Force Transfer Around Openings Update


Presented by Aleeta Dene, P.E.

Shear Wall Design Challenges (SDPWS-15 4.3.5)

Segmented

- Only full height segments considered
- Aspect ratio calculated using full wall height
- Hold-downs required on each segment

Perforated

- Openings accounted for by empirical adjustment factor
- Aspect ratio calculated using full wall height
- Uplift anchorage at full height segments required
- Hold-downs only at ends

Force Transfer

- Hold-downs only at ends
- Openings accounted for by strapping or framing
- Aspect ratio calculated using opening height

Aspect Ratio (SDPWS-15 Section 4.3.4.2)

- Definition of h and b_s is the same as previous code
- ALL shear walls with 2:1 < aspect ratios ≤ 3.5:1 shall apply aspect ratio adjustment factor
  - Formerly applied only to high seismic
- New Aspect Ratio Factor (WSP) = $1.25-0.125h/b_s$
- Previous adjustment factor can still be used (SDPWS-15 section 4.3.3.4.1 Exception #1)

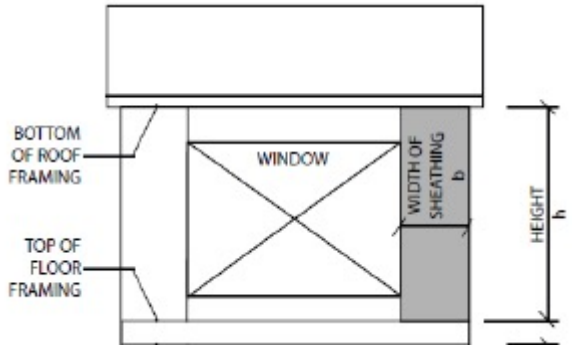


Fig 4D h:b_s ratio Segmented

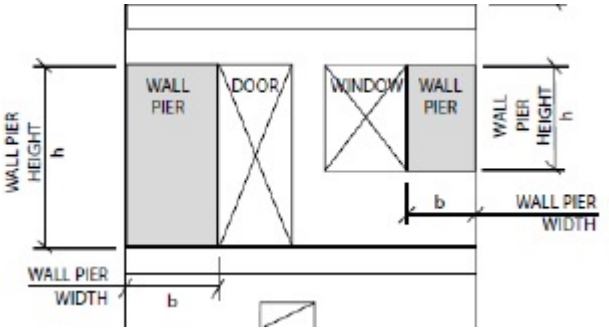


Fig. 4E h:b_s ratio FTAO

Different Techniques for FTAO

- Drag Strut Analogy
- Cantilever Beam Analogy
- Diekmann Method
- Thompson Method

FTAO Research at APA

Joint research project

- APA - The Engineered Wood Association (Skaggs & Yeh)
- University of British Columbia (Lam & Li)
- USDA Forest Products Laboratory (Rammer & Wacker)

