

<p><i>WABO/SEAW</i> <i>Liaison Committee</i> Washington Association of Building Officials & Structural Engineers Association of Washington</p>	<p>WHITE PAPER 9-2023</p>
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<p>Title: Threaded Rod Holdown Systems in Wood Frame Buildings</p>	<p>Dated: March 7, 2013 Issue Date: November, 2023¹</p>
<p>Abstract:</p> <p>This white paper establishes guidelines for specifications for building officials, design professionals, contractors and building owners relating to threaded rod holdown systems and associated anchorage of shear walls in wood frame buildings.</p> <p>Codes and Standard Reference:</p> <ul style="list-style-type: none"> • 2021 IBC • ASCE 7-16 • ACI 318-19 • 2018 NDS/2021 SDPWS 	<p>Committee Members: <i>Matt Snook (SEAW Co-chair), Julius Carreon (WABO Co-chair), Shalini Prochazka (SEAW), Rick Fine (SEAW), Nathalie Boeholt (WABO), Steve Belzak (WABO), Charlie Griffes (SEAW), Hoyt Jeter (WABO), Don Cole (WABO), Sandro Kodama (SEAW).</i></p>
<p>Committee Mission Statement:</p> <ul style="list-style-type: none"> • <i>Improve communications between the public jurisdictions that administer building codes and the engineering design community that prepares construction documents.</i> • <i>Improve consistency and quality of engineering submittals and project reviews.</i> • <i>Build consensus between the engineering design community and building officials with regard to code interpretation and submittal requirements.</i> 	

¹Appendix A added by members of the 2020 committee.

I. Introduction

Modern wood framed multi-story buildings often employ continuous threaded rod holdown systems to resist overturning forces in shear walls. The design of such systems is governed by the IBC, ACI 318, ASCE 7 and NDS. This white paper outlines recommendations and guidelines for specifying threaded rod systems including holdown anchor design in concrete.

II. Threaded Rod Holdown Specific System Specification

The Engineer of Record (EOR) can provide performance criteria for a holdown system supplier or may directly specify a holdown system and all the associated system components. Shrinkage compensating devices are often included in the design of four or more stories and must have a current approved evaluation report.

For performance criteria, the following list of items must be provided on the plans:

1. Plan view locations of shear walls and holdowns.
2. Cumulative tension loads per story.
3. Compression loads per story, including lumber grade and story wall heights.
4. Building shrinkage and consolidation allowances per story to determine the amount of travel required by the shrinkage compensating devices.
5. Rod system deformation limit (if required).
6. A requirement for the holdown submittal to be stamped by a registered design professional.

For holdown specific system criteria, the following list of items must be provided on the plans:

1. Plan view locations of shear walls and holdowns.
2. Specify the holdown system and approved alternates.
3. Specify rod diameters and steel material grade.
4. Specify bearing plate requirements.
5. Specify compression posting.
6. Specify shrinkage devices and couplers.
7. Rod system deformation limit (if required).
8. Fire-Retardant Wood Treatment (FRT) design value adjustment factors

III. Considerations for Anchor Design in Concrete

It is strongly recommended that the EOR provide the design of all anchors in concrete. This should not be a part of a deferred submittal. ACI 318 Chapter 17 provides the applicable seismic design requirements for the holdown anchorage of wood frame shear walls. The following list of items should be included in the design and shown on the drawings:

1. Anchor rod diameter and material grade.
2. Concrete strength.
3. Required anchor embedment depth including standoff distance or concrete cover.
4. Minimum anchor distance from edges and corners.
5. Reinforcement details for edge, corner and anchor group effects

COMMENTARY

C-II. Threaded Rod Holdown Specific System Specification

In four story structures and taller, the cumulative holdown forces and deformations will exceed the capabilities of conventional holdown connectors and straps. Threaded rod systems offer much higher design capacities and can provide for shrinkage compensation and building consolidation. Shrinkage compensators (or take-up devices) help eliminate loose connections for better shear wall performance.

Building Shrinkage Estimation: An estimate of dimensional change in wood due to shrinkage per story is required for the rod system supplier to determine the amount of travel required for their take-up device components. Shrinkage may be calculated on each project, or a typical value may be used for buildings having similar construction and similar initial moisture content in the lumber.

Estimation of wood shrinkage should account for the following:

- a) **Moisture content ("MC").** Consider the difference of initial MC to equilibrium MC of the region.
- b) **Building materials.** Consider sawn lumber floor joists vs I-joists and the wood species used on the project.
- c) **Framing methods.** Consider balloon or platform framing, floor joists resting or hanging on wall, etc.

Building Consolidation Estimation: Building consolidation or settlement is due to small gaps that occur between plates and studs, caused by items such as mis-cuts (short studs) and the lack of square-cut ends. These gaps can typically account for up to 1/8 inch per story. Installed lumber that is warped, bent, or twisted may also contribute to this amount of settlement.

