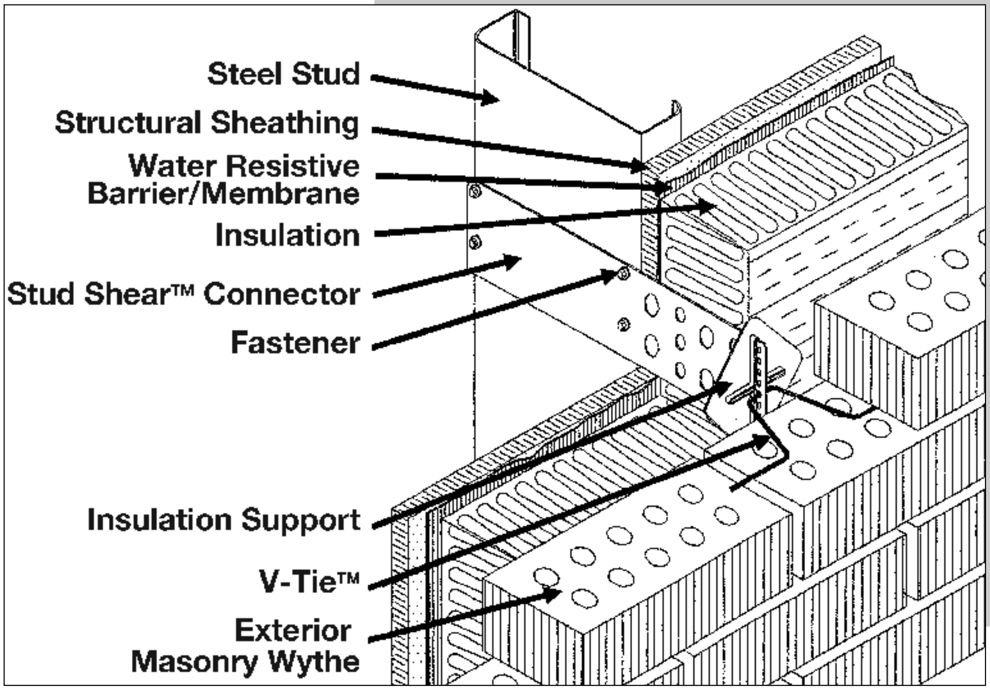
STUD SHEAR™ CONNECTOR



STUD SHEAR™ CONNECTOR APPLICATION

Design for Composite Structural Action

All FERO masonry ties are in accordance with the following codes: CSA A370, “Connectors for Masonry” and ACI 530/ASCE 5/TMS 402, “Building Code Requirements for Masonry Structures”; 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), in regards to hot-dip galvanized finish weight.

The innovative Stud Shear™ Connector dramatically changes typical masonry design when using light-frame structural backing such as steel stud. Because of the vertical orientation of the Stud Shear™ Connector and its consequent rigidity, the Stud Shear™ Connector is mechanically fastened to the stud framing and can resist moment at this junction. In addition, the V-Tie™ is pinned at the leading edge of the Stud Shear™ Connector and rigidly embedded in the exterior masonry wythe (the veneer), both axial and vertical shear forces can be resisted by the Stud Shear™ Connector to provide composite action between the exterior masonry wythe and the stud framing (forming a vertically-oriented Vierendeel truss).

FERO

Design for Composite Structural Action (cont.)

The entire wall thickness, including both exterior masonry wythe and the stud framing, thereby becomes effective in resisting lateral loads. Composite action increases system stiffness, reduces lateral deflections, and increases lateral load resistance.

With composite structural action, the masonry wythe is no longer simply a veneer because it shares lateral load resistance with the stud framing. Consequently, it is more appropriately referred to as the exterior masonry wythe.

Introduction

The Stud Shear™ Connector consists of a steel Flat Plate, a V-Tie™, and an Insulation Support. 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.

Loads applied to the exterior masonry wythe are transferred through the V-Tie™ to the Flat-Plate, which is rigidly fastened directly to the stud framing without any intervening material such as sheathing. The Flat-Plate is fastened to the side surface of the stud framing member such as a steel stud web or wood stud *(see Cover illustration, and Figure 5)*. The holes provide a positive connection between the Flat-Plate and V-Tie™ without the possi-bility of V-Tie™ disengagement during construction or in-service, and permits up to 63 mm (2.5”) of in-situ vertical adjustment so that a mortar bed joint in the exterior masonry wythe will always be coincident with the V-Tie™

The Stud Shear™ Connector can accommodate a range of insulation thicknesses, and is ideal for spanning large cavities, recommended for 102mm (4") and greater. The Flat 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 the appropriate hole along the leading edge of the Flat Plate, and placed coincident with a mortar bed joint so as to extend horizontally and normal to the stud framing, 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 (L) of V-Tie™(see Figure 2).

