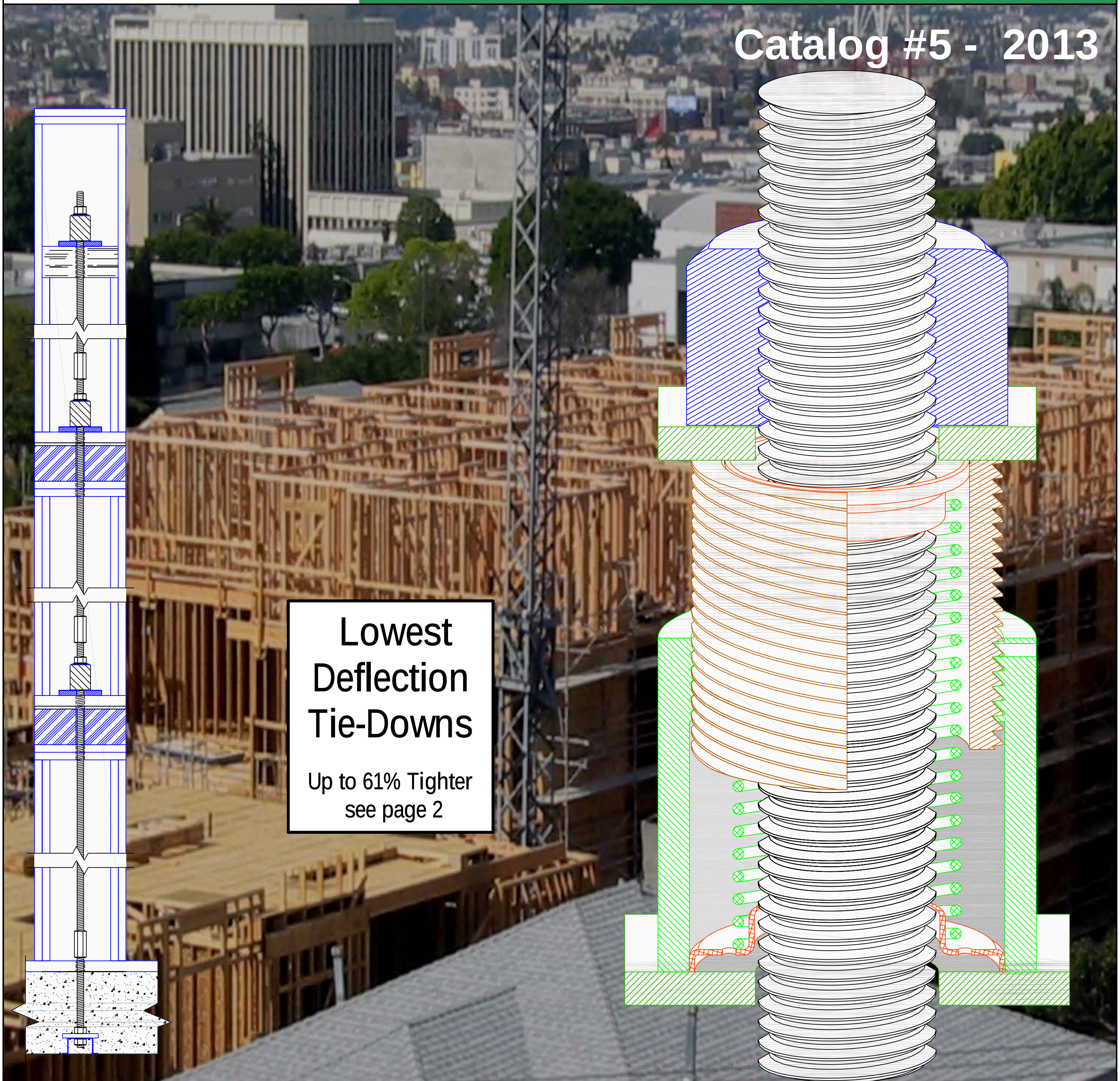
AutoTight®

Rod Tie-Downs

Catalog #5 - 2013



Lowest Deflection Tie-Downs

Up to 61% Tighter

see page 2

AutoTight Rod System and components are covered by US Patents 6390747, 6,585,469, 7,007,060. Other patents pending

www.comminsmfg.com

ICC ESR-1344 - Approved

Tie-Down Systems an Overview

Shear walls perform to the code only when the tie-downs have both the required strength and tightness. ICC ES recently determined that tie-downs systems must limit deflection to 0.200" at the design load and some engineers require deflection as low as 0.125" (⅛").

This catalog defines the new tie-down requirement and helps specify required components to meet those design requirements.

If you are new to self-adjusting tie-down systems begin with "Tie-Down Systems-Designing to the Code" (pg 20). This section covers the IBC, expected movement and wood shrinkage. Follow up with the section on Tie-Down Specifications starting on page 4. If you start with clear and precise specifications a turn key system can be designed by AutoTight in as little as 2 days.

Thank you for considering AutoTight.

Alfred Commins, President

Commins Manufacturing Inc.

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ICC ES 2013 Requirements

Effective April 1, 2013 per (ICC ES AC316) Tie-Down systems must meet a maximum elongation limit of 0.200". AutoTight designs systems to 0.200" or less every day. We make it look easy.

AutoTight is up to 61% Tighter!

When identical systems were compared, AutoTight was 61% tighter compared to a system using a leading ratchet. These systems used identical rod and identical bearing plates, the only difference is the Shrinkage Compensator. This comparison was made at a design elongation limit of 0.125". A similar comparison at the ICC ES 0.200" limit demonstrated the AutoTight system was 36% tighter. To view a side-by-side comparison of AutoTight versus a leading ratchet. Go to www.youtube.com/ Search for AutoTight

TIe-Down Design Per the IBC

As of April 1, 2013 Tie-Down Systems complying with the IBC must be designed for system strength and must limit system elongation to 0.200". Many designers believe even tighter design limit limits should be used and routinely require an elongation limit of 0.125". Tight elongation limits can be a design challenge. Using the AutoTight system with a screw type shrinkage compensator solves the problem.

We routinely design multistory systems using a proprietary algorithm. The following paragraph provides an overview of how to design a tie-down system that meets code strength and elongation limits using ICC AC 316, AC 391 and the IBC. The table below describes each component to be considered and shows how to determine both system strength and elongation.

Tie-Down Components: Strength and Elongation Summary

Component	Model #	Description	Length	Strength Limit	Elongation		Comment
Rod	Rod ID	Diameter/Material/Length		AISC 360	From Table	Adjusted	Follow AISC 360 13th ed!
Bearing Plate	Bearing or HD	Size: Width X Length X Thickness		AISC 360 and AF&PA 2005	0.040"	Per Actual Load	Double HD Elongation across a floor
Shrinkage Compensator	Model Number	Diameter, Expansion etc		Per ES Report	Per ES Report	Δ_A	Adjusted per Actual Load
				Per ES Report	Per ES Report	Δ_R	Full Value (No Adjustment)
Shrinkage	1/4" or ?	Calculate per code		Est. Cat. Pg 26		Estimated	Elongation is Cumulative
		Lowest of above		Strength Limit	Elongation	SUM	

As shown in the previous table, systems are designed floor by floor.

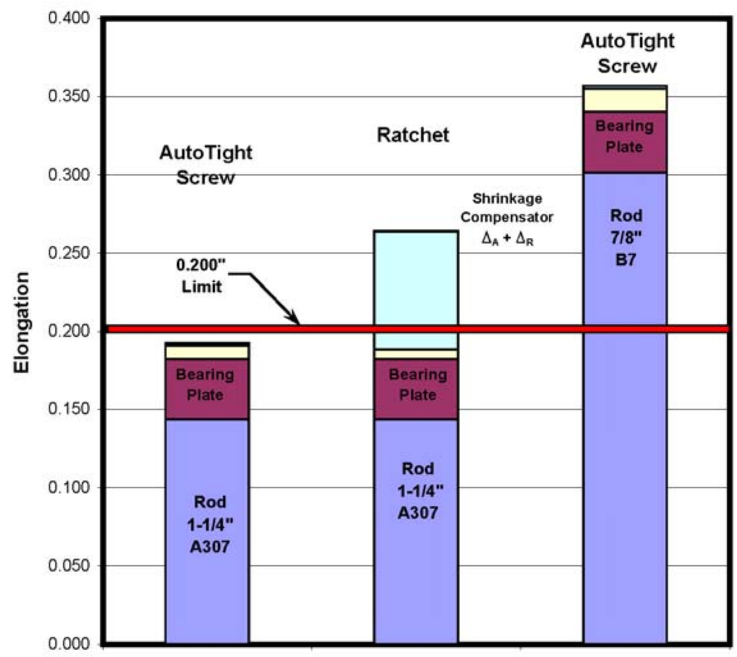
1. Design the system for strength and evaluate for system elongation (Sum the elongations).
2. Adjust elongation to specified limits by changing the rod size and/or the bearing plate. Commins Manufacturing Inc. designs systems for both strength and elongation using a custom algorithm. With this code change the AutoTight catalog now includes detailed design information on both strength and elongation.

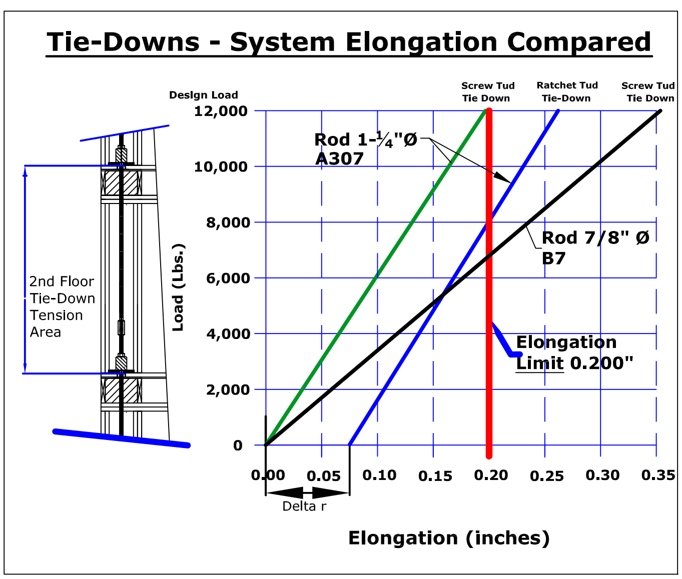
Identical Strength Systems Compared

For comparison three Identical strength systems are shown side-by-side. All systems are designed to the same strength (12,000 pounds), but because the components vary (rod, bearing plates or shrinkage compensators), system elongation ranges from 0.193" to 0.360".

The graph to the right shows the contribution to elongation that rod diameter makes and shows the contribution to elongation for a Screw Take-Up vs. a Ratchet.

AutoTight is tighter. We always uses a screw type shrinkage compensator. Code elongation limits are met by changing rod diameter, rod material or bearing plate size.





Changing the "Stacked Bar" to a load/deflection line a clear comparison emerges. All three systems have the same ultimate strength but the one with large diameter rod and a screw Tud meets system elongation limits, the others do not.

High strength rod with a screw Tud can only restrain 6,800 lbs. at the 0.200" design elongation limit (too much rod stretch.)

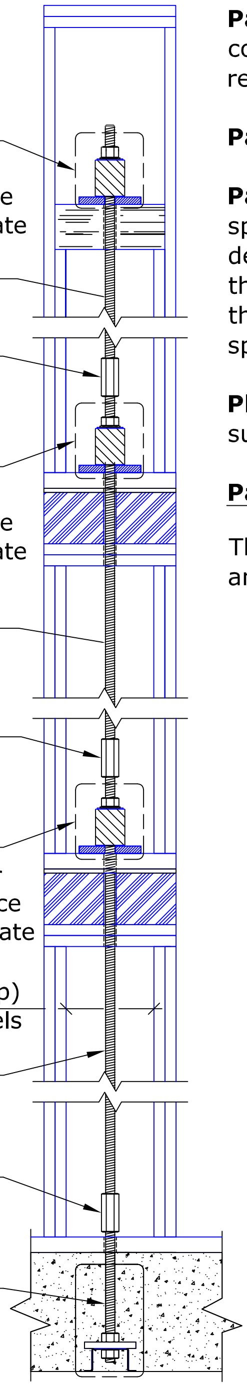
Large diameter (1-¼") rod coupled with a ratchet Tud can only restrain 8,000 lbs at the 0.200" elongation limit. (too much compensator looseness,)

Bottom Line: If you need a tightest system with the lowest elongation, AutoTight is the System of Choice.

A PDF that demonstrates the math required to meet a 0.200" limit or a 0.125" limit is available. Click here

Tie-Down Specifications

Typical System



Tie-Down systems perform to code capacity only when every component is properly selected.

Part 1 - Tie-Down System Specification provides a template to assist specifying components. The performance objective must meet the intent of the code and specific job requirements. Systems are designed for: strength, elongation, shrinkage and reliability.

Part 2 Is a **Commentary** on key specifications.

Part 3 demonstrates a manual method of designing a tie-down system to meet specifications. Designing for strength, elongation and shrinkage is complicated. Most designers use a computer program to maximize performance and minimize cost. I suggest that you review the method and steps even though you may rely on a manufacturer to do the design. Because these systems are complex you may find discrepancies between what is specified and what is supplied.

Plan check examiners should especially look at the engineering associated with the submittal to ensure it meets the stated code. Use a manual method to check calculations.

Part 1 - Tie-Down System Specification

The Tie-Down system shall be designed per the 2009 IBC for system strength and elongation and shall include applicable ICC-ES Acceptance Criteria as follows:

AC155 (June 2010, Hold Downs),
AC316 (June 2012 Shrinkage Compensators)
AC391 (June 2010 Tie-Down Systems)

1. The Tie-Down system shall have a current ICC-ES Evaluation Report and/or City of Los Angeles report.

2. Uplift forces and floor heights (carpet-to-carpet) are as shown in the Holdown Schedule. Forces shown are cumulative rod tensile load ASD (preferred) or LRFD in kips.

3. System Strength shall be limited by the lesser of: threaded rod tensile strength, bearing plate compressive strength or shrinkage compensator strength. Strength assessment shall be per AISC 360 equation J3-1 (Rod), AF&PA NDS (Bearing Plates) and/or applicable code Acceptance Criteria.

4. Elongation (between reaction points) shall be limited to 0.200". Short walls, (i.e. 10' or less) specified with an (*) shall be limited to an elongation not-to-exceed 0.125".

5. Elongation shall include all 5 tension elements including: rod elongation, bearing plate compression or hold down deflection, shrinkage and shrinkage compensator, delta A (ΔA) and delta R (ΔR). (See table page 2)

6. Only screw type shrinkage compensators shall be used.

7. The system shall accommodate an out-of-plumb condition not-to-exceed 2" per 10' floor.

8. Shrinkage compensators shall accommodate cumulative shrinkage of ¼" per floor (manufactured wood), or ½" per floor (solid sawn) (Select one).

