Arriscraft.NOTE

Vol. 1 No. 3., CONNECTORS PART 1 – MASONRY TIES

INTRODUCTION

This Arriscraft•NOTE is the first in a series of two technical papers dealing with the issues relating to connectors used in wall construction. Criteria relative to the selection of wall tie systems will form the basis of discussion for this paper. Part II will discuss criteria relative to selecting an appropriate anchor system for dimensional stone cladding.

Selecting the proper masonry wall tie system for a specific application can be both confusing and frustrating. Designers can be overwhelmed by the variety and specialized nature of the many different types of tie systems available. Often times they turn to the masonry unit manufacturer for their recommendation; but without a detailed understanding of the building's structural design, the applicable loadings, and other such criteria, no unit masonry manufacturer can reliably offer such advice. A building's tie system must be designed by a professional based upon the specific criteria relevant to the building's life expectancy, type and relative stiffness of structural back-up, wind and seismic design loads, exposure to moisture, cavity width, ease of installation, and the nature of surrounding or adjacent wall materials.

These considerations, combined with issues of availability and cost, will determine the exact type, size and finish of tie required.

Function of Wall Ties

Typically, wall ties connect two or more wythes of masonry together or connect a unit masonry veneer to a structural back-up. They generally transfer lateral loads while permitting in-plane movement to accommodate differential movement.
To fulfill these functions adequately a wall tie must be easily installed, be securely attached or embedded, have sufficient strength and stiffness to transfer lateral loads with as little deformation as possible, have a minimum amount of mechanical play, provide adequate resistance to the transfer of moisture across a cavity, and be corrosion resistant.

Masonry Veneer and Cavity Walls: When a cavity or air space exists between two or more wythes of masonry, wall ties are usually required in order to transfer lateral loads by both axial compression and tension. In the case of a masonry veneer wall where the back-up wall is designed to resist the entire lateral load, these wall ties must support the masonry veneer and transfer the loads from the veneer to the structural back-up. By tying the masonry veneer to a sufficiently stiff back-up with stiff wall ties installed at the correct spacing, the potential for bending in the veneer will effectively be reduced, thus minimizing flexural cracking.

Outer wythes of cavity or masonry veneer walls typically experience greater movement resulting from thermal and moisture gradients and less movement as a result of elastic or inelastic deformations compared to the interior wythe. This can result in substantial differential movement between the two wythes. As such, many wall tie systems incorporate a means to allow unrestrained, relative movements to occur in directions parallel to the plane of the wall.
Coupled cavity walls are multi-wythe walls which have had their wythes tied together with flexurally stiff connectors in order to increase bending strength and stiffness. When considering the design of coupled cavity walls, it is critical to also consider the effects of differential movement.

Composite Walls: In a composite masonry wall the grout-filled collar joint acts as a shear transfer mechanism between wythes. Whenever shear strengths along the interface are exceeded, the wall ties will act to resist relative movement. They must also be designed to be strong enough during construction to withstand the large tensile forces being imposed on them during grouting operations.

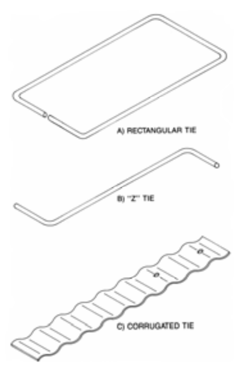
Wall Tie Types

There are a wide variety of tie systems and types available. No single type of wall tie is "*better*" than another. Rather, each type of wall tie has been designed to perform a specific task. It is critical for designers to understand what types of tie systems are available and what they are each designed to do.
Wall ties are generally classified by their:

- type of material;
- geometry;
- shape of material used;
- stiffness;
- adjustability;
- continuity; and
- corrosion resistance.

Wall tie systems have been designed for cavity, multi-wythe, grouted and veneer wall systems. These include unit ties, continuous horizontal joint reinforcement, adjustable ties and repair connectors. The first three types are used primarily in new construction; whereas, repair connectors are usually used in retrofit applications.

