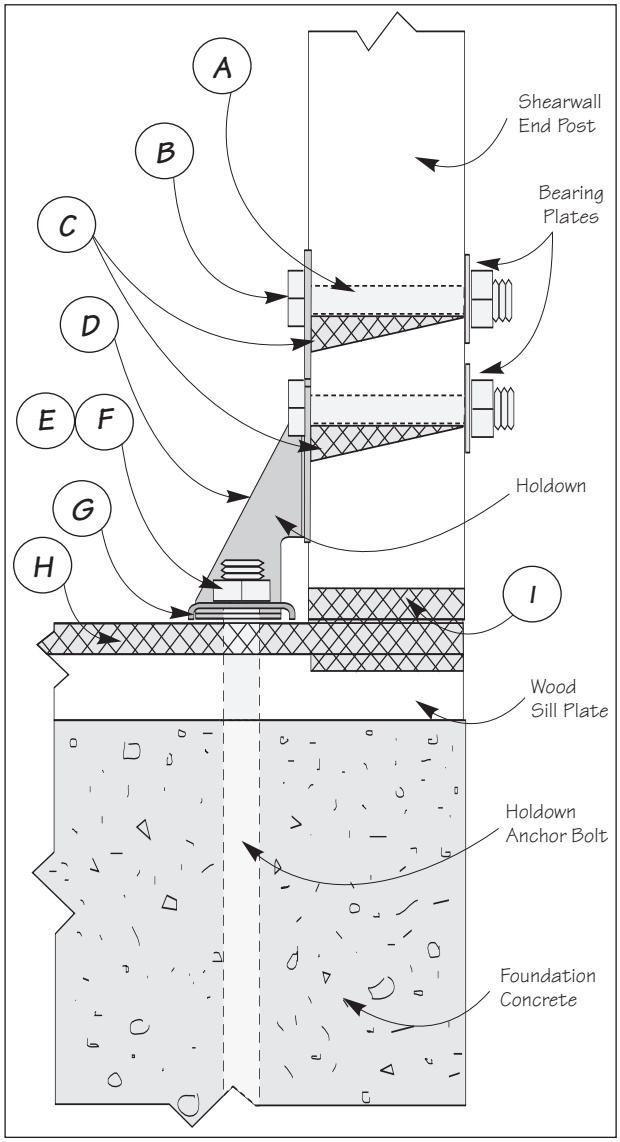
1997 UBC Wood Shearwall Deflections

Provisions of the *1997 Uniform Building Code* (UBC) require limitation of story drift due to seismic forces. Thus, it is desirable to estimate by calculation the lateral movement or drift, attributable to the wood panel sheathed shearwalls used to resist seismic action in light frame wood construction. UBC Section 2315, under Chapter 23, Division II, Part II, provides reference to UBC Standard 23-2 for a method of calculating the deflection of a blocked wood structural panel diaphragm. These site-built assemblies are often used by the building engineer to resist lateral forces induced by earthquake activity.

Section 23.223 of UBC Standard 23-2 allows calculation of the deflection of a blocked shearwall by summation of parts due to movement from several sources. One significant source of deflection can be associated with movement due to anchorage details typically employed at the end corners of the wall. Prefabricated metal holdowns or tension ties are field installed to resist overturning and uplift forces generated by seismic and wind action. Deformation of these devices, and perhaps more significantly, their connections to the shearwall wood end posts and foundation anchors contributes to the total horizontal drift of the top of the shearwall.

Sources of Deflection at the Shearwall Holdown Connections



The following are some of the sources of deflection that should be evaluated by the designer. See the illustration, which applies to other holdown configurations.

A. Improperly-sized stud/post bolt holes – increased bolt slip can occur if stud/post bolt holes are oversized and exceed the 1997 NDS® recommended bolt hole diameter.

B. Stud/Post bolt holes – bolt slip can occur.

C. Wood crushing at stud/post bolt hole perimeters – the use of larger washers/bearing plates can reduce stress-induced wood crushing at bolt bearing locations.

D. Eccentricity in stud/post caused by holdown – holdowns installed on only one side of a stud or post result in an eccentricity which causes increased stresses and movement in a shearwall system.