9. Each reaction point shall be attached through a separate shrinkage compensator.

10. Straps may not be used with vertical connections. (See page 23.)

Note: Designing the lowest cost system that meets both **Strength** and **Elongation** can only be achieved if **uplift loads** (not rod size) are provided.

Tie-Down Specification (cont.)

Append a tie down schedule. Include Tension and compression loads, floor heights, floor levels, and cumulative shrinkage. We can show you a simple method of combining and sorting individual loads into a series of Tie-Down runs. Sorting runs will allow you to minimize and simplify the tie-down runs. Call AutoTight and ask for technical assistance.

Tie-Down Schedule

Net Tension (T) & Compression (C) Loads, Loads in Kips ASD

Run Type		4A		4B		4B*		4C		2A WBS		Floor Height		Shrinkage
		T	C	T	C	T	C	T	C	T	C			
Count		43		25		10		30		3		Ft	In	Cumulative
Level	4	2	5	3	6	3	6	4	6			11	6	1
	3	4	8	7	10	7	10	10	14	3	6	10	7	3/4
	2	9	15	16	20	16	20	21	25	12	15	10	7	1/2
	1	15	23	25	33	25	33	32	38			11	4	1/4
Embedments		15K		25K		25K		32K						

Suggestions

Run Type ID: List runs by # of floors then A, B, etc. WBS is a wood beam start. SBS is a steel beam start.

T/C Tension/Compression requirements in pounds or kips. **Identify Loads** as ASD or LRFD

Run Count (Optional): If a run count is supplied, contractors will receive a more accurate and competitive bid.

Elongation Limit: 0.200" **Code:** IBC 2009 **Wood:** DFL

Floor Height: (Carpet-to-carpet) Total distance between floors including floor and wall heights. Note: Grade compatible nuts, couplers and washers made to commercial standards exceed the strength of the attaching components. The supplier will specify, but not engineer, these components.

Part 2 - Tie-Down Specification Commentary.

The governing code, including the date, is the first item that should be referenced. Adding ICC-ES references helps narrow the specification scope in a rapidly evolving area. Including the latest AC (ICC ES **A**acceptance **C**riteria) and Date is suggested.

Item 1 specifies the tie-down shall have a current ICC ES report. It may be desirable to spell out acceptable Tie-Down manufacturers. My favorite:

> The Tie Down system shall be the AutoTight® Tie-Down System as manufactured by Commins Manufacturing Inc. under ICC ESR 1344, September 1, 2012 or later. (Systems and code are changing rapidly. Old listings don't necessarily meet the current code.) Other systems may be used provided they have a current ICC-ES report number and each and every item in the specification are satisfied.

Item 2 refers to the load table that completes system specifications. Except for run count (number of runs) every item in this table is needed for design. Floor heights are carpet-to-carpet and while found on architectural drawings it is best shown on a table.

Item 3 spells out specific components that must be investigated for strength. The threaded rod must comply with AISC 360 J3-1, 13th ed., bearing plates must comply with AISC 360 13th ed., for bending and the NDS 2005 for wood bearing. Shrinkage compensators must comply with ICC ES Acceptance Criteria 316 and have a current code listing.

Special Quality Note: Some suppliers are using rod strength derived from sources other than AISC 360. All suppliers source the same rod, only the rod strength derivation is different. Non-traditional calculations provide a calculated rod strength that is up to 11% higher than AISC 360 and may lead to rod overstress. IBC 2009 & ICC-ES require using AISC 360-13th ed.

Item 4 specifies the allowable system elongation, between reaction points, as 0.200". The system elongation limit is per AC 316 section 6.9. (Note: Some jurisdictions limit elongation to 0.179 (San Francisco, San Diego). Some engineers limit system elongation to 0.125". Both limits are superior but may increase system cost. But regardless of the source, the specific system elongation limit must be spelled out. To complicate this further, some jurisdictions add a "Rod Only" limit of 0.125" in addition to the system limit. The 0.125" rod-only limit doesn't make sense with a system limit of 0.200" now in place. Some jurisdictions are dropping this alternate limit. I expect that most will drop the rod only alternate 0.125" limit in the near future. Also note some jurisdictions specify a limit of 0.2". This is often interpreted as 0.249" and rounded to 0.2". If you want 0.200" state the limit clearly.)

Short wall complications:

The goal is to limit shear wall drift. Using the shear wall drift eq.:

$$\delta_{sw} = \frac{8vh3}{EAb} + \frac{vh}{1000G_a} + \frac{h\Delta_a}{b}$$

may allow short walls to drift excessively unless Δ**a** is tightly controlled. Tie-downs may contribute as much as 90% of the shear wall drift (per h/b in the last component of the drift equation). A short wall exacerbates shear wall drift. To compensate many designers use a tighter elongation specification on the short walls.

Bottom Line: keep shear walls as long as possible. When using short walls consider an elongation of 0.125" for tie-downs. A "short wall" note and (*) in the table will assist the designer in reducing the wall drift.

Item 5 specifies the tension elements (all 5) that must be considered. These are:

1. Threaded rod: Calculate: strength and elongation,
2. Bearing plate (or HD): Calculate: strength and deflection, Note the 0.040" limit.
3. Shrinkage: To help select the best model shrinkage compensator.
4 Shrinkage compensator: Determine Strength and Elongation at load:
   Add ΔA load adjusted + ΔR Device average travel and seating increment, added in full.

   System strength is limited by the weakest element in series.
   System Elongation sums elongation for: Rod + Bearing plate+ expected Shrinkage or Tud ΔA +ΔR
   The elongation of all items is adjusted to actual load, except for ΔR which is added in full.

Item 6 Specify only screw type shrinkage compensators. AutoTight has less than 10% of the deflection of ratchets.

Item 7 Identifies the out-of-plumb that the system will accept. It is best to keep the rods vertical with a minimum floor-to-floor offset. Sometimes it is necessary to move the rod over as the rod system climbs floor-to-floor. (Note: rod systems must be kept in the wall cavity, they can't "wander" outside the wall.)

Item 8 Specifies the amount of "per floor" shrinkage. This shrinkage is cumulative. We normally see specified shrinkage of manufactured wood joists at ¼" per floor and solid sawn at ½" per floor. Wet climates may add another 1/8" per floor. See section on wood shrinkage starting on page 23.

Item 9 specifies that every item be connected through a shrinkage compensator. Some systems leave the shrinkage compensator off the top floor and/or use a strap to connect the top floors. The photo shows a building assembly before and after ¼" shrinkage. Straps don't work with shrinking wood! I recommend that you avoid straps and use a shrinkage compensator on every floor.

Item 10 The Tie-down schedule is a huge plus for the tie-down system designer. Provide it if you can. If you also provide a "run count" the bids will be more accurate and more competitive.

Part 3 Designing Tie-Down Systems (A Manual Method)

The following demonstrates a step-by-step manual design process used on tie-downs for strength and elongation. Designing a tie-down is much faster if a computer program is used. However, to understand design variables or if a design check is needed, this system will help you calculate system strength and elongation.

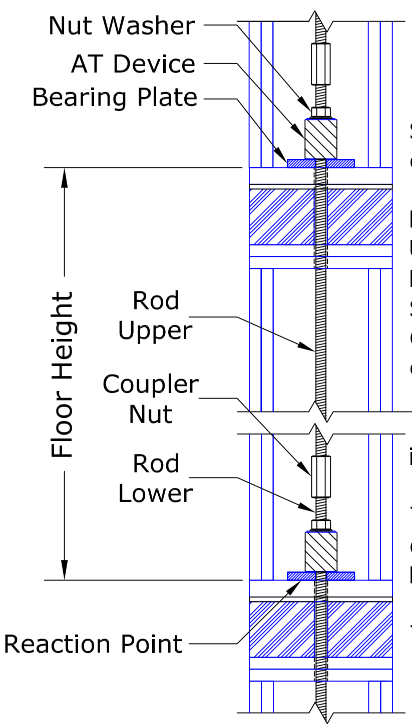
Designing a tie-down system manually requires selecting strength and elongation properties from component tables.

Run 4B

Level	Demand		
	Tie-Down Requirements		
4	Height (ft-in)	11	6
	Uplift Load (rod)	3	
	Dist Load (BP)		3
	Elongation	0.200"	
	Wall Width	6"	
	Shrinkage(fl/total)	1/4	1
	Tie-Down Requirements		
3	Height (ft-in)	10	7
	Uplift Load (rod)	6.9	
	Dist Load (BP)		4
	Elongation	0.200"	
	Wall Width	6"	
	Shrinkage(fl/total)	1/4	3/4
	Tie-Down Requirements		
2	Height (ft-in)	10	7
	Uplift Load (rod)	16	
	Dist Load (BP)		6
	Elongation	0.200"	
	Wall Width	6"	
	Shrinkage(fl/total)	1/4	1/2
	Tie-Down Requirements		
1	Height (ft-in)	11	4
	Uplift Load (rod k)	25	
	Dist Load (BP)		9
	Elongation	0.200"	
	Wall Width	6"	
	Shrinkage(fl/total)	1/4	1/4

Step 1 Define Requirements

List demand floor-by-floor (See example, right)
Floor Heights are "Carpet-To-Carpet".
Uplift load is the cumulative rod load (kips) floor-by-floor.
Distributed Load is the (bearing plate) reaction load at each floor in kips.
Elongation is usually the global limit at 0.200" or 0.179". Adjust for short walls.
Wall width is included to assist with bearing plate fit.
Shrinkage is shown per floor and totaled (cumulative).



System components are usually evaluated in the following order:

Lower Rod-	Strength and Elongation
Upper Rod-	Strength and Elongation
Bearing Plate-	Strength and Deflection
Shrinkage Compensator-components	Strength + two Deflection

Delta A (ΔA) Elongation (load adjusted).
Delta R (ΔR) Device average travel and seating increment, added in full.

The analysis that follows looks at a single floor and demonstrates a step-by-step analysis for strength. Elongation is also evaluated and compared with code limits.

The analysis is for the first floor of run 4B.

Select rod, bearing plates and shrinkage compensator using catalog tables.
Design for strength. Evaluate for total deflection.
Adjust components to minimize elongation. The template shown is run 4B, first floor.
Tie-Down Requirements provided by the EOR are shown on the left as demand.
The Tie-Down System is shown on the right. Place holders (blank cells) define required input and calculations.

	Demand			Supply								
	Tie-Down Requirements			Component	Model #	Size-Description		Strength Capacity: Rated	D/C Ratio	Elongation Contributions: @ Capacity		Final
1	Height (ft-in)	11	4									
	Uplift Load (rod k)	25		Shrinkage								
	Dist Load (BP)		9	Compensator								
	Elongation	0.200"		Bearing Plate								
	Wall Width	6"		Rod Upper								
	Shrinkage(fl/total)	1/4	1/4	Rod Lower								
					D/C Limit (Highest of the above 4 items)					Elongation ∑		
	Embedment			Rod	R9	1-1/8" NC B7	6"					

Embedments must match rod strength and size.

Tie Down System Design Run 4B

Threaded Rod

Rod is often the governing factor in system elongation. We typically select the least expensive rod. This is often the smallest diameter high strength rod available. The lowest floor is evaluated first. On the first floor the **lower** rod is usually the concrete embedment rod. This rod usually projects 6" from the slab. The specified rod is R9B7, a 1-⅛" NC B7 Rod. AutoTight (AISC) rates this for 46.6 kips. The elongation of 120" (10 feet) of rod is 0.253" at the design load (46.6 kips.). The 0.253" elongation is adjusted per the actual load and length. Final elongation is (25/46.6)*(6/120)*0.253" = 0.007"

The **upper** rod elongaton length =floor height - rod lower =(11'-4")(-6") = 134". Elongation =(25/28.19)(132/120)*0.253" = 0.243". The two rods attaching the first floor will contribute an elongation of 0.250". This exceeds the elongation limit and will be adjusted later.

Bearing Plate

The bearing plate is selected next. The threaded rod carries the entire uplift load for all floors, but the bearing plate distributes the local reaction load, in this case 9 kips. An S10 bearing plate is rated at 10.006 k on Douglas fir (625 psi.) Deflection is a straight line function with full load at 0.040" deflection. The deflection contributed by the bearing plate is (9/10.006) * 0.040" = 0.036".

Shrinkage Compensator

The shrinkage compensator is the last item to select. We select an AT100 to fit over the ⅞" rod. The AT deflects 0.032" at the rated load of 25.3K. The AT deflection contribution (Δa) is (9/25.3) * 0.032" = 0.011". The Delta R(ΔR) in the table is added to the deflection without modification.

	Tie-Down Requirements			Component		Model	Size-Description		Strength Capacity		Elongation Contributions		
	Height (ft-in)	11	4			#			Rated	D/C Ratio	@ Capacity		Final
1	Uplift Load (rod k)	25		Shrinkage Compensator		AT100	1" Dia X 1.1" Exp		25.3	0.36	TUD Δ_A	0.032	0.011
	Dist Load (BP)		9								TUD Δ_R	0.002	0.002
	Elongation	0.200"		Bearing Plate		S10	1/2" X 3-1/4 X 5	DFL	10.006	0.90	10.006	0.040	0.036
	Wall Width	6"		Rod	Upper	R7B7	7/8"-9 NC B7 X	144	28.19	0.89	120	0.253	0.243
	Shrinkage(fl/total)	1/4	1/4		Lower	R9B7	1-1/8"-7 NC B7 X	6	46.6	0.54	120	0.253	0.007
						D/C Limit (Highest of the above 4 items)				0.90	Elongation ∑		0.299

Exceeds Elongation Limit

Adjust Components

The total system deflection is **0.299** with selected components. If we switch the rod from an R7B7 to an R10A307 and use size compatible components (bearing plate and TUD) system elongation drops to 0.172. This elongation complies with both the ICC ES 0.200" deflection limit as well as the San Diego 0.179 elongation limit.

	Tie-Down Requirements			Component		Model	Size-Description		Strength Capacity		Elongation Contributions		
	Height (ft-in)	11	4			#			Rated	D/C Ratio	@ Capacity		Final
1	Uplift Load (rod k)	25		Shrinkage Compensator		AT100	1" Dia X 1.1" Exp		25.3	0.36	TUD Δ_A	0.032	0.011
	Dist Load (BP)		9								TUD Δ_R	0.002	0.002
	Elongation	0.200"		Bearing Plate		S10	1/2" X 3-1/4 X 5	DFL	10.006	0.90	10.006	0.040	0.036
	Wall Width	6"		Rod	Upper	R10A307	1-1/8"-7 NC A307 X	144	27.61	0.91	120	0.118	0.116
	Shrinkage(fl/total)	1/4	1/4		Lower	R9B7	1-1/8"-7 NC B7 X	6	46.6	0.54	120	0.253	0.007
						D/C Limit (Highest of the above 4 items)				0.91	Elongation ∑		0.172

OK **Elongation OK**

The first floor of run 4B is now complete. Required system strength is met and elongation is under 0.200"
The AutoTight web site will soon have a complete analysis of this run listed under Technical Notes.

