WoodWorks

Cantilever Wood Diaphragm Webinar Series

A Design Example of a Wood Cantilever Diaphragm

Part 4-Torsional Irregularity, Other Design Checks, and Final Comments

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

This webinar will conclude the open front diaphragm design example by analyzing the degree of torsional irregularity and amplification of accidental torsion. ASCE 7 and SDPWS irregularity code triggers and design impacts will be explained, and verification of the redundancy factor will be reviewed. Other topics will include requirements for the use of overstrength factors for struts and collectors, and new concepts on the connectivity of stacked, multi-story shear walls in wood-frame buildings.

Learning Objectives

1. Discuss evolutions in mid-rise building typology that have led to the need for open-front diaphragm analysis.
2. Review diaphragm flexibility provisions in ASCE 7 and the 2015 Special Design Provisions for Wind & Seismic (SDPWS).
3. Explore one option for open-front diaphragm analysis under seismic and wind loading in a wood-frame structure.
4. Highlight how to calculate story drift, diaphragm deflection and torsional irregularities, and discover their effects on load distribution through a cantilever diaphragm structure.

Fasten Your Seatbelts

5 out of 5 Calculators

WoodWorks **Example and Method of Analysis:**

- **The solutions paper and this webinar were developed independently from the AWC task group for open-front diaphragms. The method of analysis used in this example is based on our engineering judgement, experience, and interpretation of codes and standards as to how they might relate to open-front structures.**
- **The analysis techniques provided in this presentation are intended to demonstrate one method of analysis, but not the only means of analysis. The techniques and examples shown here are provided as guidance and information for designers and engineers.**

Contents and Learning Objectives

Torsional Irregularity, Other Design Checks, and Final Comments:

- **Torsional irregularity**

  Torsional irregularity code requirements and the method of analysis used to determine torsional irregularities will be presented.

- **Amplification of accidental torsion**

  Code requirements regarding amplification of accidental torsion will be discussed, and the amplification factor will be verified.

- **Redundancy**

  Code requirements and verification of redundancy will be reviewed.

- **Transverse direction design**

  The design will continue for the transverse direction. The selection of a flexible vs. rigid diaphragm approach will be reviewed.

