MASONRY TIE DESIGN & SELECTION CANADA

I INTRODUCTION

For projects located in Canada, the design and selection of masonry ties which satisfy the requirements of the building codes and standards has previously been confusing and difficult. The intent of this brochure is to provide a summary of the guidelines of the 2005 National Building Code of Canada, and referenced CSA Standards relating to masonry veneer and tie design, as well as to illustrate the compliance and allowable usage of FERO's line of "Engineered Masonry Connectors" within such guidelines. The performance requirements of ACI/ASCE/TMS/518 and U.B.C. are also satisfied by our connectors.

II NATIONAL BUILDING CODE OF CANADA 2005 (NBC 2005)

A. CAN3-A370-04 "Connectors for Masonry"

The safe working load of masonry ties is clearly outlined in CSA Standard CAN3-A370-04 "Connectors for Masonry". The standard requires the testing of a minimum number of actual tie assemblies in compressive and in tensile loading. The average test value for each loading is adjusted to reflect test result variability and then reduced by an appropriate factor of safety, as outlined in Table 3 of the A370 standard. The safe working loads presented in this booklet for each of FERO's engineered masonry connectors were derived following these procedures.

B. National Building Code of Canada 2005

The lateral design load for wind and for seismic conditions is detailed in the National Building Code of Canada 2005 (NBC 2005). The lateral design load due to earthquakes is specified as $V_p = v \cdot S_p \cdot W_p$ in Clause 4.1.9.1.15, where V_p is the lateral force on a part of the structure, v is the zonal velocity ratio, S_p is the horizontal force factor, and W_p is the weight of the portion of the structure. The appropriate value of S_p for masonry veneer is somewhat vague, however clarification by the NBC recommended the use of the most conservative value of 15 from Table 4.1.9.D.

III NATIONAL BUILDING CODE OF CANADA (NBCC 2005)

A number of additions and changes pertaining to the design of masonry ties and veneer are contained in the National Building Code of Canada 2005 and the revised versions of the referenced CSA masonry related standards. Included in the changes are the option for the designer to use either the Working Stress Method or Limit States Design method. A summary of these changes is itemized as follows:

A. A370-04 "Connectors for Masonry"

1. Working Stress Design (8.4.3.1)

The safe working load of masonry ties shall be determined with the same procedures as specified in CAN3-A370-04, with the exception of revised factors of safety as follows:

a) 2.0 for material failure of metal components of the connector; or

b) 4.0 for embedment failure or failure of the fasteners, or elastic buckling failure, of the connector.

2. Limit States Design (8.4.2.1.2)

The factored resistance of masonry ties shall be derived by multiplying the test average (as reduced for variability) by the appropriate resistance factor, Ø as follows:

a) Ø = 0.9 for material failure of the metal components of the connector; or

b) Ø = 0.6 for embedment failure or failure of the fasteners, or elastic buckling failure, of the connector.

3. Minimum Tie Strength (7.1)

The ultimate strength of a masonry tie shall not be less than 1000 N (224 lbs). *Note that the BVTS with Conventional Corrugated Strip Tie (0.76 mm [0.03"]) does not satisfy this requirement, although the Conventional Corrugated Strip Tie is allowed by Chapter 9 "Conventional Connectors".*

4. Serviceability Requirements (8.3.2)

a) Free Play: The total free play of multi-component ties shall not exceed 1.2 mm (0.047").

b) Displacement Under 0.45 kN (100 lbs) Load: When tested under a compressive or tensile load of 0.45 kN (100 lbs), the sum of the displacement and free play of the tie shall not be more than 2.0 mm (0.079"). Displacement includes all secondary deformations of the structural backing.

c) Positive Restraint: Adjustable ties shall provide positive restraint at the positions of maximum adjustment, and shall satisfy the requirements of free play and displacement under 0.45 kN (100 lbs) load at all positions of adjustment.

