BRICK IN ARCHITECTURE

From the Brick Industry Association




Multi-Family Residential

INSIDE THIS ISSUE:

Read the newest technical discussion on **Brick Veneer with a Backing of Cold-Formed Steel Framing** and earn one AIA/CES credit hour. The article explains how to:

1. Discuss the advantages of the brick veneer/cold-formed steel framing wall system.
2. Design and detail brick veneer/cold-formed steel framing wall systems.
3. Properly specify the materials for brick veneer/cold-formed steel framing construction.
4. Manipulate the brick veneer/cold-formed steel framing wall system to achieve desired effects.

CONTINUING EDUCATION AIA

New Addition to Denver's Historic District Uses Brick to Blend with Urban Streetscape

From its conception, Acoma, a 16-story residential tower, has been designed to play an integral part in Denver's Golden Triangle neighborhood. The building's five-story base, which contains a parking garage wrapped with two-story loft units, extends to the street edge and continues the established urban fabric.

To reinforce the tower's connection to the immediate streetscape, the architects detailed the base of the 220-unit building with brick and cast stone. These details created rich layers of pedestrian, public, and semi-private spaces around the building's streetscape. In addition, the taller residential tower above is set back to allow light and views to reach the street.

Several factors led to genuine clay brick being specified as the exterior cladding material, and ultimately it became a selling point. It was important to the owner and the community for the project to be an integrated part of the existing urban fabric of the area. The strong neighborhood group had an interest in determining the aesthetics and durability of the new project. Brick is a predominant building material throughout Denver, so it was a material that was already part of the group's vocabulary and was one with which they were comfortable.

Because of a highly detailed façade, brick afforded a cost-effective solution for all the modulations and varieties of color.

Since so many nearby buildings were clad in brick, its use on the Acoma allowed the building to seamlessly integrate into its surroundings. Brick also allowed the architects to use a traditional material in a more modern way, which would appeal to the younger, forward-looking clientele sought by the neighborhood.

Finally, because of a highly detailed façade, brick afforded a cost-effective solution for the walls that contained much articulation and a variety of color.

"Typically, the façade of a multi-family residential tower consists of repetitious panels that stack from top to bottom," says David Quenemoen, AIA. "On the Acoma, we were very interested in creating different unit types that created variety within the building. Such an approach to the design resulted in a slight variation of the façade that occurs every few floors. Using brick provided the flexibility we needed to complete our design and it gave us a system that could appear very different based on the color we used or how we recessed or projected the brick in the plane of the wall. We were able to create a highly animated building while maintaining a consistent exterior envelope that did not require complicated technical solutions."

In addition, the size of the modular brick used on the project provided a scale for the building to relate to the pedestrians on the street. Ground-floor patios and low retaining walls were also tied into the building by extending the use of brick to these hardscape elements.

The building has been so well received that certain areas are currently being expanded to accommodate additional resident amenities. In addition, the project has been honored with the Gold Nugget Grand Award for Best Multi-Family Housing Project and the Multi-Family Executive Design Awards Merit Award for High Rise Project of the Year.

Acoma – Denver, Colorado

Architect:
PageSoutherlandPage
Principal:
David Quenemoen, AIA
Brick Manufacturer:
Summit*Lakewood Brick
Brick Distributor:
Summit*Lakewood Brick
Photographer:
Frank Ooms, Ooms Photography

As verified by architect

Brick Provides Stately Details on Sophisticated Residences

Inspired by Park Place in New York City, the eight Bellingrath townhomes exude upscale urban living with large street frontage and deep 6,000-square-foot floor plans. A guiding principle was that the homes would be built to last and with quality in mind.

An elegant and polished look was the goal for the exterior cladding. At the developer's direction, the architects at Harrison Design Associates used cast stone as the first-floor cladding material, but the cladding above remained more elusive. After setting up more than ten different sample boards around the site to consider different brick and stone cladding options, a brick was ultimately chosen based on how well it blended with the cast stone. Clay brick also proved to be the more economical choice and allowed the façade to accommodate details that would not have been possible with other materials.

As the project developed, the architects realized that the brick pocket at the top of the eave was wider due to the difference in the depth of the cast stone compared to the brick. After several sketches and discussions with the builders, three brick courses at the top of the wall were corbelled into the brick pocket. This not only solved the brick pocket issue but also gave more depth to the wall. In fact, it worked so well that the architect chose to carry the same design into future projects.

Other unique details can be found on the homes' brick chimneys. Since the units sit back-to-back, the chimneys had the possibility of becoming large and cumbersome. To combat this, the architects designed multiple herringbone panels with the brick turned at 45-degree angles. This saw-tooth pattern breaks up the overall massing and is also carried over into herringbone patterns found on the loggias. Use of a herringbone pattern also allowed the brickwork to be constructed without the need to specify special brick shapes.

Unlike your typical townhome, each unit receives large amounts of light throughout the interior. The end units each have a stair element expressed on the exterior wall which allows three stories of windows to let light into the center of the house. Each interior unit has a skylight at the top of the stair hall. This conservatory-style skylight allows light throughout all four floors even down to the basement and parking area down below.

Although the economic downturn hit right as the townhomes were completed, they have received a steady flow of interested homeowners. Interest is increasing again now and their rate of sale continues to outperform many of the other townhome and condominium developments in the area.

The use of brick proved to be an economical choice and allowed the architects to specify details that would not have been possible with other materials.

Bellingrath Townhomes – Atlanta, Georgia

Architect:
Harrison Design Associates
Principals:
Richard C. (Rick) Hatch, Assoc. AIA
William H. (Bill) Harrison, AIA
Brick Manufacturer:
General Shale Brick
Brick Distributor:
North Georgia Brick Company
Photographer:
John Umberger

As verified by architect

Brick Plays Lead Role in Chicago's Tallest Masonry Building

Ideally located in Chicago's popular South Loop community, the Columbian offers unparalleled recreational, shopping, and entertainment opportunities for its residents. With such attractive amenities just steps from its doorway, the architects at DeStefano and Partners challenged themselves to create a design that would equal the charm and attraction of such a bustling neighborhood.

