, DC 20036
☎ 202.463.2700
🌐 <http://www.afandpa.org>

American Plywood Association (APA)

P.O. Box 11700
Tacoma, Washington 98411
☎ 253.565.6600
🌐 <http://www.apawood.org>

BLOCK JOIST[®] Company, LLC

109 Ralston Road
Richmond, Virginia 23229
☎ 804.285.1250

NAHB Research Center, Inc.

400 Prince George's Boulevard
Upper Marlboro, Maryland 20774-8731
☎ 800.638.8556
🌐 <http://www.nahbrc.org>

National Concrete Masonry Association (NCMA)

2302 Horse Pen Road
Herndon, Virginia 20171-3499
☎ 703.713.1900
🌐 <http://www.ncma.org>

North American Steel Framing Alliance (NASFA)

1726 M Street, N.W., Suite 601
Washington, DC 20036-4523
☎ 202.785.2022
🌐 <http://www.steel framing alliance.com>

Portland Cement Association (PCA)

5420 Old Orchard Road
Skokie, Illinois 60077-1083
☎ 847.966.6200
🌐 <http://www.portcement.org>

Precast/Prestressed Concrete Institute (PCI)

175 West Jackson Boulevard, Suite 1859
Chicago, Illinois 60604
☎ 312.786.0300
🌐 <http://www.pci.org>

Steel Joist Institute (SJI)

3127 10th Avenue, North Ext.
Myrtle Beach, South Carolina 29577-6760
☎ 843.626.1995
🌐 <http://www.steeljoist.com>

U.S. Department of Housing and Urban Development (HUD)

451 Seventh Street, S.W., Suite 8132
Washington, DC 20410
☎ 202.708.4370
🌐 <http://www.hud.gov>
Publications
☎ 800.245.2691
🌐 <http://www.huduser.org>

Wood Truss Council of America (WTCA)

6425 Normandy Lane
Madison, Wisconsin 53719-1133
☎ 608.274.4849
🌐 <http://www.woodtruss.com>



ACI 530/ASCE 5/TMS 402, *Building Code Requirements for Masonry Structures*. American Concrete Institute (ACI), American Society of Civil Engineers (ASCE), and The Masonry Society (TMS), 1999.



International Residential Code. International Code Council, Inc. (ICC), Falls Church, Virginia, 2000 (pending completion).



National Design Standard for Metal Plate Connected Wood Truss Construction. Truss Plate Institute, Madison, Wisconsin, 1995.



Prescriptive Method for Residential Cold-Formed Steel Framing, Third Edition. NAHB Research Center, Inc., Upper Marlboro, Maryland, 1998.



Metal Plate Connected Wood Truss Handbook. Wood Truss Council of America (WTCA), Madison, Wisconsin, 1994.

Finish Attachments

FS · 4

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SUMMARY

Finishes on many of the homes built in the United States are vinyl, brick veneer, wood, or stucco on the exterior and drywall or plaster on the interior. Although most homes in the United States are light-frame, these same finishes can also be installed on concrete masonry homes. In some cases, the finish system can be installed more quickly and less expensively than on light-frame homes. Home builders, however, may be unfamiliar with techniques for fastening the various finishes to concrete masonry walls.

This fact sheet focuses on general attachment details for common finish materials to concrete masonry walls. Specific tools and fasteners used to connect the finishes to the concrete masonry wall are covered in Fact Sheet 7 (FS•7). Leaving the concrete masonry wall exposed is also discussed herein.

Also of interest are requirements for moisture control (i.e., weather barrier) on masonry walls. Where weather-barriers are typically required, it is shown in the illustration. Weather-barriers allow moisture vapors to escape. Moisture, while not posing a threat to the strength of concrete masonry, may adversely affect finish and insulation systems as well as utilities. Refer to the specific finish manufacturer's technical information to determine what types of weather barriers, if required, are permitted.

As with light-frame construction, proper flashing is necessary to prevent water intrusion. Flashing should be installed around openings before the installation of finish systems.

The details shown herein are "generic". Many finish manufacturers have warranties that become void if installation does not comply with manufacturers' installation instructions. The illustrations in this fact sheet do not include guidance on the installation of flashing, window and door selection and installation, and caulking since it is not only dependent on the finish system, but also the specific finish manufacturer. As a result, it is suggested that the designer or builder consult the finish manufacturer before construction to determine what modifications are required.

EXPOSED CONCRETE BRICK OR BLOCK

The size of a "traditional" concrete masonry unit is nominally 4, 6, 8, 10, or 12 inches wide, 8 inches high, and 16 inches long. The units are typically gray with a flat finish and are usually hollow or sometimes solid. These "traditional" units are often used in residential construction to construct foundation walls. When units are used to

construct above-grade walls, builders must consider how to attach finishes to concrete masonry walls. However, exposed concrete masonry need not be gray, flat, or 8- by 16-inch modules. Today, concrete masonry units are manufactured in a wide variety of shapes, sizes, colors, and textures. Figure 4-1 illustrates various concrete blocks that are now available.

Units are also readily available in nominal 4- or 8-inch heights and nominal 8- or 16-inch lengths. These types of block are available as hollow (shown) or as solid units. Hollow units are used to construct structural walls and are available in larger widths. Hollow and solid units are installed in the same manner as traditional gray concrete blocks.

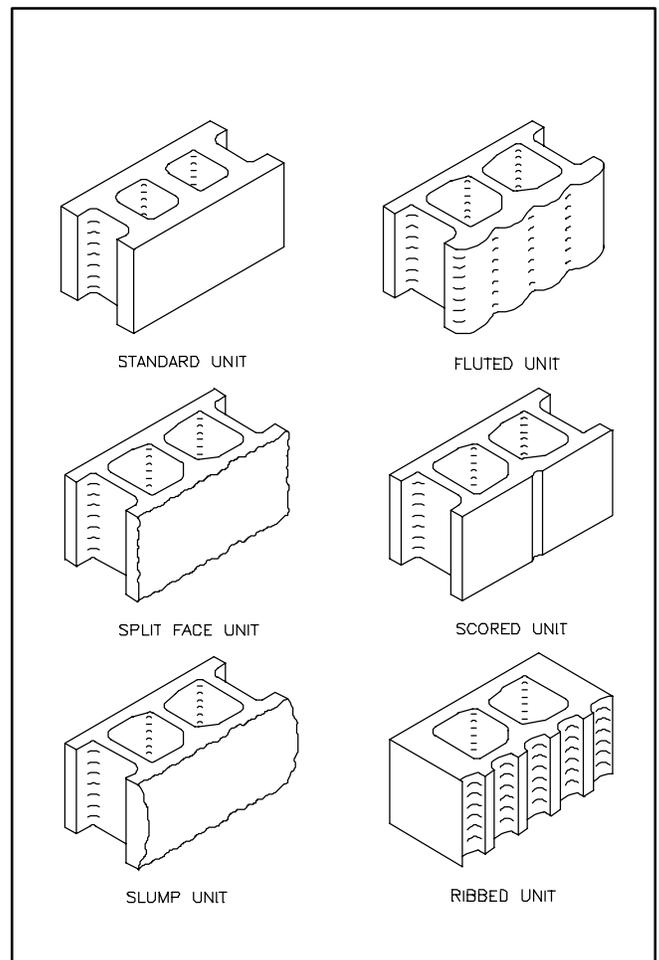


Figure 4-1: Hollow Concrete Masonry Units

Multi-colored, multitextured units are more attractive to designers, home owners, and builders than the "traditional"

gray units. A color may be used for an entire wall or designs may be created by using more than one color.

Concrete masonry units available are split-faced, slumped, fluted, ribbed, and scored. Split-faced blocks are split lengthwise by a machine to produce a rough, stone-like texture. Slump blocks are manufactured by squeezing the block after it is formed to create a bulging effect. Fluted, ribbed, and scored blocks are formed with vertical flutes, ribs, or striations that align during wall construction to give the appearance of a wall constructed of smaller units. Refer to the Resources section for more information on available shapes and sizes.

Concrete bricks may be manufactured at 3-5/8 inches wide by 2-1/4 inches high by 7-5/8 inches long -- dimensions identical to clay brick. Concrete brick may also be manufactured at 3-5/8 inches wide by 2-1/4 inches high by 15-5/8 inches long. Concrete brick veneer supports only its own weight and is anchored to a concrete masonry wall by corrosion-resistant metal ties. Refer to the local building code for the horizontal and vertical spacing requirements for brick metal ties. Figures 4-2 and 4-3 illustrate methods of anchoring concrete brick veneer to concrete masonry walls. Conventional corrugated brick ties may also be used in lieu of the ladder-type wall tie shown in Figures 4-2 and 4-3.

