NCMA TEK

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ANCHORS AND TIES FOR MASONRY

TEK 12-1A

Reinforcement & Connectors (2001)

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INTRODUCTION

Anchors and ties are types of connectors which attach masonry to a structural support system, or which connect two or more wythes of masonry together. The design of connectors is covered by national standards (refs. 2, 4) and by model building codes (refs. 1, 5, 6, 7).

The provisions of these codes and standards require that connectors be designed to resist applied loads and that the type, size, and location of connectors be shown or indicated on project drawings. The design criteria, illustrations, and tables provided in this TEK are presented as a guide to assist the designer in determining anchor and tie capacity in accordance with the applicable standards and building code requirements.

DESIGN CRITERIA

Regardless of whether connectors are being used to connect wythes of masonry, intersecting walls, or masonry walls to the structural frame, they play a very important role in providing structural integrity and good serviceability. As a result, when selecting connectors for a project, designers should consider a number of design criteria. Connectors should:

1. Transmit out-of-plane loads from one wythe of masonry to another or from masonry to its lateral support with a minimum amount of deformation. It is important to reduce the potential for cracking in masonry due to deflection. There is no specific criteria on the stiffness of connectors, but some authorities suggest that a stiffness of 2000 lb/in. (350 kN/m) is a reasonable target.

2. Allow differential in-plane movement between two masonry wythes connected with ties. This design criterion is especially significant as more and more insulation is used between the outer and inner wythes of cavity walls or where wythes of dissimilar materials are anchored together. On the surface, it appears that this criterion is in conflict with Item 1, but simply means that connectors must be stiff in one direction (out-of-plane) and flexible in the other (in-plane). Where control joints are necessary, they are typically designed to accommodate a movement of 3/16 in. (4.8 mm). Therefore, a designer can base the needed in-plane flexibility of the connector on this quantity. Some connectors allow much more movement than unreinforced masonry can tolerate, so designers should not assume that walls can actually move as much as the connector will allow without cracking the masonry. Additionally, cavity widths are limited to less than 4.5 in. (114 mm) so as not to compromise both the in-plane and out-of-plane stiffness of the wall ties (ref. 2).

3. Provide adequate corrosion protection. The protection of anchors and ties from the effects of environmental exposure is an extremely important consideration in any design. Where stainless steel anchors and ties are specified, *Specification for Masonry Structures* (ref. 4) requires that AISI Type 304 stainless steel be provided that complies with the following:

- Joint reinforcement – ASTM A 580
- Sheet metal anchors and ties – ASTM A 167
- Wire ties and anchors – ASTM A 580

Where carbon steel ties and anchors are specified, protection from corrosion shall be provided by either galvanizing or epoxy coating in conformance with the following (ref. 4):

1. Galvanized coatings:
- Joint reinforcement, interior walls – ASTM A 641 (0.1 oz zinc/ft^2) (0.031 kg zinc/m^2)
- Joint reinforcement, wire ties or anchors, exterior walls – ASTM A 153 (1.5 oz zinc/ft^2) (0.46 kg zinc/m^2)
- Sheet metal ties or anchors, interior walls – ASTM A 653 Class G60
- Sheet metal ties or anchors, exterior walls – ASTM A 153 Class B

2. Epoxy coatings:
- Joint reinforcement – ASTM A 884 Class B Type 2 (18 mils) (457 μm)
- Wire ties and anchors – ASTM A 899 Class C Type 2 (20 mils) (508 μm)
- Sheet metal ties and anchors – Per manufacturer's specification (or 20 mils) (508 μm)

4. Accommodate construction by being simple in design and easy to install. Connectors should not be so large and cumbersome as to leave insufficient room for mortar in the joints. Connectors that take up considerable space in a bed joint will result in a greater tendency to allow water migration into the

wall. In the same way, connectors should readily accommodate installation of rigid board insulation in wall cavities when necessary.

TYPES OF CONNECTORS

There are three types of connectors: wall ties, anchors, and fasteners. Wall ties connect one masonry wythe to an adjacent wythe. Anchors connect masonry to a structural support or frame. Fasteners connect an appliance to masonry. This TEK covers metal wall ties and anchors. Fasteners should be used strictly in accordance with the manufacturer's recommendations.

