TECHNICAL BULLETIN

DESIGNING WIND UPLIFT ROD TIE-DOWN SYSTEMS

ICC-ES PASSES AC391

A Quick History of Wind Uplift Rod Systems

For the past decade, rod tie-down systems have been used by the wood light-framed construction industry to resist wind uplift forces. Yet codes and standards have not provided detailed guidance for design of these systems. Designers, consequently, have been forced to rely entirely on engineering judgment to create this load path.

This lack of guidance sometimes led to rod-restraint spacing based on rod tension and bearing plate capacities alone. This design neglects the wood components of the system and may lead to rods spaced too far apart, compromising the continuous load path, causing building damage and creating life-safety issues.

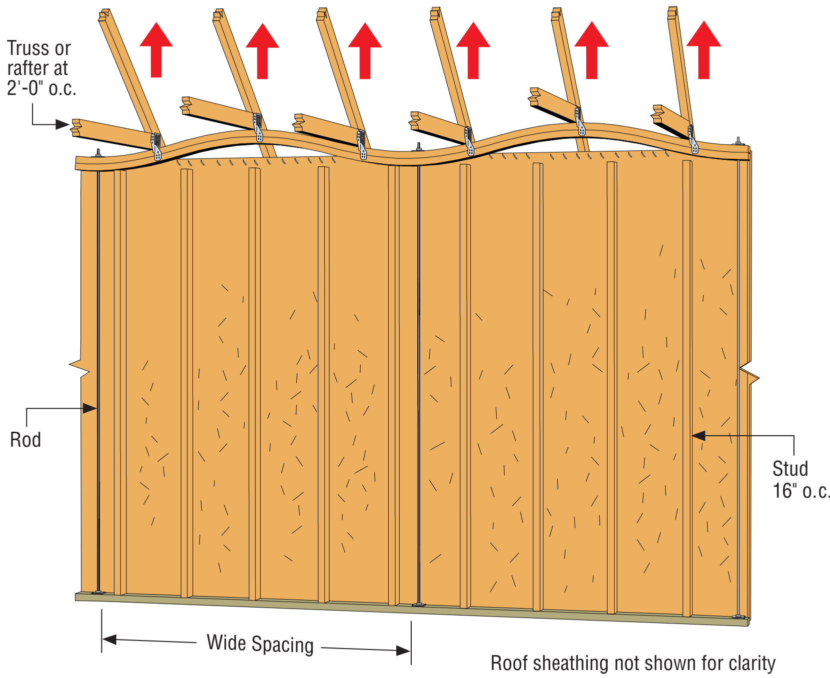


Figure 1: Excessive spacing of rod restraints to resist high uplift forces could cause failure of the top plate

Industry Guidance

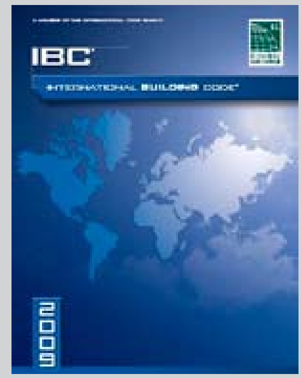
In June 2010, ICC-ES passed and made effective Acceptance Criteria #391 after multiple public hearings that garnered engineer, manufacturer, building official and other third-party input. AC391 established guidelines for the evaluation of either:

- The steel components comprising continuous rod tie-down runs (CRTR) only
- The entire continuous rod tie-down system (CRTS), which includes CRTR and the light-framed wood structure used to resist wind uplift

These same guidelines in AC391 can be used by project designers themselves to lay out continuous rod tie-down systems to resist wind uplift. This technical bulletin shows the important steps required in AC391 to design the system properly. These steps are illustrated and summarized on the following pages of this bulletin. The last page describes the two types of evaluation reports that a manufacturer can obtain from ICC-ES and clarifies the workload of the licensed design professional for the project when specifying a product with a CRTR report vs. a product with a CRTS evaluation report.

Steps for Developing an Evaluation Report

STEP 1
Refer to Building Code



STEP 2
IBC Section 104.11 Alternate Materials, Design, and Methods of Construction and Equipment

STEP 3
Acceptance Criteria Developed for Products through Public Process

STEP 4
Code Report Issued After Testing/Calculations approved by ICC-ES

TECHNICAL BULLETIN

DESIGNING WIND UPLIFT ROD TIE-DOWN SYSTEMS

ICC-ES PASSES AC391

SIMPSON Strong-Tie®

Specific Design and Detailing Requirements of AC391

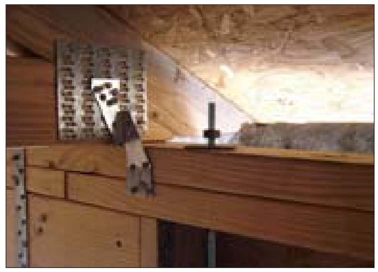
Illustrations of AC391 requirements – The letters refer to connection locations shown in the table on the next page.