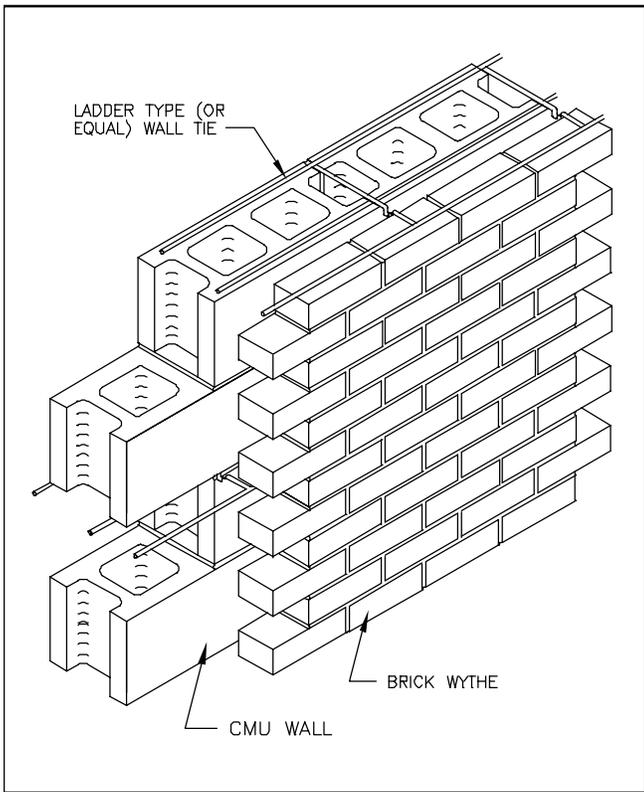


Figure 4-2: Brick Veneer (Cavity Wall)

Concrete brick is also available as a patented, tongue-and-groove interlocking concrete brick system installed in a manner similar to bevel siding. Figures 4-4a and 4-4b illustrate the interlocking concrete brick and its installation. Refer to the Resources section to obtain manufacturer information.

In single-wythe concrete masonry wall construction exposed to the weather, a water repellent is suggested. Water repellents provide resistance to wind-driven rain and protect the masonry from efflorescence and staining.

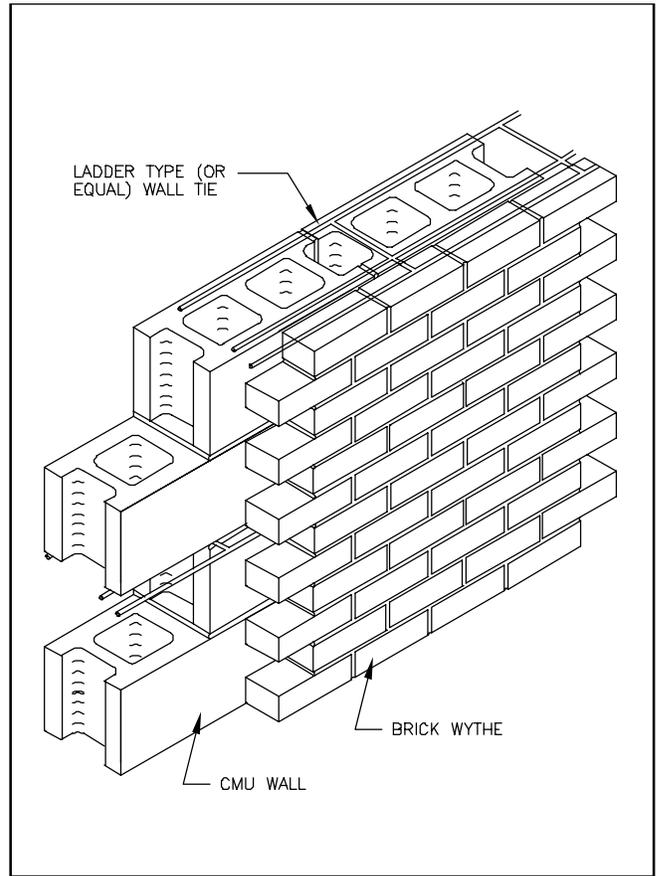


Figure 4-3: Brick Veneer (Composite Wall)

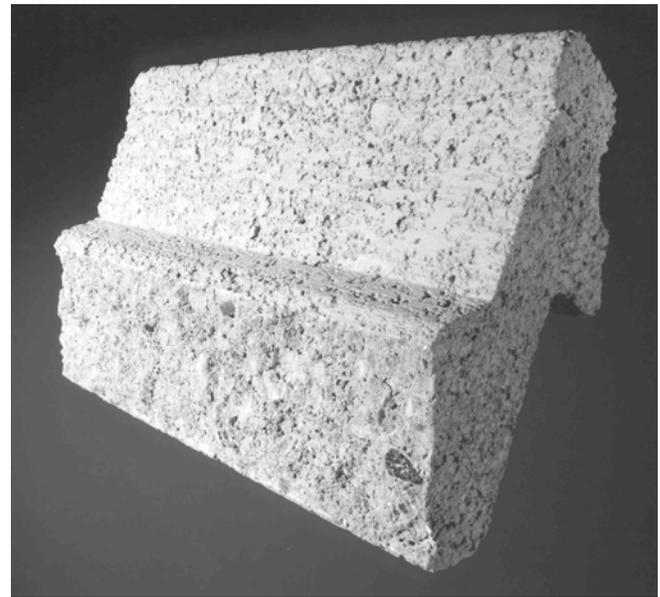


Figure 4-4a: Novabrik™ by the Allan Block Corporation

Water repellents may be surface applied after the wall is constructed or added during the manufacturing process as an admixture integral to the unit. Water repellents, whether surface applied or integral, come in a variety of colors, textures, and finishes (i.e., matte or glossy).

If used in the manufacture of masonry units, integral water repellents, should also be added to the mortar at the job site. Surface-applied water repellents should always be water vapor permeable, which means that they should allow water vapor in the wall to escape. If the water repellent does

not allow the concrete masonry wall to “breathe”, moisture can build up and cause the repellent to blister and peel. Surface repellents may be applied in addition to using an integral water repellent; however, check with the block manufacturer as well as the water-repellent manufacturer to ensure that the repellents are compatible.



Figure 4-4b: Novabrik™ by the Allan Block Corporation

CLAY BRICK VENEER

Clay brick masonry has traditionally been popular as a veneer on wood frame homes. Common face bricks are typically 3-5/8 inches wide by 2-1/4 inches high by 7-5/8 inches long. Other sizes are available in some regions. The units can be either hollow or solid and come in many different shapes, sizes, textures, and colors.

Clay brick veneer supports only its own weight and is most commonly supported by a ledge in the foundation wall. Corrosion-resistant metal ties secure the veneer to concrete masonry walls. Refer to the local building code for horizontal and vertical spacing requirements for brick metal ties. Figures 4-2 and 4-3 illustrate methods for anchoring clay brick veneer to a concrete masonry wall. Conventional corrugated brick ties may also be used in lieu of the ladder-type wall tie shown in Figures 4-2 and 4-3.

Clay brick is also manufactured as a “thin brick”, measuring 1/2-inch wide, 2-1/4 inches high, and 7-5/8 inches long. These brick units are typically fastened to the concrete masonry wall with adhesive; mortar is then applied with a mortar gun between the bricks. The resulting wall has the appearance of a traditional brick veneer wall but at less expense.

Some systems that use the 1/2-inch-thick brick also provide a patented backer board that is fastened to the concrete masonry wall. The brick is then adhered to the backer board and the mortar joints filled with a mortar gun. The patented backer board typically provides some variation of a horizontal 3/8-inch spacer to allow faster and more uniform placement of the bricks. Figure 4-5 illustrates a 1/2-inch-thick clay brick veneer system on a concrete masonry wall.

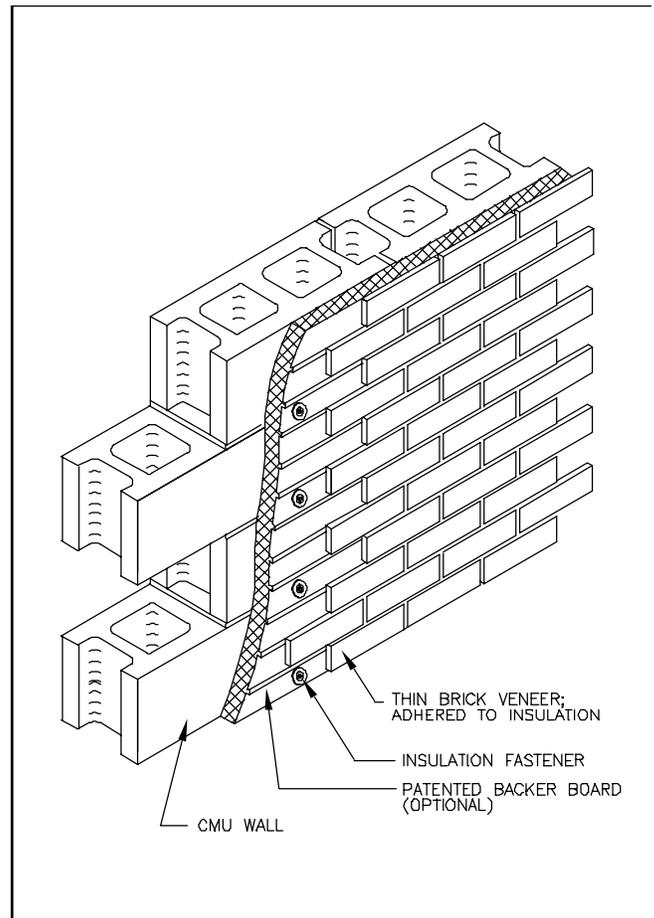


Figure 4-5: Patented Thin Brick Veneer

STONE VENEER

Unless a home is a historic or custom residence, stone is typically used as a veneer on the entry facade, or as an accent, such as for a fireplace. Stone veneer is available in thin units, between 1 and 3 inches, and in a variety of colors, textures, sizes, and shapes. Figures 4-6 and 4-7 illustrate two methods of stone veneer installation.