Wall Ties

Building Code Requirements for Masonry Structures (ref. 2) has a number of prescriptive requirements for wire wall ties and strap-type ties for intersecting walls. Wire wall ties can be either one piece unit ties, adjustable two piece ties, joint reinforcements or prefabricated assemblies made up of joint reinforcement and adjustable ties. Figure 1 shows typical wall ties. Wall ties do not have to be engineered unless the nominal width of a wall cavity is greater than 4.5 in. (114 mm). The prescribed size and spacing is presumed to provide connections that will be adequate for the loading conditions covered by the code.

Truss-type joint reinforcement is not recommended for tying the wythes of an insulated cavity wall together. In addition, truss type joint reinforcement should not be used when the cavity wall is constructed using concrete masonry backup and a clay brick outer wythe. The truss shape is relatively more stiff in the plane of a wall with respect to ladder type joint reinforcement, and hence restricts more differential movement. Ladder type joint reinforcement is less rigid, and is recommended when either of these conditions occur or when vertical reinforcement is used.

Table 1—Wall Tie Spacing Requirements

Tie Type		Wall Area per Tie or Cross Wire, ft² (m²)	Maximum Spacing, in. (mm) Horizontal	Vertical
W2.8, 3/16 in. dia.	Without drip	4.50 (0.42)	36 (914)	24 (610)
(MW18)	With drip	2.25 (0.21)	18 (457)	12 (305)
	Adjustable	1.77 (0.16)	16 (406)	16 (406)
W1.7, 9 gage	Without drip	2.67 (0.25)	36 (914)	24 (610)
(MW11)	With drip	1.33 (0.12)	18 (457)	12 (305)
	Adjustable	1.77 (0.16)	16 (406)	16 (406)
W1.7, 9 gage	Without drip	2.67 (0.25)	36 (914)	24 (610)
(MW11)	With drip	1.33 (0.12)	18 (457)	12 (305)
truss type	Adjustable	1.77 (0.16)	16 (406)	16 (406)
W1.7, 9 gage	Without drip	2.67 (0.25)	36 (914)	24 (610)
(MW11)	With drip	1.33 (0.12)	18 (457)	12 (305)
ladder type	Adjustable	1.77 (0.16)	16 (406)	16 (406)
Strap tie	Corrugated	2.67 (0.25)	32 (813)	18 (457)

Table 1 summarizes code prescriptive requirements for unit wall ties and joint reinforcement. Figure 2 also shows additional requirements for adjustable wall ties.

Anchors

Building Code Requirements for Masonry Structures (ref. 2) contains no prescriptive requirements for wall anchors, but does imply that they be designed with a structural system to resist wind and earthquake loads and to accommodate the effects of deformation. Typical anchors are shown in Figure 3. The shapes and sizes of these typical anchors have evolved over many years and satisfy the "constructability" criterion. All of the anchors shown have been tested with the resulting capacities as shown in Table 2.

Additional tests are needed for adjustable anchors of different configurations and for one piece anchors. Proprietary anchors are also available. Manufacturers of proprietary anchors should furnish test data to document comparability with industry tested anchors.

Anchors are usually designed based on their contributory

Table 2—Anchor Capacity (ref. 3)