Notes:

AutoTight^® Rod

AutoTight uses a continuous threaded rod. Typical lengths are 2', 3', 6', 10', and 12'. Field cut if needed. Rod may be ordered custom cut with sufficient lead time.

Material Identification: R (Rod) + Dia. (1/8's of an inch) + Alloy
Examples: R5-A307 = 5/8"-11 NC threaded rod, ASTM A307 Steel (Standard Strength)
R9-B7 =1-1/8"-7 NC threaded rod. ASTM A193-B7 Steel (High Strength)

Finish: **Standard** Black or zinc plated. **Optional** Hot Dip Galvanized (HDG)
Note: HDG rod must be chased to fit standard nuts & couplers. Or use special nuts and couplers.

Diameter and Thread: Rod is available from 1/2" (R4) to 2" (R16) diameter. Thread is Unified National Coarse (NC or UNC). Other sizes, material and lengths are available.

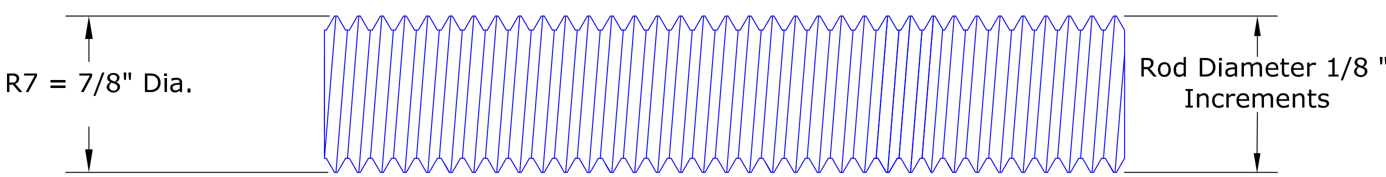
Strength: Rod Strength is per AISC 360 and ICC AC 391-3.2.1.1. Rod strength and elongation are identical for all suppliers (per AISC 360). **Some suppliers overstate strength and understate elongation. Please check!**

Elongation: Elongation for each (10') rod is shown at the maximum allowable tension load per ICC AC 391-3.2.1.1, Eq. 1. Adjust elongation based: on design load and distance between reaction points.

Code Acceptance: Tensile Values per IBC 2012, IBC 2009, IBC 2006 And AISC 360 13th edition.

Rod Basics

Rod is specified by grade, diameter and length.
Rod diameter is specified by the diameter in ⅛" increments. A ⅞" diameter rod is specified as R7.



Calculating Elongation

Both rod strength **and** elongation are critical to shear wall performance. Lower rod elongation results in lower shear wall drift and better performance. Rod is a major contributor to total system elongation. The fastest manual method of determining rod strength and elongation is to use a rod table and adjust to actual conditions.

When using a rod table: 1. select the rod for strength; 2. calculate rod elongation at the required load and rod length. 3. compare the elongation to requirements. 4. increase rod diameter to reduce elongation.

Example: Required Strength 11 kips. Floor Height (carpet-to-carpet) 11' - 4" (136").

Solution: #1 A307 Rod. Select an R7-A307 Rod from the AutoTight Rod table. This is a ⅞"Ø A307 rod with a Strength Capacity = 13,530 pounds, Elongation = 0.121" (for a 10' (120") length).
Calculated adjusted elongation: = 11,000/13,530 * 136"/120" * 0.121" = **0.1115"**

Solution: #2 B7 Rod. Select an R5-B7 Rod from the AutoTight Rod table. This rod is 5/8"Ø- B7 rod with a Strength Capacity = 14,380 pounds, Elongation = 0.263" for a 10' (120") length.
Calculate adjusted elongation = 11,000/14,380 * 136"/120" * 0.263" = **0.2280"**

AutoTight Rod (ASD Allowable Load per AISC 360)

Standard Strength

Diameter & Thread	A307 Model	A307 Allowable Tension (lb)	A307 Elong in per 10'	F1554 Grade 55 Model	F1554 Grade 55 Allowable Tension (lb)	F1554 Grade 55 Elong in per 10'
1/2"-13 UNC	R4-A307	4,418	0.129	R4-G55	5,522	0.161
5/8"-11 UNC	R5-A307	6,903	0.126	R5-G55	8,629	0.158
3/4"-10 UNC	R6-A307	9,940	0.123	R6-G55	12,425	0.154
7/8"-9 UNC	R7-A307	13,530	0.121	R7-G55	16,912	0.152
1"-8 UNC	R8-A307	17,672	0.121	R8-G55	22,089	0.151
1-1/8"-7 UNC	R9-A307	22,365	0.121	R9-G55	27,957	0.152
1-1/4"-7 UNC	R10-A307	27,612	0.118	R10-G55	34,515	0.147
1-3/8"-6 UNC	R11-A307	33,410	0.120	R11-G55	41,763	0.150
1-1/2"-6 UNC	R12-A307	39,761	0.117	R12-G55	49,701	0.146
1-3/4"-5 UNC	R14-A307	54,119	0.118	R14-G55	67,649	0.147
2"-4.5 UNC	R16-A307	70,686	0.117	R16-G55	88,357	0.146

High Strength

Diameter & Thread	C1045 Model	C1045 Allowable Tension (lb)	C1045 Elong in per 10'	A193-B7, F1554 Gr 105 Model	A193-B7, F1554 Gr 105 Allowable Tension (lb)	A193-B7, F1554 Gr 105 Elong in per 10'
1/2"-13 UNC	R4-C1045	8,836	0.258	R4-B7	9,204	0.268
5/8"-11 UNC	R5-C1045	13,806	0.253	R5-B7	14,381	0.263
3/4"-10 UNC	R6-C1045	19,880	0.246	R6-B7	20,709	0.256
7/8"-9 UNC	R7-C1045	27,059	0.242	R7-B7	28,187	0.253
1"-8 UNC	R8-C1045	35,343	0.241	R8-B7	36,816	0.251
1-1/8"-7 UNC	R9-C1045	44,731	0.242	R9-B7	46,595	0.253
1-1/4"-7 UNC	R10-C1045	55,223	0.236	R10-B7	57,524	0.246
1-3/8"-6 UNC	R11-C1045	66,820	0.239	R11-B7	69,604	0.249
1-1/2"-6 UNC	R12-C1045	79,522	0.234	R12-B7	82,835	0.244
1-3/4"-5 UNC	R14-C1045	108,238	0.236	R14-B7	112,748	0.246
2"-4.5 UNC	R16-C1045	141,372	0.234	R16-B7	147,262	0.244

Super Strength

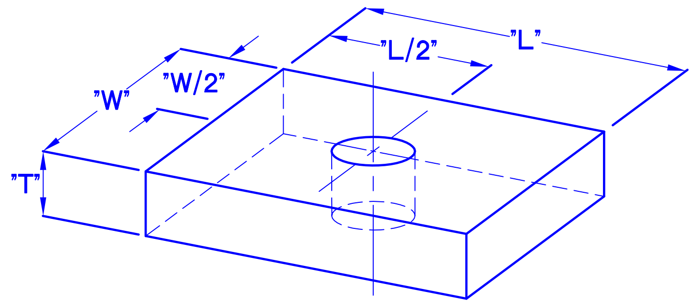
Diameter & Thread	A354 BD Model	A354 BD Allowable Tension (lb)	A354 BD Elong in per 10'
1-1/8"-7 UNC	R9-A654BD	55,910	0.303
1-1/4"-7 UNC	R10-A654BD	69,030	0.295

High strength rod is typically identified with a high strength mark. The actual identification varies by specific supplier. Consult factory for more information.

Notes:

1. Material Properties: (Other grades available, consult factory)
   ASTM A307 Fu = 60, Fy = 43 ksi. ASTM F1554 Gr. 55, Fu=75, Fy =55 ksi. ASTM A108-C1045 Fu = 120, Fy = 92
   ASTM A193-B7, Fu=125, Fy=105 ksi. ASTM F1554 Gr. 105, Fu=125, Fy =105 ksi. ASTM A354-BD Fu = 150, Fy = 130 ksi.
2. Strength P = 0.75 x Fu x nominal area / 2 Per AISC 360 13th ed Table 7.2, pg. 7-2, P16.1-108 Eqn J3-1
3. Stress increase not allowed with AISC 13th Ed capacities. (IBC 2006 & later)
4. Rod stretch calculated per AC391 3.2.1.1 as follows:
   $\Delta Rod = PL/AnE$ where: P=Load, L=length, $An=0.7854 (D-0.9743/n)^2$,
   D = nominal rod dia, n = threads per inch, E = elastic modulus = 29,000,000.
   Table elongation is 10' rod at allowable load. Depending on jurisdiction stretch limit may be 1/8", 0.179", 0.200", or not specified.
   Elongation of other length rods may be calculated from this table by length ratio.
5. Large Ø rod (1-3/8" to 2" Ø) used for stretch reduction. Consult factory for advice before using.
6. Tabulated allowable loads are ASD for IBC 2006, 2009 & 2012, CBC 2007 & 2010, OSSC 2007 & 2010, LABC 2008 & 2011.
7. LRFD Strengths are 1.5 x ASD Allowable Loads.

Bearing Plates



Bearing plates distribute compression loads into the structure at reaction points. AutoTight plates exceed the flexural requirements of AISC 360 and the wood-bearing requirements of the 2005 NDS. (ICC ES AC391 Sect 1.4.6, July 1, 2010)

Per 2005 NDS, plates deflect 0.040 inch at the compressive design value with a linear load deformation. (ICC ES AC 391 section 3.2.1.2).

Determining Compression Deflection

AutoTight bearing plates provide a maximum deformation of 0.040" at rated the capacity.

To select:

1. Determine the reaction load.
2. Select the smallest plate that can carry the reaction load.
   Check for: Bearing Capacity, Width (wall fit 4X or 6X Wall) and rod fit.
3. The wood deformation at the actual load is linear.
   With the load-deformation at the design load = 0.040" * design load / rated load.

Example:

Reaction is 11,000 pounds on Douglas Fir. Rod is 1-⅛" Ø.
Select an S11-1-¼" bearing plate with a rated capacity of 11,948 pounds.

Actual deformation (per AC 391, section 3.2.1.2) is 0.040 * 11,000 / 11,948 = 0.037"
For system deformation add the 0.037 to the rod and shrinkage compensator deformation.

Minimizing Total Deformation

To lower deformation increase the size of the bearing plate.

Example:

Reaction load is 11,000 pounds on Douglas Fir.
If an L20-1-¼" plate is selected, the plate deformation will be as follows:

Actual deformation will be 0.040 * 11,000 / 21,016 = 0.021"

Changing the bearing plate is one method to adjust the total deflection (elongation) to achieve a tight system.

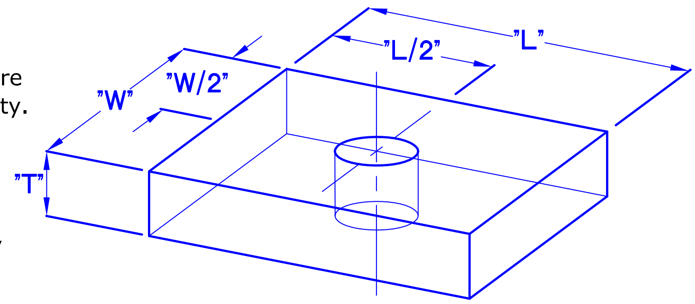
This example shows how to manually adjust components to achieve a desired deflection.
The AutoTight Software allows for a fast, easy change of rod, bearing plates or shrinkage compensators to achieve the the required system deflection.

Bearing Plates

Bearing Plates load the structure at reaction points. Bearing loads are limited by wood crushing at the NDS allowable wood bearing capacity.

Material: Complies with ASTM A36

Identification: Plates or boxes marked with Part #.
Efficiency tip: Minimize the number of sizes used on any single job, i.e. Keep it Simple.



Wall Thickness	Typical Use	Model No.	Best Sizes	T x W x L	Max Rod Ø	DFL @ 625	SYP @ 565	HF @ 425	SPF @ 405
		Bearing Plates				Allowable Load (Cross Grain Crushing)			
Fit 4x & 6X walls	AT 75 and AT 6A	S5 -5/8"		1/4" x 3" x 3"	5/8	5,964	5,391	4,055	3,864
		S5 -3/4"	***	1/4" x 3" x 3"	3/4	5,964	5,391	4,055	3,864
		For 1/2" through 1" Rod							
		S7 -1"	***	3/8" x 3-1/2" x 3-1/2"	1"	7,863	7,108	5,347	5,095
		S10 -1"	***	1/2" x 3-1/4" x 5"		10,322	9,331	7,019	6,689
		S11 -1"	***	1/2" x 3-1/2" x 5-1/2"		11,948	10,801	8,125	7,742
		S14 -1"		3/4" x 3-1/4" x 7"		13,665	12,353	9,292	8,855
		S16 -1"		1" x 3-1/4" x 8"		15,696	14,189	10,673	10,171
	AT 100 & 125	For 3/4"- 1-1/4" Rod							
		S7 -1-1/4"	***	3/8" x 3-1/2" x 3-1/2"	1-1/4"	7,540	6,816	5,127	4,886
		S10 -1-1/4"	***	1/2" x 3-1/4" x 5"		10,009	9,048	6,806	6,486
		S11 -1-1/4"	***	1/2" x 3-1/2" x 5-1/2"		11,948	10,801	8,125	7,742
		S14 -1-1/4"		3/4" x 3-1/4" x 7"		13,373	12,089	9,094	8,666
		S16 -1-1/4"		1" x 3-1/4" x 8"		15,404	13,926	10,475	9,982
Fit 6x and larger wallswalls	AT125 & AT 100	L18 -1-1/4"	***	1/2" x 5.5" x 5.5"	1-1/4"	19,292	17,440	13,119	12,501
		L20 -1-1/4"	***	5/8" x 5-1/2" x 6"		21,016	18,998	14,291	13,618
		L25 -1-1/4"		3/4" x 5-1/2" x 7-1/2"		24,936	22,542	16,956	16,158
		L30 -1-1/4"		1" x 5-1/2" x 9"		30,092	27,203	20,462	19,500
		L33 -1-1/4"		1-1/8" x 5-1/2" x 10"		33,529	30,311	22,800	21,727
		L37 -1-1/4"		1-1/4" x 5-1/2" x11"		36,967	33,418	25,137	23,955
		For 1-3/8", 1-1/2", 1-3/4" and 2" Rod							
	AT 200 Only	L18 -2"	***	1/2" x 5.5" x 5.5"	2"	17,965	16,240	12,216	11,641
		L20 -2"	***	5/8" x 5-1/2" x 6"		19,695	17,805	13,393	12,763
		L25 -2"		3/4" x 5-1/2" x 7-1/2"		23,693	21,419	16,111	15,353
		L30 -2"		1" x 5-1/2" x 9"		28,849	26,080	19,618	18,694
		L33 -2"		1-1/8" x 5-1/2" x 10"		32,287	29,187	21,955	20,922
		L37 -2"		1-1/4" x 5-1/2" x11"		35,724	32,295	24,293	23,149

Notes: Plate ID includes maximum rod diameter. Holes are 1/16" oversize.
Bearing Plate bending based on ASTM A36 Steel, Fy = 36 ksi. per AISC 13th ed.
Bearing Capacity per NDS 2005: DFL = 625, SP = 565, HF = 405, SPF = 425 psi.
Bearing area factor, Cb, included in listed capacities.
Allowable bearing capacity is not limited by plate bending. Deflection is 0.040" at Allowable Load.
Allowable Capacity = (Fc perp) * Bearing Area * Bearing Factor (per AC 391 3.2.1.2 May 2012)
S5, S7, S10 and L18 plates may be used on the first floor mudsill for end of wall connection.
Finish: S5, S7, L11 and L18 plates are HDG. All other are black iron except as noted.