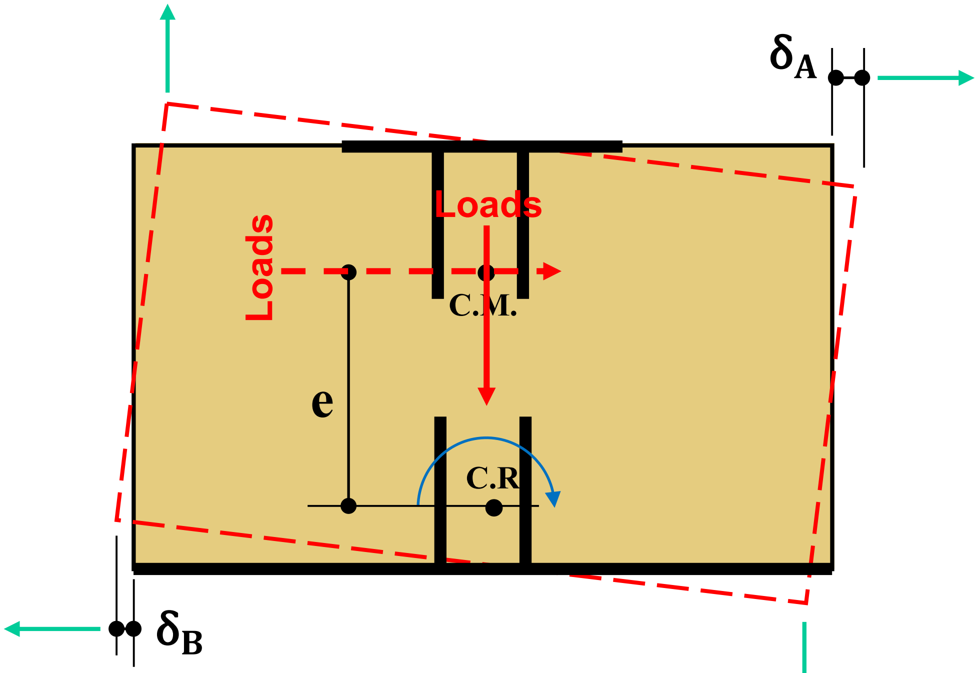
- **Multi-story shear wall effects**

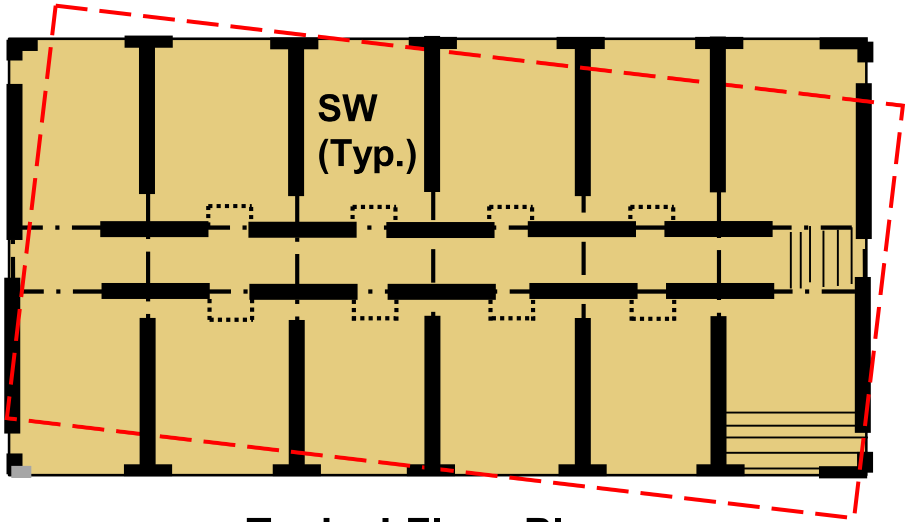
  Multi-story shear wall connectivity and it's effects will be discussed.

Questions

1. When does a loss in stiffness in the exterior walls cause an open-front diaphragm condition?
2. What is the deflection equation for open-front/cantilever diaphragms?
3. How is diaphragm flexibility defined for open-front/cantilever diaphragms vs. ASCE 7-16, Figure 12.3-1?
4. What are the available methods of distributing torsional forces into the diaphragm?
5. Do shear walls located along diaphragm chord lines affect the diaphragm chord forces?
6. Will the in-plane lateral forces of the exterior walls located at the ends of the cantilever increase chord forces, or is it acceptable to include these as part of the PSF lateral load?
7. **How are torsional irregularities determined and addressed for open-front/cantilever diaphragms?**

Torsional Irregularities



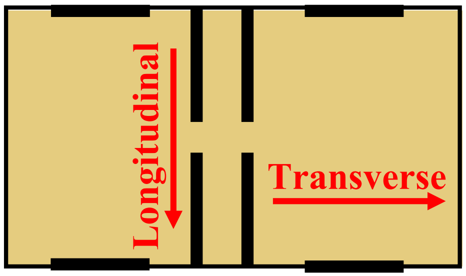


Torsional Irregularity?

Typical Floor Plan

Analysis Flow

Longitudinal Design

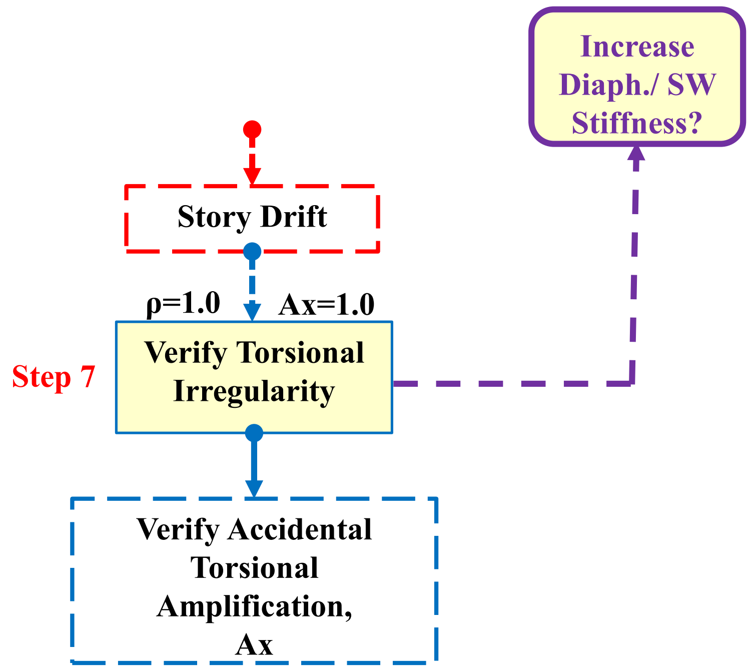


Example Plan

Legend

- Engineering judgement required
- SW & Diaph. Design
- Determine flexibility, Drift
- Determine Tors. Irreg., ρ, Ax

