

# **Mudsill Anchorage Systems in Cripple Wall Retrofits**

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International Code Council Wood Frame Retrofit Committee

**SUBJECT: Collaboration on Documents with Howard Cook**

Dear ICC Members:

First, I would like to thank you for allowing me to provide comments on the different methods of attaching new or existing sill plates to existing foundations. Howard Cook and I have collaborated on the best strategies to retrofit sill plates in existing homes and have partnered to prepare the following document.

Please note that all values provided in the document were based on testing that has been approved by the ICBO/ICC evaluation services. The following ICBO/ICC reports have been referenced in the document: ER-3631 for Wedge-All anchors (this will change to ESR-1396 by early January 2006), ESR-1772 for SET adhesive anchors, ER-4945 for ET adhesive anchors and ESR-1056 for the Titen HD concrete screws. Values in these ICC reports were based on testing performed in either 2000 psi concrete or 2500 psi concrete, varying on the specific product. Be aware that the concrete that is encountered in existing construction is assumed by the UCBC to have a compressive strength of 1500 psi. Due to this assumption, we cannot make any guarantees as to how our products will perform in this condition since we have not done testing in 1500 psi concrete. True anchor values in 1500 psi would only be established through testing.

I hope your committees will find our opinions at Simpson Strong-Tie helpful in making the final retrofit strategy recommendations.

Sincerely,

Wendy Allen, PE  
Field Engineer  
Simpson Strong-Tie Anchor Systems

## Mudsill Anchorage Systems in Cripple Wall Retrofits

For wood frame retrofit work Simpson makes a number of different fasteners that can be used. This short paper is an attempt to help the designer determine which system would be the best and most economical. All references to the "catalog" refer to Simpson Catalog C-SAS-2005 Anchoring & Fastening Systems For Concrete and Masonry.

The 5/8-inch Wedge-All is not permitted by Simpson Strong-Tie because it is not possible to meet edge distance requirements when installing these bolts through 2by blocking or flush cut mudsill. All of the other mudsill to concrete anchorage systems made by Simpson Strong-Tie do meet these requirements. The strength of the bolt to concrete connection (based on the tested concrete psi value), in order of highest strength to lowest strength, is as follows:

5/8" SET epoxy bolt	2953 pounds
1/2" SET epoxy bolt	2833 pounds
5/8" Titen HD screw	2347 pounds
1/2" Titen HD screw	2274 pounds
1/2" Wedge-All bolt	1650 pounds
5/8" ET epoxy bolt	1336 pounds
1/2" ET epoxy bolt	1053 pounds
5/8 Wedge-All bolt	(No recognized value)

The installations of the Titen HD's or 1/2 inch wedge anchors are much less labor-intensive than either the ET or SET epoxy bolt installations. The strength of the concrete to bolt connection always exceeds the bolt to wood connection when installing the bolt through full dimensioned 2 inch thick closed grained redwood, except for the ET epoxy bolts. When ET epoxy is used the wood to bolt connection is actually stronger than the bolt to concrete connection. For this reason ET epoxy should not be used.

Epoxy bolts are very labor intensive. Because labor costs are the primary expense in seismic retrofit work, 1/2 inch wedge anchors should be given the highest endorsement. To achieve published values, wedge anchors should have a 4 inch embedment into the concrete.

I called a local hardware store for retail pricing of the Titen HD's, 1/2 inch wedge anchors, and the various epoxy bolts. Prices for these products from lowest price to highest price are as follows:

1/2 inch by 7 inch Wedge-All anchor	\$1.60
1/2 inch by 6-1/2 inch Mechanically Galvanized Titen HD	\$3.69
1/2" SET epoxy bolt -2833 pounds	\$5.25
1/2 inch by 8 inch Mechanically Galvanized Titen HD	\$5.29
5/8 inch by 6 1/2 inch Mechanically Galvanized Titen HD	\$5.29
5/8" SET epoxy bolt -2953 pounds	\$5.50
5/8 inch by 8 inch Mechanically Galvanized Titen HD	\$6.69

The primary expense in any retrofit is the cost of the labor.

The Titen HD is a 2-part labor process: 1-Drilling the hole through the block and sill and into the concrete. 2-Tightening the bolt with an impact wrench or right angle drill.

