Commins Manufacturing, Inc.

2.1 Six Basic (Legacy) Single-Story Tie-Down Systems Compared

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5-29-2025

Comparing Single-Story TIE-DOWN SYSTEMS

Tie-Downs used in light frame buildings typically consist of straps, formed metal brackets or threaded rod systems. In 2021 the NDS clarified that tiedown connections must not only be designed for strength, but elongation and shrinkage must also be included per the following:

> **Δa = vertical deformation of the wall overturning anchorage system (including but not limited to fastener slip, device elongation, rod elongation and uncompensated shrinkage) plus the vertical compression deformation, the effect of which are measured at the ends of the shear wall and associated with the unit shear force induced by the design load in the shear wall, in".[1]**

The Target deflection of all systems is not-to-exceed: 0.200", 0.180" or 0.125" as needed.

Deflection includes <u>all</u> sources of deflection per NDS 4.3.4

This clarification of NDS SDPWS[2] and the ICC-ES[3] elongation code limit applies to most tie-down systems used with shear resisting walls. The shrinkage is compensated for with Shrinkage Compensators - called TUDs (Take-up devices).

Six systems are compared in section 2a.

Systems 1 through 4 use standard holdowns.
Systems 1 and 2 are slab-on-grade.
Systems 3 and 4 are connections across a floor.
Systems 5 and 6 are single story rod systems.
Systems 1, 3 and 5 do not use TUDs.
Systems 2, 4 and 6 use TUDs – which eliminate the effects of shrinkage.

All systems used a 14,000 lb. design load and were installed with 10' floor heights. While straps may carry as much as 14,000 lbs., they can't handle shrinkage and are not included.

Standard Holdowns are shown first. These are ground floor installations (Systems 1 and 2) and second floor (across floor system) installations (Systems 3 and 4). The final comparison is a threaded rod system that terminates above the first floor. Ground floor shrinkage, across a floor plate, is assumed as 1/8". All other shrinkage is assumed as 1/4" per floor.

TUD elongation includes both Δ_A and Δ_R contributions to elongation.

Δ_A is "deflection at allowable load" and is adjusted based on calculating the design load divided by the allowable load.

Δ_R is the "device average travel and seating increment" – and/or "<u>average</u> movement required to cause incremental motion from a seated position and the opposite movement required to reseat the device after incremental motion". Δ_R is a measured characteristic of the device and always added in full.

Note: screw TUDs and ratchet TUDs have very different Δ_R characteristics. Ratchet TUDs "ratchet" from thread to thread and have more intrinsic movement than screw TUDs. Ratchet TUDs typically have a Δ_R from .030" to .090" while screw type TUDs have a Δ_R from .000" to .005". This makes a substantial difference to total system elongation.

Rod elongation varies widely depending on load, rod length, rod diameter, and rod net tensile area.

Plate or HD Δ contribution demonstrates the elongation contribution to the system by a plate, a single holdown, or two holdowns in series across the floor system.

[1]SDPWS 2021, American Wood Council, 222 Catoctin Circle SE, Suite 201, Leesburg, VA 20175. www.awc.org
[2] Special Design Provisions for Wind and Seismic 2021, American Wood Council, Leesburg, VA 20175
[3] ICC AC 316

SYSTEM ELONGATIONS

The following chart compares six systems. It shows the contribution to elongation that each component supplies. Rod systems with a screw type TUD provide the lowest system elongation. When screw TUDs are used, especially with rod systems, elongation can be tuned to within a few percent of a target deflection.

Figure 1:

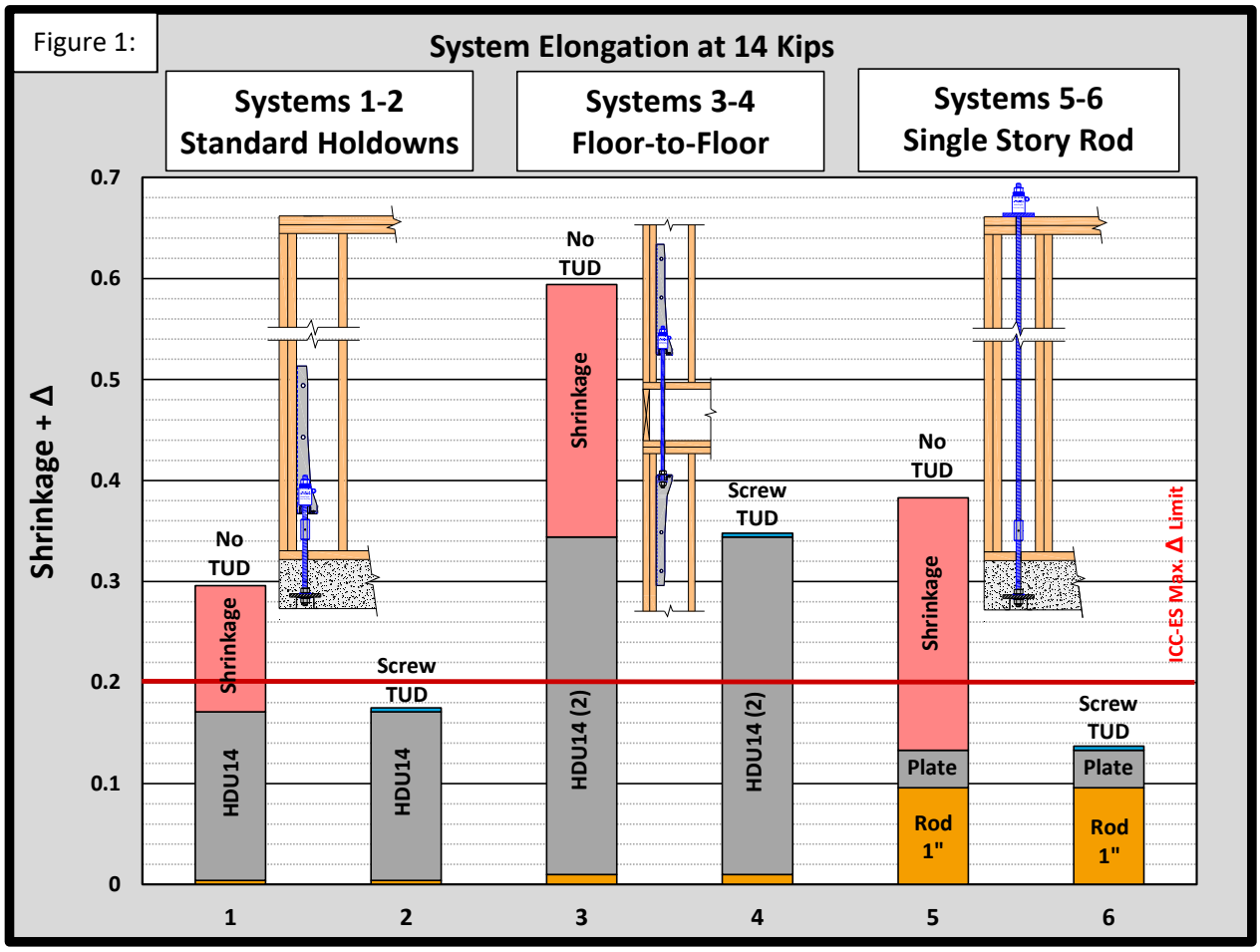


Figure 2:

ID	Connection Type	Holdown	TUD	Elongation/Shrinkage Contributions: Net Shrinkage	Plate or Holdown Δ	Threaded Rod Δ	TUD Δ_A	TUD Δ_R	Total Δ
1	Standard Holdown	HDU14	No	0.125	0.167	0.004	N/A	N/A	0.296
2			Yes	0.000	0.167	0.004	0.003	0.000	0.174
3	Floor-to Floor	HDU14 (2)	No	0.250	0.334	0.010	N/A	N/A	0.594
4			Yes	0.000	0.334	0.010	0.003	0.000	0.347
5	Single Story	Continuous Rod	No	0.250	0.037	0.096	N/A	N/A	0.383
6			Yes	0.000	0.037	0.096	0.003	0.000	0.136

All values shown in Inches (")

Systems 1 & 2 Typical Slab-On-Grade Holdowns

The analysis uses a quality hold-down with a pre-deflected seat. Attachment uses special self-drilling screws. Note: the terms holdown, hold-down and tie-down are used interchangeably in the industry.

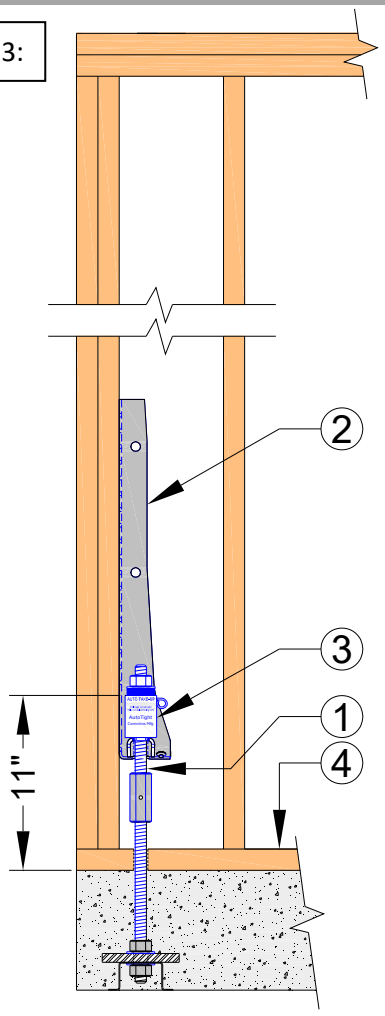
Every tie-down requires a drawing or sketch. Drawings are shown with a TUD in every case. However, calculations detail systems both with and without a TUD.

Shrinkage is shown in every case. If a TUD is used a ~~line~~ is shown through the expected shrinkage. This shows the shrinkage was calculated but not included because the TUD compensated for the shrinkage. If the shrinkage is not lined out then that movement is added to the total system movement.

The shrinkage shown is a common-practice estimate for the expected system shrinkage between reaction points. Your shrinkage may vary.

System Elevation

Figure 3:



System Specification

Standard HD Bracket on Mudsill

Wood Species:	DF/SP
Required Uplift:	14,000 lbs
Elongation:	0.20" See AC 316
Rod Length:	11"
Allowable Load	14,445 lbs.
Δ_A @ Allowable Load	0.172"

Tie-Down Legend

1. Rod, 1” Dia. R8 F1554G36
2. Bracket Tie-Down HDU14
3. Take-Up Device (TUD)
4. Shrinkage 0.125” from wood plate.

Evaluations require all components affecting the system performance be included in the analysis.

Figures 4 & 5 show rated strength and elongations for each item. Per ICC-ES AC 316, TUD elongations require two separate entries, Delta A (Δ_A) and Delta R (Δ_R).

System 1 is installed without a TUD
System 2 includes a TUD - AT8A-1.5 – 1” Dia.
Note: Nut and coupler elongation is usually less than 1/2 of 1% of the system total elongation and is not included. Long “special” couplers, over 6”, must be included in elongation.

