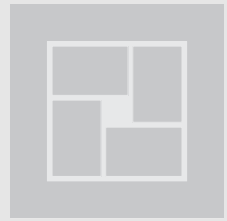
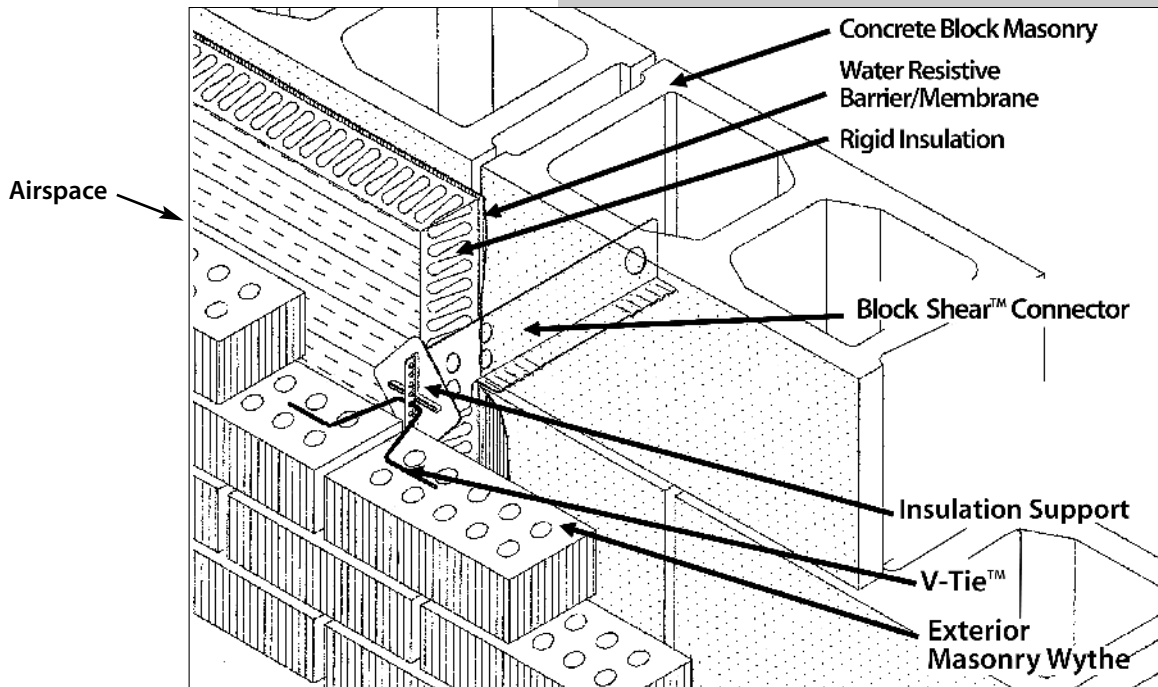


BLOCK SHEAR™ CONNECTOR



BLOCK SHEAR™ CONNECTOR APPLICATION



Design for Composite Structural Action

Exterior ashlar-type masonry veneer, typically of clay brick or concrete block masonry, are commonly used as claddings on buildings to offer aesthetics, to resist environmental loads such as precipitation, and to protect more sensitive inboard wall materials and components, such as insulation from direct exposure to the exterior environment. These veneers are typically not designed as structural members, other than to have sufficient bending resistance to span between adjacent masonry ties, and to transfer the loads to the structural backing through the ties acting only in axial tension and compression. The structural backing is designed to resist the full lateral loading incident on the wall assembly (typically due to wind and seismic, and interior pressures).

The innovative Block Shear™ Connector dramatically changes this design paradigm when using concrete block masonry as the structural backing. Because of the vertical orientation of the Block Shear™ Connector and its consequent rigidity, because the Block Shear™ Connector is positively embedded in the concrete block masonry structural backing and can resist moment at this junction, and because the V-Tie™ is pinned at the leading edge of the Shear™ Connector and rigidly embedded in the exterior

masonry wythe (the veneer), both the axial forces and the vertical shear forces can be resisted by the Block Shear™ Connector to provide *composite action* between the exterior masonry wythe and the structural backing (forming a vertically-oriented Vierendeel truss). The entire wall thickness, including both exterior masonry wythe and concrete block masonry structural backing, thereby becomes effective in resisting lateral loads. Composite action increases system stiffness, reduces lateral deflections, and increases lateral resistance.