The Wedge All is a 3-part labor process: 1-Drilling the hole through the block and sill into the concrete. 2-Driving the bolt into the hole with a hammer. 3-Tightening the bolt by hand with an impact wrench or with an angle drill. The amount of labor is practically the same as for the Titen HD, once the reduced cost of the Wedge-All is factored in, this is the preferred choice for the 1/2 inch bolt.

The cost of the epoxy bolt is more than any of the other hardware mentioned above. This is because epoxy bolts involve a 5-part labor process: 1-Drilling the hole through the block and sill into the concrete. 2-Blowing out the hole with compressed air. 3- Injecting epoxy into the hole. 4-Installation of the bolt. 5-Coming back hours later and tightening the bolt.

Given strength provided versus the material and labor costs for the hardware mentioned above, the bolt hardware can be ranked from the most preferred to the least preferred as follows. All of these bolt to concrete connections far exceed the bolt to wood connection:

1/2 inch by 10 inch Wedge-All anchor-1650 pounds  
1/2 inch by 8 inch Mechanically Galvanized Titen HD-2274 pounds  
5/8 inch by 8 inch Mechanically Galvanized Titen HD-2347 pounds  
5/8" SET epoxy bolt -2953 pounds  
1/2" SET epoxy bolt -2833 pounds

Because all of this hardware exceeds the bolt to wood connection in closed grained redwood all of these bolts acceptable.

The most cost- effective of the 1/2 inch options is the 1/2 inch by 7 inch Wedge All and then the 1/2 inch by 8 inch Titen HD

The most cost-effective of the 5/8 options is the 5/8 Titen HD.

The Strengths of the various types of bolt hardware, based on research done by Simpson StrongTie, is as follows:

### **5/8-Inch Wedge-All Anchor**

The adjustment factor table on page 113 in Simpson Catalog C-SAS-2005 catalog does not recognize a value for 5/8 wedge anchors with concrete edge distances less than 2-1/2 inches. We only have 2-1/4 inches edge distance if the wedge anchor is put through the center of the 2x4 block as shown in the Plan Set. It is not rational for us to endorse the use of the 5/8 inch wedge anchor.

### **1/2 Inch Wedge-All Anchor**

Page 108 of Simpson Catalog C-SAS-2005 rates their 1/2 inch wedge anchors in 2000 psi concrete with a 5 inch concrete edge distance at 1675 pounds in shear (The minimum embedment for this installation is 4 1/2"). Factoring in the Simpson allowed 1.33 short term loading adjustment factor; the bolts are worth 2,227 pounds in shear. If the bolts are put through

the center of the 2 by 4 blocks as shown on the plan set we end up with a 2 1/4 concrete edge distance. Interpolating from the load adjustment factor table dealing with concrete edge distances on page 113 we have a load adjustment factor of .725. The 1/2 inch wedge anchor can therefore resist of 1650 pounds of shear in the concrete. The strength of the wood to bolt is 1119 pounds per the 2005 NDS. The failure mode here will obviously be in the wood-to-bolt connection, not in the concrete. It is therefore rational for us to endorse use of the 1/2 inch wedge anchor.

### **5/8-Inch ET Epoxy Bolt**

A 5/8 inch epoxy bolt installed with ET epoxy and a 7 1/2 inch concrete edge distance has a shear value of 4890 pounds as shown on page 51 (embedded 5"). Multiply this by 1.33 short term loading adjustment factor as allowed by the Simpson catalog and we get a value of 6520 pounds. If the bolts are put through the center of the blocks as shown on the plan set we end up with a 2 1/4 concrete edge distance. Interpolating from the load adjustment factor table dealing with concrete edge distances on page 55 we have a load adjustment factor of .205 so that our epoxy bolt can now resist 1336 pounds of shear. The strength of the wood to bolt connection in 2" closed grain redwood is 1555 pounds per the 2005 NDS. The failure mode here will be in the wood to bolt connection not in the concrete. It therefore not rational to endorse use of the 5/8-inch ET epoxy bolt.