Combined Shrinkage and Consolidation Amount: An estimate for total shrinkage and consolidation for a typical story wall is 1/4 to 1/2 inch per floor¹.

Performance-Based vs Holdown Specific System Criteria:

This document provides a guide for the use of performance criteria or holdown specific system criteria. The engineer shall check with the local building authority to verify if a holdown system may be a deferred submittal or if the components of a specific threaded rod system will need to be included for permit submittal.

For performance-based criteria, the engineer shall show tension and compression loads in a consolidated multistory table format with the vertical “runs” defined. This will make it easier for both the rod system supplier to create the shop drawings and the engineer to check them. This table may include representative rod diameters with steel material grade requirements in lieu of tension forces.

For holdown specific system criteria, it is recommended that the EOR provide the specific system components on the structural plans to eliminate a deferred submittal. The engineer is encouraged to engage a specific rod system supplier to provide design assistance. Online design tools are available at no charge and will provide CAD details and calculations. If the holdown design is performed by an engineer other than the EOR, they need to stamp and seal their own sheets and the EOR shall add their deferred submittal approval stamp.

Compression Stud/Post Design: Basic design is referenced by code to use NDS. Load combinations are per ASCE 7 criteria. This includes the combination of dead and live loads with seismic or wind loads. This will control the design of the compression studs and is typically limited by buckling or bearing perpendicular to grain on the wood plate.

Building Drift. Part of the overall building analysis and design criteria is to consider the code story drift limitations. The code limits this “story drift” to about 2½% of building story height up to four stories and 2% for five stories or higher per ASCE 7. There are two primary reasons for this consideration:

- a) Building separation.
- b) Damage to interior elements.

Drift often controls the design of shear walls and the associated tie-down system on taller wood buildings that are 5 or more stories. Drift calculations should be done for all taller wood buildings and deflection design criteria and limits for the tie-down system should be specified in the design documents.

Rod System Deformation Limit: Take-up device evaluation reports conforming to ICC AC 316 will require the rod system to have a total vertical deformation (that includes steel rod elongation and the shrinkage compensating device deflection) less than or equal to 0.20 inch (5 mm) for each story, or between restraints, whichever is more restrictive, using allowable stress design (ASD). This vertical limit may be exceeded if the EOR can demonstrate 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.

The rod system deformation limit per story is required to be specified by the EOR for both performance-based criteria and holdown system specific specifications.

Shrinkage and Consolidation Amount in Drift Calculations: Note that if a holdown system with shrinkage compensation is used, the amount of shrinkage and consolidation calculated per story should not be included in the four-part drift equation. Conventional systems without shrinkage compensation will require these amounts to be included in drift analysis.

C-III. Considerations for Anchor Design in Concrete

Most wood frame walls are supported by concrete stem walls or concrete podium slabs. Some engineering firms try including the anchorage design as part of the “deferred submittal” package to be provided by the holdown system supplier. It is strongly recommended that the EOR design the anchorage in concrete prior to permit submittal. If the anchorage design is delegated to another

party, it should be submitted at the time of permit to allow the AHJ appropriate time for review unless the AHJ approves otherwise. Requirements on deferred submittals vary by jurisdiction and shall be verified before permit submittal. This may avoid a situation that is not code compliant and difficult or impossible to rectify. This would avoid creating scheduling and cost problems for the project since there may be hidden costs for anchorage design and additional reinforcement. This will also impact the project schedule including increased time for building department review and construction cost. Note that the shear wall overturning forces, and associated force couples, shall also be considered for the design of the supporting slab design. This includes the amplified design force as required by ASCE 7 Section 12.3.3.3.

Determining the Size of Rod for Anchorage to Concrete:

To design the rod size and material grade for anchorage to concrete, the EOR must consider the following:

- a) Shear loads from wind/seismic criteria as resisted by the wall sheathing.
- b) These forces then create overturning moments based on shear wall length. These moments are resisted by uplift on the holdown system and compression on the studs at the ends of the wall.
- c) Stacked shear walls will have cumulative uplift and download forces.
- d) The anchor rod size does not necessarily need to match the size of the holdown system rod immediately above. There are designs where the holdown rod above the anchor is enlarged only to reduce elongation, not for strength. In these cases, the anchor rod may have adequate strength capacity in accordance with ACI 318 Chapter 17 and may not need to be enlarged to match the holdown rod diameter above.
- e) Supporting concrete member thickness and material properties.