With composite structural action, the masonry veneer is no longer simply a veneer because it shares lateral load resistance with the concrete block masonry structural backing. Consequently, these two structural elements are more appropriately referred to as the exterior masonry wythe and the interior masonry wythe, respectively, in this masonry cavity wall system. For additional information, see FERO brochure “Shear Connector™ Cavity Wall System”.

Introduction

The Block Shear™ Connector consists of a Block Plate (a vertically oriented plate), a V-Tie™ (a V-shaped wire), and an Insulation Support (a polyethylene retainer). Individual components are shown in Figures 1, 2 and 3; the assembly is shown in Figure 4; and the installed tie system is illustrated in Figures 5 and 6.

The Block Shear™ Connector is embedded directly in a mortared head joint of the interior concrete block masonry wythe (*Cover Illustration, and Figure 5*). The V-Tie™ is inserted through the appropriate hole along the outboard end of the Block Shear™ Connector. Direct embedment of the Block Plate in the concrete masonry inner wythe offers positive connection, reduced connector free play and deflection, increased connectors strength, elimination of fasteners, and increased mason productivity. The holes along the outboard end of the Plate provide a positive connection between Block Plate and V-Tie™, without the possibility of V-Tie™ disengagement during construction and in-service (in accordance with requirements in CSA A370, “Connectors for Masonry”, and ACI 530/ASCE 5/TMS 402, “Building Code Requirements for Masonry Structures”), and permit up to 63 mm (2.5”) of in-situ vertical adjustment so that a bed joint in the exterior masonry wythe will always be coincident with the V-Tie™

The Insulation Support is inserted over the end of the Block Plate and is restrained by the V-Tie™. It mechanically fixes the cavity insulation securely in place.

The Block Shear™ Connector can accommodate a range of insulation thicknesses from 0 to 100 mm (0 to 4"), and air space widths of 25 mm (1") and greater. The Block Plate has sufficient length to accommodate the thickness of the cavity insulation, and further extends 18 mm (0.7") into the air space to expose its leading edge and facilitate in-situ placement of the V-Tie™ and Insulation Support. The V-Tie™ is inserted through one of the holes along the leading edge of the Block Plate to coincide with a mortar bed joint so as to extend horizontally and normal to the interior masonry wythe, thereby maintaining design tie capacity. The legs of the V-Tie™ are positioned along the centreline of the exterior masonry wythe within the placement tolerances permitted by the building code having jurisdiction. Adjustment normal to the wall is facilitated by on-site selection of an appropriate length of V-Tie™.

Lateral loads applied to the exterior masonry wythe are transferred through the V-Tie™ to the Block Plate, and by providing vertical shear and bending resistance, the Block Shear™ Connector resists structural differential movements between the exterior masonry wythe and the concrete block masonry. The system of Block Shear™ Connectors forms a Vierendeel truss and offers composite action between the two parallel masonry wythes. Rather than only the concrete block masonry interior wythe providing structural resistance, the entire wall thickness becomes effective in resisting lateral loads.

Components and Specifications

Block Plate: The Block Plate (*Figure 1*) is manufactured from 16 gauge sheet steel [1.367 mm (0.0538") minimum base steel thickness] and is available in both hot-dip galvanized finish and stainless steel. The weight of hot-dip galvanized finish is not less than 460 g/m²/side (1.5 oz/ft²/side), and satisfies the requirements of CSA A370 (which references ASTM A123), ACI 530.1/ASCE 6/TMS 602 (which references ASTM A153, Class B), and the International Building Code (IBC) (which reference ASTM A153, Class B).

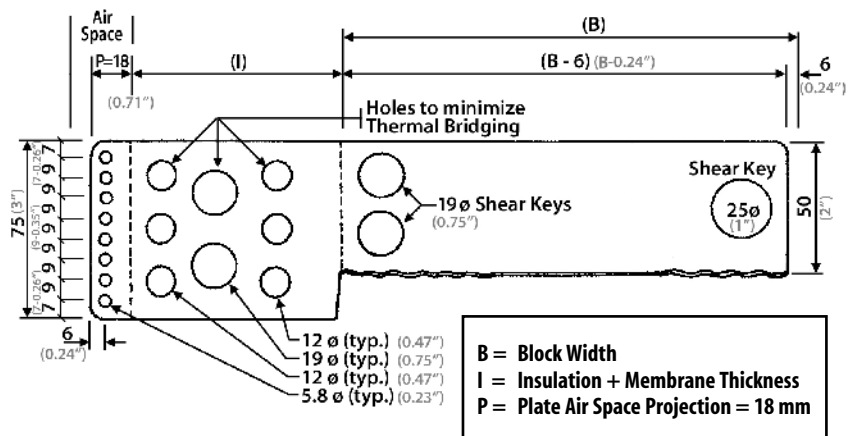


Figure 1 Block Shear™ Connector Plate

The Block Plate specification length, (B), refers to the actual width of the concrete block masonry unit into which the Plate is embedded (*Figures 1 and 5*); the specification length, (l), refers to the actual thickness of the insulation plus membrane; and the length, (P), refers to the length of projection of the Block Shear™ Connector into the air space.

