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Brick Veneer/Cold-Formed Steel Framed Walls

Abstract: This *Technical Note* addresses considerations and recommendations for the design, detailing, material selection and construction of brick veneer/cold-formed steel framed walls. This information pertains to the behavior of the veneer and cold-formed steel framing, differential movement, veneer ties, air space, cavity, detailing, selection of materials and construction techniques. The basis for these recommendations is the requirements of the 2016 edition of TMS 402/602.

Key Words: brick veneer, cold-formed steel framing, deflection, design, flashing, masonry, permeability, stability, stiffness, veneer ties, walls, weeps.

SUMMARY OF RECOMMENDATIONS (page 1 of 2)

Veneer Height
- Maximum permitted veneer height above its support is 30 ft (9.14 m) to top of wall or 38 ft (11.58 m) to top of gable unless veneer is rationally designed and detailed for differential movement by a licensed design professional
- Support veneer above this height by shelf angle or other means for each story

Air Space
- 2 in. (51 mm) minimum air space recommended; 1 in. (25.4 mm) minimum air space required

Cavity
- Cavity includes sheathing, air space and continuous insulation as required
- Cavity width is measured from back surface of veneer to face of cold-formed steel framing member
- Maximum cavity width shall not exceed 6⅝ in. (168 mm) to face of framing member for use with prescriptive ties
- For larger cavity widths, ties must be rationally designed by a registered design professional

Flashing
- Extending flashing to exterior wall face is required
- Extending flashing beyond exterior wall face is recommended
- Place flashing at all points where air space is interrupted
- Extend flashing vertically up the backing to 8 in. (203 mm) minimum height
- Install base flashing not more than 10 in. (254 mm) above finished grade
- Turn up flashing ends into head joint a minimum of 1 in. (25.4 mm) to form end dams

Weeps and Drainage
- Place weeps immediately above flashing
- Open head joint weeps preferred. Can be filled with mesh or screens. Spacing recommended to be no more than 24 in. (610 mm) o.c.

Veneer Ties
- Adjustable ties are required. Corrugated sheet metal ties not permitted with cold-formed steel framed backing
- For a cavity width not exceeding 4⅝ in. (117 mm), provide at least one tie with wire size W1.7 (MW11) per 2.67 ft² (0.25 m²) of wall area
- For a cavity width wider than 4⅝ in. (117 mm) and not exceeding 6⅝ in. (168 mm), provide at least one tie with wire size W2.8 conforming to the requirements of Table 1 per 2.67 ft² (0.25 m²) of wall area
- For a cavity width exceeding 6⅝ in. (168 mm), design ties using provisions of TMS 402, "Alternative design of anchored masonry veneer"
- Vertical spacing: maximum 25 in. (635 mm) o.c.
- Horizontal spacing: maximum 32 in. (813 mm) o.c.
- Securely attach ties to the cold-formed steel framing through the insulation, if present, and through the sheathing, not to the sheathing alone
- For high wind and seismic areas, see the "Veneer Ties/Anchors" section for tie placement requirements
- Use minimum No. 10 self-tapping corrosion-resistant screws with a minimum nominal shank diameter of 0.190 in. (4.8 mm). A minimum of three full threads should be exposed on the inside face of the framing member.

Shelf Angles and Loose Lintels
- Standoff shelf angles should be installed to allow full sections of continuous insulation to be placed in the cavity
- Suspended shelf angles must have bracing to prevent out-of-plane movement
- Loose lintels, in contrast to shelf angles, are not attached to the building structure
- Bear loose lintels 4 in. (102 mm) minimum on the veneer brickwork on each side of an opening

Expansion Joints
- Provide vertical and horizontal expansion joints through brick veneer
- Design and construct expansion joints complying with recommendations of *Technical Notes* 18 and 18A

Cold-Formed Steel Framing
- Minimum G60 galvanized coating
- Restrict allowable out-of-plane deflection of cold-formed steel framing to between L/360 to L/600 depending on the project
- Minimum 0.043 in. (18 gauge; 1.09 mm) material thickness for exterior walls
- Field welding shall comply with AWS requirements

SUMMARY OF RECOMMENDATIONS (page 2 of 2)

Water-Resistive Barrier/Air Barrier/Vapor Retarder

- Many products function as both a water-resistive barrier (WRB) and air barrier (AB)
- Use vapor retarder where required
- Install WRB/AB over sheathing
- Seal water-resistive sheathing per manufacturer to perform as water-resistive barrier

Insulation

- Select insulation appropriate for use in the "wet zone" of the wall assembly
- Confirm that insulation meets building code requirements for flame propagation within the assembly

Sheathing

- Use one of the following:
  - Appropriately rated plywood or OSB
  - Exterior grade glass fiber mat-faced sheathing or cement board; minimum ½ in. (12.7 mm) thick
  - Closed-cell rigid insulation meeting ASTM C578 or C1289; minimum ½ in. (12.7 mm) thick
  - Magnesium oxide panels, ESR needed
  - Proprietary structural insulated panels

PROPERTIES OF BRICK VENEER/COLD-FORMED STEEL FRAMED WALLS

Moisture Resistance

Brick veneer construction incorporates a drainage space/air space within its cavity to deter water penetration into the building. This is a continuous air space that creates a physical separation between the brick veneer and the inner cold-formed steel framing. When wind-driven rain penetrates the veneer, the air space allows the water to drain down the back face of the brickwork. This water is then collected by flashing and channeled out of the wall through weeps. 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, see the *Technical Notes* 7 Series.

Thermal Performance

Brick veneer systems incorporating a vented or ventilated air space within the cavity can greatly 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. This performance of the brick veneer and the air space within the wall assembly has been verified by research conducted by the National Brick Research Center using a modified ASTM C1363 hot box apparatus [Ref. 1]. Moisture-resistant continuous insulation, such as closed-cell rigid foam boards or mineral wool, should be placed outboard of the water-resistive barrier within the cavity to provide thermal resistance while reducing the influence of thermal bridging caused by the cold-formed steel framing. Batt insulation may be placed between cold-formed steel framing members to reduce sound transmission and to provide additional thermal resistance. For further information regarding the thermal resistance of brick assemblies, refer to the *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 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). A nominal 4 in. (102 mm) brick wythe composed of ASTM C216 compliant brick has a 1-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, see *Technical Note* 16.

Acoustics

Brick veneer walls are well-suited as sound insulators. Multiple mechanisms reduce the sound transmitted through the wall. The hard surface of the brickwork reflects a large portion of sound waves. The mass of the brickwork absorbs another portion of sound energy. The remaining sound energy that makes its way through the brick veneer must continue through the air space and the sheathed framing. This air space separates the brick from the cold-formed steel framing, causing a dampening effect. With only ties bridging the air space, a further reduction in sound wave propagation is realized due to discontinuous construction. Finally, the energy must vibrate the sheathing and cold-formed steel framing to reach the inside of the building. Additional information on sound transmission can be found in *Technical Note* 5A.

Aesthetics

Brick is available in a large variety of colors, textures, glazes and coatings. In addition, many sizes are manufactured, and special shapes can be created to achieve a broad range of profiles. Add to this the ability to achieve multiple bond patterns, the use of colored mortars and interesting masonry detailing, and the creative possibilities are nearly endless. For further information on sizes and patterns, refer to *Technical Notes* 10 and 30.

Ease of Construction

The cold-formed steel framing and exterior sheathing of a brick veneer/cold-formed steel framed wall can be constructed prior to laying the brick veneer wythe. This allows the building to be closed in and placed under-roof quickly. Thus, interior work can begin with brick masonry construction following at a convenient time. Further, other trades can be scheduled to work without interfering with the mason.

INTRODUCTION

The brick veneer/cold-formed steel framed (BV/CFSF) wall assembly, sometimes referred to as brick veneer/steel stud (BV/SS) framed wall assembly, offers several advantages over other claddings. The system demonstrates superior performance in many of the specific areas of concern for designers, contractors and property owners, such as attractive appearance, high resistance to water penetration, ease of construction and low maintenance while providing a very durable exterior surface. Introduced in the 1960s, the BV/CFSF wall system has evolved into a successful construction method used in a wide variety of commercial, industrial, high-density housing and institutional structures, which include such building types as churches, hospitals, apartments and office buildings. These buildings usually have structural frames of hot-rolled steel or reinforced concrete. Unlike low-rise or small-scale residential construction, they generally are taller; frequently incorporate parapets; and are designed without overhangs, eaves or gutters to protect the veneer. Consequently, many commercial and multifamily brick veneer/cold-formed steel framed wall systems have greater exposure to their environment than their low-rise residential counterparts. For this reason, it is important to closely observe proper design, detailing and construction practices to ensure that expected and required levels of performance are met.

Anchored brick veneer with cold-formed steel framed backing consists of a nominal 3 or 4 in. (76 or 102 mm) thick exterior single wythe of brick mechanically attached to a cold-formed steel framed backing with corrosion-resistant metal veneer ties spanning the prescribed cavity between the veneer and the backing, as shown in Figure 1. Within the cavity is an air space, also referred to as a drainage space, and (as required) continuous insulation.