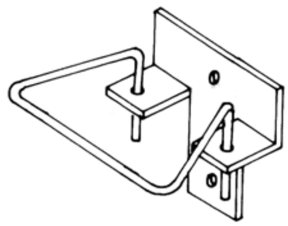
Unit Ties: Unit ties are comprised from a single component, either sheet metal or wire. These are available in various configurations, including rectangular wire ties, Z-wire ties, and corrugated strap ties.
Rectangular ties and Z-wire ties are used to bond walls constructed of two or more masonry wythes. Whereas, rectangular ties can be used to bond both hollow or solid units, Z-wire ties should only be used to bond solid units. Corrugated strap ties are typically used in low-rise applications where a masonry veneer is connected to wood frame construction. Building codes or construction standards may limit their use based upon the width of the cavity. They are not recommended for use when incorporating masonry veneer over steel studs, masonry-backed cavity walls, multi-wythe walls or grouted masonry walls.



Joint Reinforcement: Continuous horizontal joint reinforcement is prefabricated from similar components combined in a variety of configurations. They are designed to produce a lightweight yet strong method of bonding two or more wythes of coursed masonry together and provide the dual function of wall tie and horizontal joint reinforcement to control flexural cracking. The most common types are the ladder, truss and tab types.

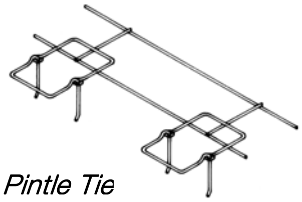
These are recommended for use in multi-wythe solid walls, masonry cavity wall, and grouted masonry walls. Truss-type joint reinforcement may restrict horizontal differential movement resulting from temperature or shrinkage differentials between wythes unless vertical expansion joints are provided at regular intervals.

Adjustable Ties: Adjustable ties are commonly two-piece systems. They are primarily intended to accommodate construction tolerances common in multi-material wall construction where non-coursing wythes of masonry are bonded together. One piece is generally installed as the back-up is constructed and the other piece as the veneer wythe is constructed. Typically they can accommodate larger differential movements than standard unit ties or joint reinforcement. Such flexibility, however, also comes with is own share of potential problems. Improperly positioned ties could result in large vertical tie eccentricities. At the very worst, if installed in a location beyond the scope of its adjustability, the tie could be rendered useless. Adjustability should never replace proper design and construction practices.

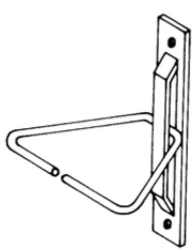


Some examples of adjustable tie types include pintles, slotted, and fastener adjusted.

- Pintle ties are typically made with bent wire and provide vertical adjustability by the pintle passing through a restraining eye or other opening in the receiving unit.



Pintle Tie



Slotted Tie

- Slotted ties employ a triangular wire tie in a vertical slot. The length of the slot governs the degree of adjustability.
- Fastener adjusted ties allow for the vertical adjustment of the tie at the fastener location during the construction of the outer wythe.

Repair Connectors: These systems are primarily used to provide ties in areas where ties were not installed during original construction, to replace existing ties, to replace failed masonry header units, to upgrade older wall systems to current code levels, or to attach new veneers over existing facades. Typically, they consist of either a mechanical expansion system, a screw system, or an epoxy adhesive system. Each type is designed to perform a particular task. Prior to their use the designer should consult with the system manufacturer to assure their proper selection and use.

Tie Strength

Historically, building codes and construction standards prescribe minimum tie size and maximum tie spacing limits to control tie loading and deformations. This data has been derived empirically from the past performance of traditional unit ties and joint reinforcement. With the increasing use of adjustable ties, however, some concern regarding tie strength and deformation has surfaced. Depending on the adjustable tie's configuration, deflections can become quite large as vertical adjustment eccentricities are increased.

Tie loads and deformations are a function of:

- tie spacing;
- tie stiffness;
- relative stiffness between the veneer material and the back-up materials;
- location of wall openings;
- cavity width;
- support conditions of the facing and back-up materials; and
- applied loads such as seismic and wind loads.

It is generally recommended that the frequency of wall ties should be increased:

- around wall openings;
- at wall perimeter conditions, such as at corners and movement joints; and
- at the tops of cavities such as along parapet walls and below shelf angles.

These areas typically experience increased levels of lateral stress and require special consideration when determining wall tie frequency and strength.