Shrinkage compensators require evaluations for: fit, strength, expansion and deflection. Two code defined deflections **(ΔA)** and **(ΔR)** are required.

Load-deflection (ΔA) design load/actual load * Rated ΔA.
Delta R (ΔR) is always added in full to system deflection. Delta R is the product internal slack.

Example:

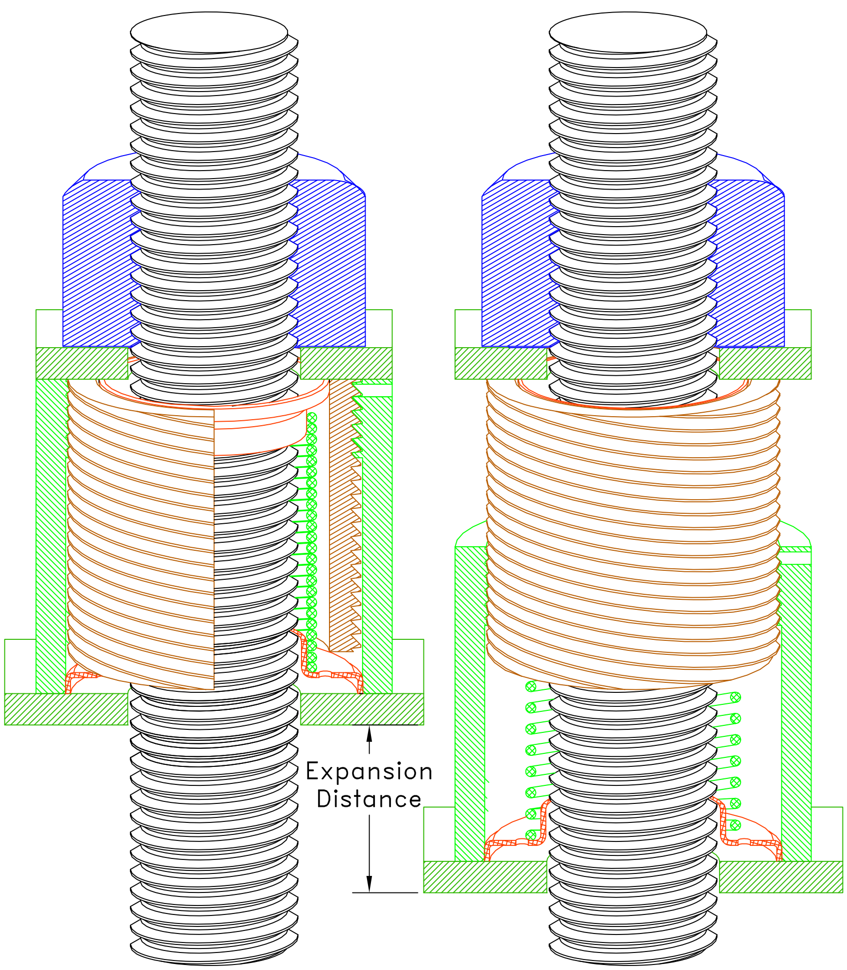
Reaction Load = 11,000 pounds

Shrinkage Compensator AT 100 (Select based on the rod size)
Rated Capacity: 25,300 pounds.
Deflection Maximum: ΔA = 0.032", ΔR = 0.002"
Expansion 1.2" (ICC ESR 1344)

Calculate Deflection: Load Deflection = 0.032 * 11,000/25,300 = 0.014"
Delta R (ΔR) (From Table) = 0.002"
Total Deformation = 0.016"
Add sum to the system elongation per AC 316 and AC 391 section 3.1.1.

Want to know more? Watch a 2 minute video that explains ΔR on our website.

US Patents 6,390,747 6,585,469. Other patents foreign and domestic, pending



AutoTight:

Rod Sizes to 2" Dia!
Larger rod = Lower Deflection

Inside Spring
= Protected Mechanism

Special thread
= 60% Lower Deflecton

Tightest Systems
= Shear Wall Performance

The AutoTight shrinkage compensator automatically expands as the building shrinks and settles. This expansion helps keep shear walls tight and performing to the code.

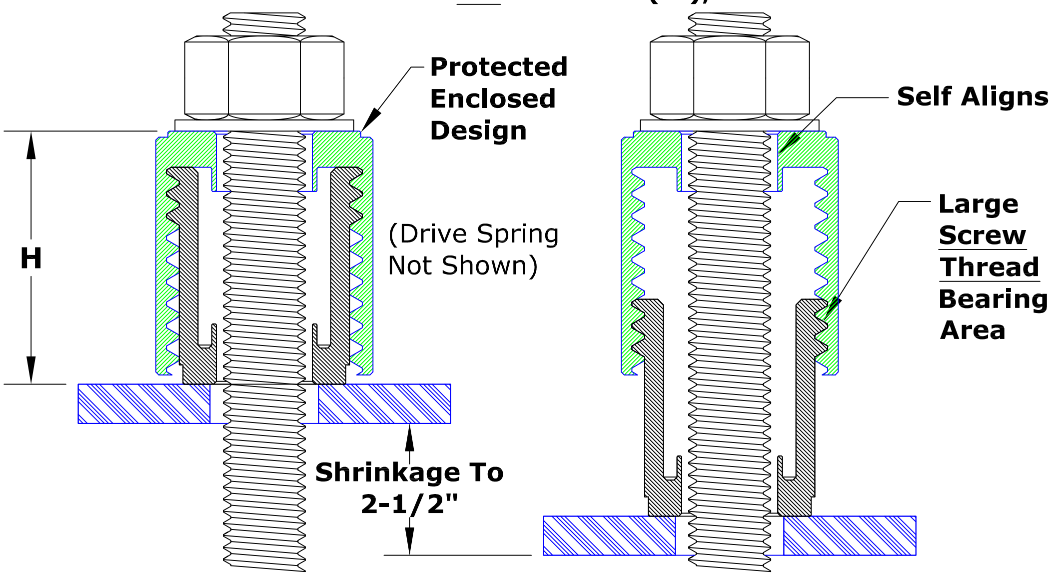
Code Listed: ICC ESR-1344, COLA RR-25480, Tested to AC 316 & AC 391, IBC 2012 Rated

Material: Aluminum - 6061 Alloy, **Finish:** Light Oil
Steel - 12L14, **Finish:** Zinc chromate, moly disulfide lubricant.

Installation: Place a steel bearing plate over the rod and onto the wood
Place the AT over the rod and onto the bearing plate,
Place Washer over the rod and onto the AT, Install and tighten Nut,
Remove the activation screw.
Listen for release

US Patents 6,390,747 6,585,469. Other patents foreign and domestic, pending

Threaded Mechanism = NO Backlash (Δr), No Looseness!



High Capacity, NO Backlash,
"Floating" Take-Up Device = Jam resistant
Tested at 3°out-of-plumb. (3° = 6-1/4" in 10 feet.)
Stackable: Doubles Expansion to 5"
Tested to 3 times rated load.
Fully functional at 2-$\frac{1}{2}$ times rated load

No Backlash with AutoTight
=
Much Better Shear Wall Performance

Some shrinkage compensators use ratchets. These ratchets can introduce looseness (backlash) up to $\frac{3}{16}$".

This looseness can reduce the shear wall capacity by 40%.

See Videos at
www.comminsmfg.com

	Model Number	Rod Diameter	Matl.	Dimensions (Inches)		Rated Take-Up (Inches)	Allowable Load Pounds	Average Ultimate Pounds	Seating Increment Δ_R*	Deflection at Allowable Load Δ_A"
				Dia.	H					
New	AT4A-1.5	1/2"	Aluminum	1-1/2"	3"	1-1/2"	6,450	24,857	0.000"	0.011
New	AT4A-2.5				4-1/16"	2-1/2"				
New	AT6A-1.5	3/4"		2-1/8"	3-3/16"	1-1/2"	10,550	40,737		0.011
New	AT6A-2.5				4-3/16"	2-1/2"				
	AT 75	3/4"	Steel	2"	3"	1.10"	16,450	50,533	0.002"	0.024
	AT 75-2.5			2"	4"	2-1/2"	15,183	54,728		0.020
	AT 100	1"		2-1/4"	3-1/8"	1.10"	25,300	78,067		0.032
	AT 125	1-1/4"		2-3/4"	3-1/8"	1.12"	34,500	104,683		0.016
New	AT 200-2.0	2"		4"	3-3/4"	2.25"	50,000	150,000		0.024

Note: Δ_R= Average Travel and Seating Increment is the "Lost Motion" with device direction change from advancing to load resistance. This is sometimes called "Backlash".
***The AutoTight Aluminum Shrinkage Compensator has 0.0002" backlash (Δ_r).**

Coupler Nuts

Coupler nuts connect threaded rod to form a continuous rod system.

Straight couplers have the same thread on both ends.
Coupler Nut Reducers have different diameter threads on each end.

Thread pitch is Unified National Coarse (NC or UNC).
Coupler nuts are available to fit rod from 1/2"-13 through 2"-4.5 NC.

Standard Couplers	
Model Number	Rod Ø Both Ends
CN-4	1/2"
CN-5	5/8"
CN-6	3/4"
CN-7	7/8"
CN-8	1"
CN-9	1-1/8"
CN-10	1-1/4"

High Strength Couplers	
Model Number	Rod Ø Both Ends
CNHS-5	5/8"
CNHS-6	3/4"
CNHS-7	7/8"
CNHS-8	1"
CNHS-9	1-1/8"
CNHS-10	1-1/4"
* CNHS-11	1-3/8"
* CNHS-12	1-1/2"
* CNHS-14	1-3/4"
* CNHS-16	2"

Identification:

Straight Coupler: Example CN-9
CN = Coupler Nut,
9 = rod Size in 9/8 inch = 1-1/8" dia.

Grade: Standard Coupler Nuts are ASTM A563 Grade A Grade 2
High Strength Couplers are ASTM A563 Grade C
Over 1-3/8" are Grade 5

Sighted couplers have one or more holes drilled to aid installation.

Installation:

Thread coupler onto rod until the rod can be seen in the sight hole. Thread the next rod until it can also be seen through the sight hole. A nail inserted into the sight hole can be used for a temporary stop.

Note: Full strength is achieved with thread engagement equal to a standard nut. This is typically one rod diameter

Options:

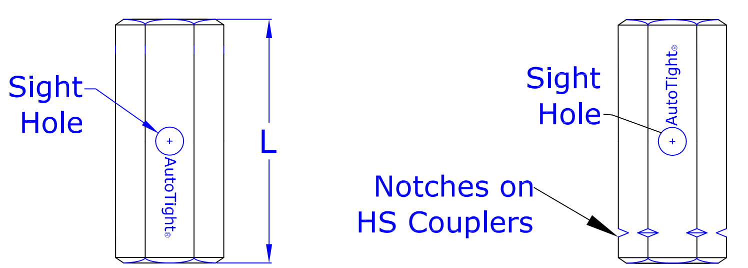
Oversize threads in coupler nuts for use with galvanized rod are available. To specify add a suffix after the product. Example CN-6 FHDG. This provides an oversize end to fit HDG rod. Contact factory for details.

Code Acceptance:

Nuts and coupler nuts shall be grade compatible and conform to ASTM A563 and IFI-128. One or two sight holes are provided to assist installation. Standard strength couplers shall be used with ASTM A307 and equivalent rod; High strength couplers shall be used with ASTM C1045, ASTM A193-B7 and other high strength rod. High strength couplers may be used with standard strength rod. See ICC ES AC 391 section 1.4.5 for additional information.

Coupler elongation is minimal and is not considered in elongation calculations.

Straight Couplers



Standard Strength
CN-X

High Strength
CNHS-X

* Check with factory for availability of these sizes.

Coupler Nut Reducer

Use coupler nut reducers to change rod size. Normally rod is reduced in size. However sometimes the rod is increased from an embedment to a "run".

Identification:

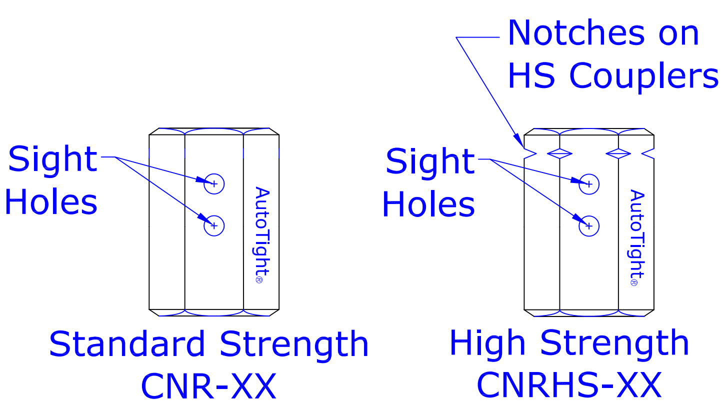
Coupler Nut Reducer
Example: CNR610
CNR = Coupling Nut Reducer,
610 = 3/4" - 10 NC to 1-1/4" - 7 NC Thread.

Grade:
Standard Coupler Nuts are ASTM A563 Grade A.
High strength Couplers are ASTM A563 Grade C.
Over 1-¼" at the big end Grade 5 is supplied
Sight holes are standard.