Systems 1 & 2, Slab-on-Grade System Calculations

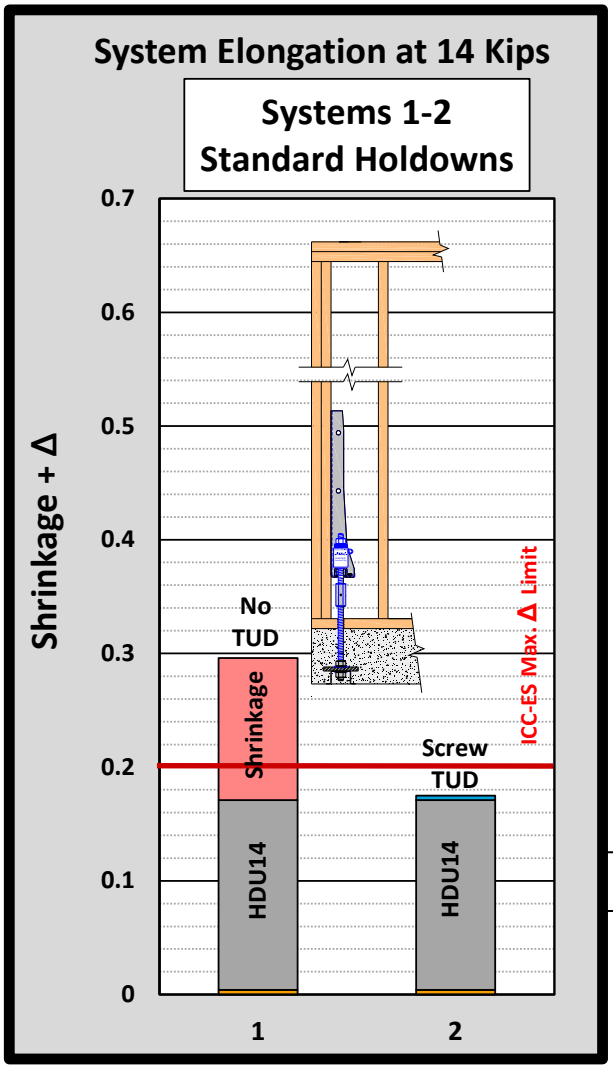


Figure 4:

- Threaded rod strength = 17,080 lbs.
- Check to verify strength is Per AISC 360 (16th)
- Threaded rod elongation = PL/A_nE
- A Common Error is using the full rod area A_b and not A_n as required by AC 391 section 3.3.1.1
- Hold-Down strength and elongation from AC 155 testing and ICC-ESR.
- Shrinkage estimated at 0.125"
- Using the TUD eliminates the effects of shrinkage
- System 1 is shown without a TUD, System 2 is shown with a TUD. Estimated shrinkage is .125”
- TUD strength and Elongation per AC316
- (3a) Δ_R of TUD Elongation is used in full This TUD has a Δ_R = 0.000" per ICC-ESR report.
- (3b) Δ_A Elongation is factored 14/20.75 X 0.004" = 0.003"
- Rod length used in calculation allows for the 6” of rod allowed for in the HDU14 ICC-ESR report.

Figure 5:

Material Input			Component Strength		Deflection/Elongation				
ID	Type	Name	Rated Capacity	Required Demand	Rated Inches		Calculations	Δ @ Load System 1 No TUD	Δ @ Load System 2 W/TUD
4	Shrinkage		NA	0.125			Estimated	0.125	~~0.125~~
3b	Take-Up Device	AT8A-1.5	20,750	14,000	ΔA	0.004	14/20.750 X0.004	TUD	0.003
3a	Commins Mfg.	AutoTight			ΔR	0.000	Use ΔR in full	Not Used	0.000
2	Holdown	HDU14	14,445	14,000	0.172		14/14.45*0.172"	0.167	0.167
1	Rod	1" F1554 G36	17,080	14,000	11"minus 6" per ESR2330		(14*5) / (0.606*29,000)	0.004	0.004
Shrinkage Per Level		0.125"	System Elongation				∑Δ	0.296	0.174
Elongation Per Level		0.200"					D/C Ratio	148%	87%

Uncompensated Wood shrinkage must be included in elongation.
Eliminating shrinkage allows this connection to perform as intended.

Systems 3 & 4, Standard Hold-Downs used Floor-to-Floor

This analysis uses a quality Hold-Down with a pre-deflected seat. Attachment uses self-drilling wood screws.

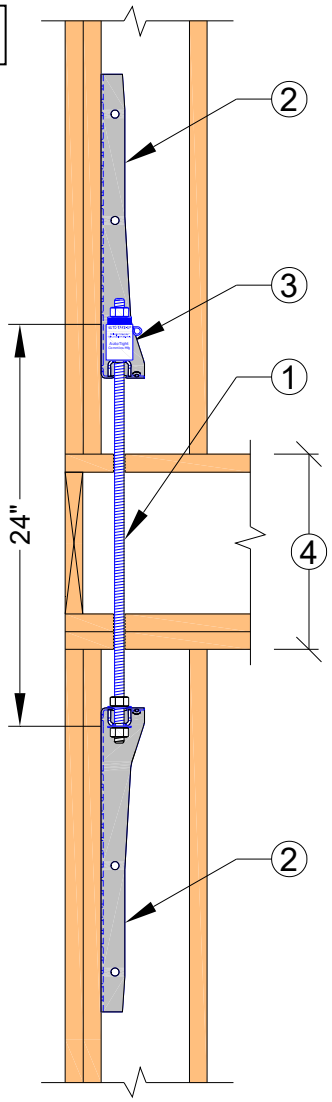
Every tie-down is shown with a drawing. Drawings are shown with a TUD in every case. However, calculations show the connection both with or without a TUD.

Shrinkage is shown in every case. If a TUD is used a ~~line~~ is shown through the expected shrinkage. This shows the shrinkage was calculated but not included because the TUD compensated for the shrinkage. If the shrinkage is not lined out then that movement is added to the total system movement.

The shrinkage shown is a "common-practice" estimate for expected Tie-Down system shrinkage between reactions. Your shrinkage may vary.

SYSTEM ELEVATION

Figure 6:



SYSTEM SPECIFICATION

Standard HD Bracket Floor-To-Floor

Wood Species:	DF/SP
Required Uplift:	14,000 lbs
Elongation:	0.20" See AC 316
Rod Length:	24"
Holdown:	2 ea. HDU14-SDS2.5
Allowable Load	14,445 lbs.
Δ_A @ Allowable Load	0.172"

Tie-Down Legend

1. Rod, 1" Dia. R8 F1554G36
2. Bracket Tie-Down #1 HDU14
2. Bracket Tie-Down #2 HDU14
3. Take-Up Device (TUD)
4. Shrinkage 0.25" from floor system.