Anchor Description		Tension	Compression Cavity 1	Compression Cavity 2	Shear
Column flange	Avg. load, lb (kN)	3,342 (14.9)	9,863 (43.9)	6,373 (28.3)	1,584 (7.05)
(2 pcs)	Standard deviation	324	1,041	1,773	438
cavity 1=1" (25 mm)	Avg. stiffness, lb/in. (kN/m)	96,063 (16,823)	191,595 (33,553)	123,452 (21,620)	25,094 (4,395)
cavity 2=4" (102 mm)	Standard deviation	39,548	116,649	86,066	14,114
Weld on triangle	Avg. load, lb (kN)	816 (3.63)	1,159 (5.16)	702 (3.12)	
cavity 1=1" (25 mm)	Standard deviation	76	332	153	
cavity 2=2" (51 mm)	Avg. stiffness, lb/in. (kN/m)	5,379 (942)	29,944 (5,244)	22,268 (3,900)	
	Standard deviation	2,428	14,700	8,332	
Dovetail triangle	Avg. load, lb (kN)	714 (3.18)	560 (2.49)	386 (1.72)	347 (1.54)
cavity 1=1" (25 mm)	Standard deviation	76	95	75	15
cavity 2=3" (76 mm)	Avg. stiffness, lb/in. (kN/m)	11,667 (2,043)	7,526 (1,318)	6,857 (1,201)	3,844 (673)
	Standard deviation	8,755	2,451	2,630	1,764
Channel slot	Avg. load, lb (kN)	832 (3.70)	271 (1.21)	310 (1.38)	
cavity 1=1" (25 mm)	Standard deviation	208	102	213	
cavity 2=4" (102 mm)	Avg. stiffness, lb/in. (kN/m)	5,207 (912)	9,494 (1,663)	5,125 (897)	
	Standard deviation	2,978	5,992	2,117	