Measured vs. Predicted Strap Forces

= analysis method less than lab results

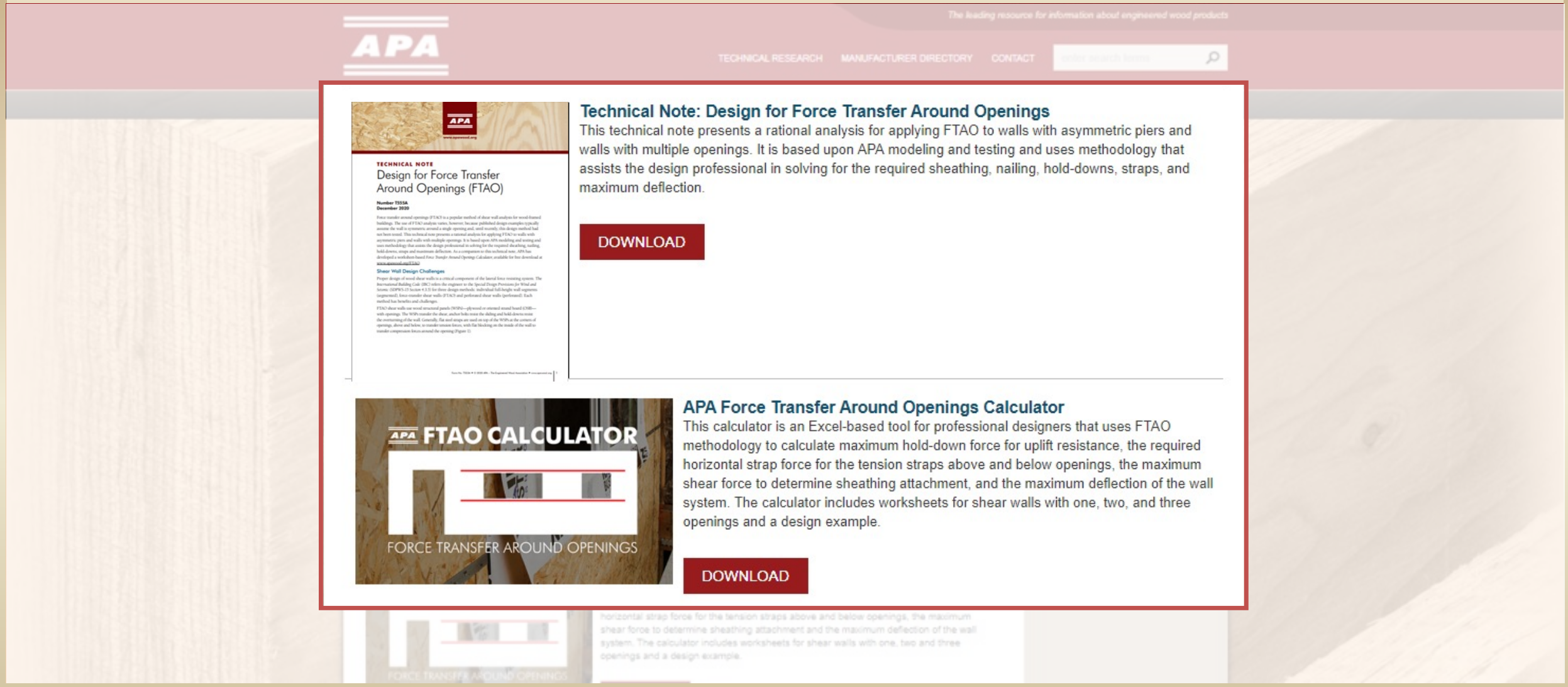
Wall ID	Measured Strap Forces (lbf) [1]		Error [2] For Predicted Strap Forces at ASD Capacity (%)						
			Drag Strut Technique		Cantilever Beam Technique		Diekmann Technique	SEAOC/Thompson Technique	
	Top	Bottom	Top	Bottom	Top	Bottom	Top/Bottom	Top	Bottom
Wall 4a	687	1,485	178%	82%	652%	183%	132%	406%	115%
Wall 4b	560	1,477	219%	83%	800%	184%	133%	499%	115%
Wall 4c [3]	668	1,316	183%	93%	670%	207%	149%	418%	129%
Wall 4d	1,006	1,665	122%	73%	445%	164%	118%	278%	102%
Wall 5b	1,883	1,809	65%	68%	327%	256%	173%	204%	160%
Wall 5c [3]	1,611	1,744	76%	70%	382%	265%	187%	238%	166%
Wall 5d	1,633	2,307	75%	53%	377%	201%	141%	235%	125%
Wall 6a	421	477	291%	256%	1063%	571%	410%	663%	357%
Wall 6b	609	614	201%	199%	735%	444%	319%	458%	277%
Wall 8a	985	1,347	118%	86%	808%	359%	138%	269%	120%
Wall 8b [4]	1,493	1,079	78%	108%	533%	449%	124%	177%	150%
Wall 9a	1,675	1,653	69%	70%	475%	383%	185%	217%	166%
Wall 9b	1,671	1,594	69%	73%	476%	397%	185%	218%	172%
Wall 10a	1,580	n.a. [5]	73%	n.a. [5]	496%	n.a. [5]	n.a. [5]	n.a. [5]	n.a. [5]
Wall 10b	2,002	n.a. [5]	58%	n.a. [5]	391%	n.a. [5]	n.a. [5]	n.a. [5]	n.a. [5]
Wall 11a	2,466	n.a. [5]	47%	n.a. [5]	318%	n.a. [5]	n.a. [5]	n.a. [5]	n.a. [5]
Wall 11b	3,062	n.a. [5]	38%	n.a. [5]	256%	n.a. [5]	n.a. [5]	n.a. [5]	n.a. [5]
Wall 12a	807	1,163	81%	94%	593%	348%	128%	172%	120%
Wall 12b	1,083	1,002	60%	109%	442%	403%	138%	128%	139%