Installation

Thread coupler onto larger rod, bottom. Thread smaller rod into coupler and bottom on the larger thread. The thread bottoming in the coupler will indicate full engagement, a sight hole is not necessary.

Coupler Nut Reducer



Standard Strength

Model Number	Rod Ø Small	Rod Ø Large
CNR-45	1/2"	1/2"
CNR-46		3/4"
CNR-47		7/8"
CN-48		1"
CNR-56	5/8"	3/4"
CNR-57		7/8"
CNR-58		1"
CNR-59		1-1/8"
CNR-67	3/4"	7/8"
CNR-68		1"
CNR-69		1-1/8"
CNR-610		1-1/4"
CNR-78	7/8"	1"
CNR-79		1-1/8"
CNR-710		1-1/4"
CNR-89	1"	1-1/8"
CNR-810		1-1/4"
CNR-910	1-1/8"	1-1/4"

High Strength

Model Number	Rod Ø Small	Rod Ø Large
CNRHS-56	5/8"	3/4"
CNRHS-57		7/8"
CNRHS-58		1"
CNRHS-59		1-1/8"
CNRHS-67	3/4"	7/8"
CNRHS-68		1"
CNRHS-69		1-1/8"
CNRHS-610		1-1/4"
CNRHS-78	7/8"	1"
CNRHS-79		1-1/8"
CNRHS-710		1-1/4"
CNRHS-89	1"	1-1/8"
CNRHS-810		1-1/4"
CNRHS-812 *		1-1/2"
CNRHS-814 *		1-3/4"
CNRHS-910	1-1/8"	1-1/4"
CNRHS-912 *		1-1/2"
CNRHS-914 *		1-3/4"
CNRHS-916 *		2"
CNRHS-1011 *	1-1/4"	1-3/8"
CNRHS-1012 *		1-1/2"
CNRHS-1014 *		1-3/4"
CNRHS-1016 *		2"
CNRHS-1112 *	1-3/8"	1-1/2"
CNRHS-1114 *		1-3/4"
CNRHS-1116 *		2"
CNRHS-1214 *	1-1/2"	1-3/4"
CNRHS-1216 *		2"
CNRHS-1416 *	1-3/4"	2"

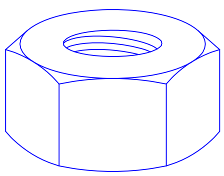
* Check with factory for availability of these sizes.

Nuts

All nuts are Unified National Coarse thread pitch (UNC or NC)

Standard Nuts are SAE Grade 2 or ASTM 563-Grade A

High Strength Nuts are SAE grade 5, ASTM 563-Grade C or A194-2H.



Nuts for HDG

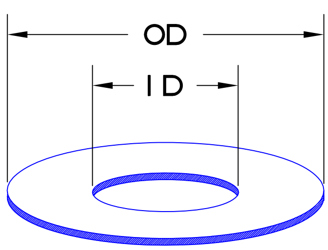
Oversize nuts to fit HDG Hot Dipped Galvanized Rod available.
Consult factory for sizes available.
Rethreading after HD Galvanizing is preferred.

Standard Nuts	
Model Number	Diameter & Thread
N-4	1/2"-13 NC
N-5	5/8"-11 NC
N-6	3/4"-10 NC
N-7	7/8"-9 NC
N-8	1"-8 NC
N-9	1-1/8"-7 NC
N-10	1-1/4"-7 NC
* N-11	1-3/8"-6 NC
* N-12	1-1/2"-6 NC
* N-14	1-3/4"-5 NC
* N-16	2"-4.5 NC

High Strength Nuts	
Model Number	Diameter & Thread
NHS-4	1/2"-13 NC
NHS-5	5/8"-11 NC
NHS-6	3/4"-10 NC
NHS-7	7/8"-9 NC
NHS-8	1"-8 NC
NHS-9	1-1/8"-7 NC
NHS-10	1-1/4"-7 NC
* NHS-11	1-3/8"-6 NC
* NHS-12	1-1/2"-6 NC
* NHS-14	1-3/4"-5 NC
* NHS-16	2"-4.5 NC

Washers

Washers supplied are SAE Washers.
Common Washers may be substituted.
W-11 thru W-16 are special 3-½" square washers.

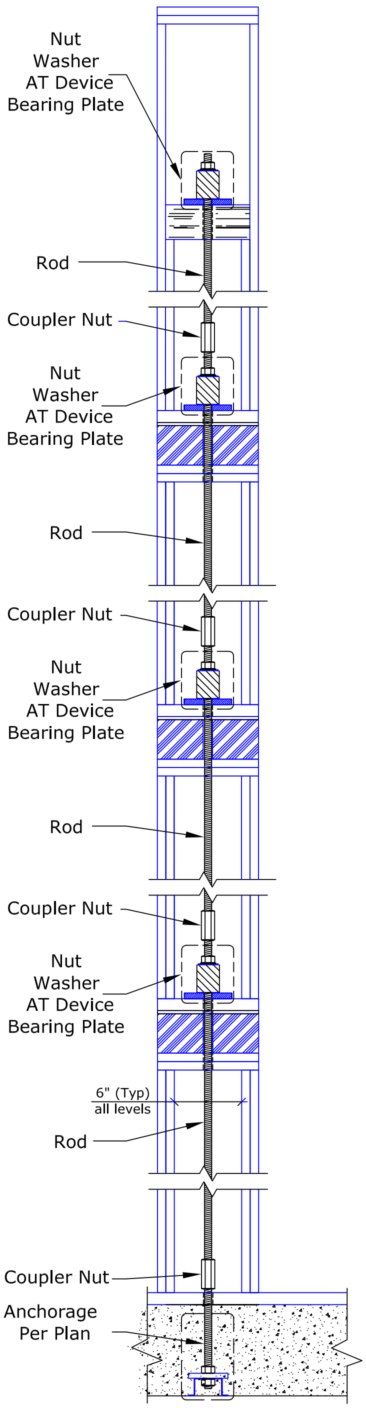


Washers		
Model Number	Nominal Diameter	Outside Diameter
W-4	1/2"	1-1/16"
W-5	5/8"	1-5/16"
W-6	3/4"	1-1/2"
W-7	7/8"	1-3/4"
W-8	1"	2"
W-9	1-1/8"	2-1/4"
W-10	1-1/4"	2-1/2"
* W-11	1-3/8"	3-1/2"
* W-12	1-1/2"	3-1/2"
* W-14	1-3/4"	3-1/2"
* W-16	2"	3-1/2"

* Check with factory for availability of these sizes.

Notes:

Typical System



Tie-Down Systems-Designing to the Code

Recent changes by ICC ES require designers to revise the tie-down system design method. The requirements have always been there, but revised ICC-ES Acceptance Criteria specifically require certain strength and elongation limits and define required items to be considered. This section provides important background information on components, elongation limits and wood shrinkage.

ICC-AC 316

In June 2012 ICC-ES established guidelines for tie-down system elongation restraining shear walls. AC 316 added the following amendment:

> "6.9 Shear wall drift limit shall consider 0.200" displacement per story or between restraints. The 0.200" displacement may be exceeded when it can be demonstrated that the shear wall story drift limit and the deformation compatibility requirements of IBC section 1604.4 are met when considering all sources of vertical displacement."

Systems approved under AC 316 shall comply with this requirement by April 1, 2013.

Why do we have this new limit?

The IBC specifies allowable shear wall drift limits using the following equation:

$$\delta_{sw} = \frac{8vh3}{EAb} + \frac{vh}{1000G_a} + \frac{h\Delta_a}{b}$$

In 2008 the SEAOC seismology committee reviewed this equation and noted that under certain circumstances the shear wall may receive 83% of the allowable drift from hold-down deformation alone. (Note: this was the "da" in the previous four part equation and is now Δ**a**). Based on their analysis, looseness introduced by the hold down system could result in excessive wall drift and mud sill splitting.

Note: the SEAOC analysis did not address wood shrinkage or building settling and did not include multiple tie down components. The SEAOC analysis included **only** the tie-down itself. Multiple tie-down components coupled with building shrinkage can radically degrade shear wall performance.

Why is the Limit Set at 0.200"?

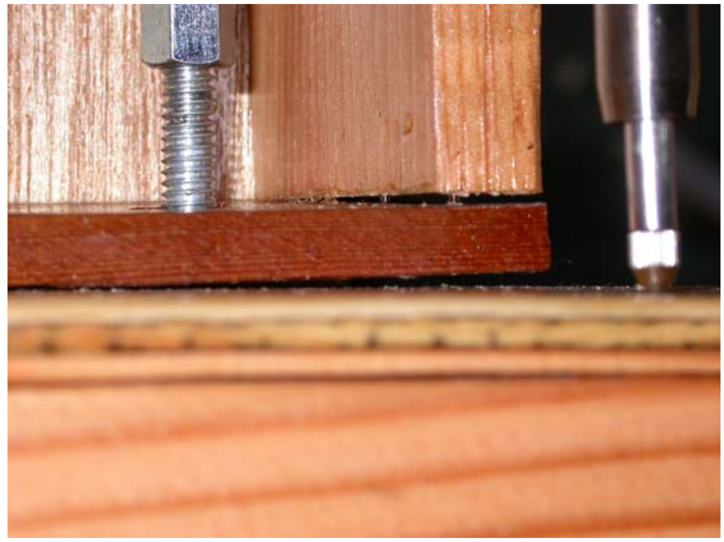
Cyclic testing of light frame shear walls has demonstrated that 0.200"looseness in a shear wall will degrade lateral performance as much as 40%. Observers have noted nails begin failing in the plywood when uplift approaches 0.100". Because of these observation's a number of jurisdictions have established elongation limits ranging from 0.125" to 0.200". Additionally, engineers who have examined the problem have established firm limits of 0.200 or below. Based on input from the engineering community ICC ES has established the 0.200" limit.

For a typical code shear wall with a height to width (or breadth h/b) ratio of 1 or less the 0.200" uplift limit makes sense. But if we look at the shear wall drift equation above note that if the wall is short the contribution to overturning of the tie-down system is excessive, so while the uplift limit is required to be at or below 0.200", shear wall drift may require an even lower limit. A lower limit may also be needed to minimize mud sill damage and to allow shear wall drift compatibility.

Tie-Down Systems

Building Damage Noted after Earthquakes

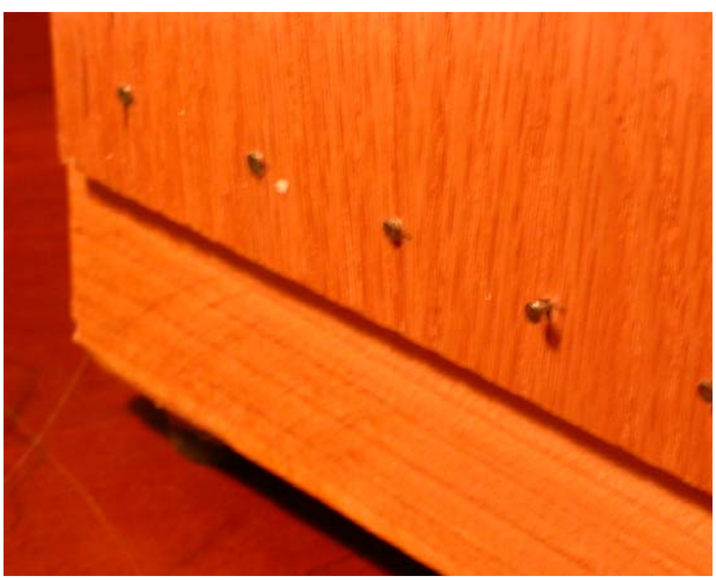
After the 1994 Northridge Earthquake researchers noted " vertical tie-down looseness due to inadequate tightening of nuts" and cross-grain splitting of mud sills due to "inadequate sole plate washers".



The looseness of the connections was certainly there along with the failed mud sills but I ascribe the failures to shrinkage, settling and stretched holdown systems. And, regardless of the size of the sole plate washers, a loose tie-down that allows the wall to rotate will stretch and bend the mud sill, destroying the mud sill and the shear wall nails attaching the sheathing to the mudsill. The photo at the right demonstrates the initial looseness and associated movement in a demonstration model

I have designed, tested and evaluated hundreds of shear walls and tie-down systems. The testing included both monotonic and cyclic protocols. Tie-down system elongation that allows a mudsill to lift 3/16" to 1/4" often leads to a cross grain bending mudsill failure. Others have observed that when a lateral load forces the mudsill to lift over 0.200" the mudsill often splits. A split mudsill can quickly destroy the performance of the wall.

Mudsill splitting can be demonstrated on a model. Looseness is introduced by backing off the nut at the top of the wall (typical of building shrinkage) and applying a lateral load. Mudsill bending is quickly observed. When tie-down looseness exceeds a certain amount the mudsill will twist. Mudsill twist imposes cross grain bending and progresses to a split. Note: the loose connection is the main source of mudsill splitting. A large mudsill washer can't solve this problem. The only real solution is a tight, low deflection connection. With a wood building this tight connection requires either dry wood (with a MC of 10% or so) or a shrinkage compensating device.



After several cyclic load reversals the nails attaching the shear panel begin to pull out or pull through.The photo to the left demonstrates the effect on nails that results from a cyclic load on a loose shear panel.

Tie-Down Components

Proper evaluation of tie-down systems requires all system components must be fully specified. If any item is left out the analysis is flawed. A complete analysis must include system strength and elongation.

System Components can include threaded rod, bearing plates, shrinkage compensators, washers, nuts, and couplers. In addition, shrinkage/settling is considered an elongation "component". For a given connection not all components are needed, but if used they must be analyzed. Shrinkage and settling should always be included. If a shrinkage compensator is used the amount of shrinkage compensation must be known. If a shrinkage compensator is not used, the shrinkage amount must be added to system elongation.

Threaded rod strength is analyzed per AISC 360, equation J3-1. Or may be take directly from AISC table J3.2 (p16.1-104). Elongation is calculated per AC391 3.2.1.1. A shortcut design method is to pre-calculate the elongation of 10' rod at the rod design capacity. A look-up table lists strength capacity and the elongation for 10' of rod. An inspection of the table then provides both allowable strength and elongation information. The rod elongation is ratio of the actual length/table length times actual load/listed load.

Bearing Plates To transfer loads into the structure either hold downs or bearing plates are used. Bearing plates are sized and load rated per AC 391 and NDS 2005. The allowable load on a bearing plate is defined as the load that deflectsthe plate 0.040".eflection is adjusted by the ratio on actual/allowable load

Hold-downs (tie-downs) are load rated per AC 155. Deflection is adjusted by the ratio of actual/allowable loads. **Note:** if two hold-downs are used in series (example to bridge a floor) the deflection of this component is doubled.