With 572,000 square feet and 48 stories housing 220 condominiums, the project was intended from the start to be a tall tower element. The city had requested a tower to serve as a physical terminus to Michigan Avenue and the nearby Grant Park. To make the project unique, the architects designed a hand-set masonry exterior, differentiating it from the typical glass and concrete surfaces seen in other modern high-rise construction. The resulting design feature made the Columbian the largest hand-set masonry building east of the Mississippi River and the tallest brick-clad building in Chicago.

Over the years, many other buildings along Michigan Avenue were built in brick, terra cotta, and stone, so it was a natural choice to keep a consistent palette and stay in harmony with the adjacent buildings. The design team, however, chose brick for economic reasons as well. Clay brick proved to be less expensive than precast concrete after factoring in the costs of a crane installation, so concrete masonry served as infill walls within the concrete frame and hand-laid brick veneer clad the exterior. To provide screening and privacy for residents, the terraces were set back within the building.

Although the economic downturn has brought sales at a slower pace than initially hoped, the final design and construction of the Columbian has been well received by new tenants and local residents. The resulting architectural design appropriately reflects its position along Michigan Avenue and underscores its commitment to providing state-of-the-art services to its residents. With both design and materials, the new building provides harmony to its surroundings and extends the standard of excellence one would expect of such a building.

The architects designed a hand-set masonry exterior to differentiate it from the typical glass and concrete surfaces seen in other modern high-rise construction.

The Columbian – Chicago, Illinois

Architect:
DeStefano + Partners

Project Architect:
James DeStefano, AIA

Brick Manufacturer:
Endicott Clay Products Company

Distributor:
Illinois Brick Company

Photographer:
Mariusz Mizera

As verified by architect

Brick Helps Building Become County's Best Example of Pedestrian-Friendly Design

In one of Arlington, Virginia's trendiest neighborhoods, Zoso Lofts has an important role of making the transition between an area zoned for mid-rise commercial buildings on one side and a neighborhood of detached single-family homes on the other. This five-story building hosts 114 apartment units and more than 22,000 square feet of retail and office space just 700 feet from a local subway station. The design team at WHA Architecture took a site formerly consisting of small buildings and industrial warehouses and transformed it into a dynamic architectural piece that serves to connect commercial to residential within the urban fabric.

The architects specifically chose clay brick as the exterior cladding material for its pedestrian-friendly qualities. Says Chris Hubbard, AIA, "We do a lot of transit-oriented urban buildings, and we love brick for its multiple functional aspects. This is an urban environment with lots of people walking around. With the site positioned between an area composed of single-family homes and an area zoned for multi-story commercial buildings, we needed to create something that was both monumental and human scaled. Brick has that capacity. We can also tune the design to achieve what is contextually appropriate. So it was logical, and it is our preferred material to use in the urban context."

One of the most important goals was to break down the 400-foot-long façade into a more visually relatable scale. The solution became a series of brick panels featuring bold, large circle and square openings. These design elements serve to balance the strong commercial forms nearby while also dividing the building into several smaller masses. The syncopated rhythm of the elements creates variety, but at the same time the pattern is not an arbitrary sequence.

From a functional standpoint, brick also fulfilled typical urban needs such as durability, fire resistance, and resistance to vandalism. In addition, the design team detailed and constructed the brickwork to form a rain screen wall that provides another layer of defense against moisture intrusion. The wall also encloses portions of the loft balconies, affording residents the opportunity to enjoy the outdoors within a semi-private space shielded from pedestrians below.

Keeping with Arlington County's push towards green building, the project achieved 33 LEED points under the County's management of the program.

The community's reaction to Zoso Lofts has been overwhelmingly positive. The property's residential spaces were fully leased after only eight months, which was particularly remarkable given the housing market and economic conditions at the time of its completion. Perhaps most impressive though was the response from Arlington County's Board and Planning Staff. The architect for the County at the time publicly stated that he felt Zoso Lofts was one of the best buildings in the county in terms examples of pedestrian-friendly design and that it was helping to improve the area's overall quality of architecture.

The architect for Arlington County publicly stated that Zoso Lofts was one of the best buildings in the county for pedestrian-friendly design.

Zoso Lofts – Arlington, Virginia

Design Architect:
WHA Architecture and Planning, PC (Exterior and Schematic)
Principal/Designer:
Chris Hubbard, AIA
Architect:
Kishimoto Gordon Dayala PC (LEED)
Brick Manufacturers:
Hanson Brick
Carolina Ceramics Brick Company
Brick Distributor:
Potomac Valley Brick and Supply Company
Photographer:
Maxwell Mackenzie

As verified by architect

Read the following learning objectives to focus your study while reading the article below. To receive credit, follow the instructions found at the end of the article which direct you to complete the AIA questionnaire found at www.gobrick.com/ArchitectCredit.

Learning Objectives

After reading this article you should be able to:

1. Discuss the advantages of the brick veneer/cold-formed steel framing wall system.
2. Design and detail brick veneer/cold-formed steel framing wall systems.
3. Properly specify the materials for brick veneer/cold-formed steel framing construction.
4. Manipulate the brick veneer/cold-formed steel framing wall system to achieve desired effects.

The brick veneer/cold-formed steel framing wall system is considered an anchored masonry veneer wall. An anchored brick veneer is one thickness (wythe) of brickwork secured to and supported laterally (horizontally) by the backing through anchors and supported vertically by the foundation or other structural elements.

The veneer transfers out-of-plane loads, typically from wind or seismic events, directly to the backing. Anchored brick veneer with a backing of cold-formed steel framing consists of a nominal 3- or 4-in. (76 to 102 mm) thick exterior brick wythe mechanically attached to a steel stud backing system with corrosion-resistant metal anchors across a prescribed air space between the veneer and the backing system as shown in Figure 1.