= analysis method greater than lab results by > 300%

Testing Conclusions

- Comparison of analytical methods with tested values for walls detailed as FTAO
  - The drag strut technique was consistently un-conservative
  - The cantilever beam technique was consistently ultra-conservative
  - Thompson provided similar results as Diekmann
  - Thompson & Diekmann techniques provided reasonable agreement with measured corner forces
- Use results to provide better guidance to engineers for FTAO
  - Summary of findings for validation of techniques
  - New tools for FTAO shear wall design

www.apawood.org/ftao



FTAO Technical Note: Form T555

APA

www.apawood.org

TECHNICAL NOTE

Design for Force Transfer Around Openings (FTAO)

Number T555A
December 2020

Force transfer around openings (FTAO) is a popular method of shear wall analysis for wood-framed buildings. The use of FTAO analysis varies, however, because published design examples typically assume the wall is symmetric around a single opening and, until recently, this design method had not been tested. This technical note presents a rational analysis for applying FTAO to walls with asymmetric piers and walls with multiple openings. It is based upon APA modeling and testing and uses methodology that assists the design professional in solving for the required sheathing, nailing, hold-downs, straps and maximum deflection. As a companion to this technical note, APA has developed a worksheet-based *Force Transfer Around Opening Calculator*, available for free download at www.apawood.org/FTAO

Shear Wall Design Challenges

Proper design of wood shear walls is a critical component of the lateral force resisting system. The *International Building Code* (IBC) refers the engineer to the *Special Design Provisions for Wind and Seismic*. (SDPWS-15 Section 4.3.5) for three design methods: individual full-height wall segments (segmented), force-transfer shear walls (FTAO) and perforated shear walls (perforated). Each method has benefits and challenges.

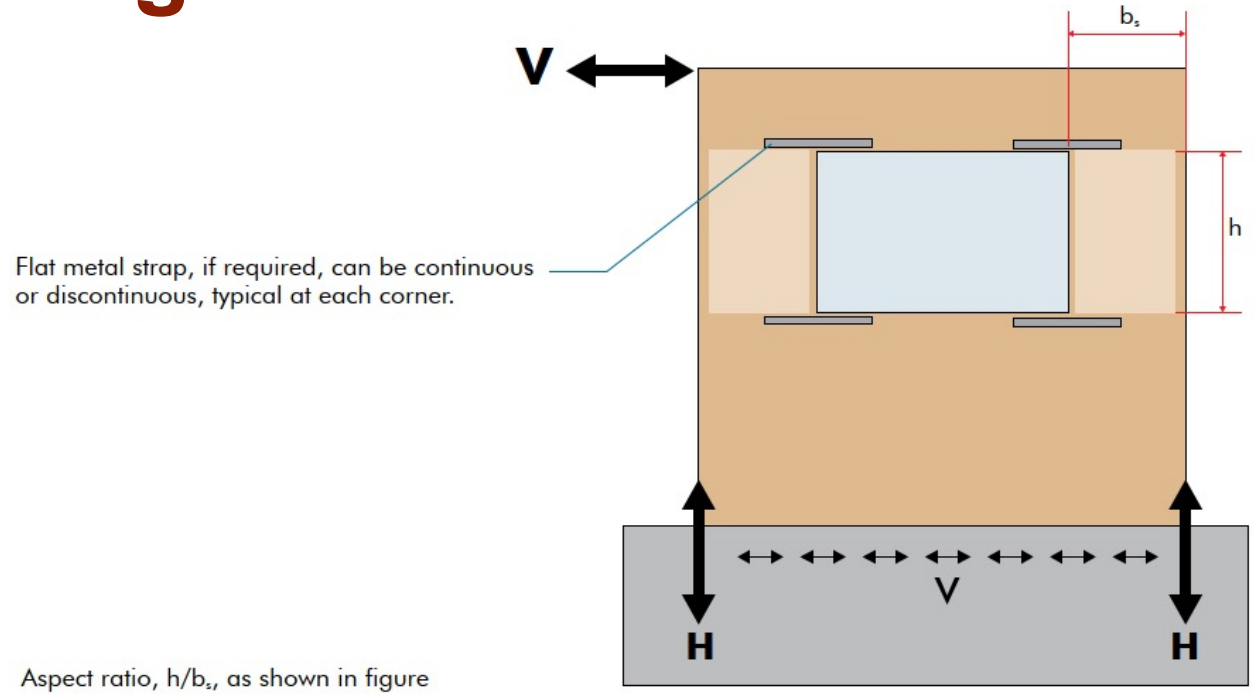
FTAO shear walls use wood structural panels (WSPs)—plywood or oriented strand board (OSB)—with openings. The WSPs transfer the shear, anchor bolts resist the sliding and hold-downs resist the overturning of the wall. Generally, flat steel straps are used on top of the WSPs at the corners of openings, above and below, to transfer tension forces, with flat blocking on the inside of the wall to transfer compression forces around the opening (Figure 1).