### **1/2 Inch ET Epoxy Bolt**

The Simpson catalog on page 51 gives us a value of 2,820 pounds of shear for a 1/2 inch bolt using ET epoxy with a 6 3/8 inch concrete edge distance (embedded 4-1/4"). Factoring in the Simpson allowed 1.33 short term loading adjustment factor allowed by the Simpson catalog allows us 3,760 pounds of shear. If the bolts are put through the center of the blocks as shown on the plan set we end up with a 2 1/4 concrete edge distance. Interpolating from the load adjustment factor table dealing with concrete edge distances on page 55 we have a load adjustment factor of .28 so that our epoxy bolt can now resist 1053 pounds of shear. The strength of the wood to bolt connection in 2" closed grain redwood is 1119 pounds per the 2005 NDS. The failure mode therefore will be in the concrete and not in the wood. It is therefore not rational for us to endorse use of the 1/2-inch ET epoxy bolt.

### **5/8-Inch SET Epoxy Bolt**

A 5/8 inch epoxy bolt installed with SET epoxy at 1-3/4 inch concrete edge distance has a shear value of 2215 pounds as shown on page 38 (embedded 5"). Note these loads are tested at 1-3/4" with shear parallel to the edge of the concrete, so no reduction factors need to be applied. In fact, loads will be higher than specified for our condition of 2-1/4" edge distance. Multiply this by the 1.33 short term loading adjustment factor allowed by the Simpson catalog, and we get a value of 2953 pounds. The strength of the wood to bolt connection in 2" closed grain redwood is 1555 pounds per the 2005 NDS. The failure mode then will be in the wood to bolt connection and not in the concrete. It therefore rational to endorse use of the 5/8-inch ET epoxy bolt.

### **½ Inch SET Epoxy Bolt**

A 1/2 inch epoxy bolt installed with SET epoxy at 1-3/4 inch concrete edge distance has a shear value of 2125 pounds as shown on page 38 (embedded 4-1/4"). Note these loads are tested at 1-3/4" with shear parallel to the edge of the concrete, so no reduction factors need to be applied. Multiply this by the 1.33 short term loading adjustment factor as allowed by the Simpson catalog and we get a value of 2833 pounds. The strength of the wood to bolt connection in 2" closed grain redwood is 1119 pounds per the 2005 NDS. The failure mode then will be in the wood to bolt connection and not in the concrete. It therefore rational to endorse use of the ½-inch SET epoxy bolt.

### **5/8-Inch Titen HD Concrete Screw**

A 5/8 inch Titen HD screw anchor installed with a 1-3/4 inch concrete edge distance has a shear value of 1205 pounds as shown in the table at the top of page 99 of the catalog. The minimum embedment depth is 2-3/4". This accounts for a 6 ½ Titen Hd that goes the ¼ inch plate washer, the nominal 2x block, and through the full dimensioned 2x sill. In this case we get an embedment depth of exactly 2 ¾ inches. Note these loads are tested at 1-3/4" with shear parallel to the edge of the concrete so no reduction factors need to be applied. Multiply 1205 pounds by the 1.33 short term loading adjustment factor as allowed by the Simpson catalog and we get a value of 1602 pounds. This value will go up to 2347 pounds if we use an 8 inch Titen HD. 5/8-inch Titen HD concrete screw. The strength of the wood to bolt connection in 2" closed grain redwood is 1555 pounds per the 2005 NDS. The failure mode then will be in the wood to bolt connection and not in the concrete. It therefore rational to endorse use of the 5/8-inch ET epoxy bolt.

### **½ Inch Titen HD Concrete Screw**

A 1/2 inch Titen HD screw anchor installed at 1-3/4 inch concrete edge distance has a shear value of 1165 pounds as shown in the table at the top of page 99. The minimum embedment depth is 2-3/4 inches. This accounts for a 6 ½ Titen Hd that goes thru the ¼ inch plate washer, the nominal 2x block, and through the full dimensioned 2x sill. In this case we get an embedment depth of exactly 2 ¾ inches. Note these loads are tested at 1-3/4" with shear parallel to the edge of the concrete so no reduction factors need to be applied. In fact, loads will again be higher than specified for our condition of 2-1/4" edge distance. Multiply 1165 lbs by the 1.33 short term loading adjustment factor as allowed by the Simpson catalog and we get a value of 1549 pounds. This value will go up to 2274 pounds if we use an 8 inch Titen HD 1/2-inch Titen HD concrete screw. The strength of the wood to bolt connection in 2" closed grain redwood is 1119 pounds per the 2005 NDS. The failure mode then will be in the wood to bolt connection and not in the concrete. It therefore rational to endorse use of the ½-Titen HD.

Also note that values given for the Titen HDs and ½ inch wedge anchors are shear values **with or without special inspections.**