The overall length of the Block Plate is 18 mm (0.7"), (P), longer than the specification lengths (B + l). Specification length can vary to accommodate: standard concrete block widths, (B), of 90 mm (3-5/8"), 140 mm (5-5/8"), 190 mm (7-5/8"), 240 mm (9-5/8") and 290 mm (11-5/8"); and insulation plus membrane, (l), of up to 100 mm (4").

A series of eight 5.8 mm (0.23") diameter holes are punched along the leading edge of the Block Plate to receive the V-Tie™, facilitating 63 mm (2.5") of construction adjustability between the Block Plate and the V-Tie™.

Shear keys (19ø and 25ø holes) in the web and corrugations along the flange pedestal of the Block Plate provide fixity during construction, and resistance to in-service tension loads. A notch formed in the web by the flange pedestal assures proper positioning of the Block Plate within the concrete block masonry interior wythe.

The incorporation of 12ø and 19ø holes through the web body, which are located within the cavity insulation when the Block Plate is suitably embedded, minimizes thermal conductivity of the tie system and associated thermal bridging through the wall system.

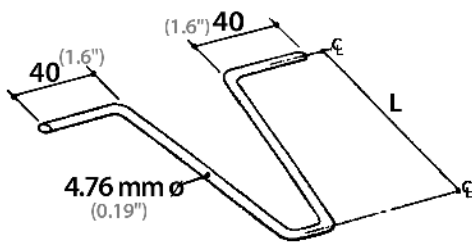


Figure 2 V-Tie™

V-Tie™: The V-Tie™ (*Figure 2*) is manufactured from 4.76 mm (0.19") diameter wire and is available in both hot-dip galvanized finish and stainless steel. The weight of hot-dip galvanized finish is not less than 460 g/m² (1.5 oz/ft²) and satisfies the requirements of CSA A370 (which references ASTM A123), ACI 530.1/ASCE 6/TMS 602 (which references ASTM A153, 458 g/m²) and the International Building Code (IBC) (which reference ASTM A153, Class B, 458 g/m²).

The V-Tie™ is available in a variety of standard lengths to accommodate different specified thicknesses of exterior wythe and design widths of air space. The V-Tie™ specification length, (L), should be selected to provide for placement of the legs of the V-Tie™ along the centreline of the exterior masonry wythe. Varying lengths of V-Tie™, appropriately selected by the mason on the jobsite, facilitate in-situ adjustment normal to the masonry interior wythe (due to construction tolerances) where the constructed width of air space differs from the design width of air space. Standard lengths of V-Tie™ include 60 mm (2.4"), 80 mm (3.1"), 100 mm (3.9"), 120 mm (4.7"), 140 mm (5.5"), 160 mm (6.3"), 180 mm (7.1"), 200 mm (7.9"), 225 mm (8.9") and 250 mm (9.8"). For example, the 60 mm (2.4") V-Tie™ is utilized in the Block Shear™ Connector system consisting of 25 mm (1") air space and 90 mm (3.5") exterior masonry wythe.

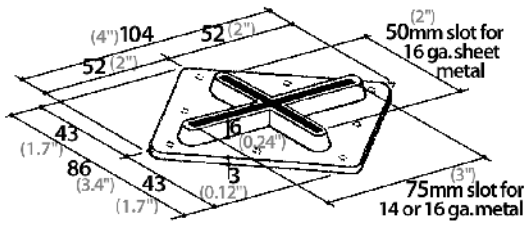


Figure 3 Insulation Support

Insulation Support: The Insulation Support (*Figure 3*) is manufactured from polyethylene. It is pressed over the outboard end of the Block Plate tightly against the cavity insulation to prevent the insulation from separating from its structural backing/air barrier. The friction fit between the Insulation Support and the Block Plate restrains the insulation during construction. Subsequent installation of the V-Tie™ sandwiches the Insulation Support between the insulation and V-Tie™, thereby locking the Insulation Support in place and ensuring a reliable and permanent insulation support system.