E. Nut spin – anchor bolt nuts that are not restrained can spin loose during cyclic loading, allowing movement; the use of steel nylon locking nuts or thread adhesive may prevent nut spin.

F. Loose nuts – increased movement can occur when nuts are not sufficiently tightened.

G. Holdown deflection – holdown deflection can occur when the shearwall system is subjected to cyclic stress from earthquakes or high wind.

H. Wood Shrinkage – due to drying, wood may shrink and cause bolted connections to become loose; periodic retightening may be required.

I. Localized crushing at wood-bearing surfaces – excessive crushing at wood-bearing surfaces may result from compressive forces due to overturning during high wind or earthquake loading.

TECH BULLETIN

Until now, manufacturers of these connecting devices did not make data readily available so a designer could determine the anticipated movement when connected to a wood post. Indeed, some published data seems to relate to the devices connected to steel jigs. While accurate as presented, this data might lead to unrealistically small movements being incorporated into designs since it does not seem to account for deformation of the fasteners in the wood wall post.

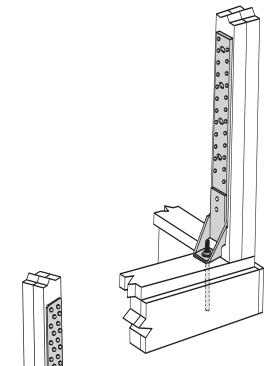
USP Structural Connectors® has researched this issue and in the accompanying tables present accurate deflection values for its primary holdowns and tension tie devices when tested connected to wood members as indicated. Some of the data is newly generated from cyclic load criteria applied in accordance with test procedure developed by the SEAOSC Committee for Testing Standards for Structural Systems and Components. The remainder of the data was secured in static load tests of the various devices connected to a variety of wood members. See the footnotes to the table for specific information and details. Test programs are ongoing and new data will be presented as available and appropriate. **Tables 1** and **2** show Allowable Tension Load and Deflection at allowable tension load values for USP's *MTS27B Tension Tie* and USP's full line of *HTT Tension Ties*. **Table 3** shows the same values for USP's full line of holdowns.

As has historically been the case, the building designer is reminded that complete design of the shearwall wood components is his or her responsibility. Adequate size and grade of wood end post member must be specified to resist applied forces. Recent shearwall/holdown cyclic testing indicates that for plywood sheathed walls, bending induced by holdown eccentricity is not significant. Post tension and compression along with sill plate bearing should be considered. *USP Structural Connectors®* has **not** accounted for these stresses in presentation of allowable load values in any of its tables.

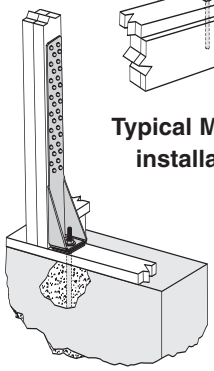
Table 1 - MTS27B Tension Tie

USP Stock No.	Ref. No.	Steel Gauge		Nail Spacing	Fastener Schedule			Allowable Loads (Lbs.) with Deflections △ (In.)[6,8]							
						Strap		Nails[4]				Bolts[5]			
		Strap	Plate		Anchor Bolts[2,3]	Nails[1]	Bolts[2]	100%	△	133%[7]	△	100%	△	133%[7]	△
MTS27B	MTT28B	10	3	2-1/16	(1) 3/4	(24) 16d	(4) 1/2	3775	0.087	4635	0.112	2880	0.071	3840	0.090

1) 16d nail is a common nail 3-1/2″ long and 0.162″ in diameter.
2) Bolts and anchor bolts shall meet or exceed the requirements of ASTM A 307.
3) The anchor bolt of the diameter shown shall be specified by the designer to resist the required tension load.
4) Wood thickness for nailed application shall be a minimum of 2″. Design of wood member is the responsibility of the building designer.
5) Bolt loads are for single shear conditions, parallel-to-grain loading, with wood thickness no less than 1-1/2″.
6) Allowable loads are based on the use of either nails or bolts; nail and bolt values cannot be combined.
7) Allowable loads have been increased 33-1/3% for wind or seismic load conditions; no further increase shall be permitted.
8) △ Deflection values derived from static load tests with device connected to 2-2x4 DF-L post with specified fasteners.