5. Corrosion Protection (4.)

Level II corrosion protection (i.e. stainless steel) is the minimum required for exterior masonry above grade in buildings greater than 11 m (36′) in height in areas of moderate or severe exposure grading. Level II corrosion protection (hot dipped galvanized as per Table 3) is the minimum required for anchor or tie components engaged in the stone or in direct contact with the stone. Note that contact between different metals is not recommended.

6. Maximum Spacing of Connectors (6.1)

a) Nonconventional Ties: The spacing of nonconventional ties shall not be greater than 600 mm (24″) on center vertically, and 800 mm (32″) on centre horizontally, except where permitted by CSA S304.1-04.

b) Spacings at Openings: At openings in masonry walls, ties shall not be spaced more than 600 mm (24″) apart around the openings and shall be located not more than 300 mm (12″) from the edge of the openings.

c) Spacings at Tops and Bottoms of Walls: The distance from the top of a wall, or the unsupported top of a wall, to the first row of ties below shall not exceed 300 mm (12″). where the bearing support for masonry does not provide adequate lateral resistance, the distance from the support to the first row of ties above shall not exceed 400 mm (16″).

7. Structural Integrity (8.5)

Connectors shall be fastened directly to structural components which resist wind or gravity loads, or to secondary components which are capable of conveying the connector loads to primary structural members. (Where screws are used in he connector assembly with steel stud backup, it is recommended that steel studs as structural backing for masonry veneer be made of minimum 1.22 mm [0.048″] thick material.) Where connectors are secured to, or bear against, materials whose strength may eventually be diminished by the effects of moisture and which may thereby reduce the performance of the connectors, adequate measures shall be taken to protect such materials from the effects of moisture, or to keep moisture from reaching them.

B. National Building Code of Canada 1995

For the determination of earthquake loading, the National Building Code of Canada 1995 includes a specific value of 5.0 for the horizontal force factor, S_p, for masonry veneer, and introduces a seismic importance factor of the structure, I, such that the lateral force on a part of the structure, V_p, will be equal to $v \cdot S_p \cdot I \cdot W_p$. The importance factor, I, is 1.5 for post-disaster buildings, 1.3 for schools, and 1.0 for other structures.

C. S304.1-94 "Masonry Design for Buildings (Limit States Design)"

1. Factored Load (7.)

CSA Standard S304.1-04 includes load factors, load combination factors and importance factors in the determination of factored loads. The load factor, α, for wind and earthquake load, α_Q, is 1.5 for wind and 1.0 for earthquake. The load combination factor, ψ, is equal to 1.0 when wind or earthquake load acts alone. The importance factor, γ, shall not be less than 1.0, except for buildings where it can be shown that collapse is not likely to cause injury or other serious consequences, it shall not be less than 0.8.

Factored Load $= \alpha_D D + \gamma\psi(\alpha_L L + \alpha_Q Q + \alpha_T T)$, and is equal to $\gamma\psi\alpha_Q Q$, where wind/earthquake load,
Q, acts without any of the dead load, D, live load, L, or thermal/material load, T.

2. Tributary Area & Tie Spacing (13.2 & 13.3.2)

CSA Standard S304.1 introduces a maximum veneer tie spacing of 800 mm (32″) horizontally and 600 mm (24″) vertically, as well as an increased tributary area for ties on flexible backup systems (e.g., steel studs). for ties on flexible structural backup systems (i.e., backup stiffness, EI, less than 2.5 times the uncracked stiffness of the veneer), all ties shall be designed for 40% of the tributary load on the stud, but not less than double the tributary lateral load on the tie. Tie spacing shall not be staggered.

3. Veneer Deflection (13.3.3)

For flexible structural backing systems, the total deflection of the veneer due to specified lateral wind loads shall not exceed the span of the structural backing system divided by 600. Note that this requirement is deemed to have been met provided that both (a) the bending deflection of the structural backing does not exceed the span of the structural backing divided by 720; and (b) the tie deflection due to one half of the total mechanical play plus a tension or compression load of 0.45 kN (100 lbs) does not exceed 1.0 mm (0.04″).

