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):
   - Galvanized coatings:
     - Joint reinforcement, interior walls – ASTM A 641 (0.1 oz zinc/ft²) (0.031 kg zinc/m²)
     - Joint reinforcement, wire ties or anchors, exterior walls – ASTM A 153 (1.5 oz zinc/ft²) (0.46 kg zinc/m²)
     - Sheet metal ties or anchors, interior walls – ASTM A 653 Class G60
     - Sheet metal ties or anchors, exterior walls – ASTM A 153 Class B
   - 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...
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>
<thead>
<tr>
<th>Anchor Description</th>
<th>Tension</th>
<th>Compression</th>
<th>Shear</th>
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<tbody>
<tr>
<td></td>
<td>Cavity 1</td>
<td>Cavity 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avg. load, lb (kN)</td>
<td>9,863 (43.9)</td>
<td>6,373 (28.3)</td>
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<td></td>
<td>Standard deviation</td>
<td>324</td>
<td>1,041</td>
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<tr>
<td></td>
<td>Avg. stiffness, lb/in. (kN/m)</td>
<td>96,063 (16,823)</td>
<td>191,595 (33,553)</td>
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<tr>
<td></td>
<td>Standard deviation</td>
<td>39,548</td>
<td>123,452 (21,620)</td>
</tr>
<tr>
<td></td>
<td>Avg. load, lb (kN)</td>
<td>1,159 (5.16)</td>
<td>702 (3.12)</td>
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<tr>
<td></td>
<td>Standard deviation</td>
<td>76</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>Avg. stiffness, lb/in. (kN/m)</td>
<td>5,379 (942)</td>
<td>29,944 (5,244)</td>
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<td></td>
<td>Standard deviation</td>
<td>2,428</td>
<td>22,628 (3,900)</td>
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<td></td>
<td>Avg. load, lb (kN)</td>
<td>714 (3.18)</td>
<td>560 (2.49)</td>
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<td>Standard deviation</td>
<td>76</td>
<td>95</td>
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<tr>
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<td>Avg. stiffness, lb/in. (kN/m)</td>
<td>11,667 (2,043)</td>
<td>7,526 (1,318)</td>
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<td>Standard deviation</td>
<td>8,755</td>
<td>2,451</td>
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<td>Avg. load, lb (kN)</td>
<td>832 (3.70)</td>
<td>271 (1.21)</td>
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<td></td>
<td>Standard deviation</td>
<td>208</td>
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<td>Avg. stiffness, lb/in. (kN/m)</td>
<td>5,207 (912)</td>
<td>9,494 (1,663)</td>
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<td>Standard deviation</td>
<td>2,978</td>
<td>5,992</td>
</tr>
</tbody>
</table>

Table 2—Anchor Capacity (ref. 3)
1.77 ft² (0.16 m²) maximum wall surface per tie

16 in. (406 mm) maximum vertical spacing

16 in. (406 mm) maximum horizontal spacing

Tie location

Maximum
1/4 in. (32 mm)

W2.8
(3/16 in.)
(4.8 mm)
wire

Elevation

Eye unit

Plan

Pintle unit

D2 - D1 = mechanical play

1/16 in. (1.6 mm) maximum

Grout both cells

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.

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 1½ 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).

REFERENCES


Provided by: Cemex, Inc.