ASD Design | STR Design



Verify Torsional Irregularity

Seismic- ρ=1.0, Ax=1.0

Torsional Irregularities $\rho = 1.0$ and $A_x = 1.0$

ASCE 7-16 Table 12.3-1, Type 1a and 1b irregularities note that $A_x=1.0$ when checking for torsional irregularities.

In many cases, open-front structures will result in torsional irregularities because of rotational effects.

SDPWS Section 4.2.5.1 addresses ASCE 7-16 torsional irregularity requirements.

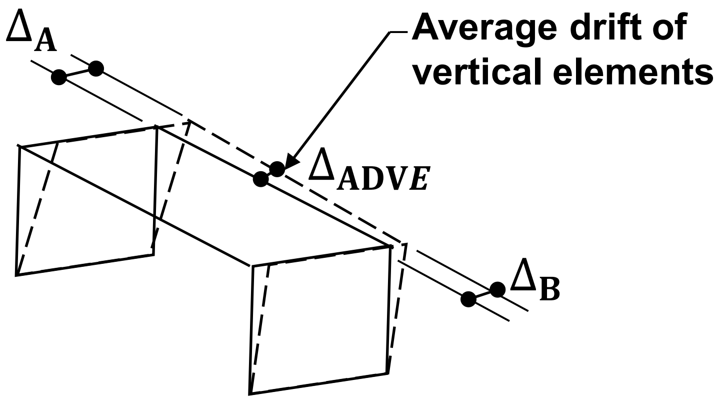
Torsional Irregularity Type 1a – seismic - Maximum story drift, Δ_{MAX}, (including accidental torsion with $A_x=1.0$), > 1.2x Δ_{ADVE}

- **Model as semi-rigid or idealized as rigid**
- **Torsional irregularity, Type 1a, is allowed in structures assigned to SDC B, C, D, E, or F.**

Torsional Irregularity Type 1b - seismic: Extreme torsionally irregular, Maximum drift, Δ_{MAX} > 1.4 x Δ_{ADVE}

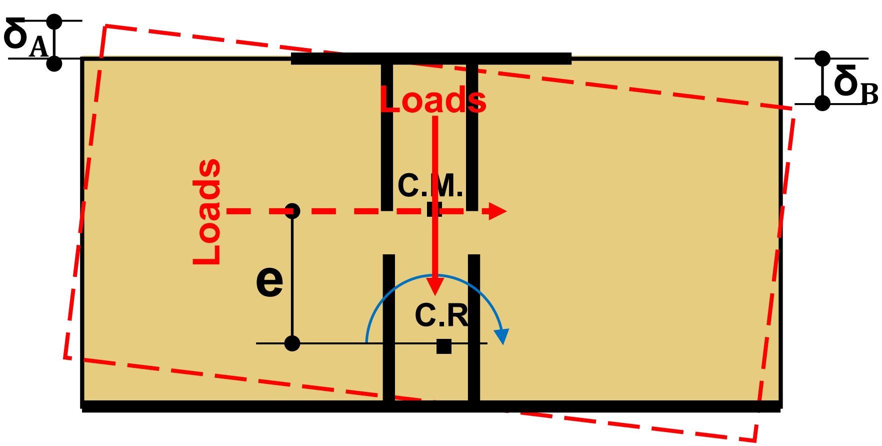
- **An extreme torsional irregularity Type 1b is allowed in structures assigned to Seismic Design Categories B, C, and D, but not in SDC E, or F.**

ASCE 7 Triggers



$\Delta_{MAX} > 1.2x\ \Delta_{ADVE}$

ASCE 7-16 Requirements Type 1a Horizontal Irregularity



ASCE 7-16: Table 12.3-1 Horizontal Structural Irregularity Requirement References

1a. Torsional Irregularity $\Delta_{MAX} > 1.2x\ \Delta_{ADVE}$

- 12.3.3.4: 25% increase in forces - D, E, and F
- 12.7.3: Structural modeling - B, C, D, E, and F
- 12.8.4.3: Amplification of accidental torsion - C, D, E, and F
- 12.12.1: Drift - C, D, E, and F