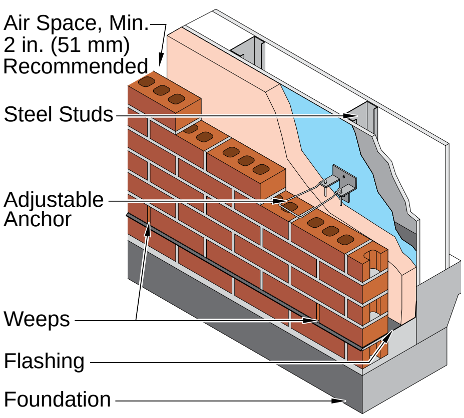

Figure 1. Brick Veneer / Cold-Formed Steel Framing

ADVANTAGES

Introduced in the 1960s, the brick veneer/cold-formed steel framing wall system has evolved into a successful construction method used in a wide variety of commercial, industrial, and institutional structures including primary and secondary schools and colleges and universities. The following advantages demonstrate superior performance in many specific areas of concern for designers, contractors, and property owners.

Acoustics. Three mechanisms reduce the sound transmitted through the wall. First, the hard surface of the brickwork reflects a large portion of sound waves. Second, the mass of the brickwork absorbs another portion of sound energy. Third, the remaining sound energy that makes its way through the brick wythe must continue through the air space which acts as a sound insulator and the sheathed cold-formed steel studs. For additional information on sound transmission, refer to BIA *Technical Note* 5A.

Moisture Resistance. Brick veneer construction incorporates an air space to deter water penetration into the building. When wind-driven rain penetrates the veneer wythe, the air space allows the water to drain down the back face of the brickwork. This water is then collected by flashing and channeled to the exterior of the veneer wythe through weeps. The outside surface of the sheathing provides a location for the water-resistive barrier. When properly designed and constructed, a brick veneer/cold-formed steel framing system is a water penetration-resistant wall assembly. For additional information regarding water penetration resistance, refer to the BIA *Technical Notes* 7 Series.

Thermal Performance. Brick veneer systems incorporating an air space can help reduce the amount of heat transmission through the system. This air space provides a thermal separation between the brick wythe and other system components, increasing the resistance of the entire wall system to heat loss or gain. Further, brickwork has a high thermal mass, giving it the ability to store and slowly release heat over time. Closed-cell rigid board insulation should be placed inside an enlarged air space for additional thermal resistance. With the board insulation located outside of the steel stud wall, there is increased resistance to heat transmission by reducing thermal bridging. For further information regarding the thermal resistance of brick assemblies, refer to the BIA *Technical Notes* 4 Series.

Fire Resistance. Brick masonry has superior fire resistance. Building codes may require that exterior walls have a fire resistance rating based on fire separation distance, size of the building, and occupancy classification. Exterior walls may require protection from one or both sides, depending on whether the fire separation distance is more or less than 5 ft (1.52 m), respectively. A nominal 4 in. (102 mm) brick wythe has a one-hour fire resistance rating and can provide this protection for the exterior surface of the wall. For fire resistance from inside the building, the cold-formed steel framing must be protected on the interior side. Fire-rated gypsum board is typically used for this purpose and can be layered to provide the required rating. For additional information, refer to the BIA *Technical Notes* 16 Series.

Ease of Construction. The cold-formed steel studs and exterior sheathing of a brick veneer/cold-formed steel stud wall can be constructed prior to laying the brick veneer wythe, allowing the building to be closed in and placed under roof quickly. Other trades can be scheduled to work and not interfere with the mason. Care should be taken to ensure that the water-resistant barrier on the cold-formed steel stud system is not compromised prior to installation of the brickwork.

Design Weight. The weight of brick veneer/cold-formed steel framing is less than a wall constructed of brick and concrete masonry units. Thus the perimeter framing member sizes and seismic forces used in the design may be reduced.

DESIGN AND CONSTRUCTION

Foundation. Although some building codes permit the support of brick veneer on wood foundations, it is recommended that the weight (gravity load) of the veneer be supported on concrete or masonry foundations or other noncombustible structural supports, such as attached steel angles. The brick wythe may extend below grade if it is properly detailed and constructed to minimize water penetration. A typical foundation detail is shown in Figure 2. Locating base flashing and weeps a minimum of 6 in. (152 mm) above grade will allow the drainage system to function properly. Base flashing should extend through the full wythe of the veneer to the exterior to preclude the migration of moisture by capillary action up through the brickwork.

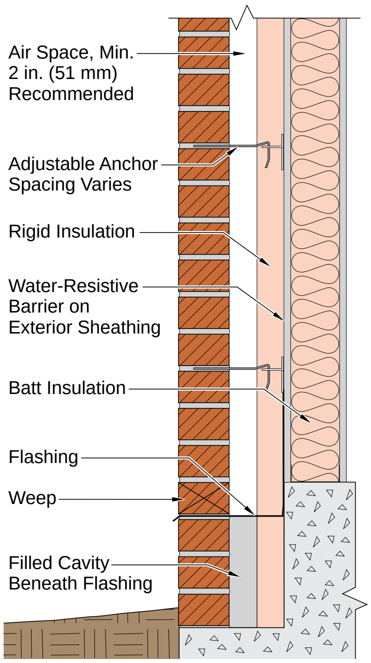

Figure 2. Wall Section at Foundation

Brickwork below the base flashing should be detailed as a barrier wall system by completely filling the cavity or air space with grout or mortar to minimize water penetration. Anchors should be located within the grout-filled cavity at the same spacing as in the brick veneer above grade if the filled cavity is higher than 12 in. (305 mm). Cold-formed steel studs should be located a minimum of 6 in. (152 mm) above grade and should not be used below grade on exterior walls under any circumstances.