Typical MTS27B installation



Typical HTT22 installation

Table 2 - HTT Tension Ties

USP Stock No.	Ref. No.	Steel Gauge	Nail Spacing	Fastener Schedule		Allowable Loads (Lbs.) with Deflections △ (in.)[4]			
				Anchor Bolts[3]	Nails[2]	100%	△	133%[1]	△
HTT16	HTT16	10	1-3/4	(1) 5/8	(18) 10d	2395	0.076	3190	0.122
					(18) 16d	2770	0.078	3695	0.101
HTT22	HTT22	10	1-3/4	(1) 5/8	(32) 10d	4255	0.082	5370	0.125
					(32) 16d	4930	0.082	5370	0.090
HTT30	-- --	7	2-1/2	(1) 7/8	(36) 10d	5220	0.084	6960	0.114
					(36) 16d	6010	0.100	7220	0.121
HTT50	-- --	7	2-1/2	(1) 7/8	(56) 10d	8120	0.097	9810	0.125
					(56) 16d	9350	0.113	9810	0.125

1) Allowable loads have been increased 33-1/3% for wind or seismic load conditions; no further increase shall be permitted.
2) 10d nail is a common nail 3″ long and 0.148″ in diameter; a 16d nail is a common nail 3-1/2″ long and 0.162″ in diameter.
16d Sinker is 3-1/4″ long and 0.148″ in diameter.
16d Sinker nails may be substituted for 10d common nails for the same load value.
3) Anchor bolts shall meet or exceed the requirements of ASTM A 307.
Anchor bolts of the shown diameter shall be specified by the designer to resist the tension load required.
4) △ Deflection is derived from static load tests with the device connected to 2 - 2x( ) DF-L wood framing with specified fasteners.
5) Design of the wood member is the responsibility of the building designer.

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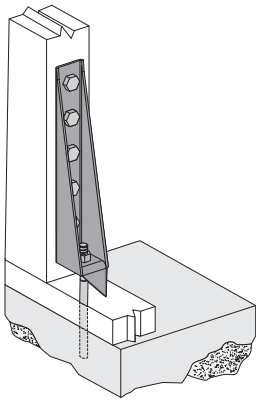
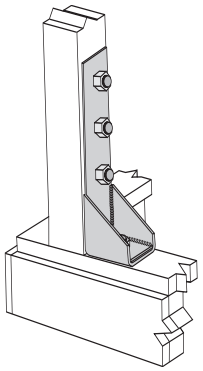
1997 UBC Wood Shearwall Deflections