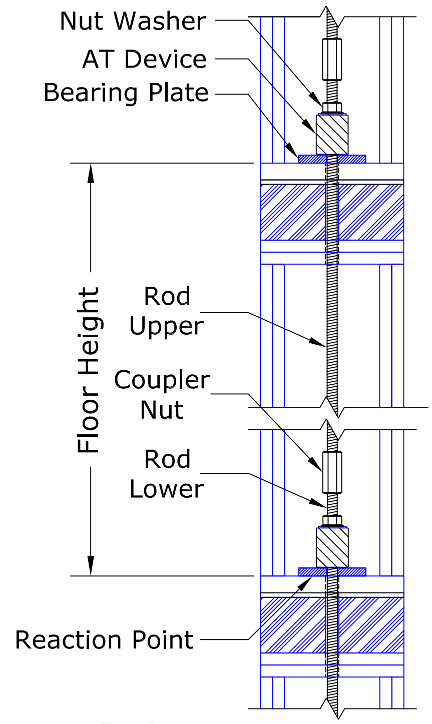
Shrinkage/Settling is a system component. Shrinkage is considered elongation without load. If shrinkage is low (1/16"-1/8") a shrinkage compensator may not be needed. If shrinkage is greater than 1/8" a shrinkage compensator should be used. Typically, engineers design for 1/4" to 1/2" of shrinkage per floor. Note: a properly applied shrinkage compensator should eliminate the need for a precise shrinkage calculation.

Shrinkage Compensators (also known as Take-Up Devices or TUDs) are rated by AC316 for rod size (fit), load capacity, deflection and shrinkage capacity. Deflection (**ΔA**) is adjusted by the ratio of actual to allowable loads.

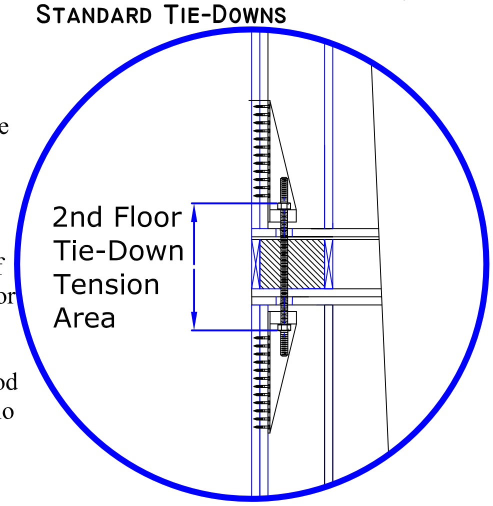
Shrinkage Compensators also have another property called delta R (ΔR). Delta R looseness is the average travel and seating increment. Delta R is not a function of load rather is a fixed attribute of the TUD. This movement is part of, and must be added in full to, system movement. Therefore shrinkage compensator total movement = $\Delta T = \Delta A + \Delta R$ (Note: ΔR must be used in full whereas ΔA may be load adjusted)

Significance

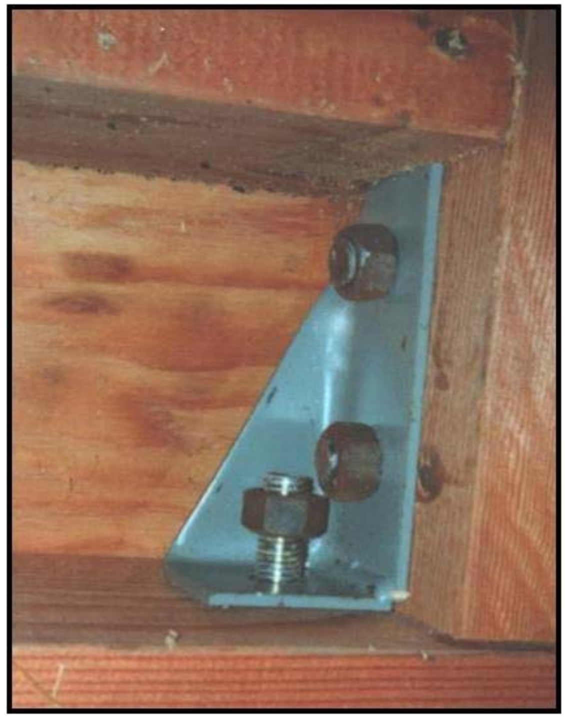
Delta R (ΔR) for shrinkage compensating devices varies from 0.000" to 0.080". System elongation consists of the sum of rod, bearing plate and shrinkage compensator deflections. If the system limit is 0.200", staying within this limit may require enlarging the rod and/or bearing plates to limit the elongation.



STANDARD TIE-DOWNS



Shrinkage



The building industry has addressed wood shrinkage with better products and better packaging. Today we can buy wood joists made from green wood with a moisture content (MC) of 30%, Kiln Dried wood with an MC of 19% and Manufactured Wood (I-Joists, Paralam etc.) with a MC at or below the equilibrium moisture point.

To estimate wood shrinkage a large number of variables must be considered. Required information includes starting MC of the mudsills, and joists; the equilibrium MC of the building; the "stack height" of the wood; the wood species, and the grain orientation. Then we should ask the question "should we consider average shrinkage or worst case shrinkage?" Finally, will a shrinkage compensator be used?

Shrinkage/Settling In May 2008 the SEAOC committee noted building settlement, excessive moisture content, sill plate crushing and slip or looseness within various shrinkage compensating devices, but they didn't address these sources or attempt a resolution.

The photo on the right was taken in Mendocino County; California in 1999. The building was 12 years old. About 12 hold-downs were installed. In every case the tie-down bolt showed 5/8" to 3/4" of looseness. This building was built with "wet" wood. The shrinkage demonstrated 12 years of shrinkage in a "dry" coastal environment

Multi-Story Shrinkage

The photo at the left is from a 5 story building in Seattle. The floor system consists of wood "I" Joists and solid sawn plates. The walls were opened because of a moisture problem When the tie-down system was investigated every floor demonstrated 1/4" to 3/8" of shrinkage. The connector shown is part of a multi-story tie-down system. Under uplift loading this looseness will be transferred to all floors connected above. For example, should the top floor lift, all floors below will contribute to the looseness. We could see four floors x 3/8" looseness or 1-1/2" of movement before the wall is restrained.

Straps

Metal straps are used ubiquitously for vertical connections in wood construction. Some builders refuse to use them at all, while others nail the top portion and wait 6 months to a year to nail the bottom. (Obviously most builders have to work somewhat faster). Building shrinkage results in bowed straps.

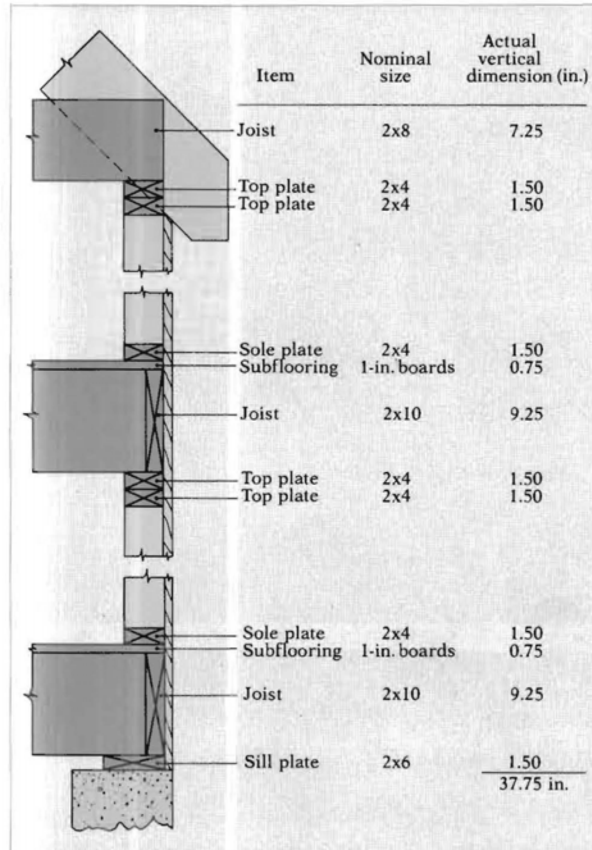
We recommend against the use of vertical metal straps.

Published Wood Shrinkage Information

Understand wood shrinkage and building settling is key to understanding and predicting shear wall and ultimately building performance. The following is a quick overview of some available information.

In his book ***Understanding Wood***, R. Bruce Hoadley takes and in-depth look at wood building shrinkage. The example at the right uses a total wood "stack height" of 37.75" and estimates the two story shrinkage to be 0.782". This example uses "dry" wood. Mr. Hoadley then estimates that if green lumber were used the shrinkage would be twice as great or about 1-1/2". Note: this is a 2 story building.

If the same approach is used for tie-downs across a 10" floor, the "stack height" is about 14-1/2". The calculated shrinkage is about 0.300" (5/16"). If green lumber were used the estimated shrinkage would be about 0.600" (5/8"). (***Understanding Wood*** A craftsman's guide to wood technology, R, Bruce Hoadley, The Taunton Press 1980)



2—Wall-framing diagram of platform construction for a two-story dwelling shows 37.75 in. of framing members stacked vertically. From this figure the potential vertical shrinkage of the house can be calculated.

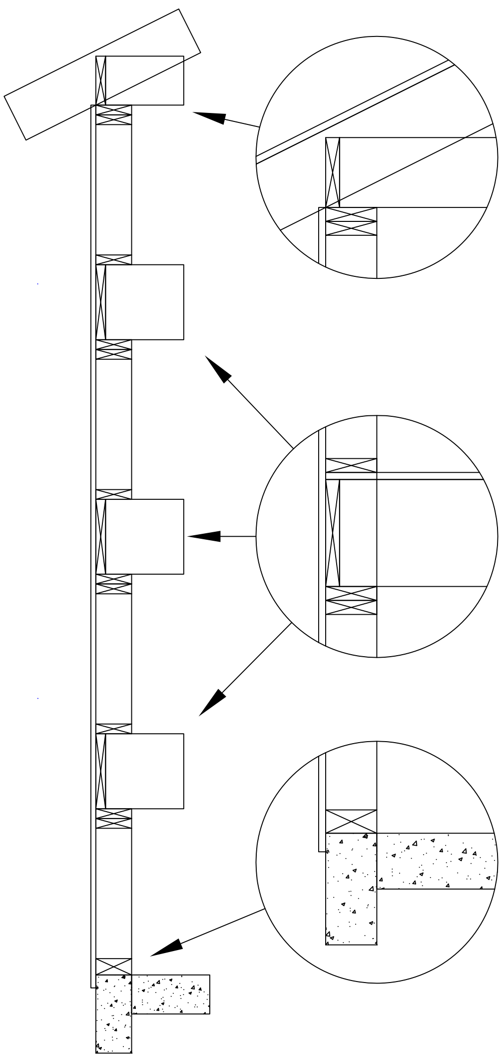


Figure 3. Shrinkage area in Multistory Wood Frame

Wood Shrinkage Information

Another widely used resource is **WWPA Technical Notes Report No 10**. Using KD (Kiln Dried) material, a shrinkage coefficient of 0.0020 (in/in/% MC change) and a stack height of 13.75" gives shrinkage across a floor of 0.248" (MC change is from 19% to 9%). If hold-downs or straps were used to connect across the floor system how is the shrinkage accounted for in the shear wall drift equation? It isn't!

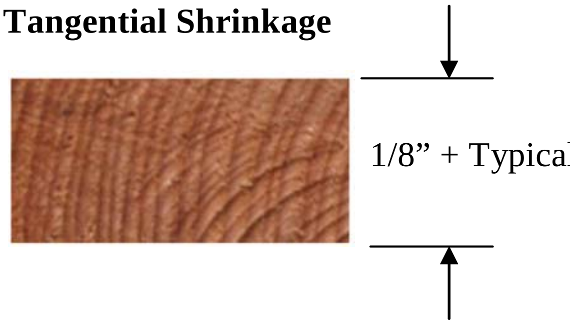
Note: the shrinkage is based on KD material with a starting MC of 19%. If green joist material were used the floor shrinkage will be 0.500" (1/2"). **Shrinkage (Calculations for Multistory Wood Frame Construction**, Tech. Notes No 10, Western Wood Products Association).

Worst Case Shrinkage?

The shrinkage calculations shown above are for average conditions, average grain orientation and average material (species and moisture). But sometimes things are not average. For marketability wood is combined in wood species groups. We may not know the actual species, and shrinkage can vary by species. The wood is sometimes delivered wet and sometimes the grain is orientated tangentially. The following graphic shows the effect of grain orientation on a 2X mudsill.

Radial Shrinkage

Tangential Shrinkage



What happens with worst case conditions? The shrinkage calculations shown above for a 2X mudsill are for average conditions; average grain orientation, average wood species, average (low) moisture content. Just for a moment consider that mudsills for multi-story buildings are often 3X and sometimes 4X material. Also consider that pressure treated mudsills are often delivered and placed wet. Finally, some wood will be used with the grain oriented tangentially. With wet 3X mudsills some of the connections will result in shrinkage of ¼". That ¼" shrinkage should be included in the calculations.

The Tale of a Semi-Scientific Experiment.

In September of 1999 I built a marketing display with 2 X 12 lumber. The wood was Douglas fir. The height of the board measured 11.591" (9/28/1999).

Six years later the wood measured 11.079" (7/19/2005.) The wood lost about ½" in about 6 years. This year it measured 10.949" (1/15/2012). The wood lost another 1/8" since 2005. The wood was always stored indoors in a dry environment. The moisture content was never checked.

To summarize what we (don't?) know about wood shrinkage:

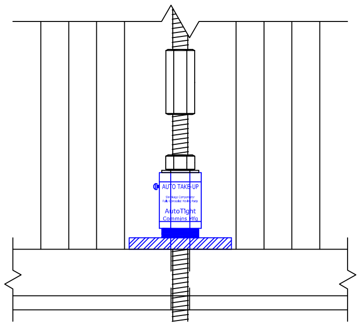
- We often don't know the exact wood species.
- We seldom know the moisture content.
- During construction buildings are often wet for several months.
- We can't know the grain orientation of a specific connection.
- It will take years for the building to come to equilibrium.

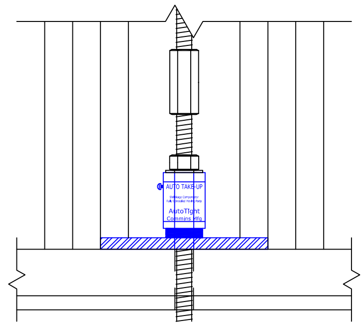
Design Shrinkage Recommendations.

With the above in mind consider using the following:

- 0.25" per floor with engineered wood I-Joist and solid sawn lumber wall framing when products are installed and kept relatively dry (at or below 19% moisture content) during construction.
- 0.375 to 0.5" per floor with engineered wood I-Joist and solid sawn lumber wall framing when products are installed and /or allowed to get relatively wet (above 19% mc) during construction.
- 0.5" to 1.0" per floor with solid sawn joists depending on the moisture content of the lumber.