This *Technical Note* is one in a series dealing with brick veneer. This *Technical Note* addresses brick veneer with cold-formed steel framed backing, which is used primarily in commercial or multifamily residential construction built in accordance with the *International Building Code* (*IBC*) [Ref. 7], but also applies to cold-formed steel framed backing construction in one- and two-family dwellings and townhouses built in accordance with the *International Residential Code* (*IRC*) [Ref. 8]. Other *Technical Notes* in the series discuss other types of brick veneer wall systems.

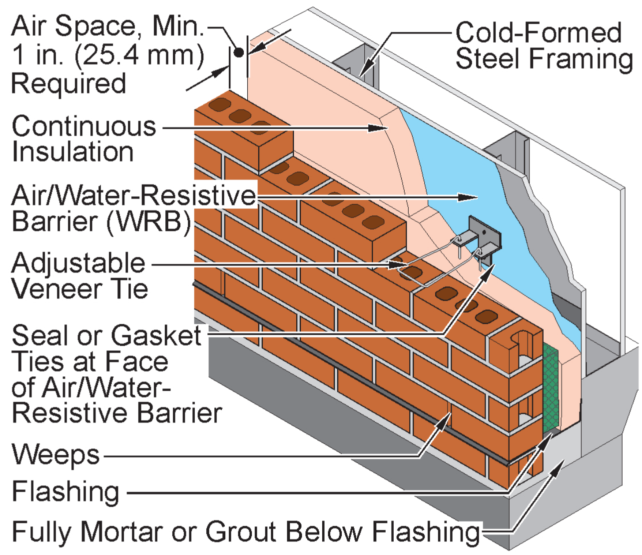

Figure 1
Brick Veneer/Cold-Formed Steel Framing

STRUCTURAL DESIGN

Minimum standards for brick veneer/cold-formed steel framed walls are established in the model building codes adopted by most local jurisdictions. Nearly all of these codes reference the *Building Code Requirements for Masonry Structures* (TMS 402) [Ref. 3] and the *Specification for Masonry Structures* (TMS 602) [Ref. 11]. TMS 402 contains both prescriptive requirements and alternative design requirements for anchored masonry veneer. To determine code provisions for a building in a specific area, the local building code authority should be consulted to confirm the adopted building code and to identify any local code provisions that supplement or supersede portions of the adopted model building code.

This *Technical Note* is based on the 2016 edition of TMS 402. Depending on the edition, TMS 402 uses the terms “anchor” or “veneer tie” to describe a connector that attaches the brick veneer to the structural backing. For the purposes of this *Technical Note*, the term “veneer tie” is used.

System Behavior

An anchored brick veneer is a single wythe of brick secured to and supported laterally by the backing wall through veneer ties and supported vertically by a foundation, shelf angle or other structural element. The veneer transfers out-of-plane load directly to the backing through the veneer tie system and is not considered to add load-resisting capacity to the wall system. Historically, brick veneer was paired with a stiff backing, comparable to or greater than the stiffness of the brick. However, brick veneer is substantially greater in stiffness than a cold-formed steel frame backing, resulting in more complex load-sharing behavior [Ref. 2].

Initially, the brick veneer carries most of the out-of-plane load. However, as the wall assembly deflects, the flexural tensile stresses that develop within the veneer will exceed the tensile capacity of the mortar joints (modulus of rupture) and several horizontal cracks will typically form, beginning near mid-height of the veneer panel, and then near the middle of the two resulting panels and so forth. This flexural cracking occurs at loads significantly less than those used for design or evaluation of serviceability. Once these cracks form, the load redistributes between the veneer and the backing such that the cold-formed steel framing carries most of the out-of-plane load. Therefore, when designing the wall assembly, the cold-formed steel framing should be designed to carry the full design load perpendicular to the face of the wall, and load sharing with the veneer should not be assumed.

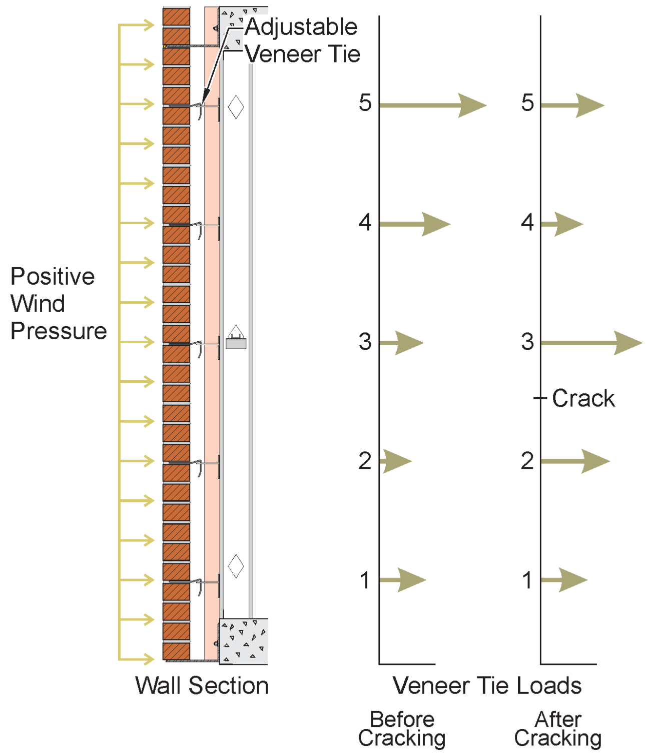

Figure 2
Veneer Tie Load Distribution

This complexity of load sharing also applies to veneer ties. The load that is transferred through each veneer tie depends on many factors, including but not limited to tie stiffness, mechanical "play" within the tie assembly, CFSF stiffness, and the location of tie relative to the span of the backing or veneer. While veneer ties are generally assumed to be loaded uniformly based on tributary area, the tie forces in a brick veneer/cold-formed steel framed wall assembly are nonuniform. Prior to cracking, veneer ties carrying the highest load will be located near the top of the wall section, as shown in Figure 2. Frictional forces at the support for the veneer also resist a portion of the load. Once the veneer cracks, the ties closest to the crack become the most heavily loaded and the forces on other ties will be reduced. The prescriptive provisions for veneer ties in TMS 402 accommodate this nonuniform loading of the ties.

Cold-Formed Steel Framing Deflection Criteria

Anchored brick veneer is designed to transfer out-of-plane lateral load through the veneer ties (anchors) to the backing. Because the veneer and the backing are tied together, the deflection of the backing is reflected in the veneer. Excessive deflection results in the development of cracking in the veneer; therefore, limiting the deflection of the backing as part of the design process is a common method used to control the amount of cracking in the veneer.

Historically, BIA has recommended a uniformly applied strict deflection limit for the design of CFSF acting as a backing for anchored brick veneer. Initially, the basis for this more conservative recommendation was intended to compensate for the lack of available research on the wall assembly and the inconsistent performance of the assembly in the field [Ref. 6]. The focus was primarily to limit the width of any cracks that developed in the brick veneer in an effort to limit moisture intrusion, even though the system is a drained assembly.

Over time, more research, analysis and field surveys have been conducted. The insights gained from these activities resulted in developing more robust detailing, improved materials and better installation methods for the components and the overall wall assembly. In addition, the building code established and implemented more stringent requirements for water-resistive barriers, air barriers and vapor retarders in general. As a result, the need for a strict deflection limit recommendation to control moisture intrusion into the drainage space for this wall assembly has significantly diminished [Ref. 5].

In light of the increased understanding and improved detailing of the assembly, it is possible to allow more deflection in many buildings to better match their intended level of performance. For common building types that are designed to provide a level of performance consistent with a code-compliant design, such as general office, industrial or residential buildings, BIA recommends the use of a design deflection of L/360 under serviceability loads. For buildings that are designed to provide a level of performance above the minimum code requirements, such as monumental, public, religious and institutional buildings, the previous BIA recommendation for a deflection limit of L/600 under serviceability loads is still recommended. Wind loads, as noted in the *IBC* requirements for serviceability, are recommended to be either 0.42 times the component and cladding loads or directly calculated using the 10-year mean return interval wind speed.

Influence of Ties. Generally, the influence of brick ties has been ignored when determining deflections; however, it is recommended that this now be considered. Brick tie stiffness contributes significantly to load transfer. Adjustable ties will deform under load and have mechanical play between parts that must be engaged before load transfer can occur. The tie deformation and mechanical play create increased deflection in the veneer that is not present in the CFSF. Per code, adjustable ties have a maximum mechanical play dimension of 1⁄16 in. (1.6 mm). It is also recommended that adjustable ties deform no more than 0.05 in. (1.2 mm) when tested at an axial load of 100 lb (45.35 kg). For the purposes of calculating the actual deflection of the veneer to account for the influence of the veneer ties, it is recommended to use one-half of the maximum mechanical play dimension and the deformation of the specified veneer tie added to the deflection of the cold-formed steel framing, following the principles of mechanics in modeling.