The evaluation requires every component affecting the system performance be included in the analysis.

Figures 7 & 8 show rated strength and the elongation for each item. Per ICC-ES AC 316, TUD elongations require two separate entries, Delta A (Δ_A) and Delta R (Δ_R).

Note: Threaded rod must be "fixed" in lower bracket with a nut top and bottom on this bracket.

System 3 is installed without a TUD
System 4 includes a TUD - AT8A-1.5 – 1" Dia

Systems 3 & 4, Standard Hold Downs used Floor-to-Floor

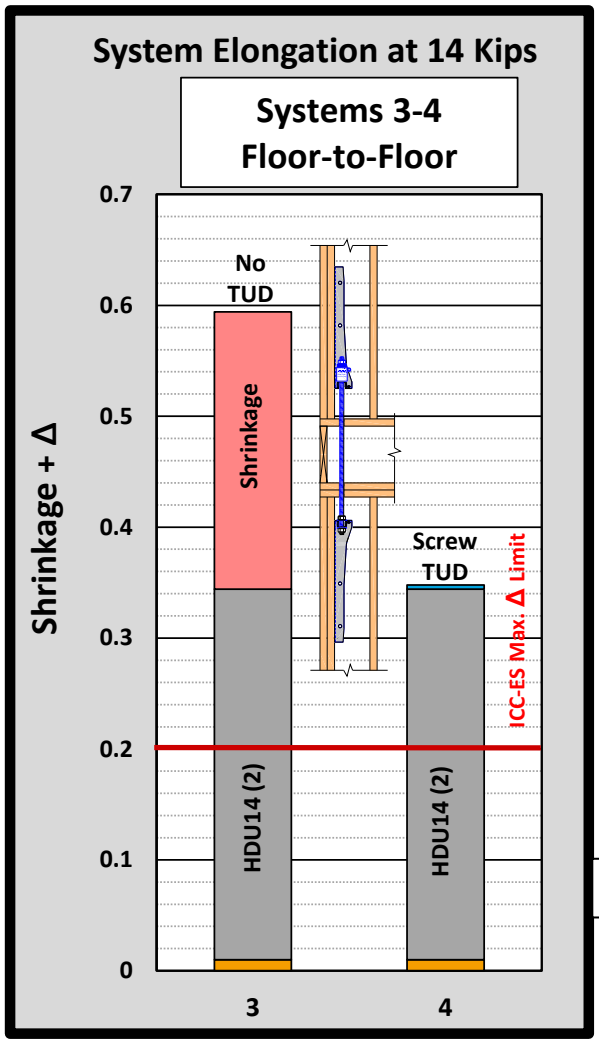


Figure 7:

- Threaded rod elongation = PL/A_nE
- A Common Error is using the full rod area A_b and not A_n as required by AC 391 section 3.3.1.1
- Hold Down strength and elongation from AC 155 testing and ICC-ESR.
- Elongation is the ratio of Actual load/HD Capacity *rated deflection. Pounds are used under "Rated Load" but converted to kips in the calculations.
- Shrinkage estimated at 0.250"
- Using the TUD eliminates the effects of shrinkage
- System 3 is shown without a TUD, System 4 is shown with a TUD.
- TUD strength and Elongation per AC316
- (3a) Δ_R of TUD Elongation is used in full This TUD has a Δ_R = 0.000" per ICC-ESR report.
- (3b) Δ_A Elongation is factored 14/20.75 X 0.004" = 0.003"
- Rod length used in calculation allows for the 12" of rod allowed for in the HDU14 ICC-ESR report. (6" for each HDU14)
- Elongation of <u>both</u> HD's must be included in the calculations per ICC-ES AC15

Figure 8:

Material Input			Component Strength		Deflection/Elongation				
ID	Type	Name	Rated Capacity	Required Demand	Rated Inches		Calculations	Δ @ Load System 3 No TUD	Δ @ Load System 4 W/TUD
4	Shrinkage		NA	0.250			Estimated	0.250	~~0.250~~
3b	Take-Up Device	AT8A-1.5	20,750	14,000	ΔA	0.004	14/20.750 X0.004	TUD	0.003
3a	Commins Mfg.	AutoTight			ΔR	0.000	Use ΔR in full	Not Used	0.000
2	Holdown	HDU14	14,445	14,000	0.172		14/14.45*0.172"	0.167	0.167
2	Holdown	HDU14	14,445	14,000	0.172		14/14.45*0.172"	0.167	0.167
1	Rod	1" Dia. F1554 G36	17,080	14,000	24" minus 12" per ESR2330		(14*12) (0.606*29,000)	0.010	0.010
Shrinkage Per Level		0.250	System Elongation				∑Δ	0.594	0.347
Elongation Per Level		0.200					D/C Ratio	297%	174%

Shrinkage takes the movement of the connection to 3 times the target elongation.
Even with a TUD (shrinkage removed) exceeds the target 0.200" elongation.

System 5 & 6 Single Story Threaded Rod

These examples show a single-story rod tie-down. It illustrates a typical rod tie-down termination used on the floor above, or in this case on the shear wall top plate.

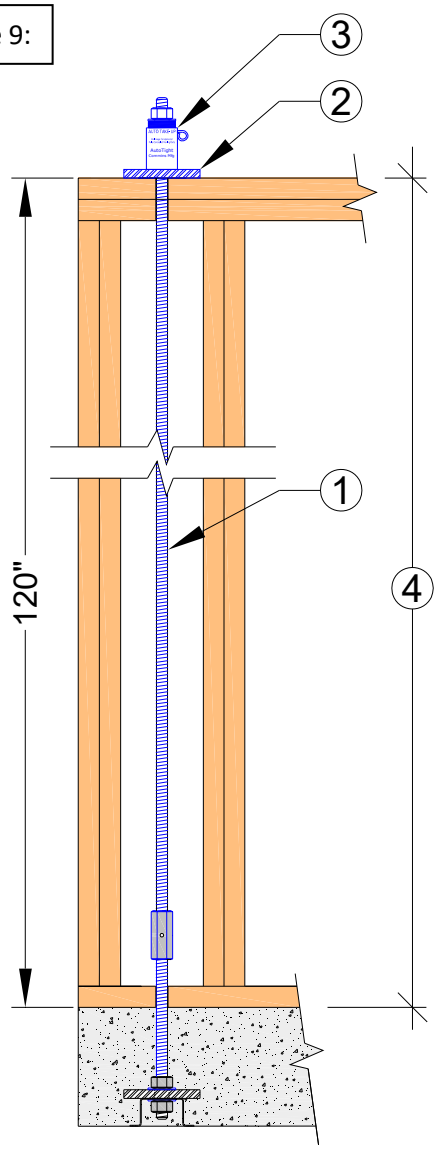
Shrinkage is shown in every case. If a TUD is used a ~~line~~ is shown through the expected shrinkage.