FERO System		Free Play mm (in)	Deflection @0.45kN (100 lbs) Load mm (in)		Tie Design Capacity		
					CAN3-A370-04	A370-2005	
					Working Stress	Working Stress	Limit States
			w/o free play	w/ free play	Safe Working Load kN (lbs)	Safe Working Load kN (lbs)	Factored Resistance kN (lbs)
Block Shear Connector		0.80 (0.031″)	0.15 (0.006″)	0.95 (0.037″)	1.65 (371 lbs)	1.86 (417 lbs)	3.35 (750 lbs)
Stud Shear Connector		0.80 (0.031″)	0.05 (0.002″)	0.85 (0.033″)	1.29 (290 lbs)	1.45 (325 lbs)	2.61 (585 lbs)
Side Mounting Rap-Tie		0.80 (0.031″)	0.11 (0.043″)	0.91 (0.036″)	1.55 (348 lbs)	1.74 (390 lbs)	3.13 (701 lbs)
Rap-Tie	Mounted Directly to Steel Stud	0.80 (0.031″)	0.47 (0.019″)	1.27 (0.05″)	0.76 (170 lbs)	0.86 (193 lbs)	1.54 (345 lbs)
	Mounted on Protected Drywall	0.80 (0.031″)	0.50 (0.02″)	1.30 (0.051″)	0.67 (150 lbs)	0.75 (168 lbs)	1.36 (305 lbs)
Slotted Block Tie (Type I)		1.04 (0.041″)	0.07 (0.003″)	1.11 (0.044″)	0.76 (170 lbs)	0.85 (190 lbs)	1.54 (345 lbs)
Slotted Block Tie (Type II)		0.5 (0.02″)	0.10 (0.004″)	0.60 (0.024″)	1.27 (284 lbs)	1.43 (320 lbs)	2.57 (576 lbs)
Slotted Stud tie (Type I)		1.04 (0.041″)	0.07 (0.003″)	1.11 (0.044″)	0.76 (170 lbs)	0.85 (190 lbs)	1.54 (345 lbs)
Slotted Stud Tie (Type II)		0.5 (0.02″)	0.10 (0.004″)	0.60 (0.024″)	1.27 (284 lbs)	1.43 (320 lbs)	2.57 (576 lbs)
Slotted Side Mounting Rap-Tie		1.04 (0.041″)	0.16 (0.0063″)	1.2 (0.047″)	1.07 (240 lbs)	1.20 (269 lbs)	2.16 (484 lbs)
Slotted Rap-Tie	Mounted Directly To Steel Stud	1.04 (0.041″)	0.63 (0.025″)	1.67 (0.066″)	0.76 (170 lbs)	0.86 (193 lbs)	1.54 (345 lbs)
	Mounted on Protected Drywall	1.04 (0.041″)	0.66 (0.026″)	1.7 (0.067″)	0.67 (150 lbs)	0.75 (168 lbs)	1.36 (305 lbs)
Adjustable BVTS		0.74 (0.029″)	0.45 (0.018″)	1.19 (0.047″)	0.67 (150 lbs)	0.75 (168 lbs)	1.36 (305 lbs)
Pac-Tie	Mounted Directly to Steel Stud	0.74 (0.029″)	0.45 (0.018″)	1.19 (0.047″)	0.67 (150 lbs)	0.75 (168 lbs)	1.36 (305 lbs)
	Mounted on Protected Drywall	0.74 (0.029″)	1.13 (0.044″)	1.87 (0.074″)	0.67 (150 lbs)	0.75 (168 lbs)	1.36 (305 lbs)
Cat-Tie		0.74 (0.029″)	0.42 (0.017″)	1.16 (0.046″)	1.50 (336 lbs)	2.25 (504 lbs)	4.05 (907 lbs)
BVTS		0.00	0.95 (0.037″)	0.95 (0.037″)	0.36 (81 lbs)	0.40 (90 lbs)	0.73 (164 lbs)
Lateral Tie Clip		N/A	1.01 (0.04″)	N/A	0.73 (164 lbs)	0.81 (181 lbs)	1.47 (329 lbs)

