

Using Bonding Enamel-Coated Steel Fixtures to Produce More Durable Brick/Masonry Structures

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Report Documentation Page

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Topics to Cover

- **Problems with Masonry Ties**
- **Properties of Bonding Coatings**
- **Effects of Corrosion and Failure**
- **Types of Ties and Installation**
- **Standardization**
- **Target Test Site**
- **Test Program and Metrics**
- **Summary and Questions**



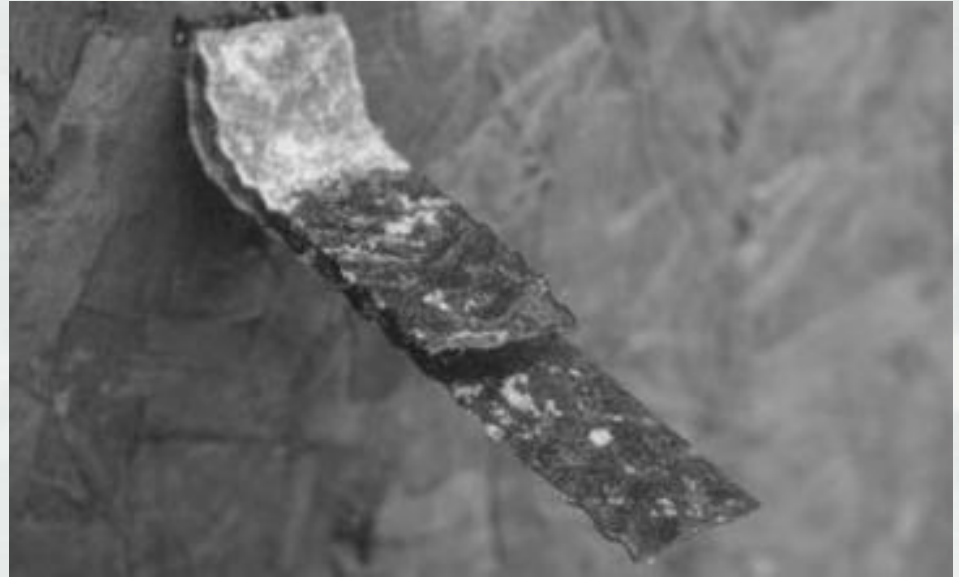
Problem

- **Masonry/brick construction involves a wide variety of metal fittings that brace the units in the wall**
- **Fittings are critical to the structural integrity of the wall**
- **Metal fitting are typically located where they can quickly corrode**



Hollow Core Walls are Ideal Spaces for Corrosion to Occur

- Bricks allow moisture to pass through
- Moisture barriers are typically on the inner wall
- The cavity is typically very moist for long periods of times

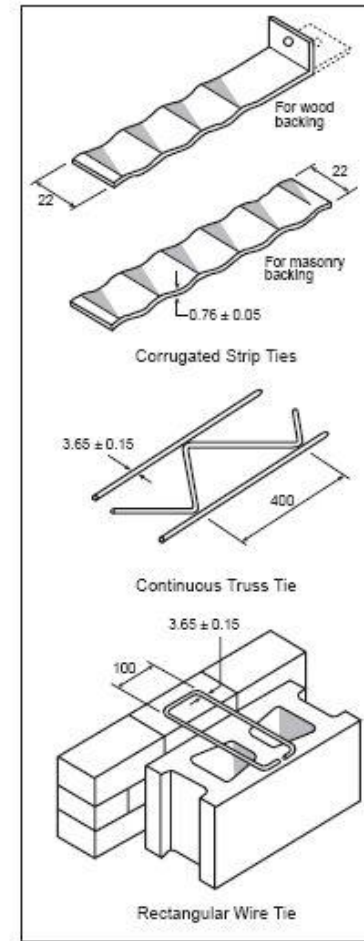


Corroded strap-type wall tie



Ties Join Courses and Lateral Units

- Ties hold brick veneer to a stud wall or a masonry block wall
- Lateral layers of block are held together with continuous truss ties
- There are a wide variety of ties designed to meet specific construction needs