This shows the shrinkage was calculated but not included because the TUD compensated for the shrinkage. If the shrinkage is not lined out then that movement is added to the total system movement.

The shrinkage shown is a "common practice" estimate for expected Tie-Down system shrinkage between reactions. Your shrinkage may vary.

SYSTEM ELEVATION

Figure 9:



SYSTEM SPECIFICATION

Rod System Single Floor

Wood Species:	DF/SP
Required Uplift:	14,000 lbs
Elongation:	0.20" See AC 316
Rod Length:	120"
Plate capacity:	15,000 lbs.
TUD:	AT8A-1.5
Allowable Load	20,750 lbs.
Δ_A @ Allowable Load	0.004"
Δ_R Seating Increment	0.000"

Tie-Down Legend

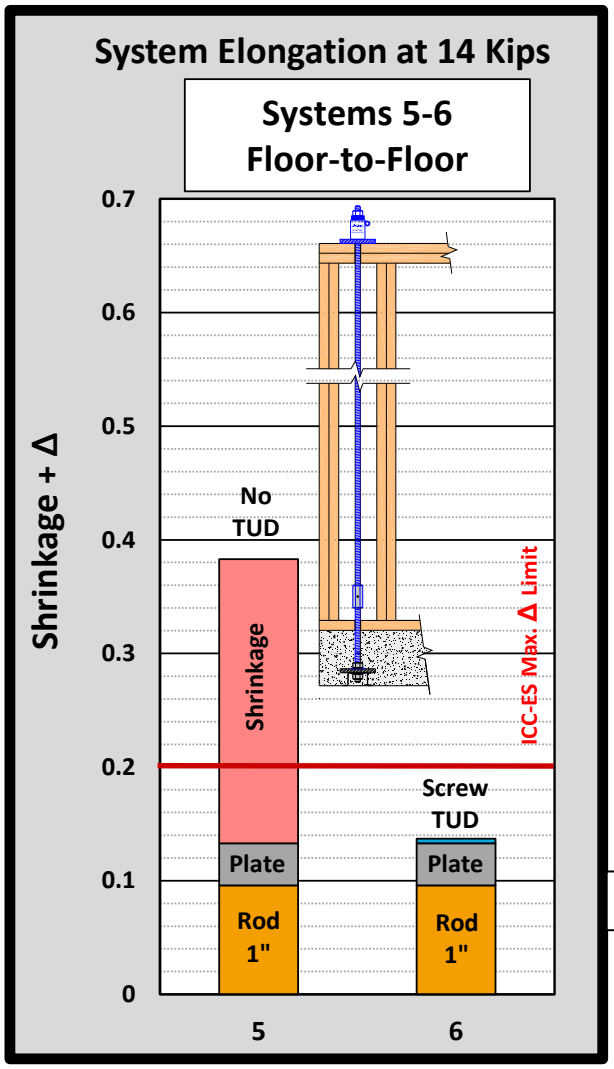
1. Rod, 1" Dia. R8 F1554G36
2. Bearing Plate
3. TUD AT8A-1.5
4. Shrinkage 0.25" per floor

Evaluations require all components affecting the system performance be included in the analysis.

Figures 10 & 11 show rated strength and elongations for each item. Per ICC-ES AC 316, TUD elongations require two separate entries, Delta A (Δ_A) and Delta R (Δ_R).

System 5 is installed without a TUD
System 6 includes a TUD - AT8A-1.5 – 1" Dia.

Systems 5 & 6, Single Story Threaded Rod



- Threaded rod strength = 17,080 lbs.
- Check to verify strength is Per AISC 360 (16th)
- Threaded rod elongation = PL/A_nE
- A Common Error is using the full rod area A_b and not A_n as required by AC 391 section 3.3.1.1
- TUD strength and elongation from AC 155 testing and ICC-ESR.
- Elongation is the ratio of Actual load/TUD Capacity *rated deflection. Pounds are used under "Rated Load" but converted to kips in the calculations.
- Shrinkage estimated at 0.250"
- Using the TUD eliminates the effects of shrinkage
- System 5 is shown without a TUD, System 6 is shown with a TUD.
- TUD strength and Elongation per AC316
- (3a) Δ_R of TUD Elongation is used in full This TUD has a Δ_R = 0.000" per ICC-ESR report.
- (3b) Δ_A Elongation is factored 14/20.75 X 0.004" = 0.003"

Figure 10:

Figure 11:

Material Input			Component Strength		Deflection/Elongation				
								Δ @ Load	
ID	Type	Name	Rated Capacity	Required Demand	Rated Inches		Calculations	System 3 No TUD	System 4 W/TUD
4	Shrinkage		NA	0.250			Estimated	0.250	~~0.250~~
3b	Take-Up Device	AT8A-1.5	20,750	14,000	ΔA	0.004	14/20.750 X0.004	TUD	0.003
3a	Commins Mfg.	AutoTight			ΔR	0.000	Use ΔR in full	Not Used	0.000
2	Plate	S16-1-1/2"	15,052	14,000	0.040		14/15.05*0.040"	0.037	0.037
1	Rod	1" Dia. F1554 G36	17,080	14,000	120		(14*120) / (0.606*29,000)	0.096	0.096
Shrinkage Per Level		0.250	System Elongation				∑Δ	0.383	0.136
Elongation Per Level		0.200					D/C Ratio	192%	68%

Uncompensated wood shrinkage must be included in elongation.
Eliminating shrinkage allows this to meet the elongation specification

Commins Manufacturing Inc

2.2 Comparing Single-Story Rod Systems

Comparing different TUDs (Take Up Devices) on single story rod systems.