Depending on the thickness and weight of each unit, stone veneer is typically installed in a manner similar to brick on a structural concrete masonry wall. One end of a corrosion-resistant anchor is inserted into the mortar joint of the stone and the other end into the mortar joint of the concrete masonry wall. For thinner (i.e., 1/4- to 5/8-inch-thick) and lighter stone veneer, a thin bed of mortar is applied directly to the surface of the concrete masonry wall. The stone veneer is placed in the bed of mortar and the joints between the stone units are grouted. Figure 4-6 illustrates the method of attaching natural stone veneer to a concrete masonry wall.

Cultured stone veneer is also available and is typically less expensive and lighter in weight than natural stone. Cultured stone veneer is cast in molds by using Portland cement, light-weight natural aggregates, and color pigments to produce units that look and feel like natural stone. The lightweight cultured stone units can be fastened to the concrete masonry wall with a thin layer (i.e., 3/8-inch-thick) of mortar. If the stone selected requires joints between each stone unit, the joints are then filled with mortar. Figure 4-7 illustrates cultured stone veneer on a concrete masonry wall.

WOOD SIDING

Wood siding has been used for more than one hundred years in the United States and has traditionally taken the form of lap-board or bevel siding. It is manufactured to standard sizes and made by sawing plain-surfaced boards at a diagonal to produce two wedge-shaped pieces. The siding is about 3/16 inch thick at the thin edge and 1/2 to 3/4 inch thick at the other edge, depending on the width of the piece. Refer to Figure 4-8, which illustrates the attachment of wood siding to a concrete masonry wall.

Plain bevel siding is lapped (hence the term lap-board) so it will shed water. A minimum lap of 1 inch is used for 6-inch widths, while 8- and 10-inch siding should lap about 1-1/2 inches.

Vertical wood siding is also commonly used. It may be plain-surfaced matched boards, pattern-matched boards, or square-edge boards covered at the joint with a batten strip.

Plywood siding is common. Panel sizes are 4 feet wide by 8, 9, and 10 feet long. To eliminate horizontal joints, plywood is installed vertically. Once installed, plywood lapped sidings may look the same as regular bevel siding.

Wood siding should not be fastened directly to concrete masonry walls. Typically, preservative-treated nominal 1 x 3 wood furring strips are fastened at 16 or 24 inches on center perpendicular to the direction of the wood siding. The wood siding is then fastened to the furring strips with zinc-coated steel, aluminum, or other noncorrosive nails. Plain steel-wire nails with large heads are not recommended because they produce unsightly rust spots on most paints and stains.

ALUMINUM SIDING

Aluminum siding is factory finished with baked-on enamel and, in appearance, closely resembles painted wood siding. A variety of horizontal and vertical panel styles in both smooth and textured designs are produced with varying shadow lines and size of face exposed to the weather. Panels are fabricated with prepunched nail and vent holes and a special interlocking design.

Aluminum siding is attached to concrete masonry walls in a manner similar to wood siding; refer to Figure 4-8. Typically, preservative-treated furring strips are fastened at 16 or 24 inches on center perpendicular to the direction of the aluminum siding. The aluminum siding is then fastened to the furring strips with zinc-coated steel, aluminum, or other noncorrosive nails; however, the siding should not be fastened tightly to the furring strips to allow for expansion and contraction. Each aluminum strip or piece hooks into the course below and is secured in place by nailing along the slotted top edge. Panels are designed with moisture-proof interlocking joints. A special corner piece covers the ends and allows for expansion and contraction resulting from temperature changes.

Aluminum siding is usually installed with a backer board or insulation board behind each panel. The insulation board adds rigidity and strength as well as insulating value to the aluminum. Many manufacturers produce siding products that include special designs or patented devices to

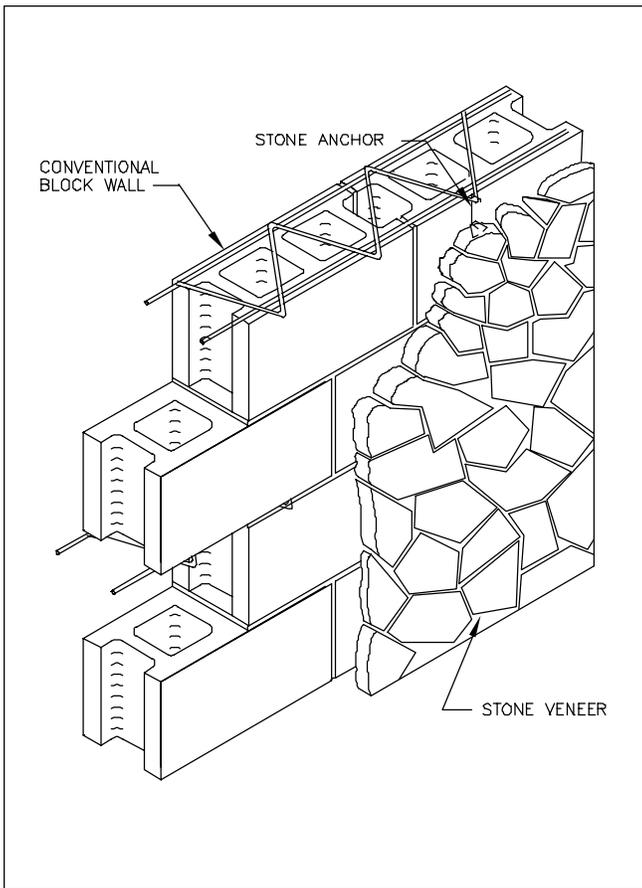


Figure 4-6: Stone Veneer

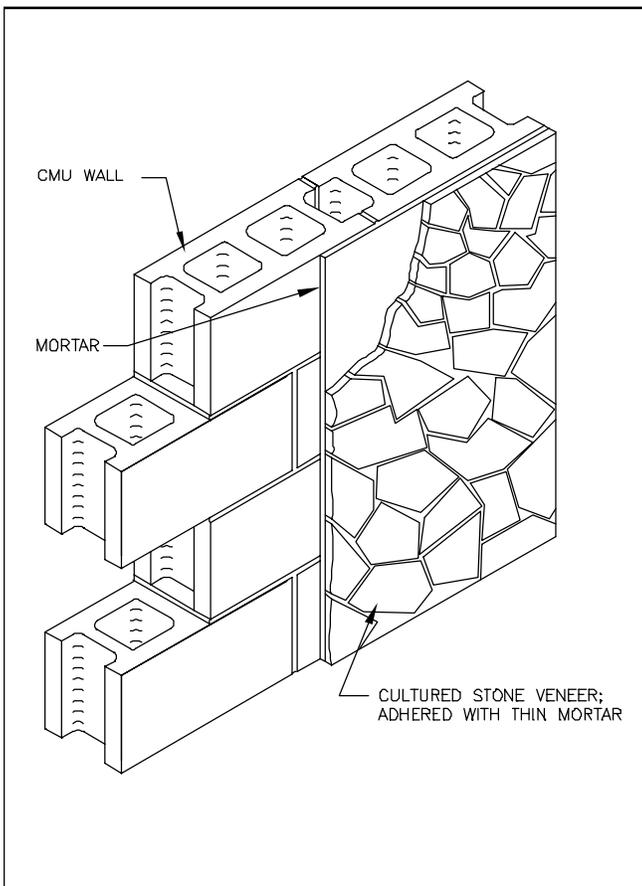


Figure 4-7: Cultured Stone Veneer

simplify installation. Figure 4-8 illustrates the attachment of aluminum siding to a concrete masonry wall.

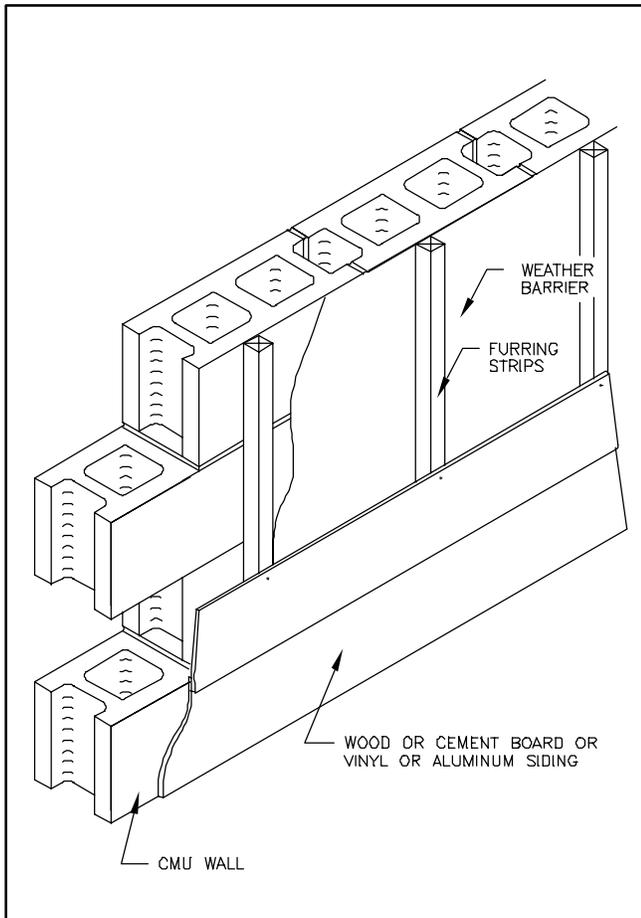


Figure 4-8: Wood, Aluminum, Vinyl, or Fiber-Cement Siding

VINYL SIDING

Vinyl siding is fabricated of a rigid polyvinyl chloride compound that is tough and durable. It is extruded into vertical and horizontal siding and accessories. It resembles painted wood siding.