Bearing Plate Installation & Fit



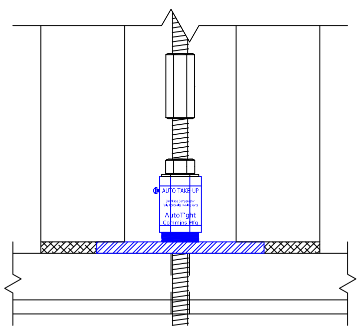


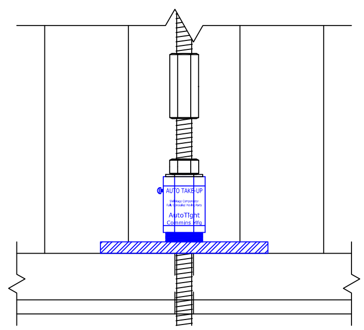
Bearing Plate Between Posts

Posts normally bear on the sill plate with 6" between them. Bearing Plate fits between them on the sill plate.
If bearing plate is longer than 6" the posts are moved apart as needed to allow the Bearing Plate to fit between them.
The final distance between the compression posts is quite flexible. Spacing is typically between about 3" and about 10". For other spacings call the factory.

Large Bearing Plate Full Bearing

If the posts must be closer than the Bearing Plate length, the posts may be moved closer to the rod by one or more post widths. This allows the posts to rest completely on the Bearing Plate.
This arrangement is often built with stacks of 2x posts with some of the 2x posts resting on the Bearing Plate and the others on the sill plate.





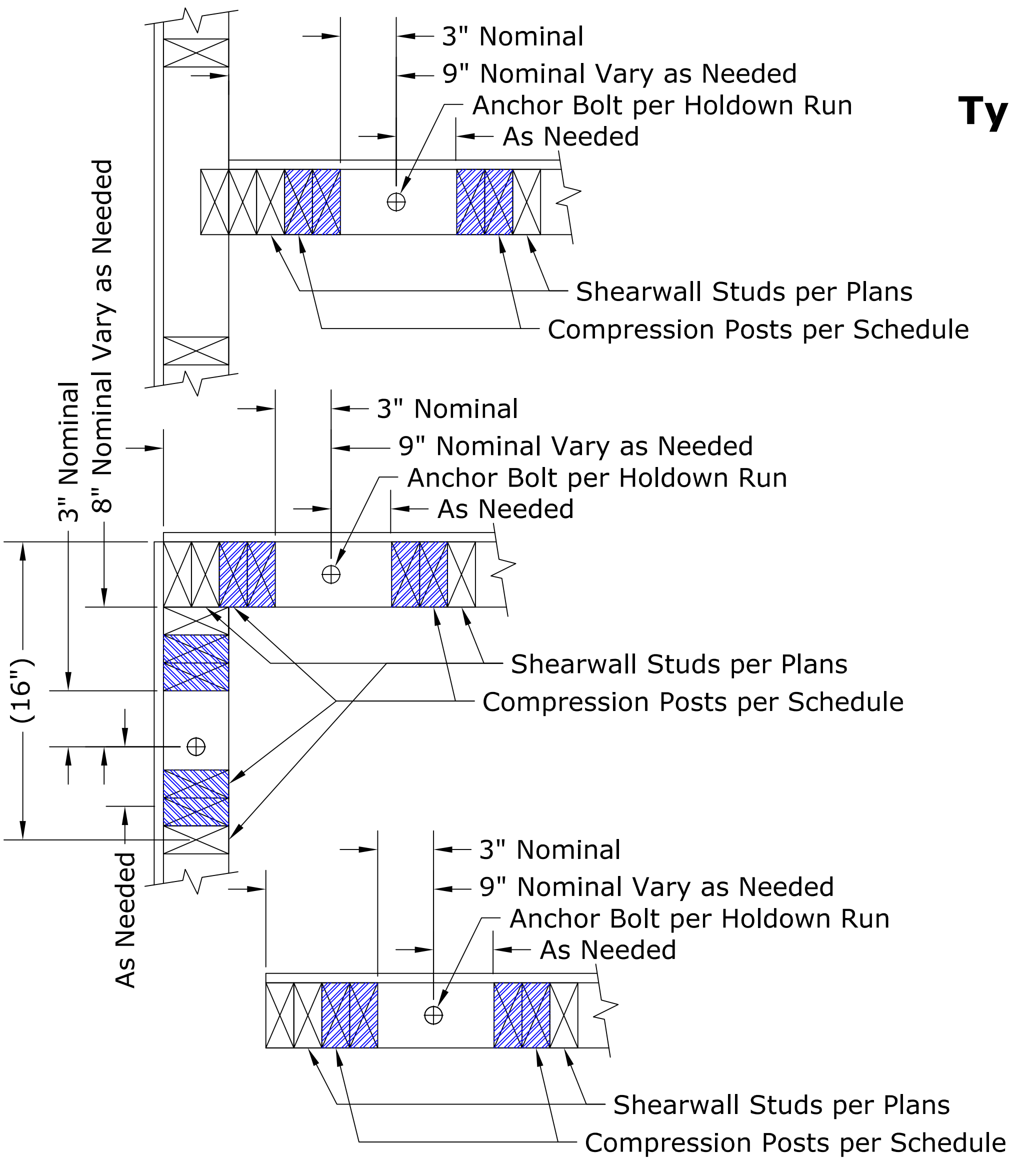
Large Bearing Plate Shimmed

If neither of the above configurations will work, shim under the bottoms of the posts with plywood the exact same thickness as the Bearing Plate.

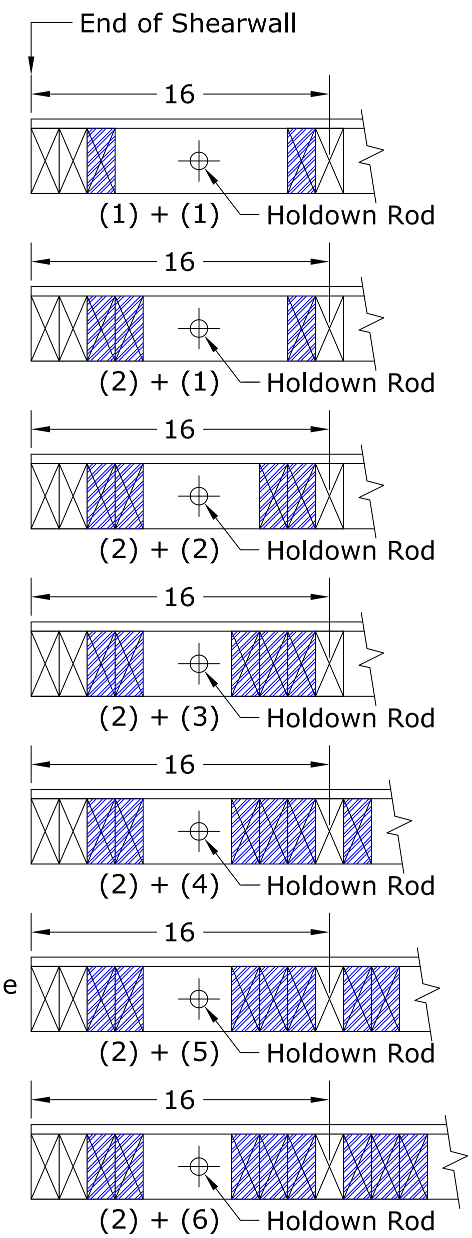
Large Bearing Plate Notched

If none of the other configurations will work. Notch the bottom of the compression posts. Part of the post will rest on the Bearing Plate and the other part of the post will rest on the sill plate.
This option is more time consuming and it is harder to get a good fit.

Typ. Tie-Down and Post Layout



Typical Post Stacking



When 6 or more 2x posts are stacked, either place some in the next bay or adjust end bay spacing to fit.

Compression Post Calculations

The allowable compression load is the lower of the Sill Plate Cross Grain Crushing or Post Buckling.

Crushing:

Allowable Crushing Load = (Fcperp x Cfrt x A)

Where:
Fcperp = Perpindicular to Grain Allowable Load for sill plate wood species per NDS 2005, Table 4A
Cfrt = Fire Retardant Treated factor = Obtain Cfrt from the the fire retardant treatment supplier
A = Total bearing Area of ends of posts = post width * post depth * post qty

Buckling:

Allowable Buckling Load = Parallel To Grain Value * Total Area of ends of compression posts (F'c x A)

Where:
F'c := Fc* x Cp

Fc* := Fc x Cd x Cf x Cfrt
Fc = Species Compression Strength Parallel to Grain per NDS 2005, Table 4A
Cd = Load Duration Factor = 1.6 (seismic) per NDS 2005, Table 2.3.2 (10 minutes seismic)
Cf = Size Factor per NDS 2005, Table 4A p.30 Adjustment Factors per species and post size
Use the through-wall thickness of the post. The shearwall construction constrains the post to bend in the thin direction of the whole wall.
4x wall: Cf= 1.15, 6x wall: Cf= 1.1, 8x wall: Cf= 1.05
Cfrt = Fire Retardant Factor = 1.0 (untreated) Obtain Cfrt from fire retardant treatment supplier.

Cp := (1 + (FcE / Fc*) / 2 x c) - sqrt[(1 +(FcE / Fc*) / 2 x c)^2 - ((FcE / Fc*) / c)]
FcE = 0.822 x E'min / (le / d1)^2
Emin = Species Minimum Modulus of Elasticity per NDS 2005, Table 4A
le = effective length of post
d1 = depth of post (through the wall direction)
Fc* = see above
c = 0.8 for sawn lumber

A = Total bearing Area of ends of posts = post width * post depth * post qty

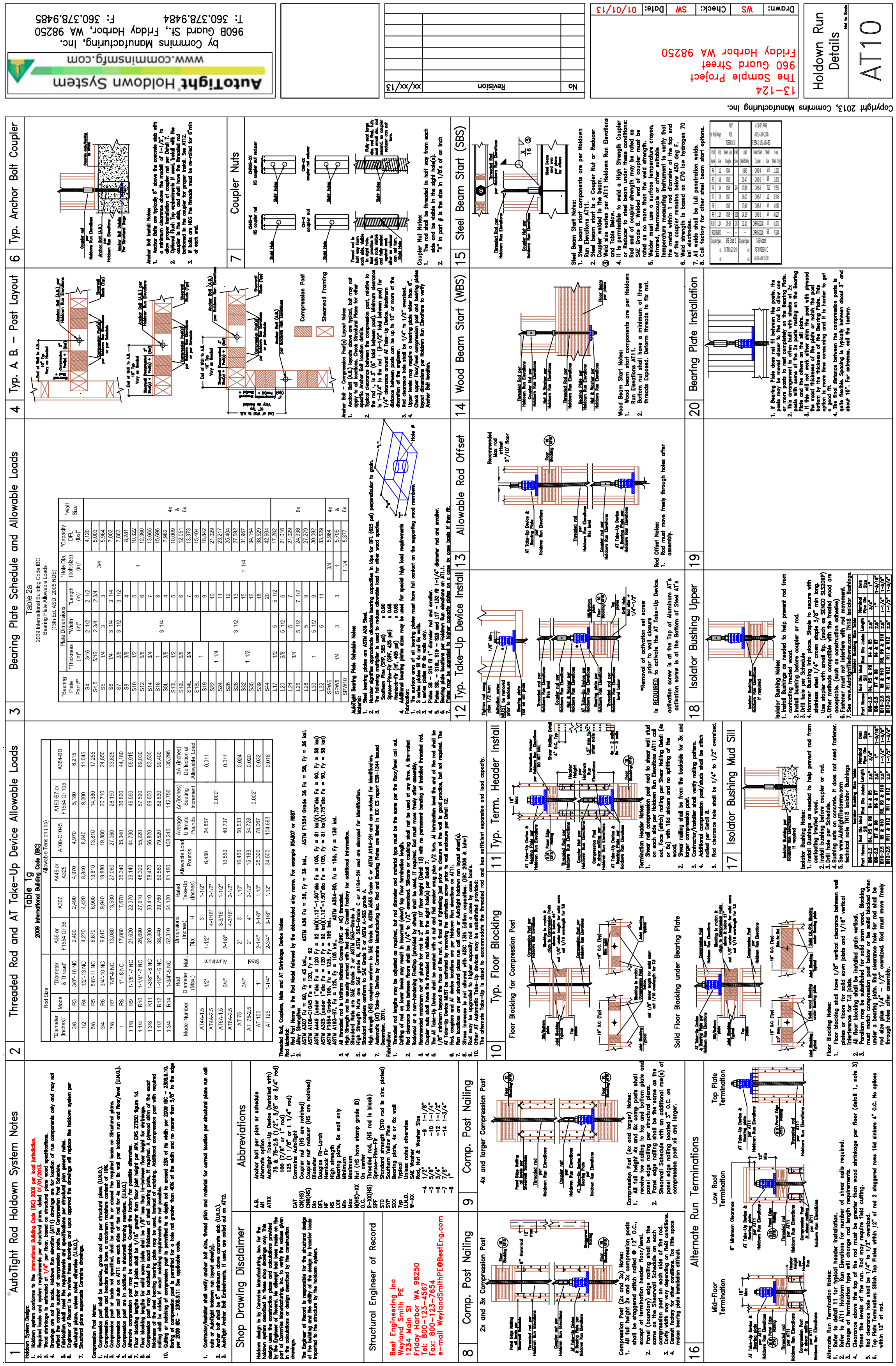
Excerpts from NDS (2005) Table 4A			
Wood Species	Fc perp psi	Fc parallel psi	Emin psi
DFL #1	625	1550	620,000
DFL #2	625	1350	580,000
HF #1	405	1350	550,000
HF #2	405	1300	470,000
SPF #1/#2	425	1150	510,000

Sample AT10 Holdown Run Details drawing

Change items in red and other items as needed for your specific job.