The insulation support is a standard component of the system, but it is optional where the insulation is otherwise supported, and not required where no insulation is placed within the cavity.

Benefits

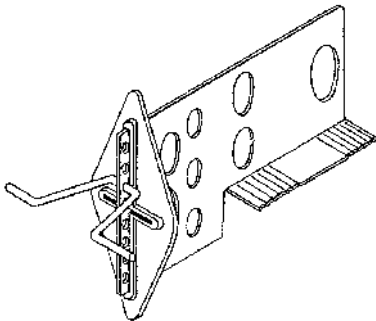


Figure 4
Block Shear™ Connector

The unique benefits offered by the Block Shear™ Connector, in comparison with other FEROTIE systems and more specifically with the Slotted Block Tie (Type I) and (Type II), are a direct consequence of providing composite action between exterior and interior masonry wythes:

1. increases stiffness of the masonry wall system;
2. eliminates cracking in the exterior wythe, and consequently, reduces the likelihood, frequency, and amount of precipitation ingress into the wall system;
3. reduces the required width (thickness) or the amount and frequency of placement of reinforcement of the concrete block masonry interior wythe, providing reduced masonry labour and material construction costs and more usable interior floor space.

Benefits (con't)

Table 1: Concrete Block Masonry Interior Wythe Wall Design Comparison
(Refer to Figure 6)

Concrete Block Masonry Interior Wythe Wall Design Comparison			
Wall Height H (mm)	Wall Type	Conventional Design Options	Shear Truss™ Composite Design Options
3000 (10')	Infill	(i) 140 mm (6") block w/ 1-#15 VertBar @ 1000 mm (39") o.c.	(i) 90 mm (4") block w/ 1-#15 VertBar @ 1600 mm (63") o.c.
		(ii) 190 mm (8") block w/ 1-#15 VertBar @ 2000 mm (78") o.c.	(ii) 140 mm (6") block, plain
6000 (20')	Infill	(i) 240 mm (10") block w/ 1-#15 VertBar @ 600 mm (24") o.c. (ii) 290 (12") mm block w/ 1-#20 VertBar @ 1200 mm (48") o.c.	240 mm (10") block w/ 1-#15 VertBar @ 1600 mm (63") o.c.
	Load Bearing	240 mm (10") block w/ 2-#15 VertBar @ 1200 mm (48") o.c.	190 mm (8") block w/ 1-#15 VertBar @ 1600 mm (63") o.c.

Notes:

- (i) Design lateral wind load = 1.0 kPa (20.8 psi) unfactored (positive or negative).
- (ii) Mortar: Type S for all masonry.
- (iii) Mortar bedding: full bedding for exterior wythe; face shell bedding for interior wythe.
- (iv) Grout only at specified vertical reinforcement bar locations.
- (v) Cavity width: 75 mm (3").
- (vi) Block Shear™ Connector spacing: 800 mm (32") horizontally; vertically as per Figure 6.

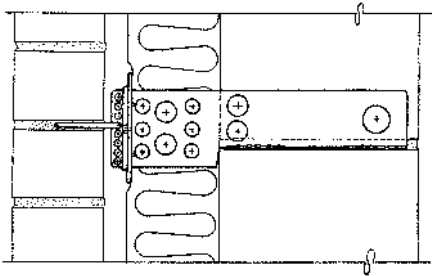


Figure 5
Block Shear™ Connector Installation

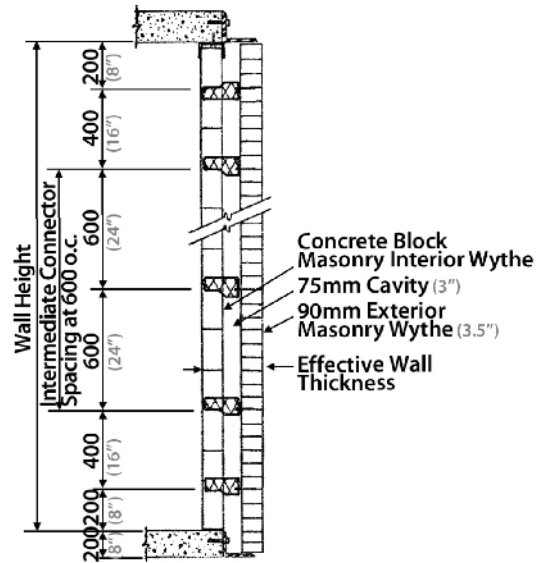


Figure 6 Block Shear™ Connector Vertical Spacing

Block Shear™ Connector Design Data

("Conventional" Use, without Composite Action)

These tabled data pertain to Block Shear™ Connector use in "conventional" application, without consideration for composite action. To design for composite action, an engineering analysis is required to establish tie loads, resistance, and displacements.