Steel Framing Design Recommendations

Cold-formed steel framing must be designed to provide adequate out-of-plane support for all loads imposed on the wall system. Framing members surrounding all openings in the veneer should be designed with loads based on the tributary area of the opening (windows and framing must be anchored only to the CFSF). Further criteria for load-bearing framing include providing adequate bearing capacity for the gravity loads. The flanges of the CFSF members must be laterally braced to resist compression in bending. This can be accomplished by fastening sheathing or board materials, such as water-resistive gypsum sheathing, plywood or cement board, to each side of the CFSF member, but this should not be assumed to contribute to increased flexural capacity or stiffness through composite action. In general, rigid board insulation does not provide the necessary bracing for CFSF. Alternatively, if sheathing or board materials are installed only on the exterior side of the CFSF, blocking or bridging in the framing cavity combined with in-plane bracing (straps) may also be used to restrain its rotation and/or lateral displacement. However, it is suggested to provide sheathing on both sides, in addition to any engineered bracing, to help support the water-resistive barrier and any interior finishes. The design of the bracing should follow the appropriate principles of mechanics, codes and technical literature [Ref. 10].

Seismic and Wind Requirements

The following requirements from TMS 402 apply to all types of anchored veneer, not exclusively those with a backing of cold-formed steel framing.

Seismic Requirements. In areas of increased risk of seismic activity, additional detailing must be incorporated for brick veneer. The following prescriptive requirements for anchored brick veneer are included in TMS 402. Refer to local building codes for additional seismic provisions.

The veneer chapter of TMS 402 addresses seismic provisions for anchored masonry veneer starting in Seismic Design Category (SDC) C and becoming increasingly more stringent as the seismic risk increases. TMS 402 requires the sides and the top of the anchored veneer in SDC C and above to be isolated from the structure so that seismic forces resisted by the structure are not imparted on the veneer. In SDC D and above, TMS 402 reduces the maximum allowable wall area tributary to each anchor. For SDC E and F, the weight of the anchored veneer at each story is to be independently supported separate from the weight of the veneer of adjacent stories [Ref. 3].

Wind Requirements. In locations where the wind velocity pressure (qz) exceeds 40 psf (1.92 kPa) but does not exceed 55 psf (2.63 kPa) and the building's mean roof height is not greater than 60 ft (18.3 m), the permissible wall area supported by each anchor is required to be reduced, and the spacing between ties at perimeter openings must be reduced. If the mean roof height exceeds 60 ft (18.3 m) within this range of velocity pressures, the veneer must be engineered by a licensed design professional using rational design following the principles of mechanics. In all cases where the wind velocity pressure exceeds 55 psf (2.63 kPa), the veneer must be engineered by a licensed design professional using rational design [Ref. 3].

MATERIALS

Brick

Brick are usually selected on the basis of their appearance, which includes color, texture and size. Selected brick units should conform to the applicable ASTM standard [Ref. 1]:

- ASTM C216, *Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)*
- ASTM C652, *Standard Specification for Hollow Brick (Hollow Masonry Units Made From Clay or Shale)*
- ASTM C1405, *Standard Specification for Glazed Brick (Single Fired, Brick Units)*
- ASTM C126, *Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units*. In the case of glazed brick specified per ASTM C126, it is recommended to also specify a material standard such as C216 or C652 for the underlying brick body.

For further information on brick material specifications, see the *Technical Note* 9 Series.

Mortar

Mortar plays an important role in the flexural strength of a brick veneer wythe. Out-of-plane strength tests of full-scale walls indicate that the bond between mortar and brick units is the most important single factor affecting wall strength when resisting horizontal joint cracking. Mortar must conform to ASTM C270, *Specification for Mortar for Unit Masonry* [Ref. 1] The designer should select the mortar with the lowest compressive strength that is compatible with the project requirements. The compatibility between a particular brick and mortar should be examined when determining mortar Type. Type N mortar is suitable for most veneer brickwork. Type S mortar is recommended where a higher degree of flexural resistance is required. In locations below grade, Type S mortar should be used. Admixtures and additives for workability are not recommended because they can potentially weaken the mortar. For more information, refer to the *Technical Notes* 8 Series.

Cold-Formed Steel Framing

Cold-formed steel studs and tracks should have a minimum nominal thickness of 0.043 in. (18 gauge) (1.1 mm) to provide sufficient thickness to engage the threads of the screws. Studs and tracks should have a protective coating conforming to one of the following ASTM standards [Ref. 1]:

- ASTM A653/A653M, *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process* with a minimum G60/Z180 or A60/ZF180 coating designation, respectively; or
- ASTM A875/A875M, *Specification for Steel Sheet, Zinc-5% Aluminum Alloy-Coated by the Hot-Dip Process* with a minimum GF30/ZGF90 coating designation.

For further information on the specification of cold-formed steel framing, refer to the *North American Standard for Cold-Formed Steel Structural Framing* (AISI S240) [Ref. 10]. For conditions of high humidity (indoor pools, laundries, kitchens, etc.) or near coastal environments, consider increasing the minimum galvanization to G90 or better.

Sheathing

Exterior-grade sheathing or insulated sheathing material should be installed on the exterior side of the CFSF. The sheathing should be one of the following:

- Exterior grade glass fiber mat-faced gypsum sheathing conforming to ASTM C1177/C1177M, *Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing* [Ref. 1];
- Cement board conforming to ASTM C1325, *Standard Specification for Fiber-Mat Reinforced Cementitious Backer Units* [Ref. 1] Type A; or

- Closed-cell insulating rigid foam conforming to ASTM C578, *Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation*, or ASTM C1289, *Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board* [Ref. 1].

The above sheathing types should be no less than ½ in. (12.7 mm) in thickness. If sheathing is used to laterally brace the CFSF members, it should be rigid enough to provide the required stiffness, which cannot be achieved by some insulation panels. Additional sheathing products include magnesium oxide panels and proprietary panels. Typically, proprietary panels combine sheathing and insulation into a single unit and are referred to as "structural insulating sheathing." These products comply with code requirements through International Code Council Evaluation Service Report (ICC-ESR).

In the majority of cases, the sheathing serves as the substrate for water-resistive barriers, air barriers and vapor retarders, where required. Some proprietary sheathing products have integral membranes or coatings that function as water-resistive barriers and air barriers when seams and penetrations are detailed per manufacturer requirements. Careful detailing at the top of walls; at transitions to other building envelope elements; and at window, door and louver openings is needed to provide continuity to achieve a watertight and airtight condition. Exterior sheathing should be suitably fastened with corrosion-resistant screws to the underlying cold-formed steel framing. Proprietary panels should be fastened in accordance with manufacturer's requirements.

Screws

Corrosion-resistant screws with a minimum nominal shank diameter of 0.190 in. (4.8 mm) are required to attach veneer ties to CFSF members. A minimum #10 self-tapping screw is recommended. Screws should conform to ASTM C1513, *Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections* [Ref. 1] or qualify through an ICC-ESR. Screws used to attach exterior sheathing and veneer ties can be either coated carbon steel or stainless steel. Carbon steel screws should have a noncorrosive coating of zinc, polymer or composite zinc-polymer. Zinc-plated screws should be either mechanically plated according to ASTM B695, *Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel*, or electroplated in accordance with ASTM B633, *Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel* [Ref. 1]. 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 protection superior 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 CFSF is much larger than that of the screw, which results in a decreased corrosion potential. Copper-coated screws are not recommended since they can react galvanically with CFSF having zinc coatings.

Screws should be bimetallic, consisting of a hardened steel drill tip and a more ductile steel shaft, to avoid potential performance issues associated with hardened steel. It is critical that a minimum of three threads beyond the drill tip section be exposed on the inside face of the CFSF member to be sure that the ductile steel portion of the screw is adequately engaged to connect the components.

To assist in water penetration resistance, screws incorporating an integral EPDM or neoprene sealing washer under the screw head may be considered. Flexible washers may reduce the shear strength of the sheathing panel; therefore, their use should be carefully considered when the sheathing is used in a shear wall or diaphragm. Placing sealant over the screw heads may also be an option. There may also be specific requirements for detailing around screw penetrations from the manufacturer of the water-resistive barrier and/or air barrier. Due to the area-relationship principle mentioned above, when stainless steel screws are used with galvanized carbon steel ties/anchors, sealing washers are highly recommended.

Water-Resistive Barriers, Air Barriers and Vapor Retarders

Resistance to water and air ingress is more critical for BV/CFSF wall assemblies than other wall assemblies. Proper detailing of the moisture and air control layers is critical, such as sealing penetrations around veneer ties. Moisture and air control layers consist of water-resistive barriers, air barriers and vapor retarders. All three of these products perform different functions. A water-resistive barrier (WRB), as defined by the *IBC*, is a material behind an exterior wall covering that is intended to resist liquid water that has penetrated behind the exterior wall covering from further intruding into the exterior wall assembly. Air barriers restrict or prevent the passage of air through the wall assembly, which prevents moisture-laden air from reaching areas of the wall assembly intended to remain dry. Vapor retarders limit water vapor diffusion from passing through portions of the wall assembly where moisture can condense. Water-resistive barriers and air barriers are required per code in nearly all cases. Vapor retarders are required by code in some locations but are otherwise optional. In cases where two or more of these are required in the wall assembly, there are single materials capable of serving multiple functions that can be considered.