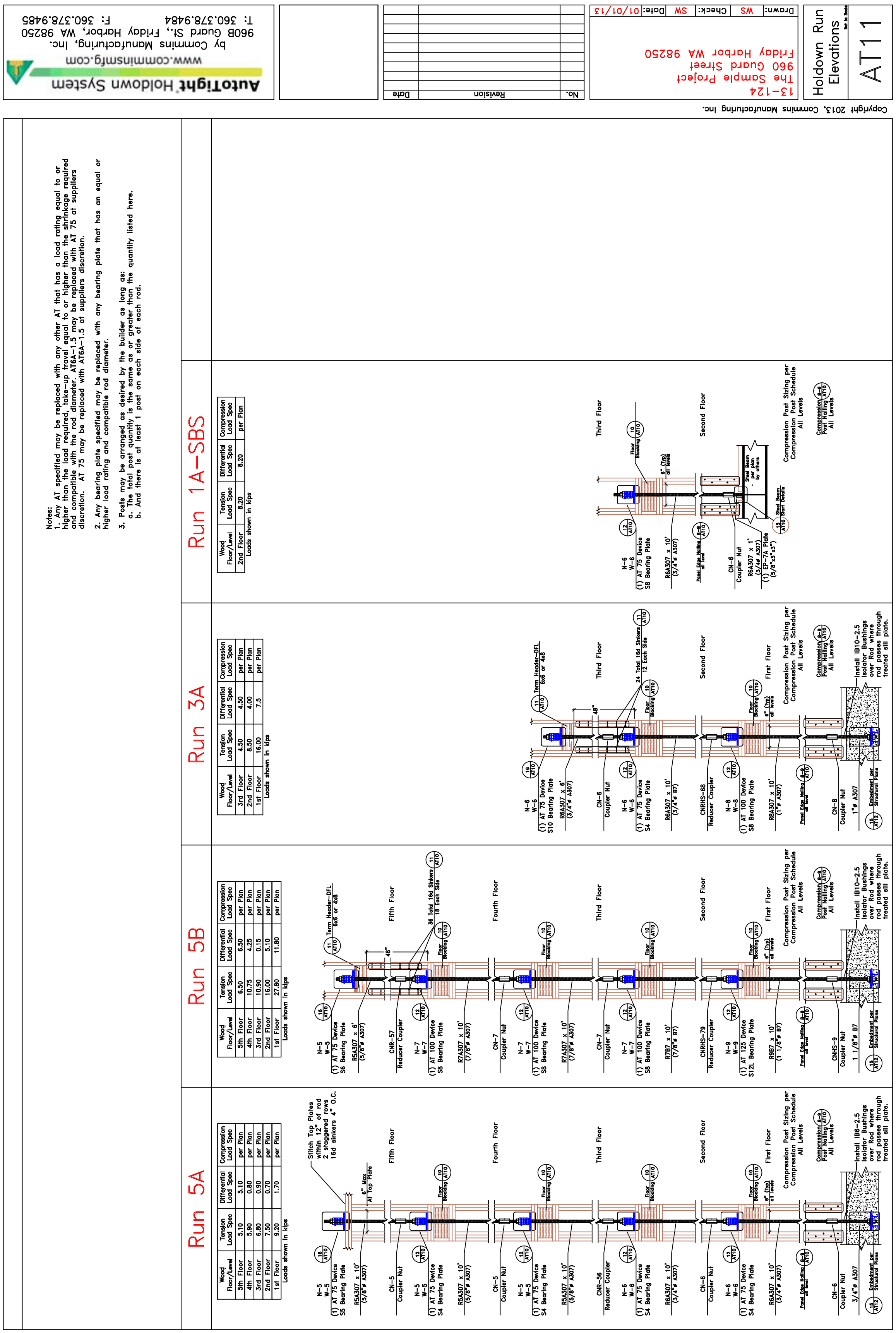
Templates are available for customer use.

AT10 Includes Typical Run Details. Download and modify as needed. Items in red are typicallychanged with each project.



Sample AT11 Holdown Run Elevations drawing

Change items in red and design runs as needed for your specific job.



AT11 Includes Typical Run Details. Download and modify as needed. This template includes several dozen typical runs from 1 to 6 stoies and with several alternative terminations. This template also requires the designer to specify arequired componenst..

Sample AT12 Anchor Bold Details drawing

Change items in red and redesign as needed as needed for your specific job.

AT12 Details Embedments.
Use this as a starting point for detailing embedments. Our experience is embedments account for the most problems with design and installation of tie-down systems.
Please consult factory for more information.

Anchor Bolt Embedment Notes

Anchor Bolt Embedment Design:

1. Anchor Bolt Embedment Design conforms to the 2009 International Building Code (IBC).
2. Required loads and system requirements per Final Shear Wall Layout Structural Plan Set, dated 01/01/2013.
3. Concrete Strength is 4,000 psi min. Drawings are not to scale.
4. Fabrication shall meet the requirements and specifications per structural plan general notes.

Anchor Bolt Installation:

1. Contractor/installer shall verify anchor bolt size, thread pitch and material for correct location per structural plans and AutoTight holdown run layout sheet(s).
2. Anchor Bolt location relative to the end of the shear wall shall be per AT1.0 Details 4 and 6.
3. Anchor bolt shall be 6" minimum above concrete slab (U.N.O.). (Excess exposure will impact lift-over heights on floors above. Less exposure will not leave enough thread for coupler.)

Holdown System Design:

1. For system design see Holdown Run Details (AT10), Holdown Run Elevations (AT11) and Structural Drawing S-203
2. Fabrication shall meet the requirements and specifications per structural plan general notes.

Shop Drawing Disclaimer

Engineering has been provided by Zbinden-Carter-Souders Engineering and Commins Manufacruring, Inc. for the holdown system described in these shop drawings only. This design uses the construction plans and calculations provided by the Engineer of Record. No attempt had been made on the part of Zbinden-Carter-Souders Engineering and Commins Manufacturing, Inc. to verify the values given in the calculations or design described by the construction drawings.

The Engineer of Record is responsible for the structural design of the building and the ability of the design to transfer loads imparted to the structure by the holdown system.

Structural Engineer of Record

Best Engineering Inc
Weyland Smith PE
1234 Main St
Friday Harbor WA 98250
Tel: 800-123-4567
Fax: 800-123-7654
e-mail
WeylandSmithPE@BestEng.com

Abbreviations

A.B.	Anchor bolt per plan or schedule
Alt	Alternate option
ATXX	AutoTight take-up device (Installed with) 75 & 75-2.5 (5/8" or 3/4" rod) 100 (7/8" or 1" rod) 125 (1 1/8" or 1 1/4" rod)
CAT	Commins AutoTight
CN(HS)	Coupler nut (HS are notched)
CNR(HS)	Coupler nut reducer(HS are notched)
Dia	Diameter
DFL	Douglas Fir-Larch
HF	Hemlock Fir
HS	High strength
LXX	Bearing plate, 6x wall only
Min	Minimum
Max	Maximum
N(HS)-XX	Nut (HS have stamp grade ID)
O.C.	On center
R-XX(HS)	Threaded rod, (HS rod is black)
SPF	Spruce-Pine-Fir
STD	Standard strength (STD rod is zinc plated)
SYP	Southern Pine
SXX	Bearing plate, 4x or 6x wall
Typ	Typical
U.N.O.	Unless noted otherwise
W-XX	SAE Washer

Rod, Nut & Washer Size

-5	5/8"	-9	1-1/8"
-6	3/4"	-10	1-1/4"
-7	7/8"	-12	1-1/2"
-8	1"	-14	1-3/4"

Anchor Bolt Allowable Loads

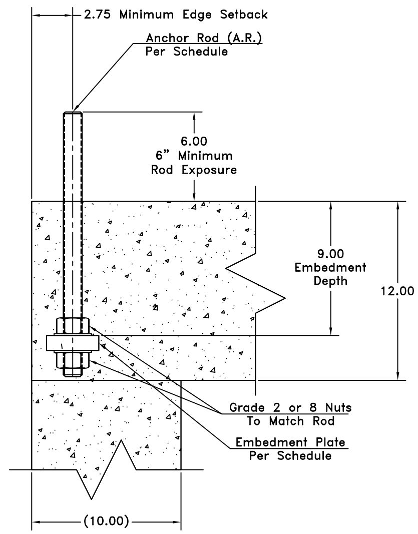
Table 2b
2009 International Building Code (IBC)

Allowable Loads 2009 IBC (lbs.)	Anchor Bolts		
	CAT Rod	Dia.-Thread	Material
6,903	R5A307	5/8"-11 NC	A307
9,940	R6A307	3/4"-10 NC	A307
13,530	R7A307	7/8"-9 NC	A307
17,671	R8A307	1"-8 NC	A307
22,365	R9A307	1-1/8"-7 NC	A307
27,612	R10A307	1-1/4"-7 NC	A307
14,381	R5B7	5/8"-11 NC	A193-B7
20,709	R6B7	3/4"-10 NC	A193-B7
28,187	R7B7	7/8"-9 NC	A193-B7
36,816	R8B7	1"-8 NC	A193-B7
46,595	R9B7	1-1/8"-7 NC	A193-B7
57,524	R10B7	1-1/4"-7 NC	A193-B7
69,029	R10A354	1-1/4"-7 NC	A354-BD

Threaded Rod, Couplers, Nuts and AT Shrinkage Device Notes:
Material:

1. Rod Alloy is incorporated in the rod part name. See AT1.0 Holdown Run Details for data on other rod alloys.
2. All threaded rod is Uniform National Coarse (NC) threaded.
3. High Strength rod is usually marked with Red paint. Consult Factory for additional information.
4. Standard couplers conform to ASTM A-563 grade A (SAE Grade 2). High strength (HS) couplers conform to ASTM A563 Grade C (SAE Grade 8) and are notched for identification.
5. Standard nuts conform to ASTM A-563 grade A (SAE Grade 2). High strength (HS) nuts conform to ASTM A563 Grade C (SAE Grade 8) and are stamped for identification.
6. Automatic (AT) Take-Up Device & Rod & Bearing Plates by Commins Manufacturing Inc. per ICC ES report ESR-1344 issued November 1, 2007.

Slab Edge Anchor

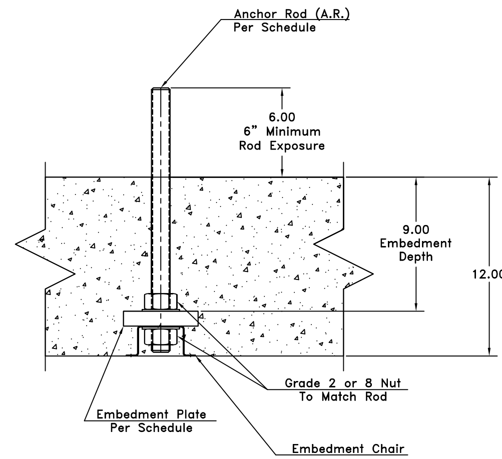


Concrete and Rebar
per Structural Plans

AutoTight Anchor Bolt Embedment Schedule

Run #	Location	Rod	Plate Size Slab Interior	Embedment Depth	Quantity
1-E	Slab Edge	R6A307	3½" x 7½" x 1"	9"	14
2-E	Slab Edge	R9B7	3½" x 7½" x 1"	9"	2
3-E	Slab Edge	R8A307	3½" x 7½" x 1"	9"	0
4-E	Slab Edge	N.A.	Steel Beam Start	N.A.	N.A.

Slab Interior Anchor



Concrete and Rebar
per Structural Plans

AutoTight Anchor Bolt Embedment Schedule

Run #	Location	Rod	Plate Size Slab Interior	Embedment Depth	Quantity
1-I	Slab Interior	R6A307	5" x 5" x 1"	9"	50
2-I	Slab Interior	R9B7	5" x 5" x 1"	9"	6
3-I	Slab Interior	R8A307	5" x 5" x 1"	9"	5
4-I	Slab Interior	N.A.	5" x 5" x 1"	N.A.	N.A.

AutoTight® Rod Holdown System
Commins Manufacturing, Inc.
960B Guard Street
Friday Harbor, WA 98250
T: 360.378.9484 www.comminsmfg.com F: 360.378.9485

No	Revision	Date

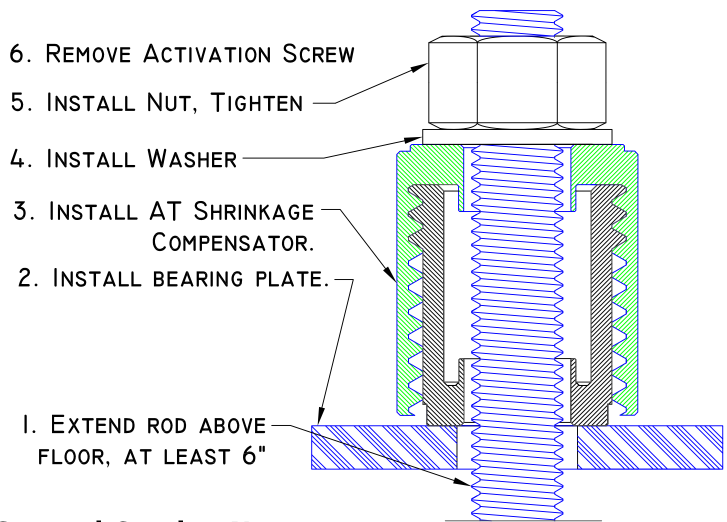
13-124
The Sample Project
960 Guard Street
Friday Harbor WA 98250
Drawn: Check: Date: 01/01/13

Anchor Bolt Details
AT12

Notes:

AT Installation, Six Steps, 30 Seconds

Start from the **bottom**, work up.



Abbreviations

A.B.	Anchor bolt per plan or schedule
Alt	Alternate option
ATXX	AutoTight take-up device
	75 & 75-2.5 (5/8" or 3/4" rod)
	100 (7/8" or 1" rod)
	125 (1 1/8" or 1 1/4" rod)
	6A (1/2", 5/8" or 3/4" rod)
	4A (1/2" rod)
	200-2.0 (1 3/8" through 2" rod)
CAT	Commins AutoTight
CN(HS)	Coupler nut (HS are notched)
CNR(HS)	Coupler nut reducer(HS are notched)
Dia	Diameter
DFL	Douglas Fir-Larch
EOR	Engineer of record.
HF	Hemlock Fir
HS	High strength
LXX	Bearing plate, 6x wall only
Min	Minimum
Max	Maximum
N(HS)-XX	Nut (HS have stamped grade ID)
O.C.	On center
R-XX(HS)	Threaded rod, (HS rod is black)
SPF	Spruce-Pine-Fir
STD	Standard strength (STD rod is black)
SYP	Southern Pine
SXX	Bearing plate, 4x or 6x wall
Typ	Typical
TUD	Take Up Device
U.N.O.	Unless noted otherwise
W-XX	SAE Washer

Rod, Nut & Washer Size

-5	5/8"	-10	1-1/4"
-6	3/4"	-11	1-3/8"
-7	7/8"	-12	1-1/2"
-8	1"	-14	1-3/4"
-9	1-1/8"	-16	2"

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3. Wood shrinkage compensation shall be determined by the EOR.
4. Contractor/installer shall verify anchor bolt size, thread pitch and material for correct location per structural plans or AutoTight holdown run layout sheet(s).
5. Anchor bolt shall extend 6" minimum above concrete.

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Commins Manufacturing Inc.
960B Guard Street
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P. 360-378-9484
www.Comminsmfg.com