A variety of horizontal and vertical panel styles in both smooth and textured designs are produced with varying shadow lines and size of face exposed to the weather. Panels are fabricated with prepunched nail and vent holes and a special interlocking design.

Vinyl siding is attached to a concrete masonry wall in a manner similar to wood or aluminum siding; refer to Figure 4-8. Typically, preservative-treated furring strips are fastened at 16 or 24 inches on center perpendicular to the direction of the vinyl siding. The vinyl siding is then fastened to the furring strips with zinc-coated steel, aluminum, or other noncorrosive nails; however, the siding should not be fastened tightly to the furring strips to allow for expansion and contraction. Each vinyl strip or piece hooks into the course below and is secured in place by nailing along the slotted top edge. Panels are designed with moisture-proof interlocking joints. A special corner piece covers the ends and allows for expansion and contraction resulting from temperature changes.

Vinyl siding is usually installed with a backer board or insulation board behind each panel. The insulation board

adds rigidity and strength as well as insulating value to the vinyl.

Many manufacturers produce siding products that include special designs or patented devices to simplify installation.

FIBER-CEMENT SIDING

Fiber-cement siding is fabricated of Portland cement, sand, cellulose fiber, and water; some manufacturers may add other materials. Fiber-cement siding closely resembles painted wood siding and is available factory primed from some manufacturers.

A variety of horizontal and vertical panel styles in both smooth and textured designs are produced with varying shadow lines and size of face exposed to the weather. Fiber-cement siding may be lapped or installed vertically with battens. It is typically 5/16 inch thick. Panels are available in 4 feet by 8, 9, or 10 feet.

Fiber-cement siding is attached to a concrete masonry wall in a manner similar to wood siding; refer to Figure 4-8. Typically, preservative-treated furring strips are fastened a maximum of 24 inches on center perpendicular to the direction of the fiber-cement siding. The fiber-cement siding is then fastened to the furring strips with zinc-coated steel, aluminum, or other noncorrosive nails.

Fiber-cement siding does not require a backer board or insulation board behind each panel for added rigidity; however, a backer board may be installed for thermal value.

STUCCO

Stucco is a finish composed mainly of Portland cement, sand, water, lime, and/or acrylic. Figure 4-9 illustrates the application of stucco to the exterior of a concrete masonry wall.

The three categories of stucco are as follows:

- ✓ Portland cement stucco;
- ✓ polymer-modified stucco; and
- ✓ polymer-based stucco.

Portland cement stucco (PC) is sometimes referred to as traditional stucco and contains no acrylic. Polymer-modified stucco (PM) is sometimes referred to as hard-coat stucco and contains a minimal amount of acrylic. Polymer-based stucco (PB) is sometimes referred to as soft-coat stucco and contains approximately 50 percent acrylic. Acrylic gives stucco some flexibility and water resistance; therefore, stuccoes containing acrylic are more popular in areas subject to severe freeze-thaw cycles.

Stucco is applied to a concrete masonry wall in two or three layers or coats. The first coat is termed the scratch coat and is approximately 1/4 to 3/8 inch thick. The second coat of a three-coat system is termed the brown coat and is approximately 3/8 to 1/2 inch thick. The third coat of a three-coat system or the second coat of a two-coat system is termed the finish coat and is approximately 1/4 inch thick. The finish coat may be tinted by adding color, or the surface may be painted with a suitable material.

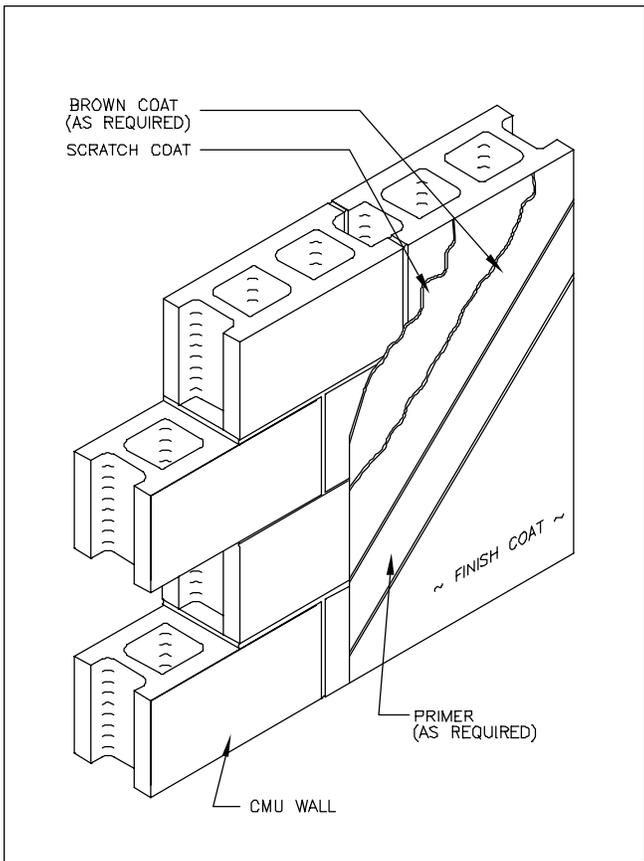


Figure 4-9: Stucco

Stucco on concrete masonry does not require a metal lath base as in its application to light-frame homes because the concrete masonry often provides a porous, textured solid surface to which the stucco attaches. Concrete masonry that does not provide a good bond for stucco needs to be treated with a bonding agent (i.e., primer) before application of the stucco. Molding (i.e., corner bead) with a groove that “keys” the stucco is applied at edges and around openings. Fasteners required to fasten accessories to the concrete masonry wall should be of noncorrosive material.

DECORATIVE MASONRY FINISH

Many homes in Florida are finished with a 3/8-inch-thick masonry decorative finish. Although the material is identical to stucco as described in the previous section, it is thinner than conventional Portland Cement stucco. Such a finish system is termed a “decorative masonry finish” and is installed primarily to provide a smooth weather-resistant finish over a concrete masonry wall and hide mortar joints.

EXTERIOR INSULATED FINISH SYSTEM

Synthetic stucco is commonly referred to as an Exterior Insulated Finish System (EIFS). EIFS is a finish system that is installed with a maximum 4-inch-thick rigid foam insulation board adhered to a concrete masonry wall as the base. Fiberglass mesh is then installed on the insulation board and covered with two coats—a cement-based base coat and an acrylic-modified synthetic finish coat in the desired color. The finish coat is troweled, sprayed, or rolled on.

EIFS is available as either a drainable system or a system without drainage. Figures 4-10 and 4-11 illustrate drainable and undrainable EIFS, respectively. Drainable systems have an additional material layer between the insulation and the concrete masonry wall to allow water to flow behind the finish system into weep holes below. Some drainable systems use patented rigid insulation with drain channels molded onto the back face of the insulation. The channels eliminate the need for installing separate drain material. At the top of openings, bottom of walls, etc., weep holes are created to allow any accumulated water to exit the wall.

Fasteners required to fasten the insulation, molding, and other accessories to the concrete masonry wall are typically required to be galvanized or of another noncorrosive material.

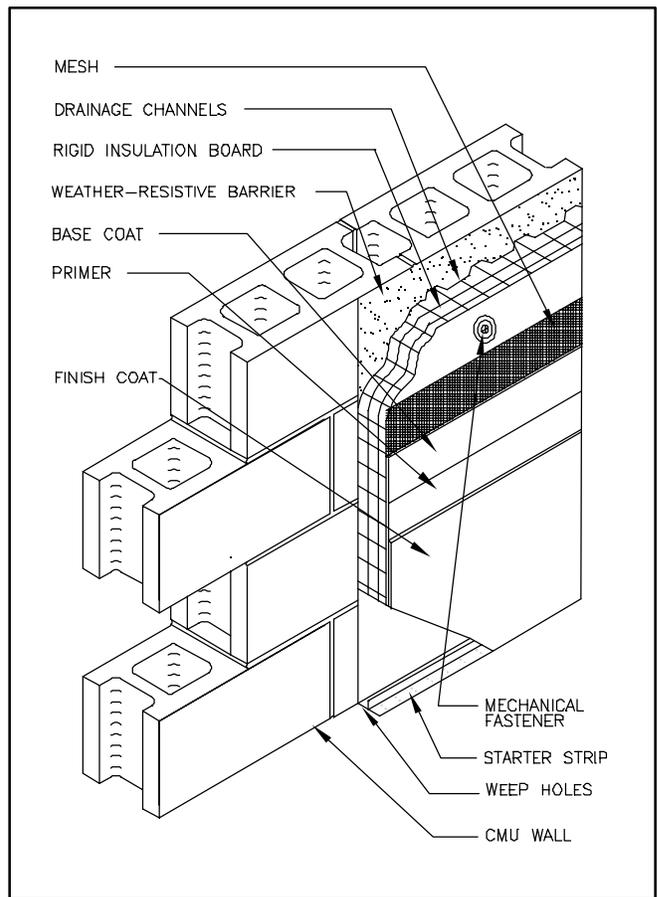


Figure 4-10: EIFS (Drainable)

INTERIOR FINISHES

Exposed brick or block, stone veneer, wood or concrete paneling, and stucco as described in earlier sections for exterior finishes may also be used for interior residential finishes; therefore, they are not discussed here. Other finishes, however, used for the interior but not commonly used for residential exterior applications include gypsum board (i.e., drywall), plaster, and wallpaper. Refer to Figures 4-12, 4-13, and 4-14 for the typical installation of these systems on a concrete masonry wall.