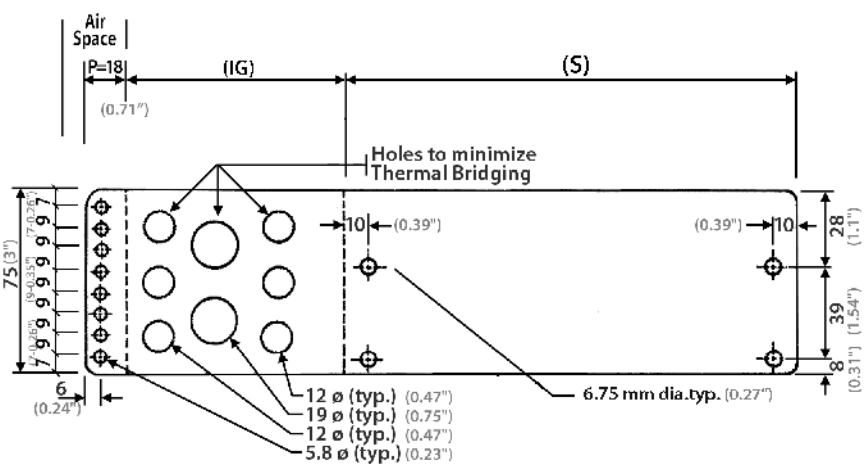
Introduction (cont.)

The engineered Stud Shear™ Connector is superior to multi-component ties. It offers positive restraint between tie components to prevent disengagement, reduce mechanical free play, limit deformation under load, and prevent "side mounting" which places the fastener connecting the tie and structural backing in shear rather than direct tension. The fastener orientation and inboard position within the wall system provide a more desirable connection to the structural backing than surface-mounted tie systems which subject the fasteners to direct tension and generally higher moisture loads. Side mounting reduces the likelihood of corrosion at the fastener/structural member interface.

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

Components and Specifications

Flat Plate: The Flat Plate *(Figure 1)* is manufactured from 16 gauge sheet steel [1.367 mm (0.0538") minimumbase steel thickness] and is available in bothhot-dip galvanized finish and stainless steel.



S = Stud Width
IG = Thickness of Insulation + Membrane + Sheathing
P = Plate Air Space Projection

Figure 1 Stud Shear™ Connector Flat Plate

The Flat Plate specificationlength, (S), refers to the actual width of the (steel) stud to which it is connected; the inboard end of the Flat Plate is intended to be installed flush with the interior flange face of the stud and the specifica-ionlength, (IG) refers to the actual thickness of the insulation plus sheathing membrane plus sheathing.

Components and Specifications (cont.)

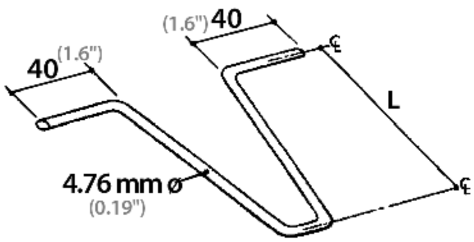


Figure 2 V-Tie™

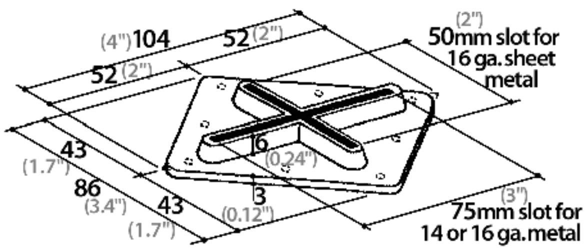


Figure 3 Insulation Support/Retainer

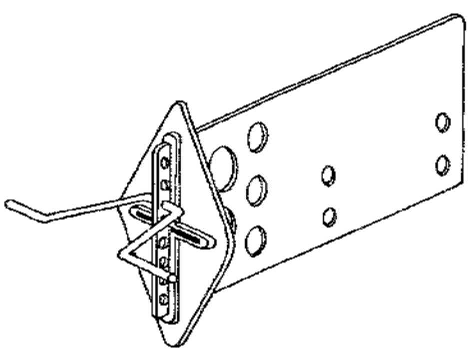


Figure 4 Stud Shear™ Connector (assembled)

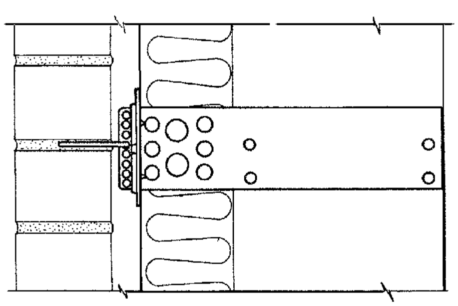


Figure 5 Stud Shear™ Connector Installation

The overall length of the Flat Plate is 18 mm (0.7"), (P), longer than the specification lengths (S + IG); to accommodate the length of projection into the air space to accommodate the V-Tie™.