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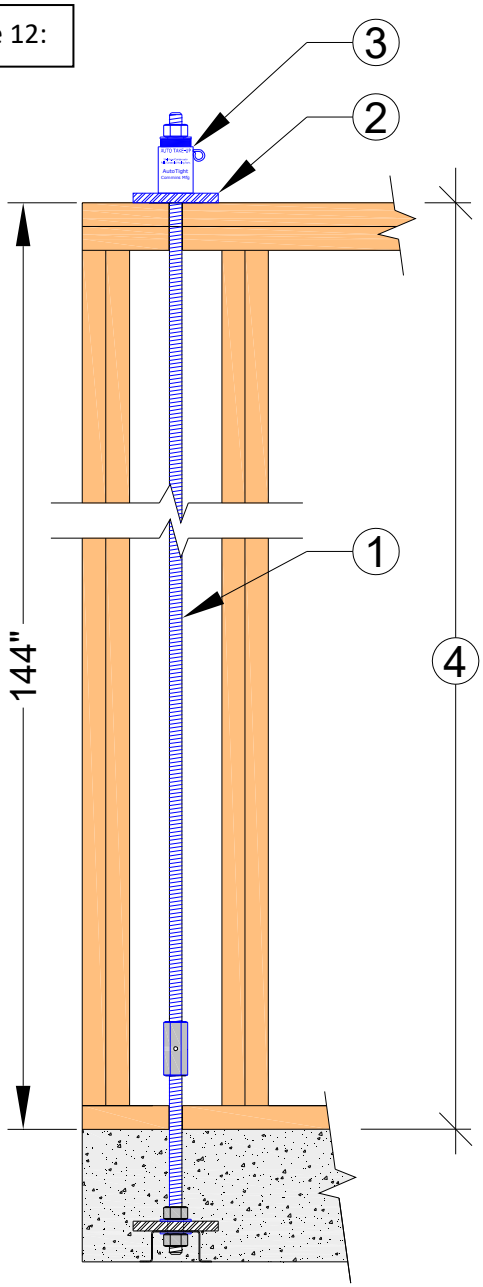
5-29-2025

Threaded Rod Systems, #7-10

Systems 7 thru 10 compare single-story rod tie-down systems designed to identical loads but with different hardware. System #7 has no TUD, #8 adds a screw TUD, #9 exchanges the screw TUD for a ratchet TUD, and #10 increases the rod diameter to help the ratchet TUD meet the 0.200" elongation specification.

SYSTEM ELEVATION

Figure 12:



SYSTEM SPECIFICATIONS

Rod Systems 7-10

Wood Species:	DF/SP
Required Uplift:	14,000 lbs.
Elongation:	0.20" See AC 316
Rod Length:	144"
Plate capacity:	15,000 lbs.
TUD:	see table
Δ_A @ Allowable Load	see table
Δ_R Seating Increment	see table

Tie-Down Legend

1. Rod, as called out, Story Height 144"
2. Bearing Plate
3. TUD as specified
4. Shrinkage 0.25" per floor

Drawing Notes:

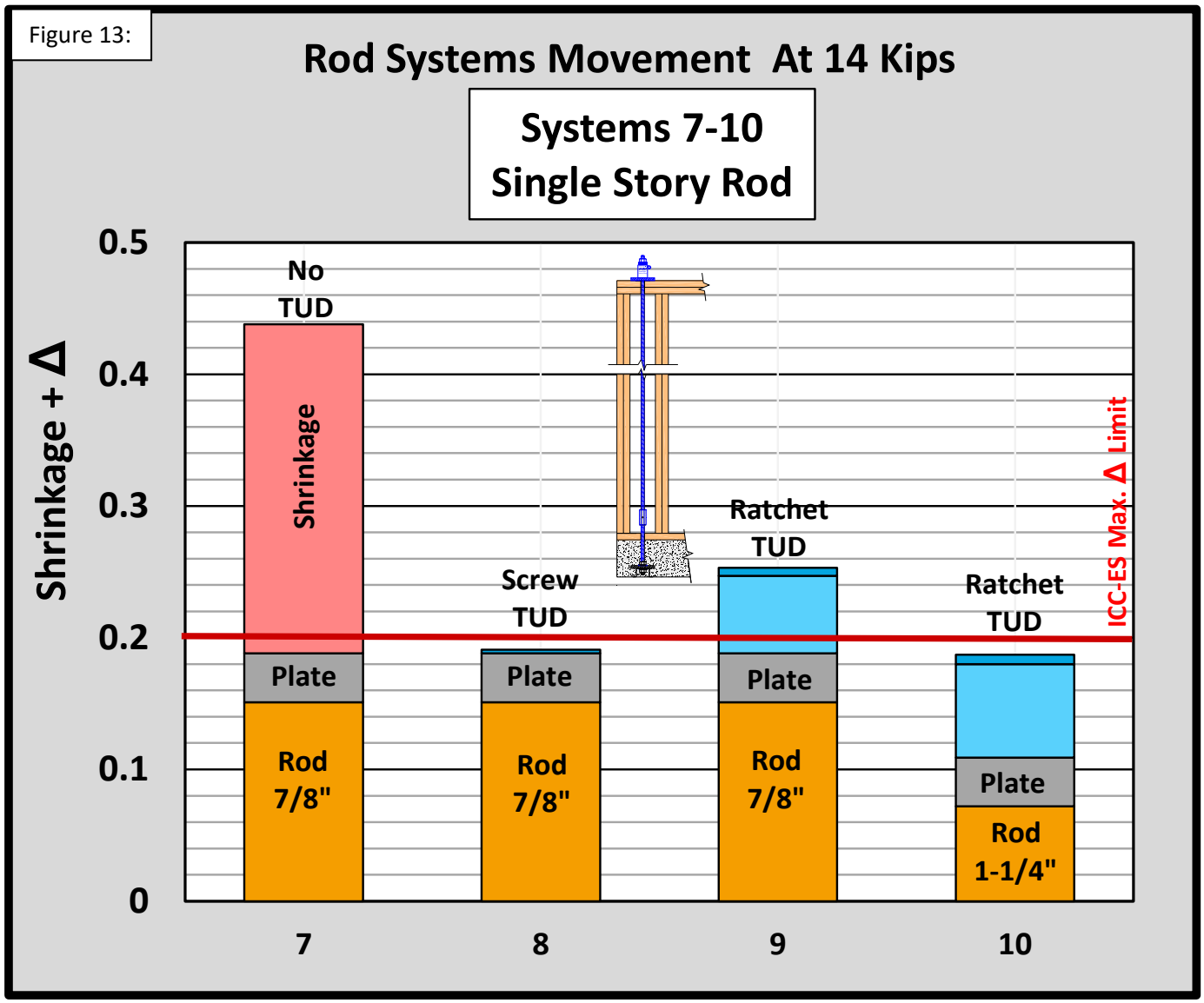
Inches are used for rod lengths and floor heights to minimize errors. The rod is out of the concrete 6". Shrinkage (per floor) and elongation (Δ_a) limit are per the EOR specification.