Gypsum board may be adhered to above-grade concrete masonry walls with construction adhesive. Bracing is

typically required to hold the gypsum board in place until the adhesive sets. Where moisture on the interior surface of the concrete masonry wall may occur (i.e., below-grade walls), gypsum board should be installed on preservative-treated furring strips 16 or 24 inches on center to provide a minimum 1/2-inch air space between the wall and the gypsum board.

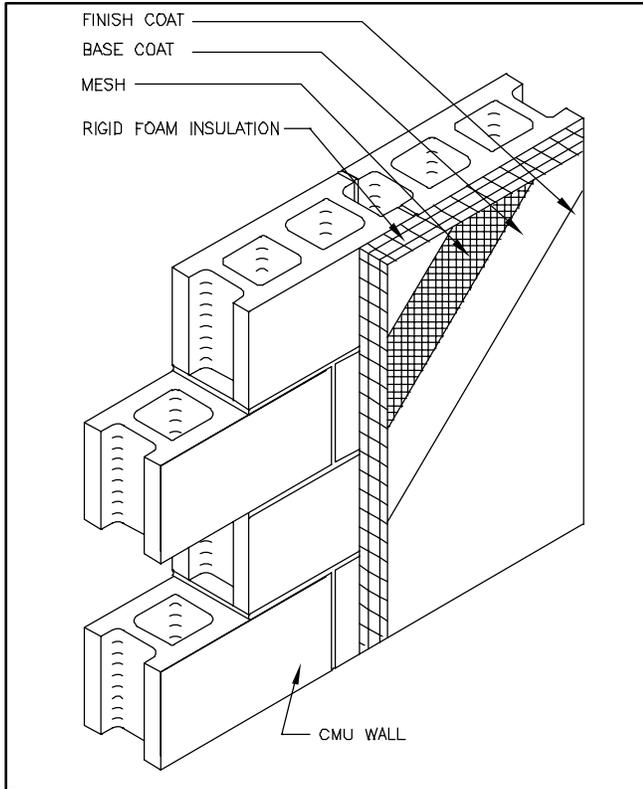


Figure 4-11: EIFS (Nondrainable)

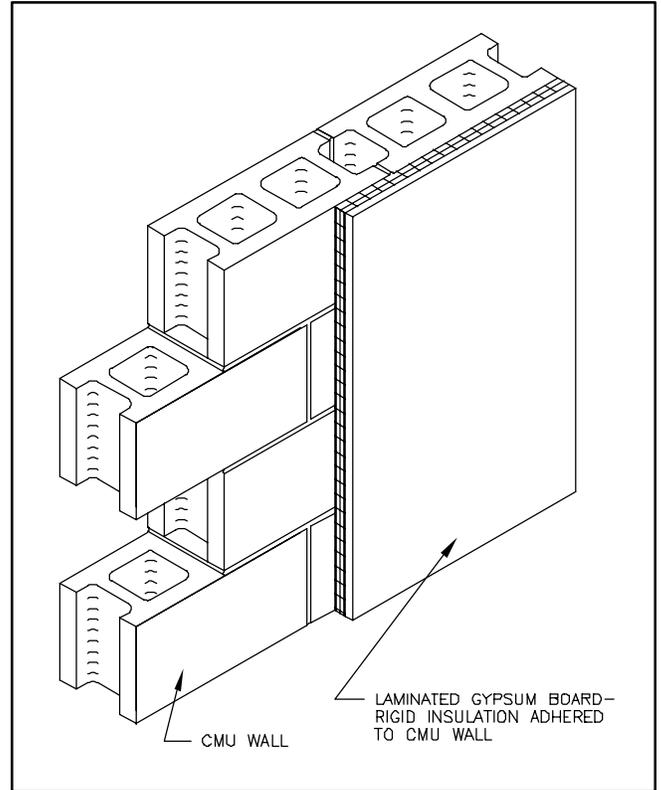


Figure 4-13: In-Sulate by Agile Building Systems, LLC

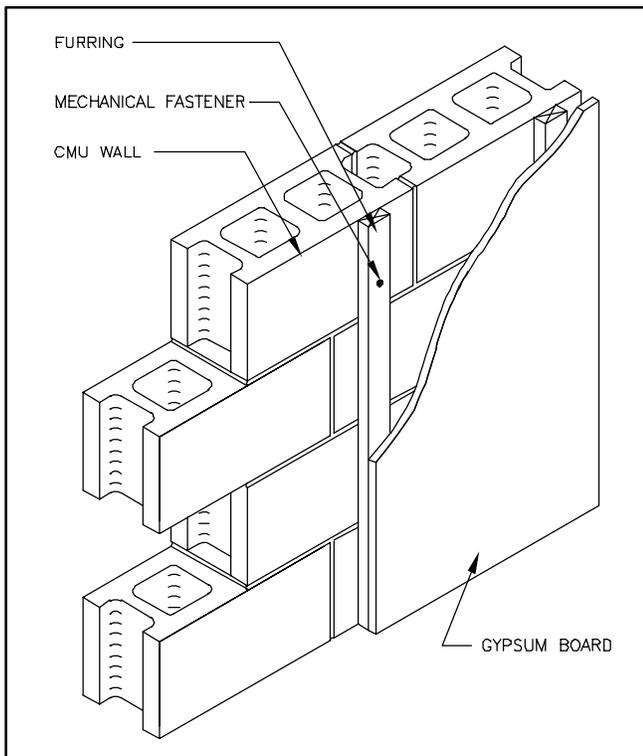


Figure 4-12: Gypsum Board

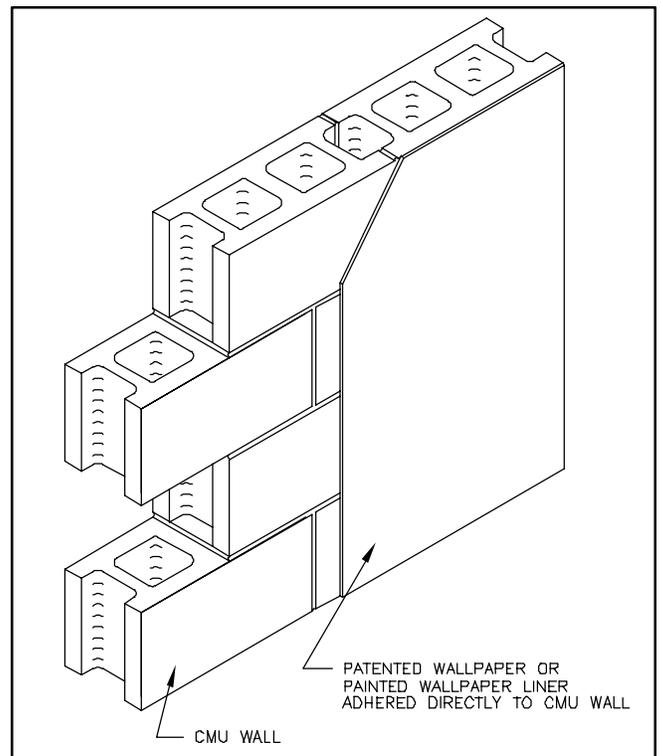


Figure 4-14: Plaster in a Roll™ by Flexi-Wall Systems

Now available is a product (In•Sulate from Agile Building Systems, LLC) that is a laminate of gypsum board and rigid board insulation. The rigid board insulation provides a moisture barrier between the block and the gypsum board and is installed in large sheets in a single step. The laminate is glued to a concrete masonry wall with construction adhesive.

Plaster is traditional Portland cement stucco for interior use. It is installed on the interior in the same way that exterior traditional stucco is applied. Refer to the Stucco section for more information about plaster (traditional (PC) stucco) and its proper application on a concrete masonry wall.