A water-resistive barrier should be located between the air space and the sheathing; between the continuous insulation and the sheathing; or, less commonly, on the outboard face of continuous insulation. A WRB should be detailed to keep out any water that finds its way across the air space via ties, mortar bridging or splashing. Where continuous insulation or water-resistive sheathings with integral membranes are used as the water-resistive barrier, they must be completely sealed with compatible tape or sealant to perform as a WRB. The WRB must be fully integrated with the flashing to direct moisture out of the assembly.

Continuity. Care should be taken to install WRBs; air barriers; and, where required, vapor retarders in order to create a continuous layer, without gaps or untreated penetrations. Any damage to these materials must be corrected prior to installation of brickwork or the systems will not function as intended.

For further discussion on air barriers, water-resistive barriers and vapor retarders, refer to the *Technical Note* 7 Series. In-depth discussion of air barriers, water-resistive barriers and vapor retarders, including their recommended placement, is outside the scope of the *Technical Notes*. There are many building science resources available for reference [see Ref. 4]. For buildings with unusual wall assemblies or functions, consultation with building envelope professionals is recommended.

Continuous Insulation

Most wall assemblies using CFSF include continuous insulation within the cavity to improve their thermal resistance. In some cases, all the required insulation can be placed in the cavity rather than in both the cavity and between the CFSF members. Although thermal resistance is the most important characteristic for insulation, other properties for consideration include water absorption, combustibility, density, insect resistance and ease of installation. Some insulation types degrade over time, reducing their heat flow resistance, and others will change their thermal resistance to heat flow properties with temperature. Materials used for continuous insulation should conform to the following requirements:

1. Must be durable and resist rot due to moisture or dryness. Must be intended for use in the “wet zone” of the wall assembly with no degradation or loss of insulating value.
2. Must meet the building code requirements for flame propagation within the assembly.
3. Must not serve as a food source for vermin or biological growth.
4. Must permit the air space to perform its function by allowing moisture to drain without wicking to the interior.

Typical continuous insulation types used in brick masonry walls include extruded polystyrene (XPS), polyisocyanurate, mineral wool and spray polyurethane foam (SPF). Each of these types, if properly used, will result in a more thermally efficient wall system but require individual detailing. SPF will be adhered to the backing. Mineral wool batts will be held in place with mechanical fasteners. Rigid boards can be adhered to or mechanically fastened to the backing. Special clips can be added to veneer anchors to secure the insulation. Refer to the *Technical Notes* 4 Series as well as *Technical Note* 47 for further information regarding insulation and energy performance of brick wall assemblies.

Veneer Ties/Anchors

For the purposes of this *Technical Note*, the term “veneer tie,” or “tie,” is used to describe a connector that attaches the veneer to the backing. Older versions of TMS 402 use the term “anchor” to describe these connectors.

Care must be taken to connect the masonry veneer to the backing in a manner that will permit each to move freely, in-plane, relative to the other. Ties that connect the veneer to the backing must provide out-of-plane restraint, resisting tension and compression, but allowing vertical in-plane differential movement between the frame and the veneer. Ties to be used with CFSF must meet the requirements listed in Table 1 and TMS 402. Examples of such ties are shown in Figure 3.

Per TMS 402, only adjustable ties are permitted to be used with cold-formed steel framing as a backing. Wire veneer ties with formed drips are not permitted by code because of their reduced load capacity. Corrugated sheet-metal ties are also not permitted for BV/CFSF walls, as they may not fully engage the CFSF member upon initial loading and typically do not have sufficient compressive strength capacity for the typical cavity widths used in this wall assembly. See Table 1 for adjustable tie/anchor requirements for this backing type.

TABLE 1

Adjustable Tie/Anchor Requirements for Brick Veneer with a Backing of Cold-Formed Steel Framing[1]

Cavity Width, in. (mm)	Minimum Wire Size	Maximum Wall Area per Tie, ft² (m²)	Backing Attachment Requirements	Pintle or Adjustable Part Requirements
≤4⅝ (117)	W1.7 (MW11)	2.67 (0.25)	**Eye:** Min. wire W1.7 (MW11) **Plate:** Min. 0.06 in. (1.5 mm) thick and ⅞ in. (22.2 mm) wide	**Wire:** Min. W2.8 (MW18) **Pintle legs:** 1 min. **Offset:** Max. 1¼ in. (31.8 mm)
>4⅝ (117) and ≤6⅝ (168)	W2.8 (MW18)	2.67 (0.25)	**Two eyes:** Min. wire W2.8 (MW18) **Barrel:** Min. ¼ in. (6.4 mm) outside diameter **Plate/prong:** Min. 0.074 in. (1.88 mm) thick and 1¼ in. (31.8 mm) wide	**Wire:** Min. W2.8 (MW18) **Pintle legs:** 2 min. **Offset:** Max. 1¼ in. (31.8 mm) **Distance from inside face of brick to end of adjustable part:** Max. 2 in. (51 mm)
>6⅝ (168)	Design ties using provisions of TMS 402, "Alternative design of anchored masonry veneer."			

1. Tie requirements shown are for brick veneer with a backing of cold-formed steel framing per 2016 TMS 402.

All ties are required to be embedded at least 1½ in. (38 mm) into the brick veneer bed joints with a minimum of ⅝ in. (15.9 mm) mortar cover to the outside face of the wall. In addition, ties are required to have a maximum clearance between connecting parts of the tie of 1⁄16 in. (1.6 mm) and should be detailed to prevent disengagement. When the distance between the inside face of the brick veneer and the steel framing exceeds 4⅝ in., then the adjustable part of the anchor should consist of two or more wires of minimum wire size W2.8 (MW18) and the distance from the inside face of the brick veneer to the end of the adjustable part of the anchor should not exceed 2 in. (51 mm), as shown in Figure 4.

Adjustable ties are required to provide the capacity to transfer loads applied to a maximum of 2.67 ft² (0.25 m²) of wall area. TMS 402 limits spacing of ties to a maximum of 25 in. (635 mm) o.c. vertically and a maximum of 32 in.

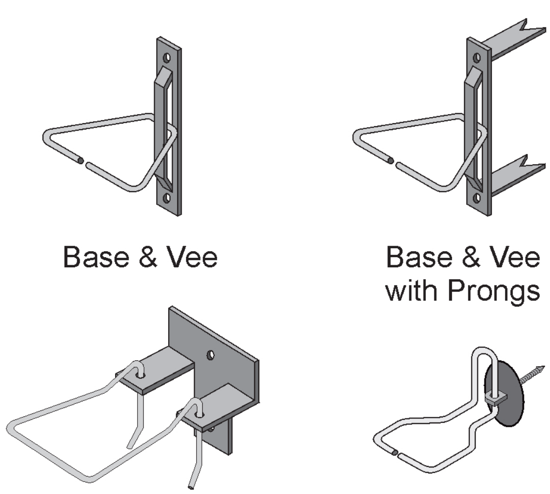

Figure 3
Adjustable Veneer Tie Assemblies

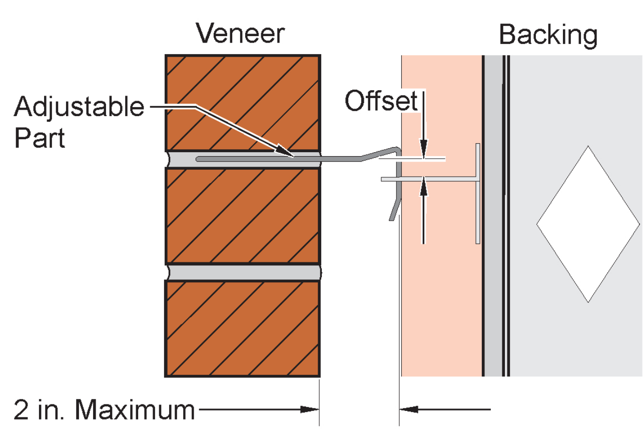

Figure 4
Adjustable Veneer Tie for Cavity Widths That Exceed 4 in.

(813 mm) o.c. horizontally. Around the perimeter of openings with any dimension larger than 16 in. (406 mm), additional ties are required to be spaced at a maximum of 3 ft (914 mm) o.c. and placed within 12 in. (305 mm) of the opening.

Previous editions of the building code required veneer ties in Seismic Design Categories E and F to be mechanically fastened to horizontal reinforcement in the brick veneer. However, shake-table research [Ref. 9] showed that this requirement was detrimental to the veneer performance, resulting in removal of this requirement from the code.

Ties are required to be made of carbon steel or stainless steel. Carbon steel ties are required to conform to ASTM A1064/A1064M, *Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement*, *Plain and Deformed, for Concrete* [Ref. 1]. Stainless steel ties are required to conform to ASTM A580/A580M, *Standard Specification for Stainless Steel Wire* [Ref. 1]. Ties made of carbon steel are required to be hot-dipped galvanized in accordance with Class B-2 of ASTM A153/A153M, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware* [Ref. 1].