If soil immediately adjacent to the brickwork below grade is not free-draining, it is recommended to take measures to enhance the drainage of water away from the brickwork. Drainboards with integral filter fabric and waterproofing membrane can be installed to drain water to the foundation drain tile system. A French drain between the soil and the wall, consisting of a gravel fill with a fabric filter surround and drain tile below, sloped a minimum of $^1/_8$ in./ft (10 mm/m) can provide some drainage. Finished grade should provide positive drainage by sloping away from the wall.

Brick Veneer Height. Structures with a maximum brick veneer height of 30 ft. (9.14 m) from foundation to top of wall and 38 ft. (11.58 m) from foundation to top of gable can have their entire brick veneer supported directly on a foundation wall, footing, or noncombustible support without shelf angles. Unless rationally designed, brick veneer above this height is required to be supported at each story by a shelf angle.

Brick. The brick in brick veneer construction should conform to 1) ASTM C216, Specification for Facing Brick; 2) ASTM C652, Specification for Hollow Brick; 3) ASTM C1405, Specification for Glazed Brick; or 4) ASTM C126, Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick and Solid Masonry Units. Classifications in these specifications for weather exposure and appearance must be selected. Salvaged brick is not recommended since such brick may not bond properly with mortar and may be less durable. For further information on brick specifications and salvaged brick, refer to BIA *Technical Notes* 9 and 15 Series, respectively.

Mortar. Mortar should conform to ASTM C270, Specification for Mortar for Unit Masonry. A designer should select the mortar with the lowest compressive strength that is compatible with the project requirements. Type N mortar is suitable for most veneer brickwork, except in areas below grade, where Type S mortar should be used. Type S mortar is recommended where a higher degree of flexural resistance is required. Admixtures and additives for workability are not recommended since they can potentially weaken the mortar. Admixtures containing chlorides should never be used since they could greatly increase the probability of efflorescence and corrosion. For more information on mortar, refer to BIA *Technical Notes* 8 Series.

Flashing. Flashing collects water at the bottom of the air space and directs it toward the weeps, which channel it to the exterior face of the wall. Flashing must be placed at all locations where the air space is interrupted. These include above and below all window and wall openings, above all shelf angles, at the base of the wall, and under the coping at parapets. Flashing should extend vertically up the backing a minimum of 8 in. (203 mm). If drainage materials that catch mortar are placed at the bottom of the air space, the flashing at the base of the wall may need to extend further up the backing. This ensures that the flashing extends above the height of the drainage material and helps deter water that migrates across mortar on the drainage material from entering the backing. The water-resistive barrier on the backing should lap the top of the flashing a minimum of 4 in. (102 mm). Individual flashing pieces should be lapped at least 6 in. (152 mm) and sealed to avoid water running under adjacent flashing pieces.

Where flashing is discontinuous, such as over and under openings in the wall, the ends should be turned up at least 1 in. (25 mm) into the next head joint to form an end dam to channel water out of the wall. When possible, flashing should extend beyond the face of the brickwork to form a drip. When using a flashing that deteriorates with UV exposure, a metal or stainless steel drip edge can accomplish this. Flashing should extend at least to the face of the brickwork and not end within the brickwork.

Flashing material should be waterproof and durable, and sufficiently tough and flexible to resist puncture and cracking. In addition, flashings subject to deterioration from UV light should not be overly exposed to sunlight. Flashing should not deteriorate when in contact with metal parts, mortar, sealants, or water. Flashing should also be compatible with adjacent adhesives and sealants. It is suggested that only superior flashing materials be selected, since replacement in the event of failure is extremely expensive.

Weeps and Vents. Weeps should be placed immediately above the wall flashing to permit water to exit the wall. Open head joint weeps are preferred and a maximum spacing of 24 in. (610 mm) on center is recommended. If wick or tube weeps are used, a maximum spacing of 16 in. (406 mm) on center is recommended. Wicks should be at least 16 in. (406 mm) long and extend through the brick into the air space and along the back of the brick. Most building codes require weep openings to have a minimum diameter of $^3/_{16}$ in. (4.8 mm) and allow weeps to be spaced up to 33 in. (838 mm) on center. Non-corrosive metal, mesh, or plastic screens can be installed in open head joint weeps if desired to deter insect access and water infiltration.

Vents (open head joints) may be placed at the top of the drainage air space to help reduce moisture buildup in the air space by promoting ventilation. Vents should be spaced at the same horizontal spacing as weeps and should be centered between weeps.

Expansion Joints. Like all building components, brickwork will expand and contract. Brick is subject to permanent expansion as a result of freezing and moisture absorption. Mortar will shrink as it cures. Changes in temperature will cause brick to expand and contract. As a result, brickwork will continually change in size during its life.

To accommodate this movement, brick veneer should be designed in discrete sections which are allowed to move independently of each other. This is accomplished through the use of expansion joints and bond breaks detailed into the veneer. An expansion joint consists of a vertical or horizontal opening through the brick wythe that is closed with a sealant joint and elastic materials. These joints separate each section of brickwork and isolate it from other sections. Expansion joints must be located and constructed so as not to impair the integrity of the wall.

The spacing and placement of vertical and horizontal expansion joints must be done on a case-by-case basis. Generally, the spacing of vertical expansion joints should not exceed 25 ft (7.6 m) in brickwork without openings and 20 ft (6.1 m) in brickwork with openings. Vertical expansion joints are also recommended where site walls adjoin buildings, at the corners of large openings, at changes in wall height, and where the support of the brick veneer changes. Outside building corners should have a vertical expansion joint located within 10 ft (3.05 m) of one side of the corner.

Horizontal expansion joints are located immediately below shelf angles, above the brickwork below. A minimum $^1/_4$ in. (6 mm) space or compressible material is recommended below shelf angles. However, each wall must be examined to determine its potential for movement based on its length, openings, offsets, corner conditions, wall intersections, means of support, changes in wall heights, and parapets. These features influence how the brickwork reacts to movement in a wall. Any portion of wall not able to resist induced stress should be isolated by an expansion joint. For more information, refer to BIA *Technical Notes* 18 Series.