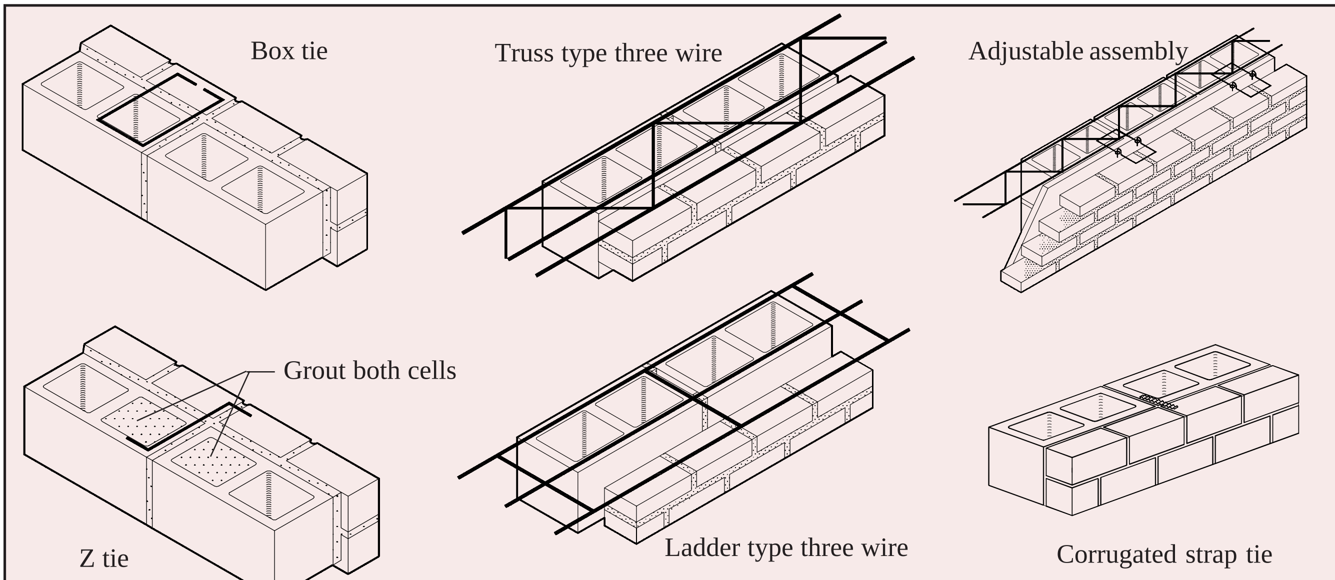

Figure 1—Typical Wall Ties

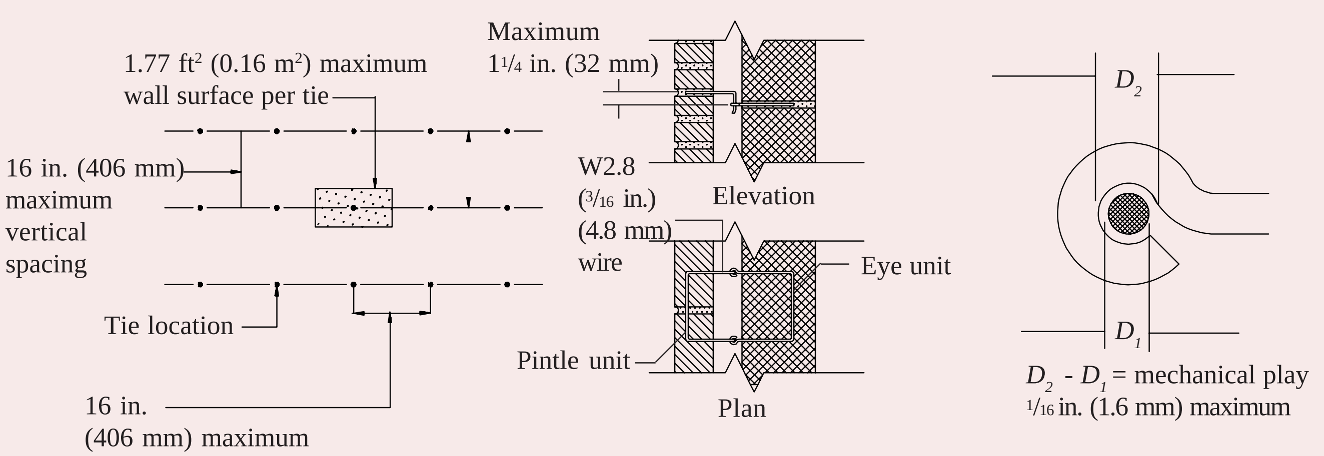

Figure 2—Additional Requirements For Adjustable Ties

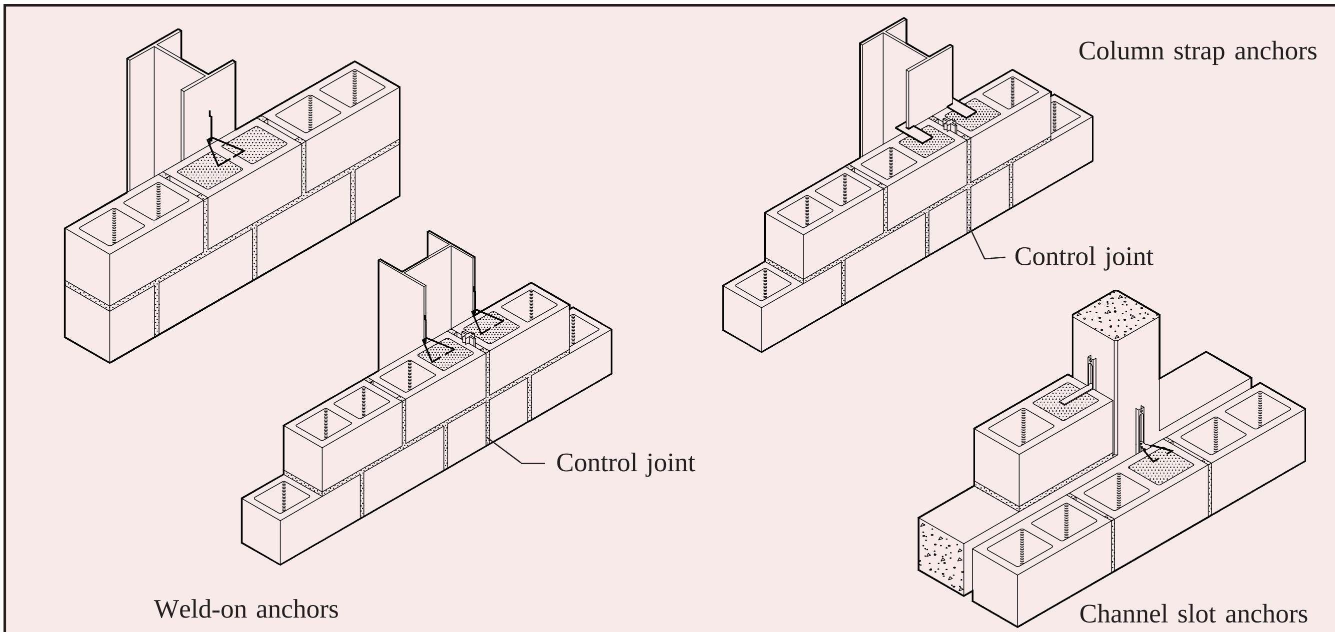

Figure 3—Typical Column Anchors

area. This is the traditional approach, but some computer models suggest that this approach does not always reflect the actual behavior of the anchorage system. However, there is currently no accepted computer program to address this point, so most designers still use the contributory area approach with a factor of safety of 3. The use of additional anchors near the edges of wall panels is also recommended and required around large openings.

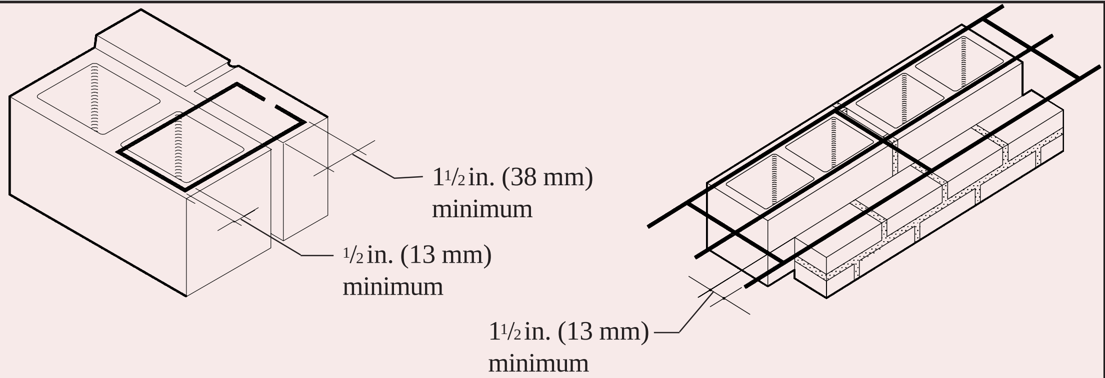

Figure 4—Minimum Embedment of Joint Reinforcement and Wire Ties

CONSTRUCTION