Veneer ties transfer load from the brick veneer to either the CFSF or the structural frame of the building. Therefore, they must be securely attached through the sheathing directly to the framing, not to the sheathing alone. Most veneer ties are intended to be fastened to the flange of the CFSF member. However, in some cases, it is preferred to use veneer ties that are fastened to the member web. These veneer tie types allow for additional screw fasteners as needed and load the screws in shear instead of tension, which can provide additional load capacity.

Prongs at each end of an adjustable tie base, as shown in Figure 3, should be considered with non-rigid sheathing to prevent compression of the insulation or sheathing and provide contact between the tie base and the CFSF flange to ensure anchorage in the event of long-term deterioration of sheathing or insulation. Installing a self-adhered modified asphalt or EPDM membrane behind the backing plate of the veneer tie is recommended to provide additional water resistance. Depending on the material used for the water-resistive barrier and/or air barrier, fluid-applied flashings may be used around veneer tie penetrations for additional moisture penetration resistance.

For projects where reduction of thermal conductivity is a requirement, stainless steel veneer ties are an option in lieu of the typical galvanized carbon veneer ties. Many veneer tie manufacturers also manufacture veneer ties that incorporate nonconductive components or coatings to reduce the transfer of heat.

For more information about veneer ties, refer to *Technical Note* 44B.

Horizontal Joint Reinforcement

Although not usually required for brick veneer construction, horizontal joint reinforcement, also called “bed joint reinforcement,” can be incorporated into brick veneer walls to alleviate cracking from high internal stress, to have the brick serve as a reinforced lintel, or laid in bed joints separating brick from other materials. Per TMS 402, horizontal joint reinforcement is necessary for veneer laid in a pattern other than running bond. Running bond is defined as the placement of units so that head joints in successive courses are horizontally offset by at least one-quarter of the unit length. It may be either single or double wire joint reinforcement and must have at least ⅝ in. (15.9 mm) mortar cover. Horizontal joint reinforcement can also be used above and below the corners of masonry openings for added strength. The reinforcing wire diameter must not exceed one half the mortar joint height. Previous code requirements mandated the use of horizontal joint reinforcing paired with anchors in Seismic Design Categories E and F. Shake-table research [Ref. 9] has shown that these requirements are not necessary or useful, and as a result, the requirements have been removed from the codes.

Sealant Joints

Sealant joints prevent water penetration at veneer expansion joints and perimeters of openings. These joints typically consist of a compressible foam backer rod, recessed and covered by elastomeric sealant. Sealant joints should be free of mortar for the entire thickness of the brick veneer. If desired, a compressible pad extending the depth of the veneer may be included behind the backer rod but is not required.

The perimeter of all exterior window frames, doorframes and sleeves should be closed with a sealant joint. This joint should be between ¼ and ½ in. (6.4 and 12.7 mm) wide, depending on the amount of expected differential movement and the movement capacity of the sealant. Wider joints will accommodate more movement than narrow joints. Fillet joints are not generally recommended, but if installed, a quarter-round backer rod or bond break tape should be used to prevent three-sided adhesion.

Sealants should be selected for their durability, extensibility, compressibility and compatibility with other materials. A sealant should be able to maintain these qualities under the temperature extremes of the climate in which the building is located. Sealant materials should be selected to comply with ASTM C920, *Standard Specification for Elastomeric Joint Sealants* [Ref. 1]. Specific sealants recommended by manufacturers for brickwork include silicone, polyurethane and polysulfide sealants. A sealant primer may be required before applying some sealants on certain brick to mitigate the potential for staining. For further information on sealants, refer to ASTM C1193, *Standard Guide for Use of Joint Sealants* [Ref. 1], and *Technical Notes* 7A and 18A.

DESIGN AND DETAILING

Cavity and Air Space

The air space or drainage space within the cavity provides a means of egress for water that has penetrated the brick veneer and permits air flow for drying. The *IBC* and TMS 402 require a specified 1 in. (25.4 mm) minimum air space. However, the air space is recommended to be a minimum of 2 in. (51 mm) in order to minimize the possibility of mortar bridging across the air space. When continuous insulation is present within the cavity, provide the same minimum dimension of 1 in. (25.4 mm) between the inside face of the brick and the exterior face of the insulation.

When standard veneer ties made of W1.7 (MW11) wire are used, the TMS 402 prescriptive provisions allow a cavity width of no more than 4⅝ in. (117 mm) between the inside face of the brick veneer and the exterior face of the CFSF. When stronger veneer ties made of W2.8 (MW18) wire are used, the prescriptive provisions allow for a cavity width up to 6⅝ in. (168 mm). Refer to Table 1 for more information about the veneer tie requirements. When the cavity width exceeds 6⅝ in. (168 mm), the TMS 402 alternative design provisions require that a registered design professional must design the veneer ties. The alternative design provisions also apply when adjustable ties are used in cavities with air spaces larger than 2 in. (51 mm).

To the extent possible, the air space must be kept clear of mortar and mortar droppings to achieve adequate drainage. Mortar collection devices may be specified at the bottom of air spaces immediately above flashing to prevent mortar from blocking the weeps. However, the use of mortar collection devices should not preclude good workmanship. Refer to the “Weeps and Drainage” section of this *Technical Note*.

When continuous insulation is placed within the cavity, it must be attached to the backing by mechanical or adhesive means to prevent it from shifting and blocking the air space. In some cases, an integral head or a separate plastic piece that slips over the projecting legs of the veneer tie can secure the insulation to the backing.

Through-Wall Flashing

Through-wall flashing is an impervious material installed in a drainage wall system to direct moisture that has penetrated the brick veneer back to the exterior. In BV/CFSF wall assemblies, flashing is required at the base of the wall, above and below all wall openings, at shelf angles and loose lintels, at the tops of walls, beneath copings, and at any other discontinuities or interruptions in the cavity. Flashing should extend to the face of the exterior brick wythe at a minimum. However, extending the flashing beyond the face of the brick and adding a bend to form a drip is preferred. Extend flashing vertically up the backing to 8 in. (203 mm) minimum height. Unless otherwise required by the WRB or air barrier manufacturer, fasten the top of flexible flashing with a termination bar. Where flashing is not continuous, the ends of the flashing should be turned up a minimum of 1 in. (25.4 mm) to form end dams.

Aspects of flashing unique to brick veneer with cold-formed steel framed backing include the following:

- Where suspended shelf angles are used, their supports are typically spaced at approximately 3 to 4 ft o.c. Infill of cold-formed steel framing with sheathing should be installed between these supports in order to properly support the vertical leg of the flashing, in addition to achieving continuity for the WRB and air barrier when present (see Figure 7).
- It is not recommended to install the vertical leg of flashing behind the sheathing, even when the sheathing has an integral water-resistive barrier. Although this is consistent with proper shingling practice, it increases the risk of moisture wicking into the sheathing, which can lead to deterioration. Use

of a properly sealed termination bar on the exterior face of the sheathing, at the top of the flashing, is a better choice in this situation.
- When taped and/or sealed, some types of exterior insulation may serve as the water-resistive barrier. In these cases, the vertical leg of the through-wall flashing should be installed behind the plane of the insulation but in front of the sheathing.
- When spray foam insulation is used, the portion of the flashing that will be concealed must be installed before the insulation. An optional installation method involves the use of premanufactured continuous brackets with a receiver slot that allows for flashing membranes to be installed after the spray foam.

For more information regarding proper flashing detailing, material selection and installation, refer to the *Technical Note* 7 Series.

Weeps and Drainage

Weeps direct moisture collected on the flashing to the exterior of the wall assembly. Weeps are required to be placed immediately above flashing, in the same bed joint, at all locations. If weeps are installed one to two masonry courses above the flashing or placed on top of bed joint mortar, they will not perform their intended function. The *IBC* and TMS 402 require weeps to be placed no more than every 33 in. (838 mm) o.c. An open head joint is the preferred type of weep because it maximizes drainage and allows for air flow in the cavity. Open head joint weeps should be at least 2 in. (51 mm) high and are recommended to be spaced no more than 24 in. (610 mm) o.c. Metal or plastic screens, channels or cell vents may be placed in the open head joint to discourage insect entry and to reduce the risk of weeps being closed during future maintenance work. Other types of weeps are available but should have closer spacing. See the *Technical Notes* 7 Series for further discussion on weep types other than the open head joint.

Vents. Some designers also incorporate vents to provide increased air flow in the cavity. Vents are typically placed within the uppermost three courses of brick at each location where the vertical air space is interrupted. These vents consist of open head joints with optional inserts, like a weep, and are typically spaced similarly. At shelf angles and other flashing locations where weeps and vents will be in close proximity, it is recommended to stagger the placement of weeps and vents horizontally so that moisture exiting the wall through a weep does not reenter through a vent in the course below.

Drainage Materials and Mortar Collection Devices. Good workmanship during construction is the primary method of creating a functional drainage space; however, mortar collection devices or full-height drainage media can be installed in the air space to help prevent obstruction by mortar. Use of drainage materials may not eliminate the risk of mortar bridging and may result in simply moving the mortar bridge higher within the air space. Therefore, many manufacturers require that the top edge of the vertical leg of the flashing be installed a minimum of 6 to 8 in. (152 to 203 mm) above the top surface of the collection device to provide adequate protection against moisture ingress when mortar droppings accumulate. While it is important to keep the air space as free of mortar as possible, some mortar is permitted to be present per the building code, provided that it does not impact the ability of the air space to provide drainage. For further discussion on weeps and mortar collection devices, refer to the *Technical Notes* 7 Series.