Bonding Enamel Coatings for Masonry Ties

- **Standard alkali-resistant glass enamel is fired onto the steel fittings**
- **A layer of portland cement is added to the heat softened glass enamel**
- **Finished reinforcement is corrosion resistant and has 3 to 4 times stronger bond to the mortar**
- **No reduction of the strength of the wall at the point of mortar-to-tie contact**



Bonding Enamel Increases Peak Pull-out Stress

- Enamel on a strap can increase the adhesion of the surface of the metal to the surrounding mortar
- Initial tests with enameled metal straps cracked all the test cylinders and straps would not pull out



New Strong Durable Ties

- Work done to date with steel pins has shown that bond strength can be three to four times more than uncoated steel
- Intact enamel can make metal very corrosion resistant



Cement fused to the glass enamel makes strong bond to surrounding mortar



Steel is protected from corrosion as long as glass enamel is intact



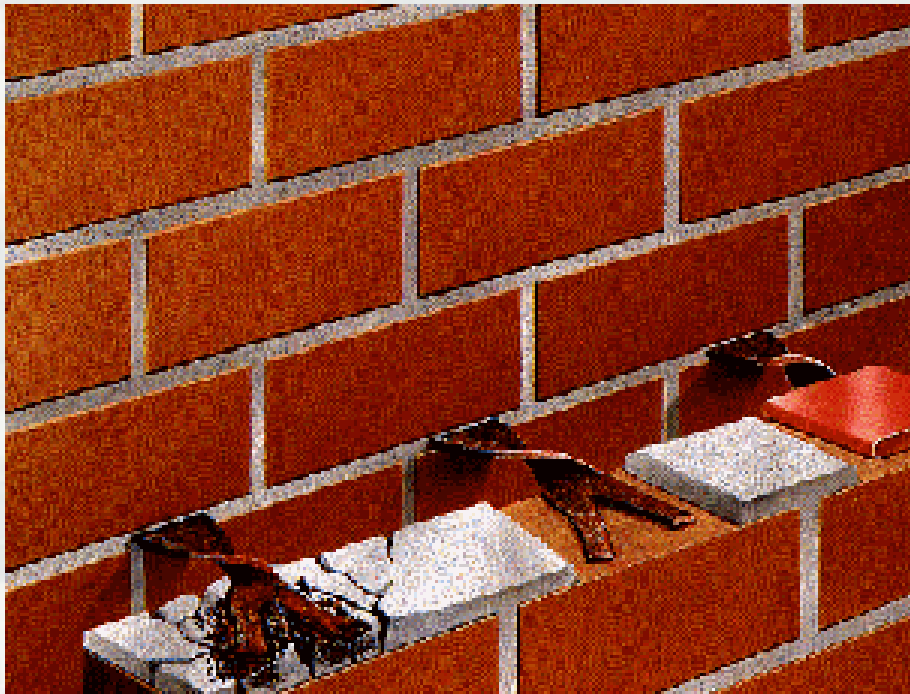
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Corrosion of Ties Breaks Bricks and Mortar

- Corrosion increases the volume of the iron that reacts by 600% and cracks the mortar
- Porosity of bricks hold moisture for long periods of times
- The thick layer of concrete (mortar) that would offer protection to steel reinforcement is not present



Modes of Failure for Wall Ties

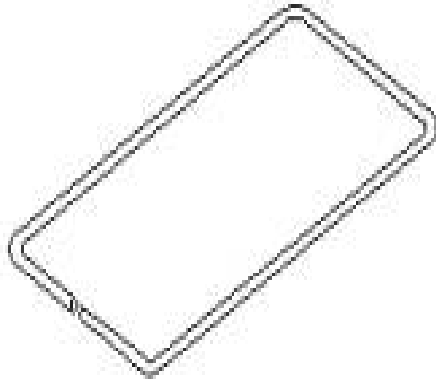


Failing Wall Ties in a Cavity Wall

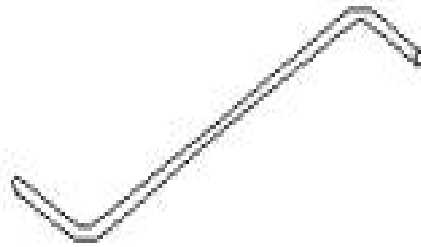
- Ties can fail by corroding through and physically breaking
- Corrosion in mortar joints can crack the mortar and break the tie-to-mortar bond
- Stress problems in walls often related to settling problems, seismic events and pressure from wind and rain