1b. Extreme Torsional Irregularity $\Delta_{MAX} > 1.4x\ \Delta_{ADVE}$

- 12.3.3.1 Type 1b is not permitted in E and F
- 12.3.3.4: 25% increase in forces – D
- 12.3.4.2: Redundancy factor – D
- 12.7.3: Structural modeling - B, C, and D
- 12.8.4.3: Amplification of accidental torsion - C and D
- 12.12.1: Drift - C and D

Longitudinal Loading e=3.8', T = 67522.2 ft. lbs. ρ=1.0, Ax=1.0

Grid Line	kx	Ky	dx	dy	kd	kd^2	Fv		F_T	Fv+F_T
2	43.54		3		130.63	391.89	8884.5		-422.2	8462.3
3	43.54		3		130.63	391.89	8884.5		422.2	9306.7
A		25.14		20	502.74	10054.73			1624.7	1624.7
B		25.14		20	502.74	10054.73			-1624.7	-1624.7
Σ	87.09	50.27			J=	20893.23	17769			

Corridor Walls

Walls at Grid lines A & B

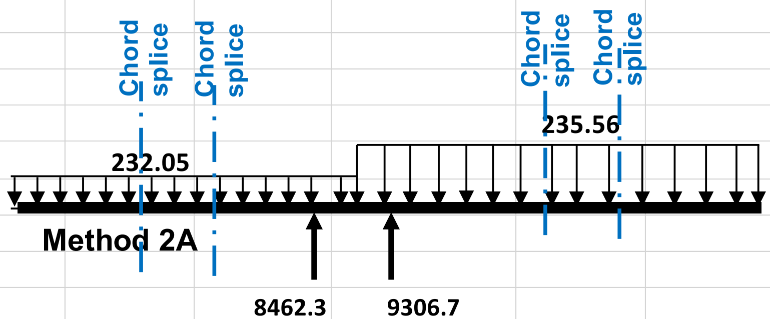
Diaphragm Deflection (STR) ρ=1.0, Ax=1.0

Rt. Cantilever

	Splice Forces (Lbs.)			Σδ_slip	v unif.	v conc.	Ga	L'	W'	δDiaph Unif	δDiaph conc	Total δ
	F 15	F23	F35	In.	plf	plf	k/in.	Ft.	Ft.	In.	In.	In.
	983.2	1236.9	3542.8	0.075	227.49	0.00	25.0	35.00	40.00	0.260	0.00	0.260
ails Req'd=	4.35	5.47	15.68									
Use Nails =	8	16	24									
Slip=	0.021	0.013	0.025									