Base of Wall

Support. Foundations of concrete masonry or concrete are generally used to support BV/CFSF walls. 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. A typical detail at the base of a wall is shown in Figure 5.

Flashing. Base flashing is required to be installed above the foundation to allow the drainage system to function properly, but it must not be more than 10 in. (254 mm) above the finished grade level. Base flashing is required to extend to the exterior face of the veneer at a minimum to preclude any moisture from migrating by capillary action up through the brickwork. Brickwork below the base flashing should be detailed to completely fill the cavity or air space with grout or mortar to minimize water penetration. Veneer ties should be located within the grout-filled cavity according to the same spacing as in the brick veneer above grade.

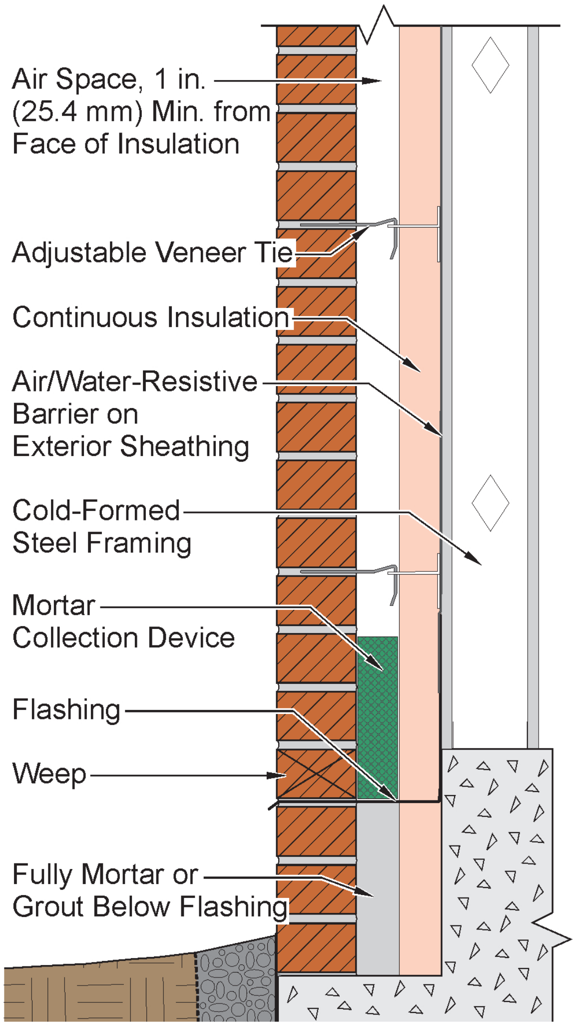

Figure 5
Section at Base of Wall

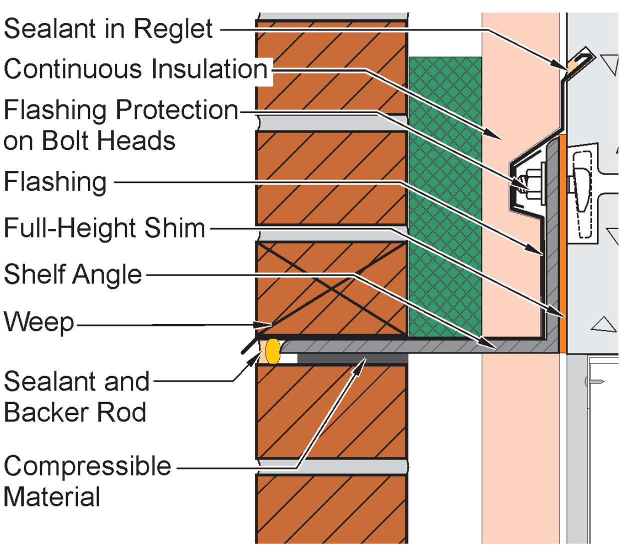

Figure 6
Shelf Angle with Concrete Frame

Cold-formed steel framing 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. Brickwork should extend below grade only when special detailing and construction provisions are incorporated to minimize water penetration. Refer to *Technical Note* 7 for more information related to detailing of flashing and use of brick below grade.

Shelf Angles and Loose Lintels

Veneer with a maximum height above its support of 30 ft (9.14 m), or 38 ft (11.58 m) with a gable can be supported directly on a foundation wall, footing, or noncombustible support without shelf angles. Brick veneer taller than these heights is required to be supported by shelf angles at each story unless rationally designed.

Shelf angles provide continuous support for the brickwork through connection to the primary building structure, typically located near the floor line or at the window head, as shown in Figure 6. Shelf angles are occasionally referred to as relieving, ledge/ledger or relief angles. In contrast, loose lintels are not attached to the building structure and provide support by bearing on the brickwork on each side of an opening.

Shelf angles and loose lintels are not interchangeable. A shelf angle must carry the full weight of brick masonry above, while a loose lintel is typically permitted to carry a reduced load due to the arching action of the supported brickwork, depending on the brickwork orientation and the bond pattern. Steel angles are most frequently used as both shelf angles and loose lintels; however, loose lintels can also consist of reinforced masonry, precast concrete or stone. Brickwork must be supported over all masonry openings unless the brick is self-supporting, such as a structural arch. Loose lintels must bear a minimum of 4 in. (102 mm) on brick on each side of the opening. Loose lintel and shelf angle deflection between support points must not exceed L/600, and where applicable the total rotation of the toe of a shelf angle or loose lintel must be less than 1⁄16 in. (1.6 mm).

Steel used for shelf angles and loose lintels must conform to the requirements in ASTM A36/A36M, *Standard Specification for Carbon Structural Steel* [Ref. 1]. All carbon steel angles should be primed and coated to prevent corrosion. In harsher environmental conditions, such as coastal regions, consider the use of hot-dipped galvanized or stainless-steel angles.

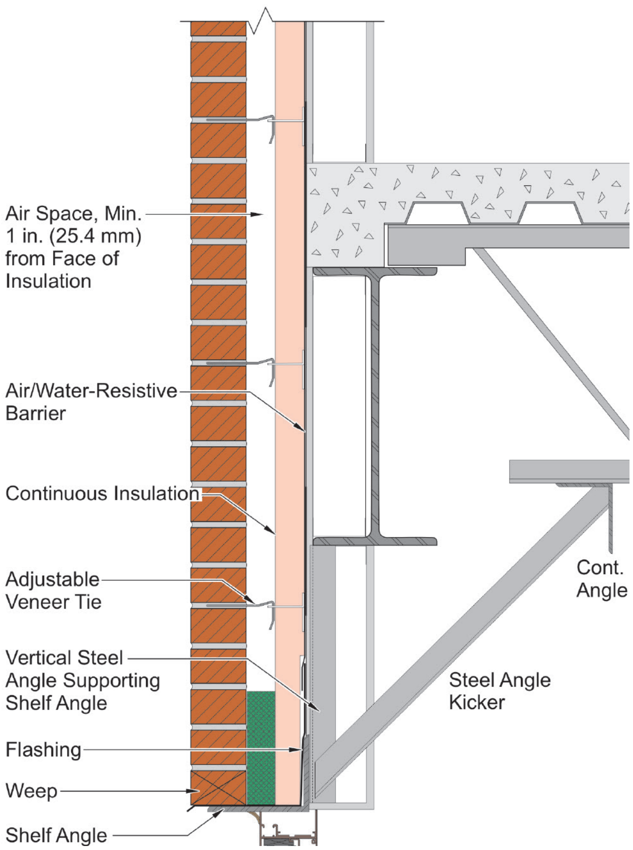

Figure 7

Suspended Shelf Angle on Steel Frame with Bracing

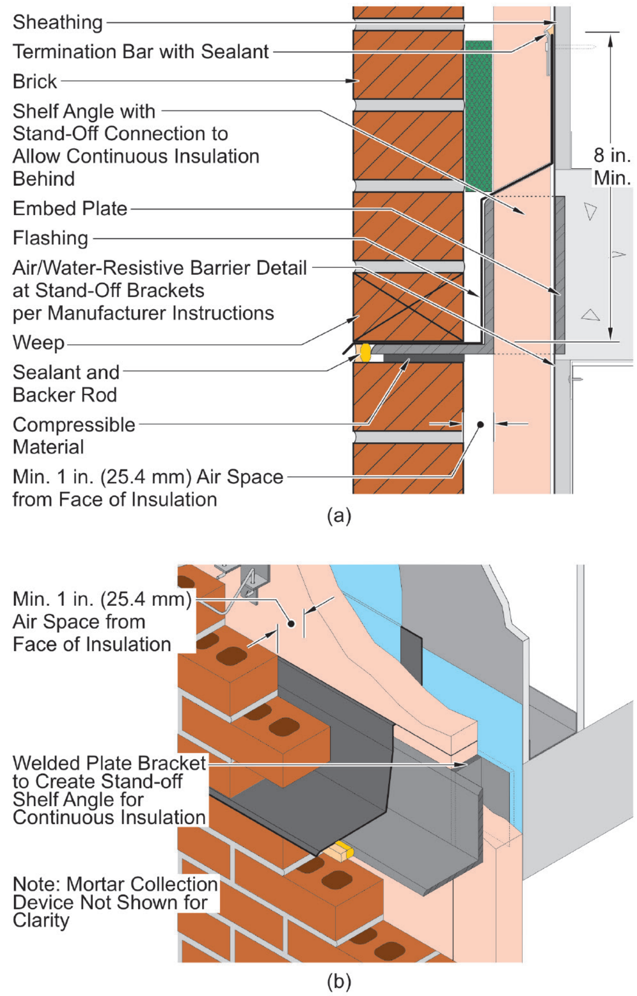

Figure 8

Shelf Angle with Stand-Off Attachment

Miscellaneous metal fabrications may be used to suspend a shelf angle from the structural frame. Suspended shelf angles must be braced to prevent out-of-plane movement of the wall, as depicted in Figure 7. The structural engineer for the project should design these fabrications and connections. It is preferred to support shelf angles from the primary structure rather than the cold-formed steel framing. However, shelf angles potentially can be connected to CFSF if engineered and approved by the cold-formed steel design engineer.