- Technical Note: Design for Force Transfer Around Openings (FTAO)
- Presents a rational analysis for applying FTAO to walls with asymmetric piers and walls with multiple openings
- Based on Wall 12 testing configuration
- Includes a design example with 2 wall openings

What's New – Technical Note?

Technical note T555 changes:

- Graphics modified to show corner strapping discontinuous
- Text modified to emphasize strapping does not need to be continuous



APA FTAO Calculator

- Excel-based tool
- Based on Diekmann method
- Calculates:
  - Max hold-down force for uplift resistance
  - Required horizontal corner force above and below openings
  - Max shear force for sheathing attachments
  - Max deflection

APA Force Transfer Around Openings Calculator

This calculator is an Excel-based tool for professional designers that uses FTAO methodology to calculate maximum hold-down force for uplift resistance, the required horizontal strap force for the tension straps above and below openings, the maximum shear force to determine sheathing attachment, and the maximum deflection of the wall system. The calculator includes worksheets for shear walls with one, two, and three openings and a design example.

DOWNLOAD

Calculator Expiration Date

When the expiration date is past:

- Calculator will continue to function properly
- Header will change to indicate it has expired

What's New?

Calculator changes:

- User has the option to select no aspect ratio factor be applied
  - To allow use with wind loads under 2008 SDPWS
- User must enter the induced shear load in the deflection section
  - To allow use with wind loads and LRFD
- Error messages added in deflection section regarding materials selections
  - Alert user regarding material availability and code limitations
- Error message added in shear wall analysis section regarding minimum 18" pier length requirement
  - Alert user regarding design limitations
- Calculator has an expiration date
  - Ensure user is using the most current version

APA CASE STUDY

Going for Bold:
Window into Affordability

Long Beach looks to an inclusive future with Las Ventanas development

To help address the local homelessness crisis, Long Beach, California, enacted the "Everyone Home Long Beach" plan—an initiative that encouraged innovative, low-income housing solutions for the community. This plan sparked the bold vision for the development of a modern, affordable housing complex dubbed Las Ventanas, which means "the windows," a fitting name for a project that provides new windows of opportunity to low-income residents looking for housing options.

With a modest $28 million budget, it was vital for the designers and contractors to provide creative and strategic planning and construction of the affordable housing complex. Three local companies brought their unique expertise to tackle the project: AMCAL General Contractors, of Agoura Hills; CORE Structure Inc., with locations in Laguna Hills and the Bay Area; and William Hezmalhalch Architects (WHA), with offices in Orange County, Los Angeles and the Bay Area. These firms came equipped with decades-long histories of providing creative and cost-efficient multifamily construction solutions.

The striking bright red, four-story apartment complex was designed by WHA and CORE Structure Inc., though AMCAL was involved during the early design stage and provided regular feedback to the design team.

APA

It's an FTAO World!

- Narrower Piers
- Larger Openings
- Reduced Hold-downs