G AC391 – Section 3.2.1.2

E AC391 – Section 3.2.2.2

F AC391 – Sections 3.1.1, 6.2.1.3 and 6.3.1.3

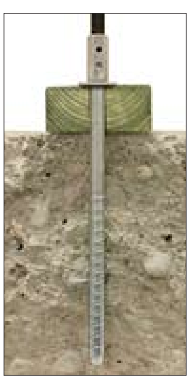
D AC391 – Section 3.2.2.1



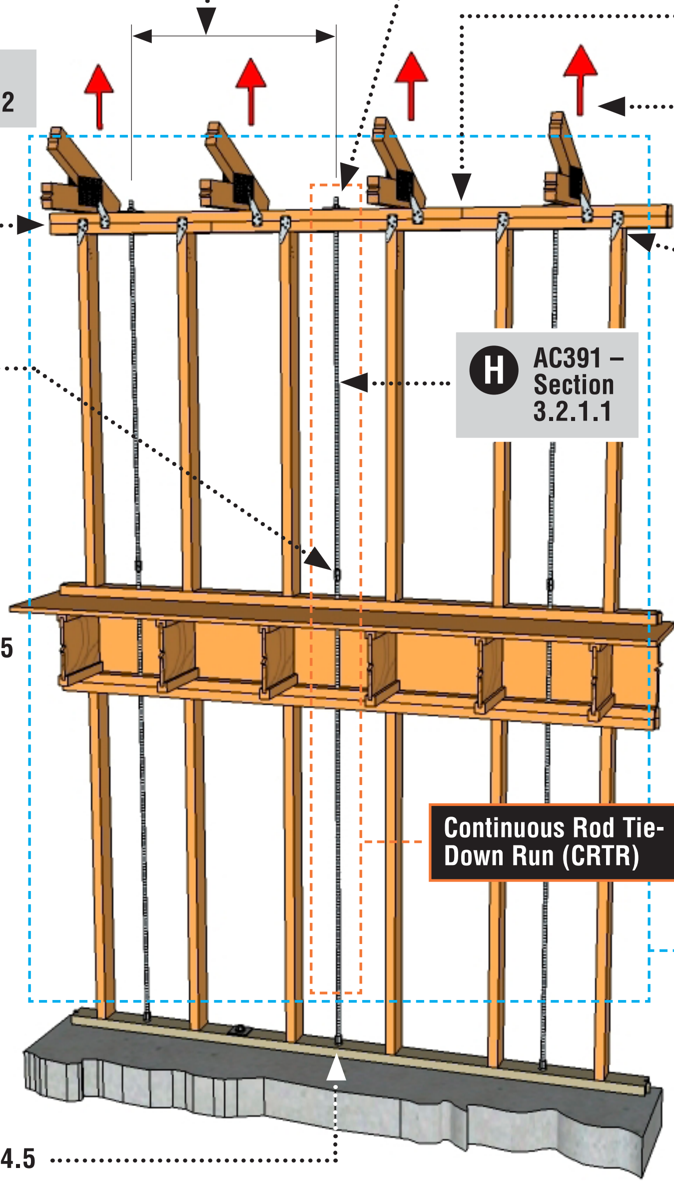
B AC391 – Section 3.2.2

A AC391 – Section 1.2.1.1

I AC391 – Sections 1.4.5 and 3.4.1.1

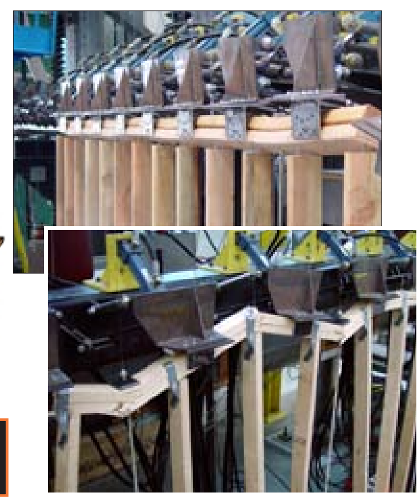


J AC391 – Sections 6.2.4.5 and 6.3.3.5



H AC391 – Section 3.2.1.1

C AC391 – Section 3.2.2.3



Continuous Rod Tie-Down System (CRTS) (includes CRTR)