To allow for continuous insulation within the cavity, special detailing of shelf angles may be required. Standoff shelf angles should be installed to allow full sections of continuous insulation to be placed in the cavity, as shown in Figure 8. Standoff shelf angles can be designed by the structural engineer, by fabricating miscellaneous metal brackets, or by using proprietary prefabricated standoff shelf angle brackets or other hardware.

For further information regarding the design of steel loose lintels and shelf angles, refer to *Technical Note* 31B.

Head, Jamb and Sill Details

Openings in brick veneer walls should be carefully detailed to prevent water from entering the BV/CFSF wall assembly. Provision should be made for differential movement between the brick veneer and the frame or backing. Window frames, doorframes 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

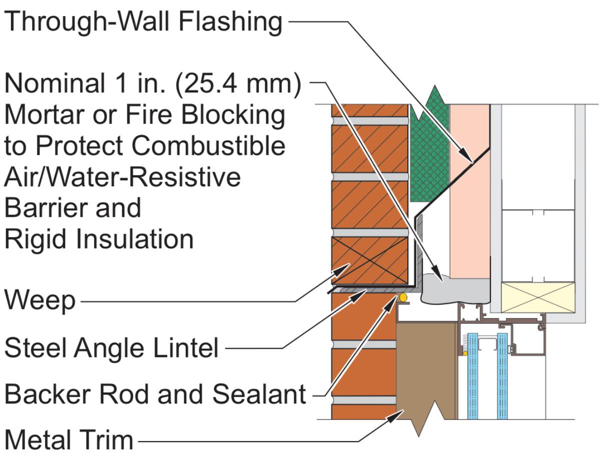

Figure 9
Window Head Detail

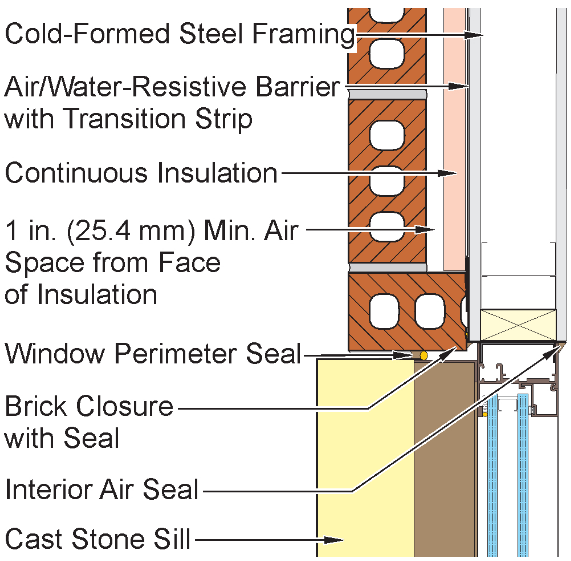

Figure 10
Window Jamb with Brick Closure Detail

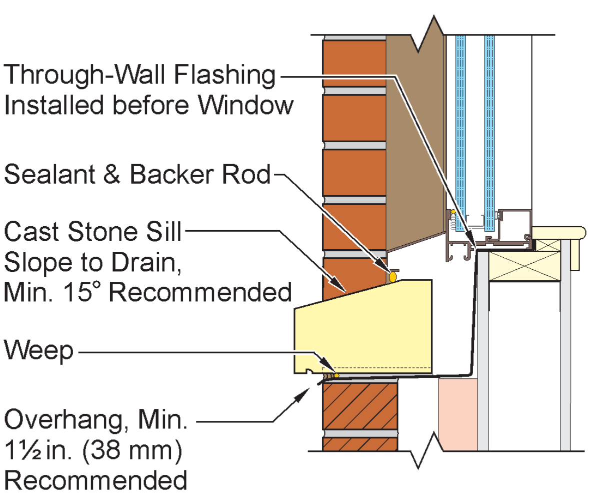

Figure 11
Window Sill Detail

intrusion, as shown in Figure 9, Figure 10 and Figure 11. Sills should be sloped to the outside for drainage. Refer to the *Technical Notes* 7 Series for further information.

Expansion Joints

Brickwork will expand and contract continually during its life, but it experiences an overall net expansion. Newly fired brick undergoes irreversible volumetric change after it exits the kiln. This volumetric change follows a geometric curve, with the largest changes occurring at time intervals nearest the firing process. For more information about the volume changes in brickwork, refer to *Technical Note* 18.

This expansion must be accommodated in the design and construction of the wall system to deter cracking, spalling and other potential brick masonry issues. Accommodation of movement is accomplished through the use of expansion joints, oriented both horizontally and vertically, detailed into the brick veneer. An expansion joint consists of an opening through the brick wythe that is closed with sealant, backer rod and optional compressible filler materials.

The size, spacing, placement and compressibility of veneer expansion joints is critical to achieving the proper performance of the veneer. Any portion of veneer not able to resist induced stress should be isolated by an expansion joint. No single recommendation for the placement and spacing of veneer expansion joints can be applicable to all structures. The spacing and placement of vertical and horizontal expansion joints must be determined on a case-by-case basis. In addition, expansion joints must be located and constructed to not impair the integrity of the wall. For more information on recommended placement locations and detailing for expansion joints, refer to the *Technical Notes* 18 Series.

Horizontal Expansion Joints. A horizontal expansion joint is one that is oriented horizontally on the wall and accommodates the movement of the brickwork in the vertical direction. Typically, these occur below shelf angles, which support the brick veneer above it. Horizontal expansion joints also occur at transitions between the top of brick veneer and other cladding materials.

Vertical Expansion Joints. A vertical expansion joint is one that is oriented vertically on the wall and accommodates the movement of the brickwork in the horizontal direction. Vertical expansion joints should extend from the foundation to the top of the brickwork without deviating from vertical. When this is not possible, they can be terminated at horizontal expansion joints. Generally, the spacing of vertical expansion joints should not exceed 25 ft (7.6 m) in walls without openings. For walls with multiple openings, the spacing between expansion joints should not exceed 20 ft (6.1 m). Building corners should have a vertical expansion joint located within 10 ft (3.05 m) of the corner. Be aware that buildings located in areas with higher Seismic Design Categories may require placement of vertical expansion joints closer to or at building corners in order to accommodate the large story drifts.

Parapet Walls

Parapets are exposed on three adjacent surfaces and consequently are potentially more vulnerable to water penetration and condensation. Therefore, if used, the parapet must be properly designed, detailed, and constructed to function as intended. It is strongly discouraged to use balloon or bypass framing (continuous vertical framing outboard of the structure from the topmost floor to the top of the parapet) to construct CFSF parapets. Although there can be a structural benefit to doing so, such a configuration creates difficulties in establishing and maintaining continuity of, as applicable, the thermal insulation, air barrier and vapor retarder at the roof-to-wall interface. When continuity cannot be achieved, air leakage and energy loss through the roof-to-wall interface can lead to condensation. CFSF parapets that are mounted to the roof structure have been successfully installed and detailed. Reinforced masonry has also been used successfully to construct parapets above BV/CFSF walls, as shown in Figure 12. A gravel stop detail as shown in Figure 13 can be used instead of a parapet wall.