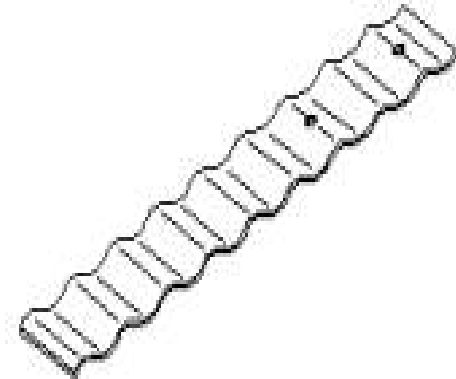
Types of Masonry Ties



Rectangular Tie



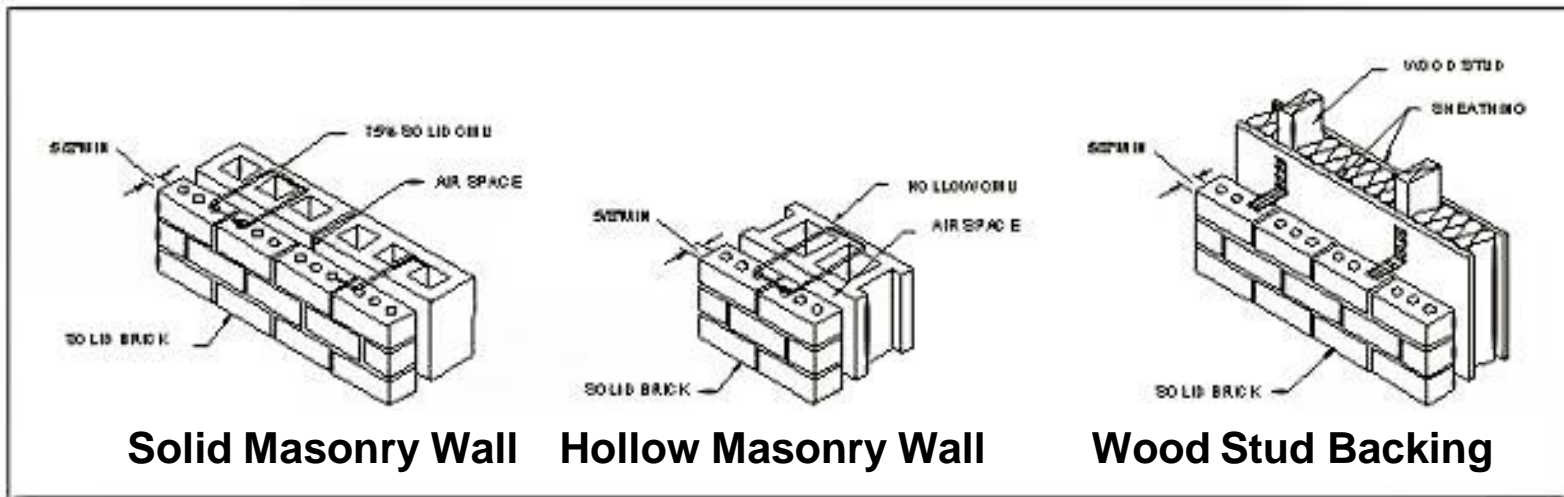
Z-tie



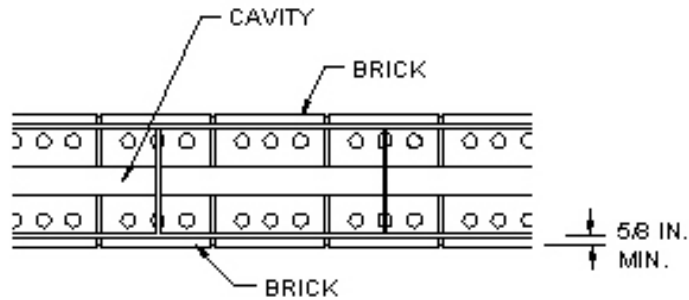
Corrugated Tie



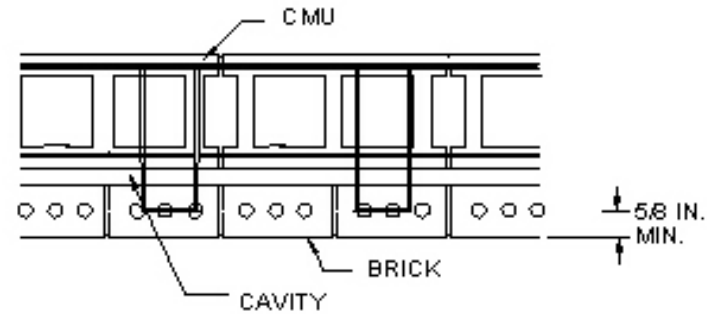
Installation of Ties in Solid and Cavity Walls