Generally, wallpaper cannot be installed directly on concrete masonry; however, some wallpapers (i.e., gypsum-based, fabric-backed wallpaper) are designed specifically for use over concrete masonry, concrete, or other surfaces that have shallow joints, holes, etc. The wallpaper is typically a heavy, jute-type fabric impregnated with gypsum plaster that bridges small cracks and mortar joints. It is installed in a manner similar to traditional wallpaper and is available in a variety of colors. However, instead of drywall paste, a patented adhesive is required. This wallpaper is known as Plaster in a Roll™. Available too is a plaster wall liner known as Faster Plaster™. The wall liner is similar to heavy, jute-type fabric impregnated with gypsum plaster and is installed like wallpaper; however, it provides a fine-textured plaster finish on which paint or regular wallpaper can then be applied.

CONCLUSIONS

Several finishes and finish systems are available in today's market that can be used with masonry wall construction.

Good and practical construction details are vital to the satisfactory performance of exterior and interior finishes on concrete masonry wall construction. The details herein are generic, but represent good practice. Many finish manufacturers have warranties that become void if installation does not comply exactly with the manufacturers' installation instructions; therefore, the designer or builder is advised to consult the finish manufacturer before installation to determine if the generic details require modification.

RESOURCES

Agile Building Systems, LLC

30 West Third Street, Third Floor
Williamsport, Pennsylvania 17701

☎ 888.326.5640

🌐 <http://www.freeyellow.com/members5/agilebuilding>

Allan Block Corp.

7400 Metro Boulevard, Suite 185
Edina, Minnesota 55439

☎ 612.835.5309

🌐 <http://www.allanblock.com>

🌐 <http://www.novabrik.com>

Aluminum Association (AA)

900 19th Street, N.W., Suite 300
Washington, DC 20006

☎ 202.862.5100

🌐 <http://www.aluminum.org>

American Forest and Paper Association (AF&PA)

1111 19th Street, N.W., Suite 800

Washington, DC 20036

☎ 800.890.7732

🌐 <http://www.afandpa.org>

American Hardboard Association (AHA)

1210 W. Northwest Highway

Palatine, Illinois 60067

☎ 708.934.8800

American Plywood Association (APA)

P.O. Box 11700

Tacoma, Washington 98411-0700

☎ 253.565.6600

🌐 <http://www.apawood.org>

Association of the Wall and Ceiling Industries (AWCI)

803 West Broad Street, Suite 600

Falls Church, Virginia 22046

☎ 703.534.8300

🌐 <http://www.awci.org>

Brick Institute of America (BIA)

11490 Commerce Park Drive, Suite 300

Reston, Virginia 22091

☎ 703.620.0010

🌐 <http://www.brickinst.org>

Building Stone Institute (BSI)

85 Yerkes Road

Purdys, New York 10578

☎ 914.232.5725

Cast Stone Institute (CSI)

10 W. Kimball Street

Winder, Georgia 30680

☎ 770.868.5909

🌐 <http://www.caststone.org>

Flexi-Wall Systems

208 Carolina Drive

P.O. Box 89

Liberty, South Carolina 29657-0089

☎ 800.843.5394

Gypsum Association (GA)

81 First Street, N.E., Suite 510

Washington, DC 20002

☎ 202.289.5440

🌐 <http://www.gypsum.org>

NAHB Research Center, Inc.

400 Prince George's Boulevard

Upper Marlboro, Maryland 20774-8731

☎ 800.638.8556

🌐 <http://www.nahbrc.org>

National Concrete Masonry Association (NCMA)

2302 Horse Pen Road

Herndon, Virginia 20171-3499

☎ 703.713.1900

🌐 <http://www.ncma.org>

National Paint and Coatings Association (NPCA)

1500 Rhode Island Avenue, N.W.

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☎ 202.462.6272

🌐 <http://www.paint.org>

National Stone Association (NSA)

1415 Elliott Place, N.W.

Washington, DC 20007

☎ 202.342.1100

🌐 <http://www.aggregates.org>

Portland Cement Association (PCA)

5420 Old Orchard Road

Skokie, Illinois 60077-1083

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🌐 <http://www.portcement.org>

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Vinyl Siding Institute (VSI)

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Washington, DC 20006

☎ 202.974.5200

🌐 <http://www.vinylsiding.org>



Concrete Shapes and Sizes Manual. National Concrete Masonry Association (NCMA), Herndon, Virginia, 1997.



Concrete Masonry Handbook, fifth edition. Portland Cement Association (PCA), Skokie, Illinois, 1991.

Insulation Placement

FS • 5

An information series on residential concrete masonry technology

SUMMARY

Several types of insulation systems as well as insulation materials are available for use in residential concrete masonry construction; however, some home builders may be unfamiliar with the appropriate installation techniques. This fact sheet discusses basic types of insulation, thermal properties, and general installation guidelines; refer to Fact Sheet 7 (FS•7) for more information on specific fasteners and tools.

Insulation types are discussed in terms of method of installation. A concrete masonry wall system may be insulated by

- ✓ inserting insulation into the concrete masonry unit core;
- ✓ applying insulation to the surface of the concrete masonry unit; or
- ✓ manufacturing concrete masonry units that have inherent insulating properties.

The details shown herein are generic in nature. The designer or builder is advised to consult the insulation or specialty block manufacturer before installation to determine specific installation requirements.

R-VALUE VERSUS THERMAL MASS

Recent years have seen greater emphasis on the thermal performance of a home in terms of the complete home “envelope”, taking into account thermal resistance, thermal mass, and air infiltration.

Thermal resistance, commonly referred to as R-value, is a standard measure of the thermal performance of a material or system. The R-value describes the steady state resistance to heat flow through a building component. While thermal resistance is an effective and popular tool for comparing component performance, it is not the only factor in determining whether the whole-house system is energy-efficient.

The role of thermal mass in energy efficiency is less clear and difficult to calculate and quantify. Thermal mass materials have the ability to absorb and store heat, slowly releasing the heat over an extended period. In addition, thermal mass materials absorb and release heat at a slower rate than low-mass materials, a feature that may be used to keep a room at a more constant temperature. Materials such as concrete have a high thermal mass; therefore, thermal mass influences heating, ventilating, and air conditioning (HVAC) design in a concrete masonry home much more so

than in light-frame construction. The higher the thermal mass of a material, the better its ability to keep interior temperatures constant as exterior temperatures vary throughout the day. For example, in the Southwest, the sun heats the exterior of a concrete masonry wall to temperatures over 100 degrees F during the course of a day. Due to the concrete masonry unit’s high thermal mass, the heat given does not penetrate to the other side of the wall until 2 to 4 hours later (i.e., late afternoon or early evening) for hollow concrete masonry walls or 6 to 8 hours later for solid grouted concrete masonry walls. By that time, outside temperatures tend to drop significantly and heat may be provided by the thermal mass effect. If the structure is located in an area in which exterior temperatures do not vary widely, thermal mass has less impact on energy savings.

Monolithic installation of masonry can help decrease air leakage through the wall system provided penetrations through the wall are sealed. Thermal mass and reduced infiltration, do not, however, provide sufficient resistance to heat flow. In many climates in the United States, insulation must be installed. Refer to Table 1 for a comparison of R-values for common insulating materials and concrete masonry units. The following sections discuss many different insulation materials.

Table 5-1: Typical R-Values

Insulating Material	Representative R-Value (per inch of thickness)
Fiberglass batt	3
Polyisocyanurate	7
Polystyrene--expanded	4
Polystyrene--extruded	5
Polyurethane	8
Perlite	3
Vermiculite	2
Foamed-in-place	5
Material	Representative R-Value
Radiant insulation	4.5
Concrete Masonry Unit	Representative R-Value (total)
<i>Normal-Weight</i>	
4-inch-thick	0.8
8-inch-thick	1
12-inch-thick	1.2
<i>Light-Weight</i>	
4-inch-thick	1.5
8-inch-thick	2
12-inch-thick	2.5

CORE INSULATION

Core insulation refers to insulation placed into the inner cores of a concrete masonry unit. A variety of insulation materials may be used for this purpose. When core insulation is used in traditionally shaped concrete masonry units the concrete masonry webs of the unit remain uninsulated, preventing the overall wall system's R-value from reaching values as high as those associated with some other insulation placement techniques described herein. Inserting insulation into the cores of the unit, however, may reduce the time needed to install an insulated concrete masonry unit (CMU) wall and allows the CMU to remain exposed on both faces for aesthetic reasons if desired.

If the surfaces of the concrete masonry wall are not desired to be exposed, surface-applied insulation described in the following sections may further enhance the R-value.

Three types of insulation may be used to fill the concrete block core as follows:

- ✓ poured-in-place;
- ✓ foamed-in-place; and
- ✓ standard molded inserts.

Poured-in-Place Insulation

Poured-in-place insulation typically consists of vermiculite or perlite either poured in upon completion of an unreinforced wall or poured in stages in a horizontally reinforced wall. Poured-in-place insulation provides increased thermal resistance, although it may settle over time; as a result, the top of the wall or core may eventually have little to no insulation. Poured-in-place materials vary in their ability to retard fire and moisture; consult the manufacturer to ensure that the product selected meets local code requirements.

Foamed-in-Place Insulation

Foams may also be installed in the core in a manner similar to poured-in-place insulation. Most foams consist of two separate chemicals that, when mixed, react to each other and create the foam. A foam applicator is available to mix the two chemicals during application, simplifying installation.