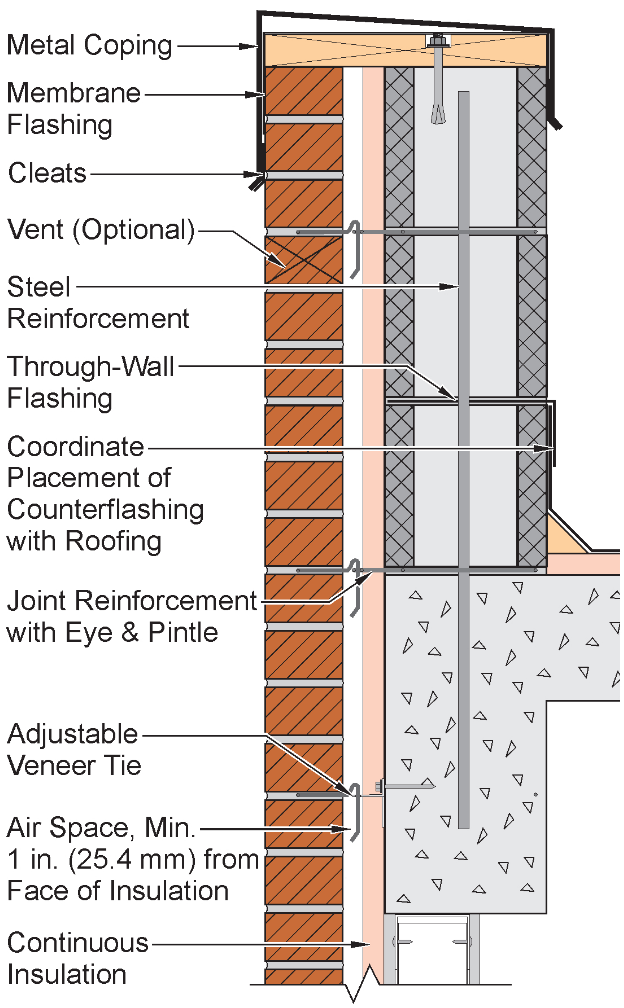

Figure 12
Reinforced Parapet Detail

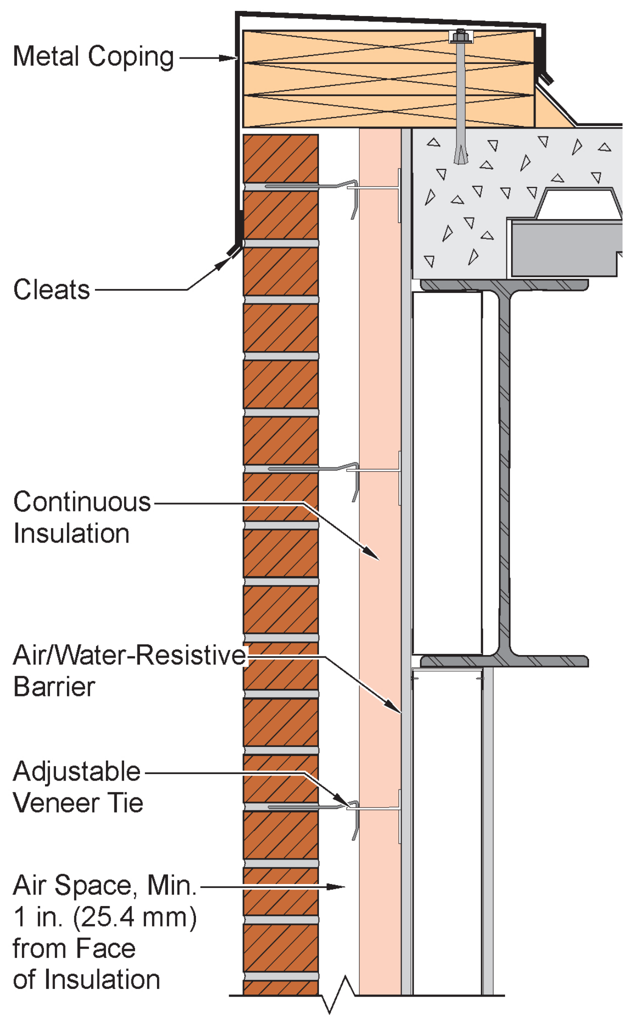

Figure 13
Gravel Stop Detail on Non-Parapet Wall

Condensation

Experience has shown that most water or moisture found between framing members in a BV/CFSF wall assembly can be attributed to condensation. Condensation occurs at the point in the wall where the temperature is below the dew point. If this point is within the cavity, then the condensation will find its way out of the wall via the air space/drainage space, flashing and weeps. This portion of the wall assembly is considered the "wet zone." However, if condensation occurs inboard of the WRB, within the sheathing or in the framing cavity, an area that is generally considered the "dry zone," then it may dampen or eventually saturate the backing materials; the batt insulation, if present; and surrounding materials, which leads to microbial growth, rot of the sheathing and/or corrosion problems.

Continuity of the air barrier and the use of a vapor retarder impacts the potential for condensation. The placement and properties of these materials must be carefully considered, as improper placement or incorrect material selection can result in trapped moisture or poor performance. Consequently, 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 inboard of the WRB, then the wall design should be reevaluated and potentially modified. See *Technical Note* 47 for further information.

CONSTRUCTION

Construction requirements are found in model building codes and in referenced specifications. TMS 602 is invoked by TMS 402. Project manuals prepared for specific buildings also contain construction requirements.

All materials at the job site should be stored off the ground and under adequate cover to prevent deterioration and contamination. Brick should not be placed directly on the ground to preclude any potential staining from the earth and to prevent absorption from wet ground of latent salts that can later manifest as efflorescence.

A box or other measuring tool should be used for measuring sand when mortar is mixed by volume at the job site. Only full bags of cement and lime should be added to the mixer unless accurate volumetric measurements are used. In general, the mortar should be mixed with the maximum amount of water that produces a workable consistency. Retempering of mortar by adding water is permitted as necessary to maintain proper consistency. Caution should be exercised when retempering white or colored mortar to avoid significant color variations. Water content and stiffness of mortar during tooling also affect color. Unless hot weather masonry provisions are in effect, all mortar should be used within 2½ hours of mixing. See *Technical Note* 8B for further information on controls for mixing mortar.

Brick that have an initial rate of absorption (suction) of more than 30 g/min • 30 in² (30 g/min • 194 cm²) should be wetted and permitted to surface dry (also referred to as "saturated surface dry") prior to laying. This will increase the bond between the mortar and the brick by slowing the absorption of water from the mortar. For additional information, refer to *Technical Note* 7B.

TMS 602 contains requirements for hot- and cold-weather construction. Hot- or cold-weather protection is required when temperatures are above 100 °F (37.8 °C), above 90 °F (32.2 °C) with wind speeds exceeding 8 mph (129 km/hr), or below 40 °F (4.4 °C). For more information about hot- and cold-weather construction, see *Technical Note* 1 and TMS 602.

Workmanship

Prior to laying the first brick, the mason should confirm that the backing wall system has been installed to the prescribed project tolerances and in conformance with the required construction requirements. Any and all deviations from specified construction should be immediately brought to the attention of the general contractor and/or the owner's representative. Best practice would suggest that all deviations be corrected prior to preceding with installation of the brickwork.

Lay out brickwork prior to placing in mortar, and adjust head joint width as needed to fill the space intended without using units shorter than one-half the typical stretcher length.

Care should be taken to completely fill all bed and head joints with mortar. Conversely, any location not intended to receive mortar, such as air spaces, weeps and expansion joints, should be kept clean of mortar and mortar droppings. Mortar joints should be properly tooled to enhance the water resistance of the wall by consolidating the mortar. Joints should be tooled when thumbprint hard with a jointer tool slightly larger than the joint. Concave, "V" or grapevine mortar joints are the most water-resistant since they do not provide a ledge for water to remain on the brickwork.

Coordination of trades is advised between the cold-formed steel framing, sheathing installation and masonry subcontractors. This coordination is especially needed when the scope of the masonry subcontractor does not include the installation of the water-resistive barrier or air barrier, which may need to be applied or detailed by others after the installation of the veneer tie backing plates but before the brick are laid.

Protection

Protection of unfinished walls is extremely important. The entry of rain or snow into brickwork in progress may increase the drying time of the brickwork as well as the potential for efflorescence and distress in the finished wall. Water-resistive coverings should be placed over the brickwork at the end of each workday and extend a minimum of 2 ft down on both sides. Coverings may need to be weighted or clamped to the brickwork to hold it in place in the event of high winds. Wind screens and enclosures may also be necessary in hot or cold weather. See *Technical Note* 1 for more information.

MAINTENANCE

Generally, brickwork that is properly designed, detailed and constructed using good workmanship will require very little maintenance over time. However, the components of a brick veneer/cold-formed steel framed wall system should be inspected periodically to ascertain performance and identify any potential problems. Ideally inspections should be performed on a seasonal basis and on an annual basis at a minimum. Neglecting maintenance of certain wall components may lead to deterioration of other elements in the wall system. For additional information regarding maintenance, see *Technical Note* 46.

SUMMARY

The brick veneer/cold-formed steel framed wall system is a viable construction option with high performance related to weather protection and energy conservation when proper attention is given to design and detailing, material specification, construction, and maintenance procedures.

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Volume 2.05

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B695	Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel

Volume 4.01

C1177/C1177M	Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing
C1513	Standard Specification for Steel Tapping Screws for Cold-Formed Steel Framing Connections

Volume 4.05

C126	Standard Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units
C216	Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)
C270	Standard Specification for Mortar for Unit Masonry
C652	Standard Specification for Hollow Brick (Hollow Masonry Units Made from Clay or Shale)
C1325	Standard Specification for Fiber-Mat Reinforced Cementitious Backer Units
C1405	Standard Specification for Glazed Brick (Single Fired, Brick Units)

Volume 4.06

C578	Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
C1289	Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board
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