Sealant Joints. Sealant joints prevent water penetration at expansion joints and perimeters of openings. These joints are typically a compressible, foam backer rod recessed and covered by a sealant. Sealant joints should be free of mortar through the entire thickness of the brick veneer and closed with the backer rod and sealant. The perimeter of all exterior window frames, door frames, and sleeves should be closed with a sealant joint.

Sealants should be selected for their durability, extensibility, compressibility, and their compatibility with other materials. Sealant materials should comply with ASTM C920, Specification for Elastomeric Joint Sealants. Specific sealants recommended for brick include polysulfide, solvent release acrylic, silicone, and urethane sealants. A sealant primer may be required before applying some sealants on certain brick to preclude staining. Sealants containing acetoxic silicone should not be applied to brickwork since they will attack cement in mortar. Oil-based caulks should not be used since they may stain the adjacent brickwork. Backer rods should be placed behind all sealant joints. They should be made of closed-cell plastic foam or sponge rubber. A bond-breaking tape may be required with some types of backer rods. For more information on sealant joints, refer to BIA *Technical Note* 18A.

Air Space. The air space or drainage cavity provides a means to drain water which penetrates the brick veneer. The air space between the back of the brickwork and the sheathing or rigid board insulation is recommended to be at least a nominal 2 in. (51 mm) and required to be at least a nominal 1 in. (25 mm) in order to minimize the possibility of mortar bridging the air space. The distance between the back of the brick wythe and the cold-formed steel framing can be a maximum of 4-$^1/_2$ in. (114 mm) unless the anchors are rationally designed. If this distance is exceeded and rational design provisions are used, additional or stronger anchors may be required. Insulation must be attached to the backing by mechanical or adhesive means to keep it from blocking the air space.

Water-Resistive Barrier. Water-resistive barriers are surfaces or membranes which prevent liquid water from passing through. These are different from vapor retarders, intended to prevent water vapor diffusion, and air barriers, intended to prevent air flow through the wall system. A water-resistive barrier should be located between the air space and the sheathing or between the rigid insulation and the sheathing. A water-resistive barrier should keep out any water which finds its way across the air space via anchors, mortar bridging, or splashing. Individual pieces of water-resistive barrier should be installed with their edges and ends lapped at least 6 in. (152 mm). Water-resistive sheathings alone are not qualified to act as a water-resistive barrier.

A water-resistive barrier is required and can be provided by asphalt felt, building paper, qualifying plastic membranes (wraps), or liquid-applied membranes. Asphalt felt should be No. 15 and comply with Type I of ASTM D226, Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing. Asphalt felt should not be left exposed to ultraviolet light for an extended period of time; otherwise, it will lose the asphalt saturation and water-resisting characteristics.

Some plastic membranes (wraps) may have qualities similar to those of a qualifying water-resistive barrier, but ascertaining the effectiveness of a particular plastic as a water-resistive barrier can be difficult. While felts tend to seal themselves when penetrated by fasteners, plastics may not. In addition, some plastic membranes also act as vapor retarders and hence can potentially trap water vapor inside the stud wall where it can condense if the temperature gradient in the wall drops below the dew point. The length of time a plastic membrane will be exposed to sunlight should also be considered. Most show serious degradation with 3 to 12 months of exposure to UV rays. Thus, all plastic membranes should not be regarded as equivalent and the manufacturer's literature should be consulted. Care should be taken to reduce the likelihood of tearing the membrane or breaking the barrier. Such tears or breaks must be corrected prior to installation of brickwork.

Anchors. Anchors should provide the capacity to transfer loads applied to a maximum of 2.67 ft^2 (0.25 m^2) of wall area. Each anchor should be spaced a maximum of 25 in. (635 mm) on center vertically and a maximum of 32 in. (813 mm) on center horizontally. They must be securely attached through the sheathing to the cold-formed steel studs, not to the sheathing alone. Around the perimeter of openings, additional anchors should be installed at a maximum of 3 ft (914 mm) on center within 12 in. (305 mm) of the opening.

In high wind areas where the velocity pressure is between 40 and 55 psf (2.63 kPa) and the building's mean roof height is not more than 60 ft (18.3 m), the maximum area of wall supported by one anchor should not exceed 1.87 ft^2 (0.18 m^2) and anchors should be spaced at a maximum of 18 in. (457 mm) horizontally and vertically.

Care must be taken to anchor the masonry veneer to the cold-formed steel framing in a manner that will permit each to move freely, in-plane, relative to the other. Anchors that connect the veneer to the backing must provide out-of-plane support, resisting tension and compression forces, while not resisting shear forces in the plane of the wall. This permits in-plane differential movement between the frame and the veneer without causing cracking or distress. Corrugated anchors are not permitted when brick veneer is anchored to cold-formed steel framing since they do not fully engage the stud upon initial loading and do not have sufficient compressive capacity for the given air space.

All anchors must be embedded at least 1-1/2 in. (38 mm) into the brick veneer with a minimum mortar cover of 5/8 in. (16 mm) to the outside face of the wall. For structures located where the velocity pressure, *qz*, exceeds 40 psf (1.92 kPa) or where the Seismic Design Category is D, E, or F, the anchoring requirements may be more stringent. Consult the adopted building code for your area.

Anchors are required to be made of carbon steel or stainless steel. Carbon steel anchors are required to conform to ASTM A82. Stainless steel anchors are required to conform to ASTM A580. Anchors made of carbon steel are required to be hot-dipped galvanized in accordance with Class B-2 of ASTM A153/153M, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

Two-piece adjustable anchors with a minimum wire size of W1.7 (MW11) are required. Eye and pintle adjustable anchors are required to have a minimum wire size of W2.8 (MW 18) with a diameter of 3/16 in. (4.8 mm). Wire anchors are available in a variety of standard lengths from 3 to 5 in. (76 to 127 mm) and diameters from 0.15 to 0.25 in. (3.7 to 6.4 mm). In addition, anchors should have a maximum horizontal out-of-plane mechanical play of 1/16 in. (1.6 mm) and should be detailed to prevent disengagement.