A design professional, in consultation with the tie system manufacturer, should carefully consider all of these factors in order to properly select the appropriate type, quantity and strength of tie required to perform the necessary task.

Materials and Corrosion Resistance

Use of thinner masonry walls has contributed to the need for masonry wall ties to better resist the effects of corrosion. Typically, wall ties are available in one of three available corrosion-resistant finishes: mill galvanized steel, hot-dip galvanized steel and stainless steel. Other finishes such as fusion-bonded epoxy coatings and hard-drawn copper cladding are also available but are not as commonly used due to their higher costs.

Zinc galvanizing, using either the mill or hot-dip methods, has been the most popular and economical method of protecting connectors. Zinc acts as a barrier, becoming the sacrificial material which is consumed before the steel is attacked. Generally, the thicker the zinc coating is, the longer its protective life will be.

Mill galvanizing takes place after steel wire or sheets have been processed to their specified dimensions and prior to the fabrication of the tie itself. A zinc coating is applied in a variety of specified thicknesses to provide the required level of corrosive protection. As the coated steel wires and sheets are bent to form the desired shape, however, deformations in the coating may occur, weakening the integrity of the corrosive protection.

Hot-dip galvanizing is performed by dipping the completely fabricated tie assembly into a molten zinc bath until the specified amount of zinc is bonded to the base metal. Hot-dip galvanized coatings are typically thicker than mill galvanized coatings and should provide a greater level of corrosive protection.

Zinc galvanizing has lately been criticized for not providing adequate levels of protection. Investigations conducted by the National Research Council of Canada suggest that tie corrosion typically occurs more quickly wherever moisture is retained for long periods of time. This can occur at under-tie mortar droppings, within the mortar joint and within wet cavity insulation. Tie durability under these wet conditions significantly decreased below levels generally considered acceptable, despite having been protected with currently recommended zinc coatings.

Stainless steel ties are commonly used in corrosive environments or where a building's life expectancy dictates a greater level of corrosive protection. They are typically fabricated from one of the austenitic stainless steels conforming to ASTM A167. Generally they offer excellent protection over long periods of time under extreme conditions, unless combined with carbon- or galvanized-steel components, in which case the potential for corrosion is increased.

Summary

This Arriscraft•NOTE is the first in a series of two technical papers dealing with issues relative to connectors used in masonry wall construction. It is primarily concerned with the types of wall ties used in multi-wythe unit masonry or unit masonry veneer construction.

Decisions regarding tie spacing, size, type, material and finish must be based on individual project conditions, performance requirements and safety factors. Minimum recommendations required by building codes and construction standards may not be adequate in every instance and should not be substituted for engineering judgement or investigation.

The information and suggestions contained herein are based upon the available data and information published by the listed references and the experience of Arriscraft International architectural and engineering staff. More detailed information may be found by referring to any of the related references listed below.

The information contained herein must be used in conjunction with good technical judgement and a competent understanding of masonry construction. Final decisions on the use of the information contained in this Arriscraft•NOTE are not within the purview of Arriscraft International and must rest with the project designer or owner, or both. It remains the sole responsibility of the designer to properly design the project, ensure all architectural and engineering principles are properly applied throughout, and ensure that any suggestions made by Arriscraft International are appropriate in the instance and are properly incorporated through the project.

Related References

1. American Concrete Institute/American Society of Civil Engineers/The Masonry Society, ACI 530-02/ASCE 5-02/TMS 402-02, Building Code Requirements for Masonry Structures, 2002.
2. American Concrete Institute/American Society of Civil Engineers/The Masonry Society, ACI 530.1-02/ASCE 5-02/TMS 402-02, Commentary on Building Code Requirements for Masonry Structures, 2002.
3. Brick Industry Association, Technical Notes on Brick Construction 44B (Revised), Wall Ties for Brick Masonry, September 1988 (Reissued May 2003).
4. Canadian Standards Association, CSA A370-94, Connectors for Masonry, 1994.
5. Drysdale, Hamid, Baker; Masonry Structures - Behavior and Design - Second Edition, The Masonry Society, 1999.
6. Masonry Council of Canada/Canadian Masonry Research Institute, Modern Masonry's Constituent Materials, November 1996.

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