When typical ties and anchors are properly embedded in mortar or grout, mortar pullout or pushout will not usually be the controlling mode of failure. The standard (ref. 4) requires that connectors must be embedded at least 1 1/2 in. (38 mm) into a mortar bed of solid units. The required embedment of unit ties in hollow masonry is such that the tie must extend completely across the hollow units (Figure 4). Proper embedment can be easily attained with the use of prefabricated assemblies of joint reinforcement and unit ties. Because of the magnitude of loads on anchors, it is recommended that they be embedded in filled cores of hollow units. To save mortar, screens can be placed under the anchor and 1 to 2 in. (25 to 51 mm) of mortar can be built up into the core of the block above the anchor (Figure 5).

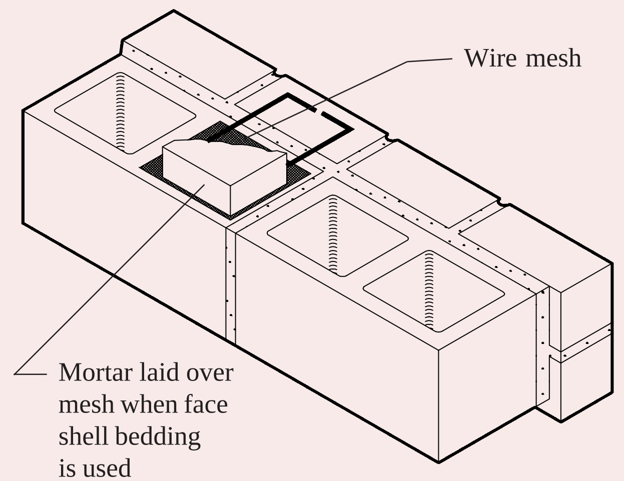

Figure 5—Use of Mesh to Facilitate Embedment of Anchor in Mortar

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