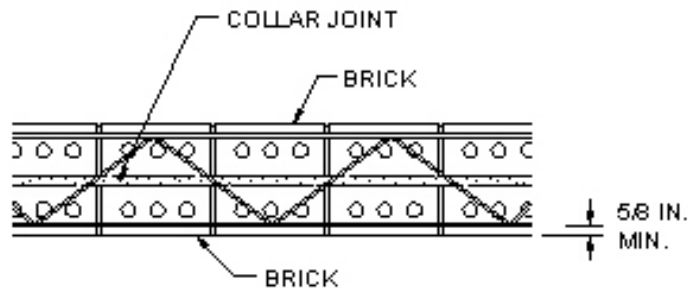
Ladder Type Wall Ties



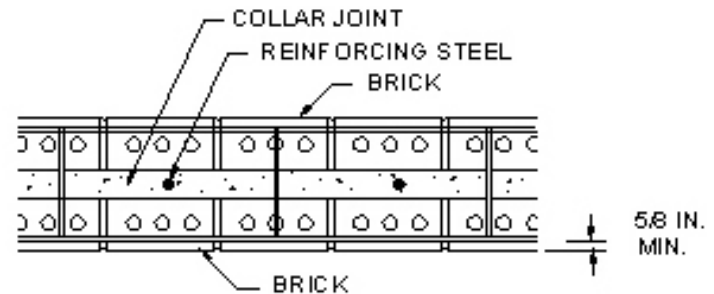
Ladder-Type



Tab-Type



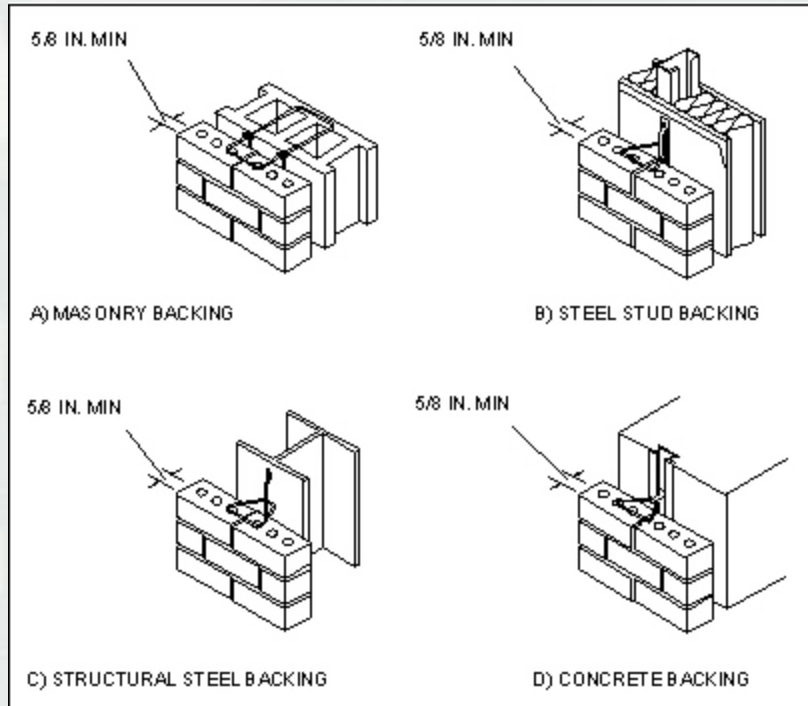
Truss-Type



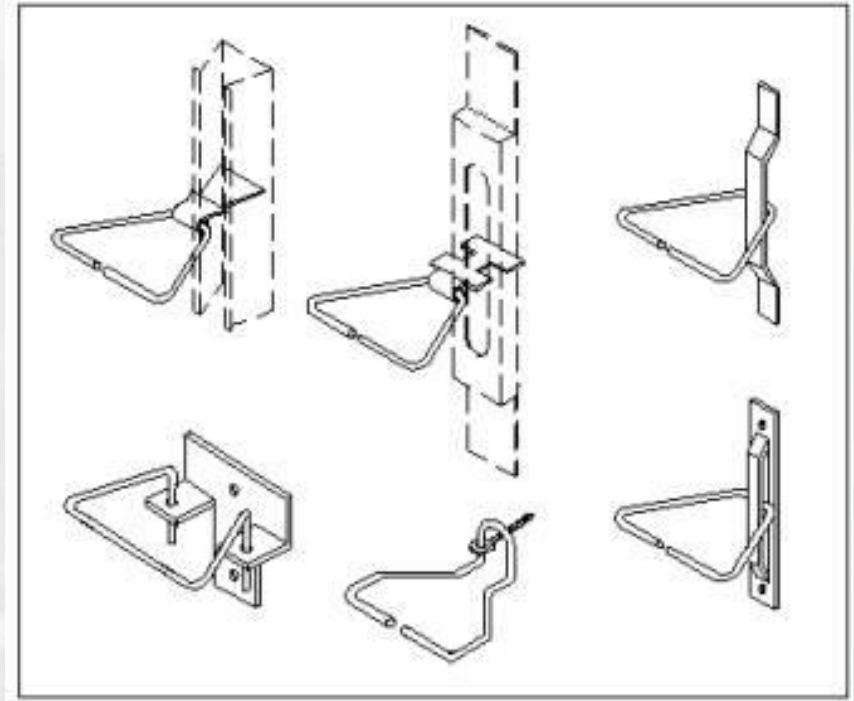
Ladder-Type w/Reinforcement



Adjustable Masonry Ties



Set-ups for Ties



Details for Adjustable Ties



Ties are All Standardized as to Materials Specifications

Corrugated Type

Tie System		Minimum Specified Dimension ¹		
		Wire Size	Gage	Dimension, in. (mm)
Unit Ties	Rectangular and "Z"	W1.7 W2.8	9 ---	0.15 (3.8) 3/16 (4.8)
	Corrugated	Not applicable	22	0.03 (0.8)
Joint Reinforcement, Standard and Adjustable	Ladder and Truss Type and Tabs	W1.7 W2.8	9 ---	0.15 (3.8) 3/16 (4.8)
Adjustable ties	Rectangular and "Z"	W1.7 W2.8 (pintle legs min. W2.8)	9 ---	0.15 (3.8) 3/16 (4.8)
	Dovetail/ Channel Slot Wire	W1.7 W2.8 (pintle legs min. W2.8)	9 ---	0.15 (3.8) 3/16 (4.8)
	Sheet Metal Connector Slot	Not applicable	16	0.06 (1.5)
		Not applicable	22	0.03 (0.8)
	Slotted Plate Wire	W1.7	9	0.15 (3.8)
	Slotted Plate Backer Plate	Not applicable	14	0.08 (2.0)
Not applicable		14	0.08 (2.0)	