Reaction load is the design uplift per floor.

Note ; this analysis is for a single-story system. For multiple stories the reaction load would transfer through each floor while rod load would be the sum of the reaction loads from above.

Single Story Rod Systems #7-10

Figure 13:



Run		Movements							Totals
ID	TUD	Net Shrinkage	Plate Deflection Δ	Threaded Rod		TUD		Total Δ	% of
				Dia.	ΔA	ΔA	ΔR		Δa
7	No	0.250	0.037	7/8"	0.151	0	0	0.438	219%
8	Screw	0.000	0.037	7/8"	0.151	0.003	0	0.191	95%
9	Ratchet	0.000	0.037	7/8"	0.151	0.006	0.059	0.253	127%
10	Ratchet	0.000	0.037	1-1/4"	0.072	0.007	0.071	0.187	99%

All values shown in Inches (“)

Figure 14

Single Story Rod Systems #7-10

Commentary:

At the 0.200" mark a red line bisects the graph to show how each system meets the elongation limit.

Systems are rated at 14 kips.

Items contributing to Elongation are shown. ICC-ES code limit is 0.200".

Floor Height for the Rod System is 144"

Shrinkage 1/4".

Rod used in systems 7, 8, and 9 is F1554, Gr 55, 7/8" diameter.

Rod used in system 10 is F1554, Gr 36, 1-1/4" diameter.

NOTE: For TUD's the ΔR is always added in full and the ΔA is calculated at the specified loading. The ICC-ES code reports are the source of the appropriate numbers.

Usually, ΔR is the big difference between a ratchet and screw TUD.

System 7 does **Not** use a TUD. This adds 0.250" of shrinkage. Total movement is 219% of the elongation limit.
System 8 uses a screw TUD. Per AC316, Total elongation = 95% of elongation limit.
System 9 uses a ratchet TUD. Per AC316, Total elongation = 127% of elongation limit.
System 10 is identical to system 9 and uses a TUD. To meet the increased movement of the TUD, the rod size was increased from 7/8" to 1-1/4" (F1554 Gr 36). The reduced elongation of the larger rod enabled system 10 to meet the elongation limit. The cost upcharge would be about 50% !

For threaded rod, elongation is a function of the net tensile area. Increasing the rod diameter allows the system to meet the elongation limit with a ratchet, but at a substantial cost increase.

Note: The deflection on ratchet TUDs is highly variable. The testing required by ICC ES AC 316 is based expanding and loading on a minimum of 5 cycles. My observations of test cycles ycle has a large variation from the mean variability can easily be double the ΔR on some cycles.. This variability may rule out the use of ratchets. A step-by-Step calculation spread sheet is available for systems 7-10. (See Section 2.3)

Per ICC-ES AC 316:
Delta R is the looseness in a take-up-device as it moves to eliminate shrinkage or settling. (Per Section 1.4.7).
Per section 4.3.1, a minimum of 5 test replications shall be performed and the movements averaged.
Per section 4.3.2 Continuously varying devices (Screw TUDs) may have a very small .4.7 Device Average Travel and Seating Increment ("DR"): dR is defined as the average of the movement required to cause incremental motion from a seated position abnd the opposite movement required to reseat the device agter the actuation or ratching). The movement causing actuation or ratcheting is devined as D1 and the seating movement … is defined

Calculations: Systems 7-10. Section 2.3 (See section 3 for template instructions)

Figure 15:

Calculations: System 7, No Shrinkage Compensation

Level	1	Expected Shrinkage		0.250	AT unused expansion		N/A	Shrinkage compensated ?	N0	Shrinkage		0.250
		1.Rod Length Inches	2. Material Inputs				Component Strengths (kips)			6. Shrinkage-Elongation (Inches)		
Top Plate Term			Item	Name	Description		3. Capacity	4. Demand	5. D/C ratio	Name	Δ_{Design}	Rated	Elong.
Floor Above		6.00	TUD		N/A		N/A	14.00	-		ΔT= Δ_R	N/A	0
Termination		0.00									Δ_A	N/A	0
Story Height		144.00	Plate	S16-1-1/2"	1 x 3-1/4 x 8 x 1-1/2"		15.05		93%	S16-1-1/2"	Δ_A	0.040	0.037
Total		150	Item	rod	Dia	Alloy	Capacity	Demand	D/C ratio	Rod "L"	Demand "P"	Area	Elong.
Main		144	Rod-AT	R7 G55	7/8"	G55	16.91	14.00	83%	138.00	14.00	An 0.462	0.144
Start	CONC	6	Rod-AT	R7 G55	7/8"	G55	16.91		83%	6.00	14.00	An 0.462	0.006
DFL	100%		Strength Limiting		Plate	S16-1-1/2"	15.05	14.00	93%	Req.∑ ΔA	0.200	D/C 218.9%	∑ Δ 0.438

At 14 kips design load, system 7 has the same loading as the previous 6 examples. The difference? The story height is 12 feet and a TUD is not used. The system elongation of 0.438 is 219% higher than the design limit of 0.200".