Anchors incorporating an EPDM sealing membrane between the sheathing or insulation and the wall base of the anchor should be considered for superior water resistance. Prongs at each end of an adjustable anchor base, as shown in Figure 3, may also be considered with non-rigid sheathing to provide a mechanical connection between the anchor and the stud. These prongs provide positive, independent anchorage in the event of long-term deterioration of sheathing or insulation and prevent compression of the insulation or sheathing. When using a prong-leg base, a modified asphalt pad with self-adhesive is recommended. This pad is installed under the anchor base and will seal openings created by the prongs and screws in the sheathing or insulation.

Screws. Exterior sheathing on cold-formed steel studs should be suitably fastened with corrosion-resistant screws. Veneer anchors are required to be attached to the cold-formed steel studs with a minimum No. 10 corrosion-resistant screw or a fastener with equivalent or greater pullout strength. A self-tapping screw is recommended. Screws used to attach exterior sheathing and anchors can be either carbon steel or stainless steel. Carbon steel screws should have a non-corrosive coating of zinc, polymer, or composite zinc-polymer. Polymer-coated screws do not have the self-healing properties of zinc; however they can offer acceptable, long-term protection. A composite zinc-polymer coating offers superior protection to either coating alone. Stainless steel screws may be acceptable even though a galvanic potential exists between stainless steel and carbon steel. This is possible because of an area-relationship principle where the surface area of the cold-formed steel stud is much larger than that of the screw which results in a decreased corrosion potential. Copper-coated screws are not recommended since they can have a galvanic reaction with cold-formed steel studs that have zinc coatings.

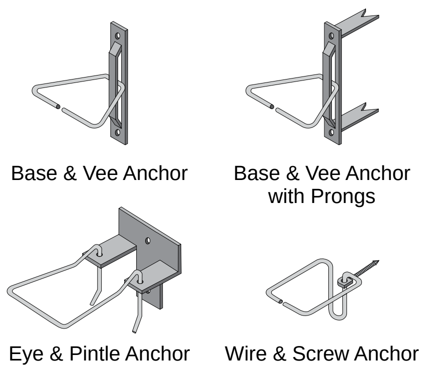

Figure 3. Adjustable Anchor Assemblies

Screws incorporating an integral EPDM or neoprene sealing washer under the screw head may also assist in water penetration resistance. Due to the area relationship principle mentioned above, when stainless steel screws are used with carbon steel anchors, sealing washers are highly recommended.

Sheathing. An exterior grade sheathing or insulation material should be installed on the exterior side of the stud. Edges and joints of sheathing may be sealed with compatible tape or sealant to reduce moisture intrusion. Such joint treatment will also reduce air infiltration. Careful detailing at the top of walls, at transition to other opaque materials, and at window openings should reduce moisture intrusion. If sheathing is used to laterally brace the studs, it should be rigid enough to provide the required stiffness. If the sheathing does not provide lateral bracing, engineered steel straps or channels must be added.

Exterior sheathing on cold-formed steel studs should be suitably fastened with corrosion-resistant screws. The sheathing should be one of the following: exterior grade gypsum sheathing or glass fiber mat-faced sheathing or cement board, not less than 1/2 in. (13 mm) in thickness closed-cell insulating rigid foam not less than 1/2 in. (13 mm) thick conforming to ASTM C 578 or ASTM C 1289; oriented strand board (OSB) not less than 1/2 in. (13 mm) in thickness; or exterior grade plywood not less than 3/8 in. (10 mm) in thickness.

Cold-Formed Steel Studs. Studs must be designed to provide adequate out-of-plane support for all loads imposed on the wall system. This is done by establishing a maximum deflection limit on the stud while maintaining steel stress values in the stud within permissible limits. This deflection is calculated assuming the entire out-of-plane load is resisted by the studs alone, neglecting contribution of the brick veneer. While a number of design tables are based on a stud deflection of stud span length divided by 360 (L/360), using this criterion may permit more deflection than the veneer is able to tolerate. Therefore, to obtain sufficient backing stiffness, the allowable out-of-plane deflection of the studs should be restricted to L/600 with no reduction factor applied to the load. Such deflection criterion will allow a maximum crack width of about 0.015 in. (0.38 mm) in the brick veneer wythe for typical floor-to-floor dimensions.

The top connection of non-loadbearing studs must be detailed to prevent inadvertent vertical load transfer to the stud framing. No rigid connection should be allowed between the top track and the studs. This allows for the structural member above the track to deflect without transferring loads to the studs. Field welding of studs should not be permitted. Shop welding may be permitted on steel studs with a minimum nominal thickness of 0.068 in. (1.7 mm) (14 gage) studs. To increase quality assurance, welders and welding procedures should be qualified as specified in AWS D1.3 by the American Welding Society. A corrosion-inhibiting coating such as zinc-rich paint should be applied to all welded areas after the weld has cooled to ambient temperature. To increase quality assurance, specify that installation of coating complies with ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

Cold-formed steel studs should have a minimum nominal thickness of 0.043 in. (1.1 mm) (18 gage) to provide sufficient thickness to engage the threads of the screw. Studs should have a protective coating conforming to one of the following ASTM standards: 1) ASTM A653/653M, Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process with a minimum G60/Z180 coating designation or 2) ASTM

A792/792M, Specification for Steel Sheet, 55% Aluminum-Zinc Alloy Coated by the Hot Dip Process with a minimum AZ50/AZM150 coating designation. For more information on cold-formed steel studs, refer to the Cold-Formed Steel Engineers Institute Technical Note D001 – Durability of Cold-Formed Steel Framing Members.

Lintels and Shelf Angles. Lintels provide support of brickwork over masonry openings by bearing on the brickwork on each side of the opening. They are not attached to the building structure. Shelf angles provide support for the brickwork above by attaching to the building structure. Shelf angles are at times referred to as relieving angles.