22-gage



Specifications for Ties

Standard joint reinforcement

Wall Type	Tie System and Material	Maximum Cavity Width ¹ , in. (mm)	Maximum Area Per Tie, ft ² (m ²)	Maximum Vertical Spacing, in. (mm)	Maximum Horizontal Spacing, in. (mm)
Cavity (Both Wythes Designed to Resist Out of Plane Stresses)	Unit Tie W1.7 W2.8	4 ½ (114)	2.67 (0.25) 4.50 (0.42)	24 (610)	36 (914)
	Standard Joint Reinforcement W1.7 W2.8	4 ½ (114)	2.67 (0.25) 4.50 (0.42)	24 (610)	16 (406)
	Unit Adj. Double Eye & Pintle	4 ½ (114)	1.77 (0.16)	16 (406)	16 (406)
	Adj. Joint Reinforcement	4 ½ (114)	1.77 (0.16)	16 (406)	16 (406)
Brick Veneer/ Wood Stud	Corrugated	1 (25)	2.67 (0.25)	18 (457)	32 (813)
	Other than Corrugated	4 ½ (114)	2.67 (0.25)	18 (457)	32 (813)
	Adj. 2 piece W1.7	4 ½ (114)	3.50 (0.33)	18 (457)	32 (813)
Brick Veneer/ Steel Stud	Adj. Unit Veneer Ties	4 ½ (114) (2 in. (50 mm) recommended)	2.67 (0.25) (2.0 ft ² (0.18 m ²) recommended)	18 (457)	32 (813) (24 in. recommended)
Brick Veneer/ Concrete or CMU Backing	Adj. Unit and W1.7	4 ½ (114)	2.67 (0.25)	18 (457)	32 (813)
	Sheet Metal and W2.8		3.50 (0.33)		
Multi Wythe Masonry Composite	Unit ties W1.7 W2.8		2.67 (0.25) 4.50 (0.42)	24 (610)	36 (914)
	Joint reinforcement W1.7 W2.8	No Cavity	2.67 (0.25) 4.50 (0.42)	24 (610)	36 (914)

16 in. horizontally

24 in. vertically

This is one tie for each 2.67 sq. ft.

A 30 ft. by 10 ft. wall would require 113+ ties



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Target Test Site

- Ft. Stewart, GA
- Southern-- 21 deg N latitude
- Average annual rainfall = 48.3 in.
- Max rainfall (July), average = 8.9 in.
- Average high monthly temperature = 93 deg F
- Elevation = 33 ft. above MSL
- In hurricane hazard area
- 30 miles from coast



Ft. Stewart, GA



Proposed Test Program for Bonding Enamel Ties

- **ASTM E754 - 80(2006) Standard Test Method for Pullout Resistance of Ties and Anchors Embedded in Masonry Mortar Joints to establish the bond strength for the new ties**
- **Optical monitoring to detect corrosion of ties in a cavity wall**
- **Electrical corrosion detection systems**



Standard Optical Inspection Technology to Determine Condition of Wall Ties



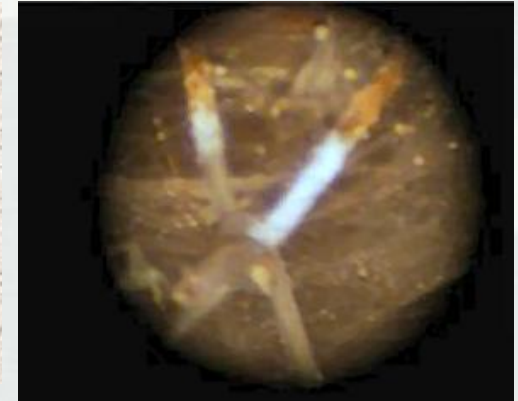
Locate the Metal Ties



Drill View Port



Fiber-optical Inspection



Evaluate Image

Ports can be installed as the wall is assembled

Progress of corrosion can be documented with series of photos



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Electrical Corrosion Monitoring

- **Half-cell corrosion potential method - accurate field potential measurements aid in detecting active corrosion**
- **Electrical corrosion monitor leads installed during construction**



Summary

- **Project will demonstrate new corrosion-resistant masonry wall ties**
- **Corrosion of wall ties can cause damage to masonry construction**
- **Proposed test site has serious wind problems**
- **Result of demonstration will be stronger, more durable masonry construction that can be used DoD-wide**



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Masonry Wall Construction



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