EA= 28050000, (2)2x6

Iincludes effects of sw's along chord line

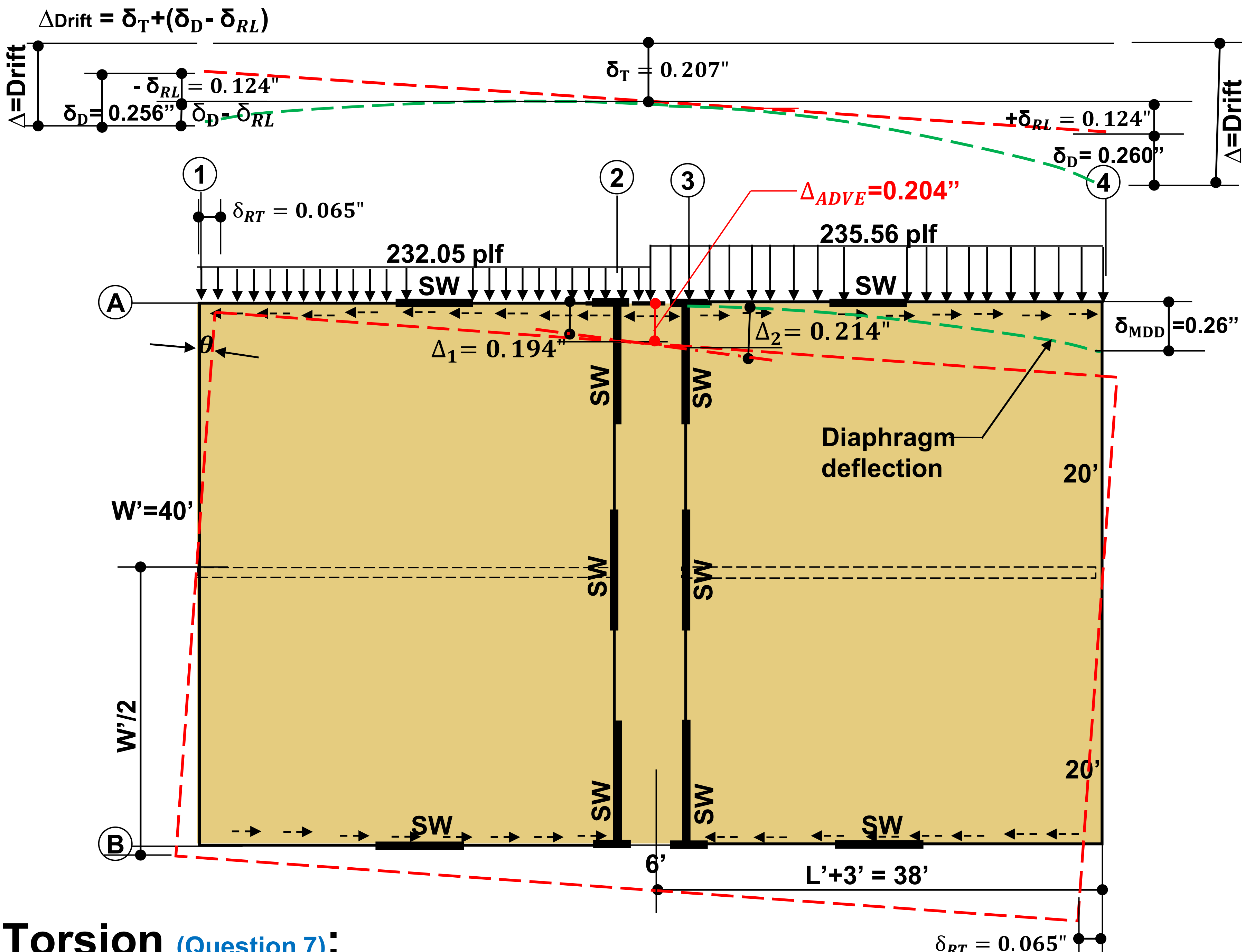


Diaphragm Deflection (STR)

Lft. Cantilever

332.0	1855.1	3617.4	0.073	224.42	0.00	25.0	35.00	40.00	0.256	0.00	0.256
1.47	8.21	16.01									
8	16	24									
0.007	0.020	0.026									

Torsional Irregularity Check-Method 2A



Torsion (Question 7):

Check for Torsional Irregularity Type 1a - ρ=1.0, Ax=1.0

SDPWS 4.2.5.2 (2):

A.R. ≤ 1:1 if torsional irregularity - one-story structure

A.R. = 0.67:1 - multi-story structure

A.R. = 0.875 < 1, ∴ O.K. Had this been a multi-story structure, the A.R. would have been exceeded and adjustments made accordingly.

$\Delta_2 = 0.194"$, $\Delta_3 = 0.214"$

$$\Delta_{Aver} = \frac{0.194 + 0.214}{2} = 0.204"$$

$\delta_{SWA,B}$**=0.065" =** δ_{RT} **Transverse displacement at Lines A and B from rigid diaphragm rotation**

δ_{RL} **=** $\frac{2\delta_{SWA,B}(L'+3')}{W'}$ **=0.124" Vertical component of rotation**

Diaphragm deflections:

$\delta_{D,1}$**=0.256"**

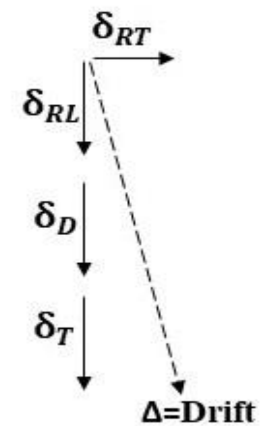
$\delta_{D,4}$**=0.260"**

Drift $\Delta = \sqrt{(\delta_T + \delta_D \pm \delta_{RL})^2 + (\delta_{RT})^2}$