Steel for lintels and shelf angles should conform to ASTM A 36/A 36M, Specification for Carbon Structural Steel. Steel angles should be a minimum of $^1/_4$ in. (6.4 mm) in thickness. All angles should be primed and painted as a minimum to inhibit corrosion. Galvanized and stainless steel angles should be considered in harsh environments such as coastal areas.

Lintel and shelf angle deflection between support points should not exceed the lesser of L/600 or 0.3 in. (7.6 mm) and the total rotation of the toe of the angle should be less than $^1/_{16}$ in. (1.6 mm). The horizontal leg of all angles should be sized to support a minimum of $^2/_3$ the thickness of the brick wythe.

Lintels should be installed over all masonry openings unless the brick is self-supporting. Lintels can be loose steel angles, stone, precast concrete, or reinforced masonry. They should bear a minimum of 4 in. (102 mm) on brick on each side of the opening and should be sized to carry the brick veneer above them. For further information on lintels, refer to BIA *Technical Note* 31B.

Vertical expansion joints should not cross a lintel without making provisions for potential movement. When an expansion joint crosses a lintel, the lintel must be sized to support the full weight of the brickwork above it.

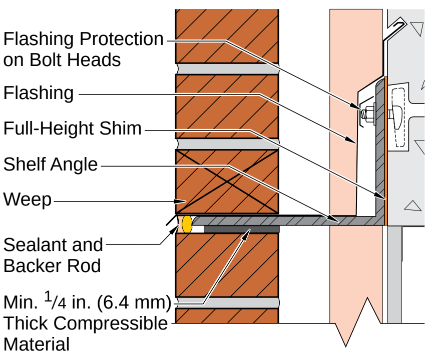

Figure 4. Shelf Angle with Concrete Frame

Unless rationally designed, brick veneer higher than 30 ft (9.14 m) above the foundation, 38 ft (11.58 m) for a gable above the foundation, should be supported by a shelf angle. The brickwork for each floor above this height is required to be supported by a shelf angle. Shelf angles should consist of steel angles sized and installed to carry the brickwork above. Shelf angles are typically located near the floor line or at the window head. Shelf angles attached to rigid concrete or steel elements should have full-height shims to reduce rotation, as shown in Figure 4. Any shelf angle attached to miscellaneous steel elements must have bracing to prevent out-of-plane movement, as depicted in Figure 5.

Shelf angles should not be installed as one continuous member. Space should be provided at intervals to permit thermal expansion and contraction of the steel angle to occur without causing distress to the masonry. Lipped brick may be used above or below a shelf angle to maintain the same joint width at the angle as other joints in the brickwork.

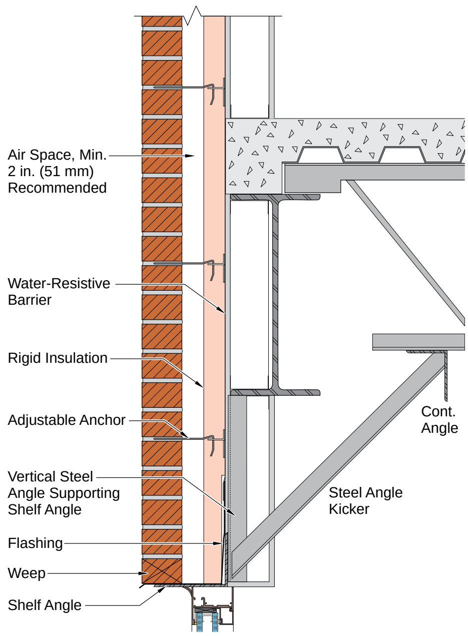

Figure 5. Brick Veneer / Cold-Formed Steel Framing Bracing System

Shelf angles should be supported by miscellaneous structural steel elements and not by steel studs. Field welding of shelf angles to studs should not be permitted since the thin wall of the steel stud increases the potential for burn-through. Further, a stud which supports a shelf angle may require additional strengthening and may be more prone to corrosive action from exposure to the moist air space. For more information on shelf angles, refer to BIA *Technical Note* 18A.

Head, Jamb, and Sill Details. Openings in brick veneer walls should be carefully detailed to prevent water from entering the brick veneer/steel stud wall system. Provision should be made for movement between the brick veneer and the frame or backing. Window frames, door frames, and opening sleeves must be attached to the backing, not the brick veneer. Window and door flashing must be integrated with the water-resistive barrier to provide a continuous barrier to moisture intrusion as shown in Figure 6. Sills should be sloped to the outside for drainage. Refer to BIA *Technical Note* 36 for further information.

Thermal Design. The best location for insulation is outboard of the stud wall in order to establish a continuous insulation layer within the wall. Outboard insulation should be placed on the exterior side of the exterior sheathing adjacent to the air space. The insulation should be closed cell to resist moisture absorption and should be either rigid or spray foam. Insulation in cavity may be required to be tested and comply with the acceptance criteria