Numerous chemicals are currently on the market. In the past, some foams contained formaldehyde; many jurisdictions have subsequently banned them. It is important to determine the content of the foam under consideration and verify compliance with local codes.

Molded Insulation Inserts

Molded insulation typically consists of a molded expanded polystyrene (EPS) insert that is wedged into the core of a concrete masonry unit; refer to Figure 5-1 for an illustration of one such unit currently available.

Some molded insulation core inserts are fitted in the field; however, most inserts are already inserted into the concrete masonry unit's core at the factory. Preinsulated concrete masonry unit cores eliminate the need for an additional crew in the field, simplifying the installation of the masonry unit and reducing labor costs. Preinsulated

concrete units typically, however, have higher material costs.

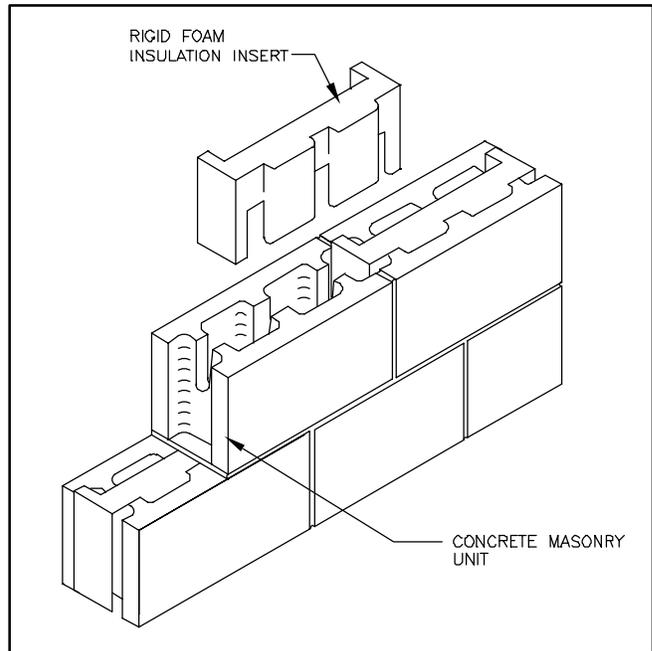


Figure 5-1: Molded Insert Core Insulation

SURFACE INSULATION FOR SINGLE-WYTHE CONSTRUCTION

Several insulation systems may be installed to the concrete masonry wall's surface upon completion of the masonry wall.

Applying rigid insulation to the interior or exterior face of a single-wythe concrete masonry wall is common. Surface insulation is particularly labor-intensive in that it requires additional steps during construction; however, by covering the entire wall surface of one or both faces of the concrete masonry wall, surface insulation increases the R-value of the concrete masonry wall more than core insulation.

Insulation Types

Three insulation materials are used for this application as follows:

- ✓ polystyrene;
- ✓ polyurethane; and
- ✓ polyisocyanurate.

Polystyrene comes in two basic categories: expanded bead and extruded. Expanded bead is made by superheating pellets of styrene until they expand to form a foam insulation that is both light and inexpensive. Extruded polystyrene is the same chemical product as expanded polystyrene, but is extruded and does not possess beads or visible voids. Extruded polystyrene is more expensive than expanded polystyrene; however, the material has a higher R-value per inch of thickness. Refer to Table 5-1 for respective R-value ranges.

Polyurethane and polyisocyanurate foam insulations are similar. Both are closed-cell foams that contain a low-conductivity gas in the cells. The high thermal resistance of

the gas contributes to the foams' high R-values; refer to Table 5-1 for R-values. Polyisocyanurate is more fire-resistant and has a slightly higher R-value than polyurethane foams, but both have a propensity to absorb moisture, which limits their use in moist exterior applications, particularly below grade.

Radiant "insulation" is also available and serves as both a reflective insulation and vapor retarder. It is comprised of a very thin sheet of paper-backed aluminum foil laminated to expanders that separate the paper from the foil creating a reflective air space. It is designed for use in interior applications. The R-value of the system is dependent on the depth of the air space formed. Refer to the Resources section for manufacturers' information.

Exterior Surface Application

Regardless of type, foam insulations are applied in a similar manner; refer to Figure 5-2.

A below-grade concrete masonry wall must be dampproofed before installation of insulation board. The insulation board may be secured to the foundation wall by using either chemical adhesives or mastic. Adhesives or mastics produce few, if any, breaks in the thermal barrier. Another alternative for fastening insulation is to use a masonry screw with a large washer. Another technique uses screws with plastic anchors to retard thermal bridging.

For exterior above-grade applications, the insulation is attached to a concrete masonry wall in much the same way as in below-grade applications. Although dampproofing is not required, a weather-resistant barrier (i.e., finish system) is required to protect the insulation from water damage, sunlight, insects, and physical damage.

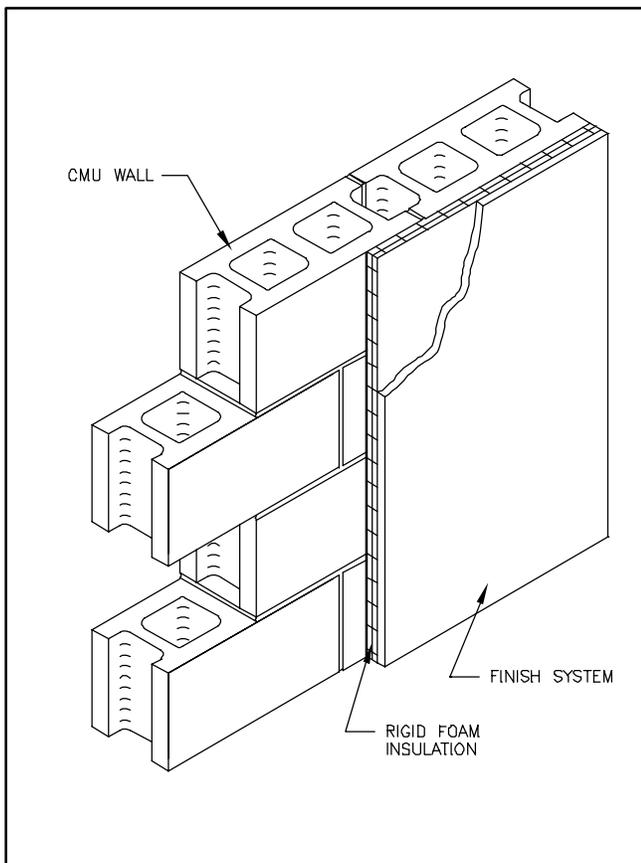


Figure 5-2: Exterior Surface Insulation

Interior Surface Application

Installing insulation to the interior of a concrete masonry wall prevents exposure to the elements (i.e., wind, rain, etc.). However, insulation installed on the interior face of the wall presents some challenges with respect to interior finish attachment and utility placement; refer to Fact Sheets 4 and 6 (FS•4 and FS•6), respectively. Refer to Figure 5-3 for illustrations regarding insulation installation alternatives.

The most common interior finish in residential construction is gypsum board, also known as drywall. Some builders install drywall directly to the insulation by using construction adhesives or manufactured composite drywall-insulation boards; refer to Fact Sheet 4 (FS•4). In some cases, the rigid insulation board contains a metal furring strip that acts as a "stud" to which the gypsum board is attached. Another alternative is to attach metal, wood, or plastic furring strips or channels directly to the masonry with typical masonry connectors such as cut nails, helically threaded concrete nails, or powder-actuated masonry fasteners. The rigid insulation is then installed between the furring strips.

While the resulting R-value for the gypsum board-insulated wall is good, it is not as high as in exterior surface applications. Installation of the insulation between furring strips leaves small wall areas uninsulated just as in light-frame stud construction.

One insulation manufacturer has altered its insulation product so that when used with z-channels the entire wall surface is insulated, providing a continuous thermal break. The system is known as Hatton Batten Tuff-R®. In this particular system, the z-channel depth is less than that of the insulation thickness. The insulation has grooved ends allowing it to insert into and over the z-channel-furring strip. With the insulation spanning the entire wall area, the system results in a higher R-value than if traditional insulation board and full-depth z-channel or traditional furring strips were used.

If local climate conditions are severe and the required R-value cannot be met by using one of the previously mentioned insulation methods, a 2x-stud wall on the interior of the home may be constructed. The stud wall is then insulated in a manner similar to the furring strip system described earlier. If a stud wall is constructed, fiberglass batt insulation may be used to insulate the wall, just as in light-frame construction.

Radiant insulation may be used in lieu of, or in addition to, rigid insulation board and is typically installed over the furring strips. One manufacturer's product, known as Vapor Shield, is available in rolls. The R-value is based on the size of the air space created by the furring strip. The walls are "wrapped" with the Vapor Shield and stapled to the furring strips before installing the interior finish. Refer to the Resources section for the manufacturer's contact information.