DESIGNING WIND UPLIFT ROD TIE-DOWN SYSTEMS

ICC-ES PASSES AC391

SIMPSON Strong-Tie®

Specific Design and Detailing Requirements of AC391

Connection Location	Requirement	Section
A	Use of Continuous Rod Tie-down Runs (CRTR) and Continuous Rod Tie-down Systems (CRTS) evaluated under AC391 is limited to resisting roof wind uplift in wood light-framed construction. Specifically excluded from AC391 is the use of rod tie-down runs to resist shear wall overturning forces or use in cold-formed steel framing.	1.2
B	CRTS allowable loads shall be evaluated and be limited by • Tie-down run steel component capacities per 3.1.1, or • Wood deflection limitations per 3.2.2.2, or • Flexural (bending) stress per 3.2.2.1, or • Shear stress perpendicular to grain per 3.2.2.4, or • Combined axial (chord/drag force) and flexural (bending) stresses per 3.2.2.5	3.1.1 and 3.2.2
C	Top-plate torsion (rotation) must be prevented due to offsets between the point of load application *(e.g. hurricane ties at the sides of the top plates)* and load resistance *(e.g. rods at the center of the top plate)*. This can be accomplished by providing a positive connection from the top plate to stud on the same side of the wall as the roof framing to wall connection.	3.2.2.3
D	Approved top plate splice details must be provided for the CRTS to utilize both top plates in bending, otherwise only the capacity of a single top plate may be used.	3.2.2.1
E	The deflection of the top plates in bending occurring between CRTR is limited to L/240, where L is the length of the top plates between tie-down runs. Additionally, the sum of the rod elongation and the deflection of the top plates between tie-down runs shall not exceed 0.25 inches at the applied (ASD) load.	3.2.2.2
F	The effects of wood shrinkage on the overall deflection of the CRTS shall be analyzed by a registered design professional, and a method of addressing wood shrinkage in the system shall be provided. If shrinkage compensating devices are used, they shall meet AC316 requirements.	3.1.1, 6.2.1.3, and 6.3.1.3
G	Steel bearing plates shall be sized for proper length, width and thickness based on steel cantilever bending action and wood bearing. Deflection from bearing compression (up to 0.04") must be included in overall deflection calculations.	3.2.1.2 and Figure 1
H	Rod elongation is limited to 0.18 inches for total rod length at the applied (ASD) load.	3.2.1.1
I	Proof of positive connection between threaded rod and threaded rod couplers shall be provided *(e.g. sight holes or other method)*. Rod couplers must also be tested to prove they can develop at least 100% of the rod's tensile strength and 125% of the rod's yield strength.	1.4.5 and 3.4.1.1
J	Design of the anchorage is the responsibility of the design professional and must be performed in accordance with the applicable code.	6.2.4.5 and 6.3.3.5

AC391 can be found on the ICC-ES web site: ***http://www.icc-es.org/criteria/pdf_files/AC391.pdf***

DESIGNING WIND UPLIFT ROD TIE-DOWN SYSTEMS

ICC-ES PASSES AC391

SIMPSON Strong-Tie®

CRTS Reports Make Specifications Easier

Evaluation reports that meet all the testing and calculation requirements for a CRTS will provide a comprehensive description of the system, including CRTR spacing, framing member requirements, and allowable uniform uplift load that can easily be reviewed and approved by engineers and building officials. The Designer then only needs to follow the tables provided to design the wind uplift restraint system.

Evaluation reports that meet only the testing and calculation requirements for the steel components comprising the CRTR leave the bulk of the design work for the Designer; including all the wood component stresses, deflections and shrinkage. ICC-ES has not evaluated anything but the CRTR component information in this type of report. Simpson Strong-Tie recommends that Designers should always choose CRTS reports.

What rod system manufacturer do I specify?

Tie-Down Component Only Report (CRTR)

1. Designer Responsibilities:

- ☐ Design of wood top plates
  - ☐ Design top plate splice detail to utilize both plates in flat bending when required
  - ☐ Calculate top-plate deflection between CRTR
  - ☐ Calculate top plate flexural stress
  - ☐ Check combined axial and flexural stress when top plate is a drag strut
- ☐ Calculate top-plate rotation force and provide method to restrain torsion forces
  - ☐ Ensure cross-grain tension is not a system failure mode
- ☐ Calculate wood shrinkage and provide a means to account for shrinkage effects
- ☐ Calculate bearing plate deformation and crushing and add to overall deflection
- ☐ Define CRTR layout based on wind uplift loads and system capacities calculated
  - ☐ Define all wood detailing requirements for wood uplift system
- ☐ Design shearwall overturning restraint system *(It is outside the scope of AC391)*

2. Manufacturer Responsibilities:

- ☑ Provide CRTR steel component properties
- ☑ Test coupler nuts & other proprietary components
- ☑ Calculate steel rod strength and elongation *(limited to 0.18")*
- ☑ Calculate bearing plate capacities *(based on wood bearing and steel bending limits)*

Full Tie-Down System Report (CRTS)

1. Designer Responsibilities:

- ☐ Determine project wind uplift loads
- ☐ Select approved CRTS system and required details from MFG evaluation report
- ☐ Design shearwall overturning restraint system *(It is outside the scope of AC391)*

2. Manufacturer Responsibilities:

- ☑ Provide CRTR steel component properties
- ☑ Test coupler nuts and other proprietary components
- ☑ Calculate steel rod strength and elongation *(limited to 0.18")*
- ☑ Calculate bearing plate capacities *(based on wood bearing and steel bending limits)* and deflection based on wood plate crushing
- ☑ Design of wood top plates
  - ☑ Calculate or test top plate deflection between CRTR
  - ☑ Calculate or test top-plate flexural stress
  - ☑ Check combined axial and flexural stress when top plate is a drag strut
  - ☑ Provide approved top plate splice detail where both plates are used in flat bending
- ☑ Calculate top-plate rotation force and provide method to restrain torsion forces
  - ☑ Ensure cross-grain tension is not a system failure mode
- ☑ Calculate wood shrinkage and provide a means to account for shrinkage effects
- ☑ Define CRTS, including CRTR layout and detailing requirements