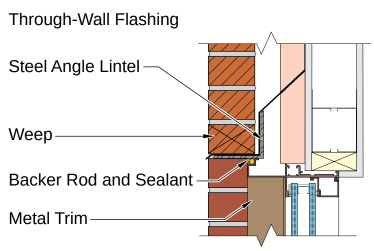

Figure 6a. Window Head Detail

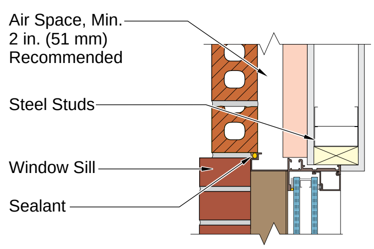

Figure 6b. Window Jamb Detail

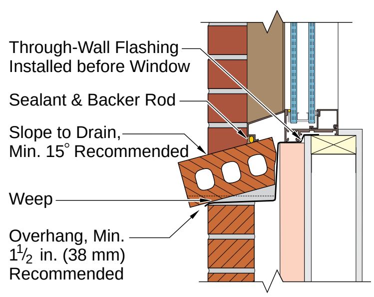

Figure 6c. Window Sill Detail

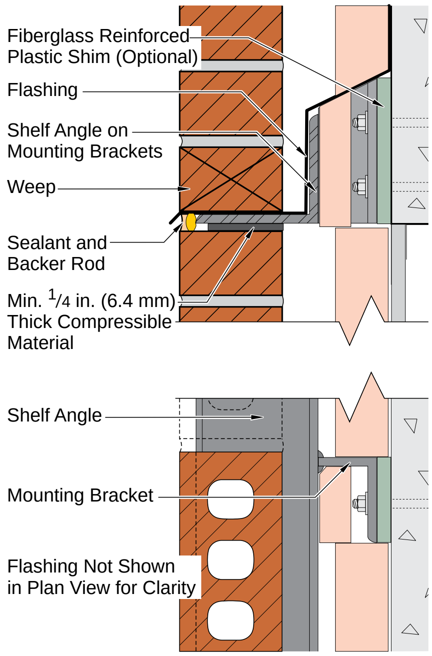

Figure 7. Shelf Angle with Thermal Break

of NFPA 285. Rigid insulation may be extruded polystyrene foam or polyisocyanurate foam and should be mechanically attached to the substrate wall. Spray insulation may be accomplished using spray polyurethane foam. The veneer anchors may be used to gauge the proper thickness of the spray, but in no case should the foam encroach on the drainage space.

Insulation located within the cold-formed steel stud cavity can be fiberglass or rock wool batts and loose-fill insulation in addition to rigid or spray foam. Installation should comply with the building code and the insulation manufacturer's requirements.

Incorporating certain details into the wall assembly can increase its thermal effectiveness. To reduce heat loss through shelf angles, the angle may be attached to the edge of slab or other support with steel clips spaced as far apart as the angle will accommodate. Insulation may be inserted between the clips and behind the angle to further isolate the angle. Fiberglass-reinforced plastic (FRP) and stainless steel (SS) have higher resistance to heat transfer than carbon steel. Using FRP and SS angles and plates as shims between steel elements as shown in Figures 7 and 8 can reduce the heat loss through shelf angles by acting as a thermal break. However, be aware that use of non-steel elements such as FRP within a steel connection is currently a departure from AISC design specifications and may invoke further NFPA 285 testing. To reduce heat loss through the cold-formed steel studs, proprietary studs with slit-webs can be used. Such studs have been shown to decrease the heat loss across the studs with minimal effect on the studs' strength. Structural and wall components should be positioned and detailed so that continuous insulation is not disrupted. For more information on the thermal design of cold-formed steel framing, refer to the Design Guide for Thermal Design and Code Compliance for Cold-Formed Steel Walls distributed by the American Iron and Steel Institute.

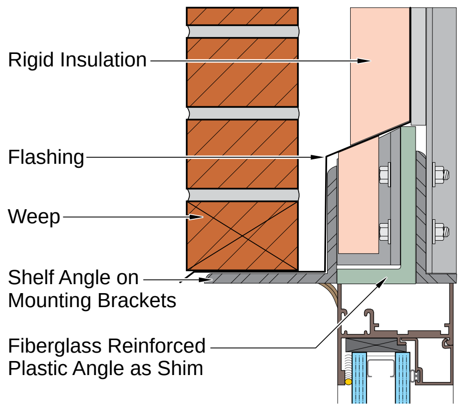

Figure 8. Hung Shelf Angle with Thermal Break

Condensation. Experience has shown that most water or moisture found within a wall constructed of cold-formed steel framing can be attributed to condensation. Condensation occurs at the point in the wall where the temperature gradient exceeds the dew point. If this point is within the air space between the brick veneer and the substrate wall, then the condensation will find its way out of the wall via the drainage system. However, if it is on the inside of the cold-formed steel framing within the substrate wall, then wall elements will dampen, may eventually saturate the surrounding materials, may have reduced thermal performance, and may lead to mold and/or corrosion problems.

It is recommended that a condensation analysis be conducted to determine if the potential for condensation exists in a wall. If results indicate that it may occur within the sheathing or cold-formed steel framing, then the wall design should be changed. Rigid board insulation may be placed on the outside of the exterior sheathing to increase the thermal resistance of the wall, or an air barrier or vapor retarder may be installed to decrease air and vapor movement through the wall. Installing required insulation in the air space also helps reduce or eliminate thermal bridging through the cold-formed steel studs.

Air Barriers and Vapor Retarders. Where analysis indicates a probability of condensation, an air barrier or vapor retarder should be provided. Air barriers are membranes made of polyethylene, polypropylene, or polyolefin. They are intended to prevent air leakage through the building envelope, hence reducing the associated energy losses and moisture movement. Most allow the transmission of vapor, while some also act as vapor retarders. Manufacturers provide data based on different standards, including 1) ASTM D726, Test Methods for Resistance of Nonporous Paper to Passage of Air and 2) ASTM E283, Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure. For this reason, caution should be exercised when evaluating and specifying air barriers.

Vapor retarders minimize moisture movement due to water vapor diffusion and are made of materials similar to air barriers. While some air barriers will also inhibit vapor transfer, all vapor retarders can be air barriers if they are installed and thoroughly sealed with no tears or holes. Materials which qualify as vapor retarders should have a perm rating of 1 or less.

Summary

The brick veneer/cold-formed steel framing system is a viable construction option when proper attention is given to design, detailing, material specification, construction, and maintenance procedures. For a full summary of recommendations for proper design and construction of the brick veneer/cold-formed steel framing system, refer to BIA *Technical Note* 28B on the Brick Industry Association website at www.gobrick.com.

BIA *Technical Notes on Brick Construction*

Since 1950, the Brick Industry Association's *Technical Notes on Brick Construction* have provided guidance on brickwork to the design and construction professional. For further recommendations on brick veneer/cold-formed steel framing construction, including a summary of recommendations and detailed drawings, refer to BIA *Technical Note* 28B on the Brick Industry Association website at www.gobrick.com.

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