Notes:

1. The above design values reflect both the windward and leeward capacity of the FERO tie system, with the lessor governing values tabulated.
2. The allowable mortar pull-out or push-out design load for 22 gauge corrugated strip ties (i.e. BVTS tie system) embedded a minimum of 50 mm (2″) into 90 mm (3.5″) brick veneer utilizing either Type M, S, or N mortar, equals or exceeds the recommended BVTS tie system load.
3. The allowable mortar pull-out or push-out design load for the FERO V-Tie™ embedded at the centerline of 90 mm (3.5″) brick veneer utilizing type M, S or N mortar, equals or exceeds the recommended design loads listed above for applicable FERO tie systems.
4. The allowable mortar pull-out or push-out design load for block Shear™ Connector Plates and Slotted block Plates embedded in the mortar joint of 90 (3.5″), 140 (5.5″), 190 (7.5″), 240 (9.5″) and 290 mm (11.4″) concrete blockwork utilizing Type S mortar, equals or exceeds the applicable recommended design loads listed above.
5. For the Rap-Tie and Slotted Tap-Tie tests, "protected drywall" consisted of Perma-Barrier (W.R. Grace) adhered to 12.7 mm (0.5″) drywall. For the Pac-Tie tests, "protected drywall" consisted of Tyvek placed on 12.7 mm (0.5″) drywall.
6. The Stud and Block Shear™ Connector design load values pertain to conventional tie usage. For composite wall applications, engineering analysis is required to determine allowable loads, deflections and connector spacings.
7. Where required, a minimum of 2 Lateral Tie Clips per V-Tie™ should be used (one per V-Tie™ leg).
8. The spacing of the Cat-Tie will be governed by design with maximum spacings as per A370.
9. The above design values relate to the capacity of the FERO tie components. A compatible fastener (or fasteners) capable of resisting the design loads must be selected.
10. The above design values are based on test results utilizing the following FERO Tie components (no insulation was used).

    (A) Block Shear™ Connector: 114 mm (4.49″) cavity**
    (B) Stud Shear™ Connector: 127 mm (5″) cavity**
    (C) Side Mounting Rap-Tie: 76 mm (2.9″) cavity**
    (D) & (E) Rap-Tie: 127 mm (5″) cavity**, one fastener (center hole)
    (F) Slotted Block Tie (Type I): 127 mm (5″) cavity**
    (G) Slotted Block Tie (Type II): 127 mm (5″) cavity**
    (H) Slotted Stud Tie (Type I): 127 mm (5″) cavity**
    (I) Slotted Stud Tie (Type II): 127 mm (5″) cavity**
    (J) Slotted Side Mounting Rap-Tie: 140 mm (5.6″) cavity**
    (K) & (L) Slotted Rap-Tie:: 127 mm (5″) cavity **
    (M) Adjustable BVTS: 78 mm (3.07″) BVTS, 100 mm (4″) cavity**
    (N) & (O) Pac-Tie: 50 mm (2″) cavity
    (P) Cat-Tie: 25 mm (1″) cavity
    (Q) BVTS: 78 mm (3.07″) BVTS, 22 ga. corrugated strip tie, 100 mm (4″) cavity**
    (R) Lateral tie Clip: Two per V-Tie

    Where ** indicates a 25 mm (1″) air space

11. For smaller cavity widths and/or with the addition of insulation sheathing providing lateral tie support increased tie system design loads and reduced tie system deflections may be realized.

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