Drift $\Delta_4 = \sqrt{(0.204 + 0.260 + 0.124)^2 + (0.065)^2} = 0.592"$

Drift $\Delta_1 = \sqrt{(0.204 + 0.256 - 0.124)^2 + (0.065)^2} = 0.342"$

$$\Delta_{Aver} = \frac{0.592 + 0.342}{2} = 0.467"$$



δ_{RT} = Transverse component of rotation

δ_{RL} = Longitudinal component of rotation

δ_D = Diaphragm displacement

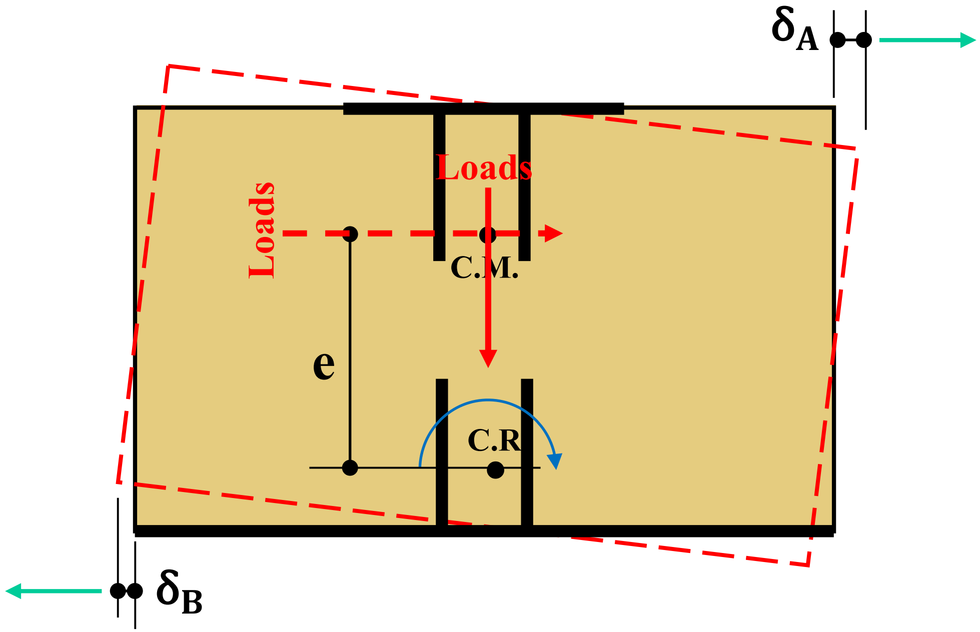
δ_T = Translational displacement

0.592 > 1.2(0.467) = 0.56", ∴ Horizontal torsional irregularity Type 1a <u>does</u> exist in this direction.

0.592 < 1.4(0.467) = 0.654", ∴ Horizontal torsional irregularity Type 1b <u>does not</u> exist in this direction.

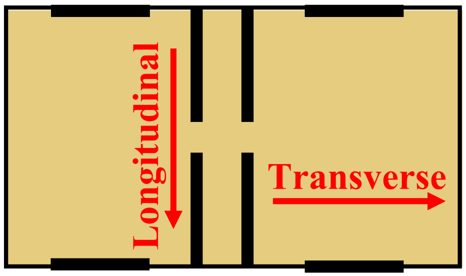
Amplification of Accidental Torsion

Seismic- ρ=1.0, Ax=1.0

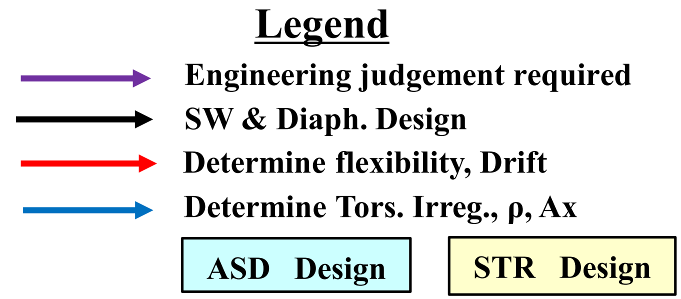


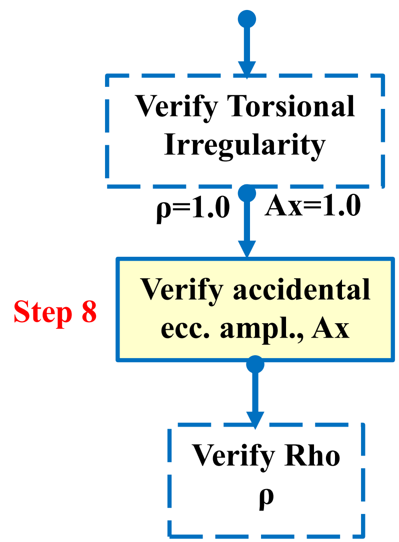
Analysis Flow

Longitudinal Design



Example Plan





Verify Amplification of Accidental Torsion, Ax

Seismic- ρ=1.0, Ax=1.0

ASCE 7-16 12.8.4.3 Amplification of Accidental Torsional Moment.