INSULATION FOR MULTIPLYTHE CONSTRUCTION

Though not used often in residential construction because of cost and complexity of construction, the multiplythe wall system has been in use for many years and is

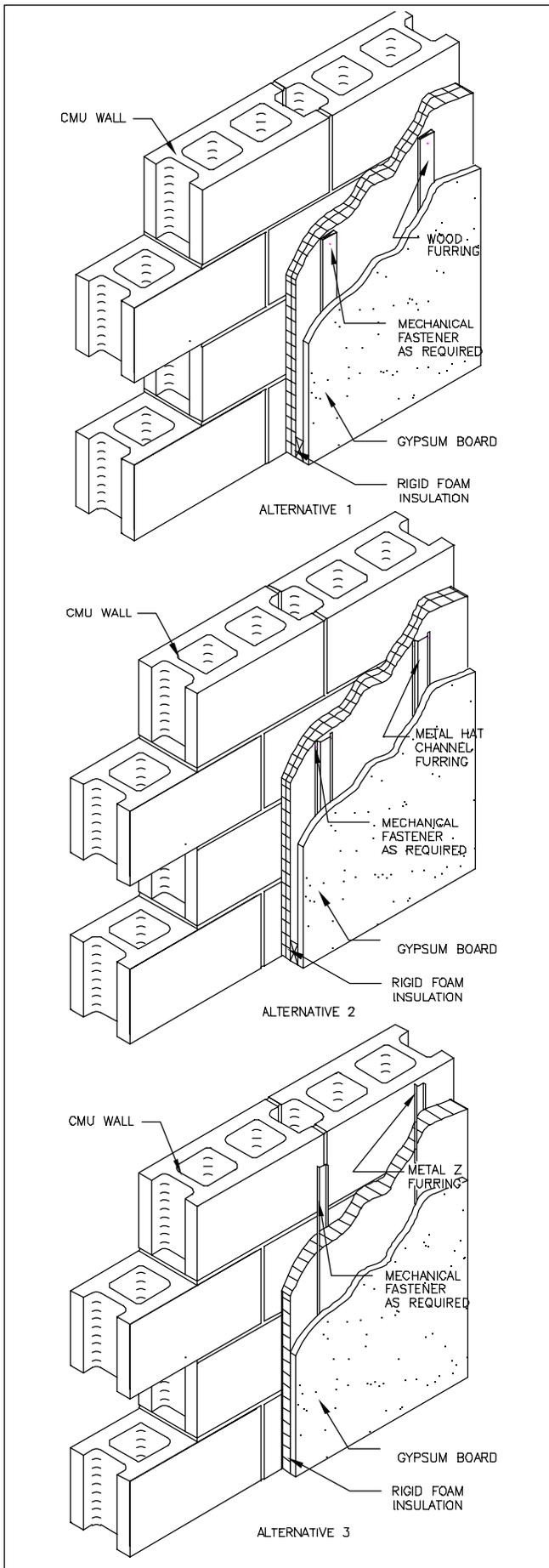


Figure 5-3: Interior Surface Insulation

still used in commercial construction. It is included herein because it may be used with a brick exterior finish for residential construction.

Multiwythe cavity wall construction consists of two walls (wythes) built parallel to each other with a minimum of 2 inches between the wythes. Both wythes may be concrete masonry; however, in residential construction, it is more typical for one wythe to be constructed of brick and the other wythe (backup wythe) of concrete masonry. Multiwythe construction increases sound attenuation, fire resistance, and moisture resistance.

The air space between the two wythes, if present, is an excellent location for rigid board insulation as well as for poured-in-place insulation; refer to Figure 5-4. The distance between the two wythes can vary up to a maximum of 4-1/2 inches, thus facilitating multiple sheets of insulation. It is possible to construct a wall in this manner with an R-value of 25 to 30. However, it is critical to ensure that a clearly defined air gap (1 inch minimum) exists between the insulation and the exterior wythe.

Consult an engineer before increasing the cavity between wall wythes more than 4-1/2 inches to ensure that the wall is structurally adequate.

Composite Wall Insulation

Composite concrete masonry unit construction is similar to cavity wall construction; however, no air space exists between the two wythes. Insulation usually takes the form of either concrete masonry unit core insulation or surface-applied insulation. A system available on today's market delivers rigid insulation to the job site already adhered and inserted between a concrete masonry wythe unit and an exterior wythe unit. The exterior wythe may be a variety of materials such as faux stone, brick veneer, etc., refer to Figure 5-5.

The wall system arrives in a single piece and thus is installed in a manner similar to a conventional concrete masonry unit, with mortar joints between the units. The mortar joints are not insulated; therefore, the R-values, though higher than in conventional concrete masonry, are not as high as that of walls entirely covered by insulation. Studies are underway to determine alternative installation methods to increase the R-value of this system. The R-value range for the system is approximately R-8 and depends on the size of the mortar joint.

INSULATING CONCRETE MASONRY UNIT

Insulating concrete masonry units combine concrete and insulation materials into one unit by modifying the properties of the concrete itself during the block manufacturing process. Refer to the manufacturer for detailed installation guidelines as well as for material information. Many products are proprietary.

One type of insulating concrete masonry unit is manufactured by using a lightweight aggregate with synthetic and mineral content. The units depend on polystyrene for their insulating value, but sacrifices some strength. The units may be installed in a manner similar to a normal-weight concrete masonry unit or with a mortarless system. This unit is available from Sparfil International, Inc.

Refer to the Resources section for manufacturer's contact information.

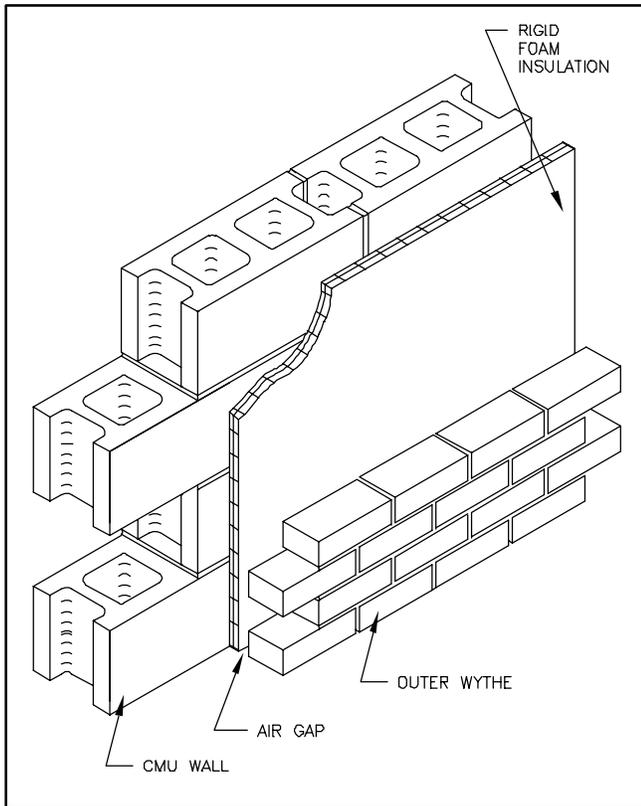


Figure 5-4: Multiwythe Wall Insulation

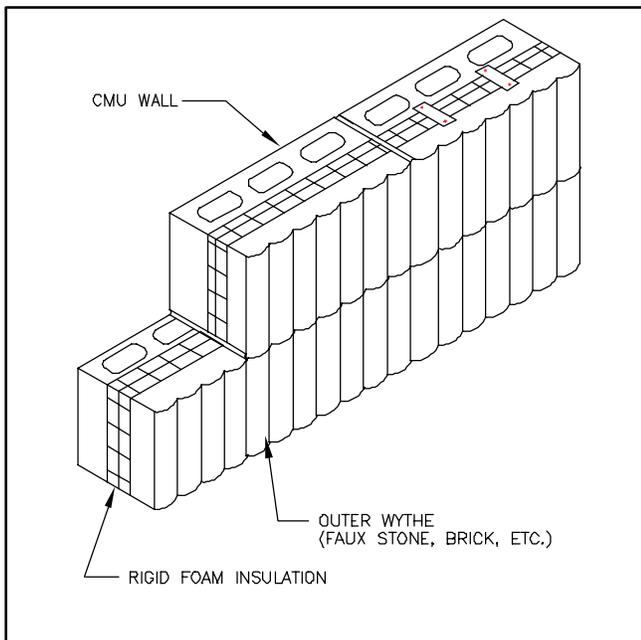


Figure 5-5: Patented Composite Wall Insulation

CONCLUSIONS

Several conventional and innovative techniques and systems are available to increase the energy efficiency of a concrete masonry home. Each technique or system has advantages and disadvantages based on the given application and budget. In addition, there are many

variations on the methods discussed herein. It is the responsibility of the designer and builder to determine which method satisfies local code requirements, while still addressing budget constraints, labor availability, and client desires.

RESOURCES

Hatton Batten Tuff-R[®]

P.O. Box 31602
Tampa, Florida 33631
☎ 800.celotex
🌐 <http://www.celotex.com>

NAHB Research Center, Inc.

400 Prince George's Boulevard
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☎ 800.638.8556
🌐 <http://www.nahbrc.org>

National Concrete Masonry Association (NCMA)

2302 Horse Pen Road
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☎ 703.713.1900
🌐 <http://www.ncma.org>

North American Insulation Manufacturers Association

44 Canal Center Plaza, Suite 310
Alexandria, Virginia 22314
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🌐 <http://www.naima.org>

Portland Cement Association

5420 Old Orchard Road
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🌐 <http://www.portcement.org>

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