References:

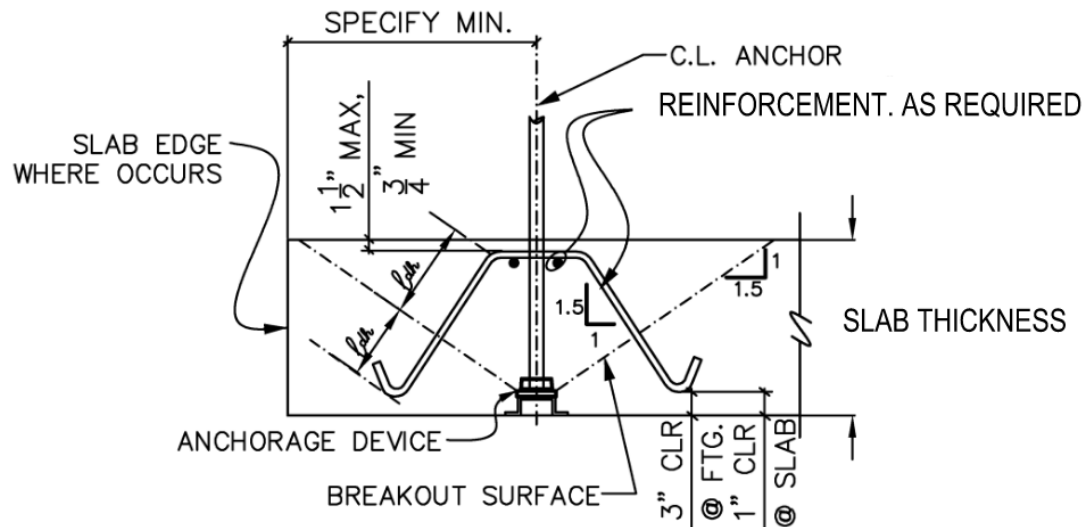
- ¹ Five-Story Wood-frame Structure over Podium Slab, Woodworks.org Design Example, March 2017, Douglas Thompson, PE, SE, SECB, STB Structural Engineers.

<https://www.woodworks.org/wp-content/uploads/Five-Story-Wood-Frame-Structure-over-Podium-Slab-WoodWorks-Dec-2017.pdf>

Thank you to the following original committee members for their contributions to this white paper: Mark D'Amato (SEAW), Charlie Griffes (SEAW), Lee Kranz(WABO), Chris Ricketts (WABO), Jon Siu (WABO), Rick Fine (SEAW), Larry Lindell (SEAW), Mary Kate Martin (WABO), and Ed Chin (SEAW).

Sample Detail #1 REBAR REINFORCEMENT

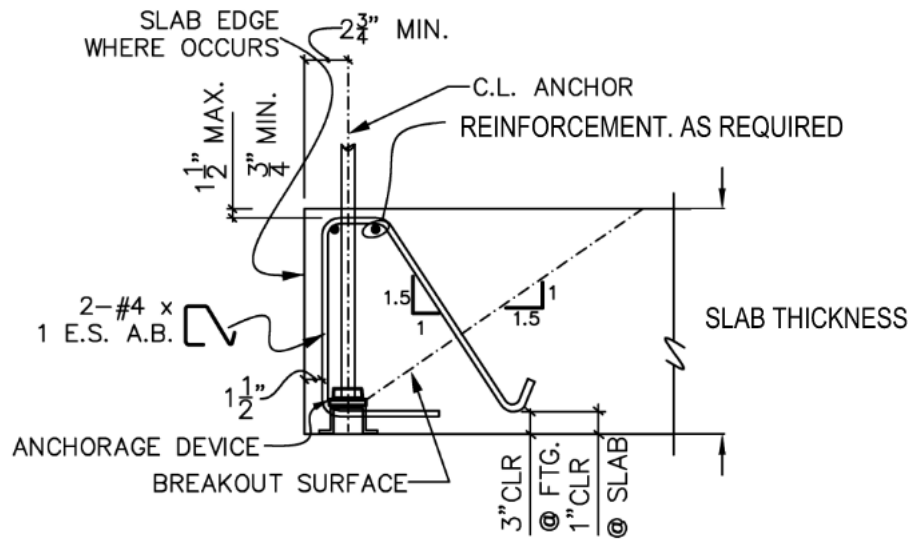
Anchors in the field of thicker slabs may develop the rebar hook development length “ l_{dh} ” on each side of the breakout surface. Reinforcement, spacing and layout shall be determined per ACI. See below for an example detail.



REBAR REINFORCEMENT EXAMPLE

Sample Detail #2 REBAR REINFORCEMENT EDGE CONDITION

Anchors near slab or footing edges are usually controlled by one of the concrete modes of failure in ACI 318 Chapter 17 and thus will require reinforcing. When wood frame shear walls are parallel to the slab edge, “side breakout” mode will always govern and therefore reinforcing will be required. Anchoring the rebar is the key to proper detailing when there is limited concrete space. This detail will work in thicker slabs and footings.



REBAR REINFORCEMENT EDGE EXAMPLE