Design data for the Block Shear™ Connector are reported separately for Canada and the United States in the following tables because design methods and requirements for masonry ties and their uses differ between their respective codes and standards.

Block Shear™ Connector Design Data (Conventional) (Canada)^(vii)

Design Parameter	Design Data ^{(i), (ii), (vii)}	
1. Mechanical Free Play ⁽ⁱⁱⁱ⁾ (with Fero V-Tie™)	0.80 mm (max) [0.031"]	
2. Serviceability at 0.45 kN [100 lbs.] ⁽ⁱⁱⁱ⁾		
Displacement	0.15 mm [0.006"]	
Displacement + Mechanical Free Play	0.95 mm (max) [0.037"]	
3. Factored Resistance (ϕP_{ult}) ^{(iv), (v)}	3.3 kN [735 lbs.]	
4. Maximum Recommended Spacing ^(vi)	Horiz.	Vert.
	800 mm [32"]	600 mm [24"]

Notes

- (i) These design data are based on connector testing in accordance with CSA A370-14, *Connectors for Masonry*, with no surcharge and with test samples having the following configuration: 114 mm [4.5"] cavity; Block Shear™ Connector having (l) of 89 mm [3.5"]; 25 mm [1"] air space; no insulation; standard FERO V-Tie™; and V-Tie™ engaged into Block Plate at position of maximum vertical adjustment. Smaller cavity widths and/or the addition of insulations providing lateral support to the Block Plate will increase the tabled factored resistance of the tie and reduce tie deflection.
- (ii) These design data reflect both the windward (compression) and leeward (tension) capacities of the Block Shear™ Connector system, with the governing values listed.
- (iii) The Block Shear™ Connector satisfies the limiting requirements for serviceability (tie displacement and mechanical free play) in CSA A370-14. Tabled mechanical free play is for stainless steel components. The mechanical free play for hot-dip galvanized components is less.
- (iv) The ultimate strength of the Block Shear™ Connector, ϕP_{ult} , is determined in accordance with CSA A370-14 and is calculated by multiplying the average tie strength established by testing by (1 – 1.64 cov). The factored resistance of the tie system, ϕP_{ult} , is calculated using the Limit States Design procedures of CSA A370-14.
- (v) The factored resistance of the mortar pull-out or push-through for the V-Tie™ embedded at the centreline of 90 mm (3.5") brick wythe utilizing Type S or N mortar exceeds or equals the tabled factored resistance, ϕP_{ult} . That is, failure by pull-out/push-through of the mortar joint does not govern. Similarly, the factored resistance of the Block Shear™ Connector embedded in the head joint of 90 mm [3-5/8"], 140 mm [5-5/8"], 190 mm [7-5/8"], 240 mm [9-5/8"], and 290 mm [11-5/8"] concrete block masonry constructed using Type S mortar exceeds or equals the tabled factored resistance, ϕP_{ult} . Failure by pull-out/push-through of the Block Plate from the concrete masonry does not govern.
- (vi) Maximum recommended tie spacings are the maximum spacings permitted by CSA S304-14, *Design of Masonry Structures*. For a particular design, the actual tie spacings are calculated such that the factored resistance of the tie, ϕP_{ult} , equals or exceeds the effect of factored loads. See S304-14 for the design of masonry veneer systems where the Block Shear™ Connector is not relied upon for composite action (conventional use). See Note (vii) when designing for composite action.
- (vii) These tabled data pertain to Block Shear™ Connector use in "conventional" application, without composite action. To design for composite action, an engineering analysis is required to establish tie loads, resistance, and displacements. Use the FERO Shear Truss (Composite Wall Design) software program to evaluate forces in the assembly.