Typical TD15 installation



Typical TDX8 installation

Table 3 - TDX and TD Holdowns

USP Stock No.	Ref. No.	Steel Gauge	Bolt Schedule[1] Anchor Bolts[2] To Sill Plate	Bolt Schedule[1] To Stud	Allowable Loads (Lbs.) with Deflections △ (in.) for wood thickness of . . .[3,8] 3″ 100%	3″ △	3″ 133%[4]	3″ △	3-1/2″ 100%	3-1/2″ △	3-1/2″ 133%[4]	3-1/2″ △	5-1/2″ 100%	5-1/2″ △	5-1/2″ 133%[4]	5-1/2″ △
TD2	HD2	7	(1) 5/8	(2) 5/8	2145	0.044	2860	0.069	2145	0.044	2860	0.069	2135	0.044	2850	0.069
									2145	**0.035**	2860	**0.080**				
TD5	HD5	7	(1) 3/4	(2) 3/4	2820	0.061	3755	0.086	3070	0.075	4090	0.101	3050	0.075	4070	0.101
									3070	**0.018**	4090	**0.050**				
TD6	HD6	3	(1) 1	(3) 3/4	4160	0.063	5545	0.083	4600	0.052	6135	0.061	4605	0.052	6140	0.061
TD7	HD7	3	(1) 1-1/8	(3) 7/8	4770	0.085	6360	0.098	5600	0.034	7465	0.044	6220	0.056	7600	0.065
TD9	HD9	3	(1) 1-1/8	(3) 1	5370	0.052	7165	0.069	6325	0.045	8435	0.060	8040	0.06	10485	0.078
									6325	**0.050**	8435	**0.095**				
TD12	HD12	3	(1) 1-1/8	(4) 1	6715	0.061	8955	0.079	8010	0.066	10680	0.095	10390	0.086	13260	0.113
									8010	**0.110**	10680	**0.180**				
TD15	HD15	3	(1) 1-1/4	(5) 1	7755	-- --	10340	-- --	9370	-- --	12495	-- --	12445	0.040	16590	0.075
TDX2	HD2A	12	(1) 5/8	(2) 5/8	2080	0.083	2775	0.104	2075	0.083	2770	0.104	2075	0.083	2765	0.104
TDX5	HD5A	10	(1) 3/4	(2) 3/4	2770	0.064	3695	0.083	3000	-- --	4000	-- --	2685	-- --	3580	-- --
TDX6	HD6A	7	(1) 7/8	(2) 7/8	3275	-- --	4365	-- --	3825	0.041	5100	0.051	4145	0.042	5525	0.051
TDX8	HD8A	7	(1) 7/8	(3) 7/8	4795	-- --	6390	-- --	5645	0.048	7530	0.064	6070	0.060	8095	0.077
TDX10	HD10A	7	(1) 7/8	(4) 7/8	6140	0.050	8185	0.071	7305	0.072	9740	0.094	7785	0.075	10380	0.095
TDX14	HD14A	3	(1) 1	(4) 1	6815	0.061	9090	0.079	8125	0.066	10835	0.095	10175	0.086	13570	0.113
TDX20	HD20A	3	(1) 1-1/4	(4) 1	7105	-- --	9475	-- --	8415	-- --	11220	-- --	10165	0.083	13555	0.107

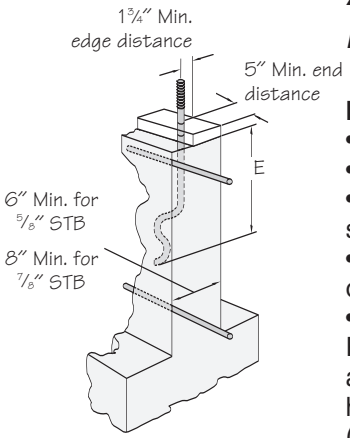
1) All bolts shall meet or exceed the requirements of ASTM A 307.
2) The anchor bolts shall be designed by a licensed professional engineer or architect, taking into account edge distance, corner end distance, concrete cover, embedment length, concrete compressive strength, and other conditions of construction.
3) Allowable loads are valid for loads parallel-to-grain with respect to the stud or post.
4) Allowable loads have been increased 33-1/3% for wind or seismic load conditions; no further increase shall be permitted.
5) The design of the wood member for the actual load conditions is the responsibility of the building designer.
6) Concrete shall be normal weight with a minimum of 2,000 psi compressive strength at 28 days.
7) The minimum edge distance for the anchor bolts shall be four bolt diameters without concrete reinforcing steel; concrete cover for the anchor bolt shall meet code requirements.
8) △ Deflections are derived from static load tests of the devices connected to DF-L wood members with specified fasteners.

Note: *Deflection values in* ***bold face type*** *are derived from cyclic load tests in accordance with SEAOSC standards with the device connected to a DF-L wood post with the specified fasteners.*

Accessory Hardware

Anchor Bolts – STB series

Materials: ASTM A 36 steel, also conforms to ASTM A 307 requirements for bolts
Codes: ICBO 5321, L.A. City RR 25325



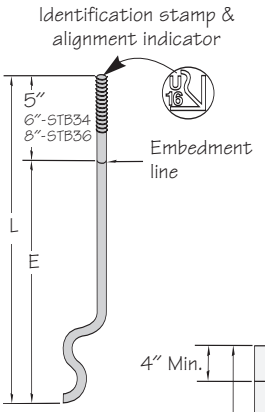
Typical STB mono pour installation

Installation:

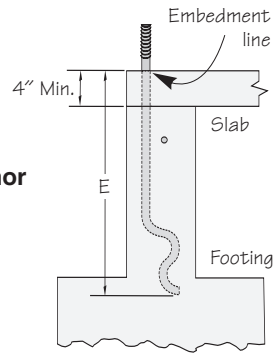
- Select appropriate *STB* Anchor Bolt.
- Use concrete with a minimum compression strength of 2,500 psi at 28 days.
- Minimum center-to-center spacing between bolts is 2(E) for anchors acting simultaneously in tension.
- Match embedment depth with embedment line on the STB shaft.
- **Monolithic or Double Pour Foundations** - Prior to pour, install *STB* in an upright position and at a 45° angle to the wall. Install one horizontal #4 rebar at a depth of 4″ minimum. (See illustrations.)
- **Concrete Block Applications** - Prior to pour, install *STB* in an upright position and at a 45° angle to the wall. (See illustrations.) Use the embossed angle guide on the end of the *STB* shaft as a guide. Install one horizontal #4 rebar at a depth of 4″ and one vertical #4 rebar maximum 48″ o.c. spacing. Fill all cells with concrete having a minimum 2,000 psi compressive strength.
- The STB does not need to be tied to the rebar.
- Nuts and washers are not included.

USP Stock No.	Ref. No.	2X, 3X, (2) 2X Sill Plates	
		Mono Pour	Double Pour
TDX2	HD2A	STB16	STB20
LTS20B	LTT20B		
HTT16	HTT16		
TDX5+	HD5A	STB20	STB24
MTS27B	MTT28B		
HTT22	HTT22	STB24	-- --
TDX6	HD6A	STB28	STB34
TDX8	HD8A		
TDX10	HD10A		
HTT30	-- --		
HTT50	-- --		

+ Recommend installation of washer under nut of anchor bolt.



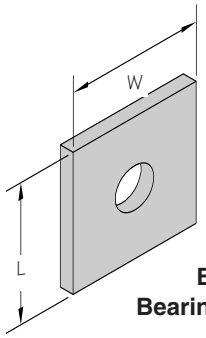
STB Anchor Bolt



Typical double pour installation

USP Stock No.	Ref. No.	Bolt Dia.	Length (L)	Min. Embed. (E)	Allowable Tension Load[1,2,3]			
					Concrete[5]		Concrete Block[8]	
					Minimum End Distance[6]		Minimum End Distance[6]	
					5″ from end	24″ from end	5″ from end	11″ or > from end
					Wind / Seismic	Wind / Seismic	Wind / Seismic	Wind / Seismic
STB16	SSTB16	5/8	17-13/16	12-13/16	5215	5215	1850	4315
STB20	SSTB20	5/8	21-13/16	16-13/16	5215	5215	1850	4315
STB24	SSTB24	5/8	25-13/16	20-13/16	5215	5215	1850	4315
STB28	SSTB28	7/8	31	26	9335	10425	-- --	-- --
STB34	SSTB34	7/8	36	30	9335	10425	-- --	-- --
STB36	SSTB36	7/8	38	30	9335	10425	-- --	-- --

1) Design loads are based on the average ultimate, from a series of five tests, with a safety factor of three.
2) Loads may not be increased for short term loading. Loads apply to wind and seismic loading per 1997 U.B.C.
3) Minimum center to center spacing between bolts is 2(E) for anchors acting in tension.
4) Minimum edge distance is 1-3/4″.
5) Concrete stemwall shall be a minimum of 6″ thick for 5/8″ anchor bolts and 8″ for 7/8″ anchor bolts.
6) End distance shall be no less than 5″.
7) Connection is limited by lowest of bolt or holdown capacity.
8) Concrete block shall be minimum 10″ block.



BP Bearing Plate

Bearing Plates – BP series

Materials: See chart
Options: BP models are available in Hot-dip galvanized. To order, add *HDG* to stock number, as in **BP12-HDG**.

USP Stock No.	Ref. No.	Plate Thickness	Dimensions		Bolt[1] Dia.
			W	L	
BP12	BP1/2	3/16	2	2	1/2
BP58	BP5/8	1/4	2-1/2	2-1/2	5/8
BP583	-- --	1/4	3	3	5/8
BP34	BP3/4	5/16	2-3/4	2-3/4	3/4
BP78	BP7/8	5/16	3	3	7/8
BP1	BP1	3/8	3-1/2	3-1/2	1

1) Bolt holes are sized 1/16″ larger than listed bolt diameter.

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