Figure 16:

Calculations: System 8. Same as #7 but with Screw TUD.

Level	1	Expected Shrinkage		0.250	AT unused expansion		1.50	Shrinkage compensated ?	Yes	Shrinkage		0.000
		1.Rod Length Inches	2. Material Inputs				Component Strengths (kips)			6. Shrinkage-Elongation (Inches)		
Top Plate Term			Item	Name	Description		3. Capacity	4. Demand	5. D/C ratio	Name	Δ_{Design}	Rated	Elong.
Floor Above		6.00	TUD	AT10A-1.5	Fits 1-1/8" rod and a 1-1/4" rod. Has 1.62" Exp.		28.05	14.00	50%	AT10A-1.5	ΔT= Δ_R	0.000	0.000
Termination		0.00									Δ_A	0.020	0.003
Story Height		144.00	Plate	S16-1-1/2"	1 x 3-1/4 x 8 x 1-1/2"		15.05		93%	S16-1-1/2"	Δ_A	0.040	0.037
Total		150	Item	rod	Dia	Alloy	Capacity	Demand	D/C ratio	Rod "L"	Demand "P"	Area	Elong.
Main		144	Rod-AT	R7 G55	7/8"	G55	16.91	14.00	83%	138.00	14.00	An 0.462	0.144
Start	CONC	6	Rod-AT	R7 G55	7/8"	G55	16.91		83%	6.00	14.00	An 0.462	0.006
DFL	100%		Strength Limiting		Plate	S16-1-1/2"	15.05	14.00	93%	Req.∑ ΔA	0.200	D/C 95.4%	∑ Δ 0.191

The screw TUD adds 0.003" to elongation but eliminates the 0.250" (1/4") of shrinkage.

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Figure 17:

Calculations: System 9. Same as #7 but with Ratchet TUD

Level	1	Expected Shrinkage		0.250	AT unused expansion		N/A	Shrinkage compensated ?		Yes	Shrinkage		0.000
		1.Rod Length Inches	2. Material Inputs				Component Strengths (kips)			6. Shrinkage-Elongation (Inches)			
Top Plate Term			Item	Name	Description		3. Capacity	4. Demand	5. D/C ratio	Name		Δ_{Design}	Rated	Elong.
Floor Above		6.00	TUD	RTUD7	Ratchet TUD		28.18	14.00	50%	RTUD7	ΔT=	Δ_R	0.059	0.059
Termination		0.00										Δ_A	0.012	0.006
Story Height		144.00	Plate	S16-1-1/2"	1 x 3-1/4 x 8 x 1-1/2"		15.05		93%	S16-1-1/2"		Δ_A	0.040	0.037
Total		150	Item	rod	Dia	Alloy	Capacity	Demand	D/C ratio	Rod "L"	Demand "P"	Area		Elong.
Main		144	Rod-AT	R7 G55	7/8"	G55	16.91	14.00	83%	138.00	14.00	An	0.462	0.144
Start	CONC	6	Rod-AT	R7 G55	7/8"	G55	16.91		83%	6.00	14.00	An	0.462	0.006
DFL	100%		Strength Limiting		Plate	S16-1-1/2"	15.05	14.00	93%	Req.∑ ΔA	0.200	D/C 126.4%	∑Δ	0.253

The RTUD7 (ratchet) TUD adds 0.065" to the system movement. What is not said is the ratchet elongation is the average of 5 tests that may range from 0.010" to 0.125". This information is not shared. See below.

Figure 18:

Calculations: System 10. Same as #7, but with Ratchet TUD and rod changed to 1-1/4".

Level	1	Expected Shrinkage		0.250	AT unused expansion		N/A	Shrinkage compensated ?		Yes	Shrinkage		0.000
		1.Rod Length Inches	2. Material Inputs				Component Strengths (kips)			6. Shrinkage-Elongation (Inches)			
Top Plate Term			Item	Name	Description		3. Capacity	4. Demand	5. D/C ratio	Name		Δ_{Design}	Rated	Elong.
Floor Above		6.00	TUD	RTUD10	Ratchet TUD		47.94	14.00	29%	RTUD10	ΔT=	Δ_R	0.071	0.071
Termination		0.00										Δ_A	0.025	0.007
Story Height		144.00	Plate	S16-1-1/2"	1 x 3-1/4 x 8 x 1-1/2"		15.05		93%	S16-1-1/2"		Δ_A	0.040	0.037
Total		150	Item	rod	Dia	Alloy	Capacity	Demand	D/C ratio	Rod "L"	Demand "P"	Area		Elong.
Main		144	Rod-AT	R10 G55	1-1/4"	G55	34.51	14.00	41%	138.00	14.00	An	0.969	0.069
Start	CONC	6	Rod-AT	R10 G55	1-1/4"	G55	34.51		41%	6.00	14.00	An	0.969	0.003
DFL	100%		Strength Limiting		Plate	S16-1-1/2"	15.05	14.00	93%	Req.∑ ΔA	0.200	D/C 93.6%	∑Δ	0.187

Ratchet TUDs may work in Tie-Down Systems. But ratchet TUDs introduce movements that require large diameter rod to meet elongation requirements. I have seen calculations that leave out the movements in spite of the latest NDS requirements. Ratchet TUDs have also demonstrated large variations in the ΔR (Code listed ΔR +/- 0.070") which are not disclosed or used in the calculations.

To make an RTUD system perform to the stated 0.200 elongation limit requires using R10 (1-1/4") rod and changing to an RTUD 10 !

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