**Block Shear™ Connector Design Data (Conventional)
(United States)^(ix)**

Design Parameter	Design Data ^{(i), (ii), (ix)}	
1. Mechanical Free Play ⁽ⁱⁱⁱ⁾	0.031" (max) [0.80 mm]	
2. Serviceability at 0.45 kN [100 lbs.] ⁽ⁱⁱⁱ⁾		
Displacement	0.006" [0.015 mm]	
Displacement + Mechanical Free Play	0.037" (max) [0.95 mm]	
3. Nominal Strength ^{(iv), (v), (vi), (viii)}	990 lb. [4.4 kN]	
4. Recommended Design Load ^{(iv), (v), (vi), (viii)}	440 lb. [1.95 kN]	
5. Maximum Recommended Spacing ^(vi)	Horiz.	Vert.
	32" [800 mm]	24" [600 mm]

Notes

- (i) These design data are based on connector testing in accordance with CSA A370-14, *Connectors for Masonry*, with no surcharge and with test samples having the following configuration: 114 mm [4.5"] cavity; Block Shear™ Connector having (l) of 89 mm [3.5"]; 25 mm [1"] air space; no insulation; standard FERO V-Tie™; and V-Tie™ engaged into Block Plate at position of maximum vertical adjustment. The test method for ties in CSA A370-14 is comparable to that of ASTM E754, *Test Method for Pullout Resistance of Ties and Anchors Embedded in Masonry Mortar Joints*, and provides similar and more conservative results. Smaller cavity widths and/or the addition of insulations providing lateral support to the Block Plate will increase the tabled factored resistance of the tie and reduce tie deflection. Prescriptive requirements for anchored masonry veneer under ACI 530/ASCE 5/TMS 402 limit the cavity to a maximum width of 4-1/2" [114 mm] unless the veneer is alternatively designed using a rational, engineered design method (termed "Alternative Design of Anchored Masonry Veneer").
- (ii) These design data reflect both the windward (compression) and leeward (tension) capacities of the Block Shear™ Connector system, with the governing values listed.
- (iii) The Block Shear™ Connector with V-Tie™ satisfies the 1/16" [1.6 mm] maximum permissible clearance between connecting parts required by ACI 530/ASCE 5/TMS 402. Tabled mechanical free play is for stainless steel components. The mechanical free play for hot-dip galvanized components is less.
- (iv) The nominal strength of the Block Shear™ Connector is determined by test and is reported as the average ultimate strength of the tie samples. In accordance with ACI 530/ASCE 5/TMS 402, using Strength Design, a suitable strength-reduction factor must be applied to the nominal strength to determine the tie design strength. Similarly, under Allowable Stress Design, an appropriate safety factor must be applied to determine an allowable load value. The tabled "Recommended Design Load" reflects a safety factor of 2.25 (that is, 75% of 3.0).
- (v) The nominal strength (and corresponding recommended design load) of the mortar pull-out or push-through for the V-Tie™ embedded at the centerline of 3.5" [90 mm] brick wythe utilizing Type M, S or N mortar exceeds or equals the tabled nominal strength (and recommended design load). That is, failure by pull-out/push-through of the mortar joint does not govern. Similarly, the nominal strength (and corresponding recommended design load) of the Block Plate embedded in the head joint of 90 mm [3-5/8"], 140 mm [5-5/8"], 190 mm [7-5/8"], 240 mm [9-5/8"], and 290 mm [11-5/8"] concrete block masonry constructed using Type S mortar exceeds or equals the tabled nominal strength (and recommended design load). Failure by pull-out/push-through of the Block Shear™ Connector from the concrete masonry does not govern.
- (vi) Maximum recommended tie spacings are the maximum spacings permitted by ACI 530/ASCE 5/TMS 402 using prescriptive requirements for anchored masonry veneer. The prescriptive requirements in ACI 530/ASCE 5/TMS 402 further limit a tie tributary area to not more than 2.67 ft.² (0.25 m²) wall area [with reduced areas for high Seismic Design Categories and in areas of high winds] unless the veneer is alternatively designed using a rational, engineered method (termed "Alternative Design of Anchored Masonry Veneer"). Where an Alternative Design is used, the required tie spacing may be calculated such that the design strength of the tie equals or exceeds the required strength. See ACI 530/ASCE 5/TMS 402 for the design of masonry veneer systems where the Block Shear™ Connector is not relied upon for composite action (conventional use). See Note (ix) when designing for composite action.
- (vii) The Block Shear™ Connector with V-Tie™ satisfies ACI 530/ASCE 5/TMS 402 requirements for minimum wire size of W1.7 (MW11) and for ends bent to form a minimum 2 in [50.8 mm] extension.
- (viii) ACI 530/ASCE 5/TMS 402 requires joint reinforcement in masonry veneer in high Seismic Design Categories to be mechanically attached to the masonry tie.
- (ix) These tabled data pertain to Block Shear™ Connector use in "conventional" application, without composite action. To design for composite action, an engineering analysis is required to establish tie loads, resistance, and displacements.



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