A series of eight 5.8 mm (0.23") diameter holes are punched along the leading edge of the Flat-Plate to receive the V-Tie™, facilitating63 mm (2.5") of construction adjustability between the Flat-Plate and the V-Tie™.

Holes having 12ø and 25ø diameter are punched through the mid-body of the Flat-Plate. When the Plate is mounted these holes are located within the cavity insulation and minimize thermal conductivity through the tie system. All FERO masonry ties are thermally broken with holes to minimize thermal conductivity.

Four (4) 6.75 mm (0.27") diameter screw holes within length, (S), of the Flat-Plate provide for plate fastening to the structural backing member. Maximum screw size is #12, use 2 per tie, recommended locations to be diagonal from each other.

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 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, to accommodate construction tolerances, where the constructed width of air space differs from the design width of air space.

Insulation Support: The Insulation Support *(Figure 3)* is manufactured from 100% recycled polyethylene . The friction fit between the Insulation Support and the Flat-Plate restrains the insulation during construction to prevent the insulation from separating from the structural backing/ air barrier. 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 no insulation is placed within the cavity.

Benefits

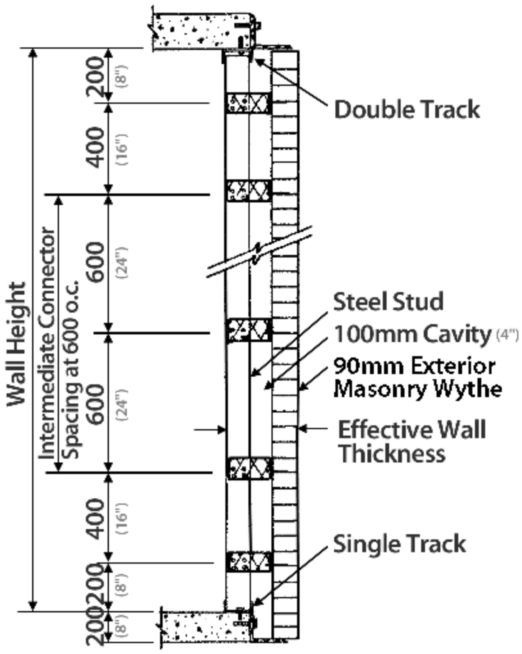


Figure 6 Stud Shear™ Connector Vertical Spacing

The unique benefits offered by the Stud Shear™ Connector, in comparison with other FERO tie systems and more specifically with the Slotted Stud Tie (Type I) and (Type II), and the Slotted Side Mounting Rap-Tie, are a direct consequence of providing composite action between the exterior masonry wythe and stud framing:

1. increases stiffness of the wall system;
2. eliminates cracking in the exterior masonry wythe, and consequently, reduces the likelihood, frequency, and amount of precipitation ingress into the wall system;
3. reduces the required gauge, spacing, and width of the steel stud framing, providing reduced labour and material construction costs, and more usable interior floor space.

Steel Stud Backup Wall Design Comparison

	Steel Stud Wall Design Requirements	
Wall Height H (mm)	**Conventional Design**	**Shear™ Connected Composite Design**
3000 (10′)	152 mm (6″) x 18 ga. @ 400 mm (16″) o.c. (H/720 = 4.2 mm) (0.17″)	102 mm (4″) x 20 ga. @ 400 mm (16″) o.c. (H/2098= 1.4 mm) (0.055″)
4500 (15′)	203 mm (8″) x 16 ga.@ 400 mm (16″) o.c. (H/720 = 6.3 mm) (0.25″)	152 mm (6″) x 18 ga. @ 400 mm (16″) o.c. (H/ 2010 = 2.2 mm) (0.087″)
6000 (20′)	203 mm (8″) x 14 ga.@ 200 mm (8″) o.c. (H/720 = 8.3 mm) (0.33″)	203 mm (8″) x 18 ga. @ 400 mm (16″) o.c. (H/2000 = 3.0 mm) (0.12″)

Notes:

1. Design lateral wind load = 1.0 kPa (20.8 psi) unfactored (positive or negative).
2. Design deflection limit = H/720.
3. Assumed deflection at stud framing top and bottom connections due to ties, twist, etc. = 1.0 mm (0.04″).
4. Wall lateral deflections are provided in parentheses.
5. Cavity width: 100 mm (4″).
6. Mortar: Type S for all masonry.
7. Mortar bedding: full bedding for exterior wythe.
8. Stud Shear™ Connector spacing: 400 mm (16″) horizontally; vertically as per Figure 6.

Stud Shear™ Connector Design Data
(“Conventional” Use, without Composite Action)

These tabled data pertain to Stud 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 Stud 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.

Stud Shear™ Connector Design Data
(Conventional, without Shear Connection) **(Canada)**
(viii)

Design Parameter	Design Data (i),(ii),(viii)	
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 Displacement + Mechanical Free Play	 0.05 mm [0.002″] 0.85 mm (max) [0.033″]	
3. Factored Resistance (ø P_{ult}) (iv),(v),(vi)	2.5 kN [560 lbs.]	
4. Maximum Recommended Spacing (vii)	Horiz. 800 mm [32″]	Vert. 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: 127 mm [5″] cavity; Stud Shear™ Connector having a length of 102 mm [4″]; 25 mm [1″] air space; no insulation or sheathing; standard FERO V-Tie™; and V-Tie™ engaged into Flat-Plate at position of maximum vertical adjustment. Smaller cavity widths and/or the addition of rigid insulations providing lateral support to the Flat 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 Stud Shear™ Connector system, with the governing values listed.

(iii) The Stud 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 compo-nents. The mechanical free play for hot-dip galvanized components is less.

(iv) The ultimate strength of the Stud Shear™ Connector, P_{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, ø P_{ult}, is calculated using the Limit States Design procedures of CSA A370-14.

(v) The stated tie factored resistance is based on the capacity of FERO tie components, and does not consider fastener resistance. A compatible fastener having an adequate factored resistance must be selected (by design in accordance with CSA A370-14).

(vi) The factored resistance of the mortar pull-out or push-through for the V-Tie™ embedded at the centreline of a 90 mm (3.5″) brick wythe utilizing Type S or N mortar exceeds or equals the tabled factored resistance, ø P_{ult}. That is, failure by pull-out/push-through of the mortar joint does not govern.

(vii) Maximum recommended tie spacings are the maximum spacings permitted by CSA S304-14, Design of Masonry Structures. For a partic-ular design, the actual tie spacings are calculated such that the

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Notes: (cont)

factored resistance of the tie, ø P_{ult}, equals or exceeds the effect of factored loads. See S304-14 for the design of masonry veneer systems where the Stud Shear™ Connector is not relied upon for composite action (conventional use). See Note (viii) when designing for composite action.

(viii) These tabled data pertain to Stud 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.

Stud Shear™ Connector Design Data *(Conventional, without Shear Connection)* (United States)[x]

Design Parameter	Design Data [i],[ii],[x]	
1. Mechanical Free Play [iii]	0.031″ (max) [0.80 mm]	
2. Serviceability at 0.45 kN [100 lbs.] [iii] Displacement Displacement + Mechanical Free Play	0.002″ [0.05 mm] 0.033″ (max) [0.85 mm]	
3. Nominal Strength [iv],[v],[vi],[viii]	760 lb [3.4 kN]	
4. Recommended Design Load [iv],[v],[vi],[viii],[ix]	340 lb [1.5 kN]	
5. Maximum Recommended Spacing [vii],[ix]	Horiz. 32″ [813 mm]	Vert. 18″ [457 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: 127 mm [5″] cavity; Stud Shear™ Connector having (l) of 102 mm [4″]; 25 mm [1″] air space; no insulation or sheathing; standard FERO V-Tie™; and V-Tie™ engaged into Flat-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 Plate tie 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, engi-neered design method (termed "Alternative Design of Anchored Masonry Veneer").

(ii) These design data reflect both the windward (compression) and leeward (tension) capacities of the Stud Shear™ Connector system, with the governing values listed.

(iii) The Stud 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 Stud 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). [See also Note (v) when assigning a strength-reduction factor to the nominal strength].

(v) The stated nominal strength and the recommended design load do not consider fastener capacity. A compatible fastener having an adequate strength must be selected (by design, in accordance with ACI 530.1/ASCE 6/TMS 602).

(vi) 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 a 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.

(vii) 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 m^2) 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 Stud Shear™ Connector is not relied upon for composite action (conventional use). See Note (x) when designing for composite action.

(viii) The Stud 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" (50.8 mm) extension.

(ix) 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.

(x) These tabled data pertain to Stud 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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