Structures assigned to Seismic Design Category C, D, E, or F, where Type 1a <u>or</u> 1b torsional irregularity exists as defined in Table 12.3-1 shall have the effects accounted for by multiplying M_{ta} at each level by a torsional amplification factor (Ax) as illustrated in Fig. 12.8-1 and determined from the following equation:

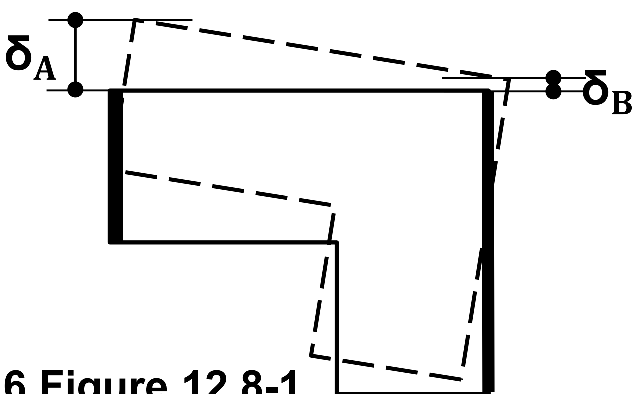
$$A_x = \left(\frac{\delta_{max}}{1.2\delta_{avg}}\right)^2 \qquad \textbf{12.8-14}$$

Where

δ_{max} =maximum displacement at level x computed assuming Ax = 1

δ_{avg} =average of the displacements at the extreme points of the structure at level x computed assuming Ax = 1.

M_{ta} =accidental torsional moment



ASCE 7-16 Figure 12.8-1
Amplification of accidental torsion

From torsion section:

$$A_x = \left(\frac{\delta_{max}}{1.2\delta_{avg}}\right)^2 = \left(\frac{0.592}{1.2(.467)}\right)^2 = 1.116 < 1.25 \text{ assumed.}$$

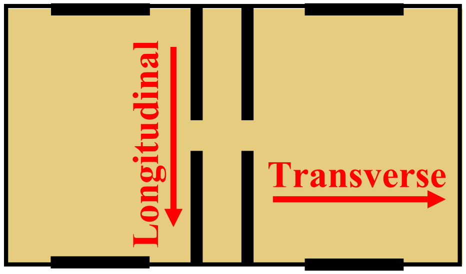
∴ Can recalculate if desired.

ASCE 7-10 (1st printing) 12.8.4.1 Inherent Torsion **Exception below is <u>not in 3rd printing</u> of ASCE 7-10 or ASCE 7-16**

Most diaphragms of light-framed construction are somewhere between rigid and flexible for analysis purposes, that is, semi-rigid. Such diaphragm behavior is difficult to analyze when considering torsion of the structure. As a result, it is believed that consideration of the **amplification of the torsional moment is a refinement that is not warranted for light-framed construction.**

Analysis Flow

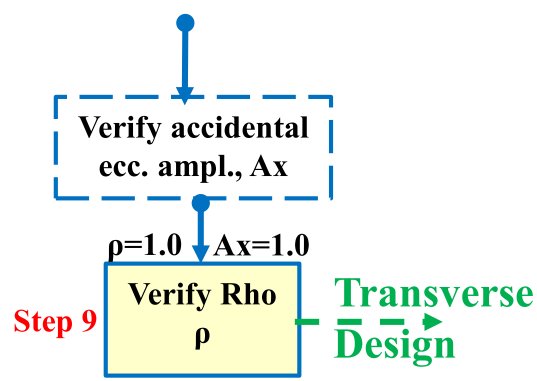
Longitudinal Design



Example Plan

Legend

- Engineering judgement required
- SW & Diaph. Design
- Determine flexibility, Drift
- Determine Tors. Irreg., ρ, Ax
- ASD Design
- STR Design

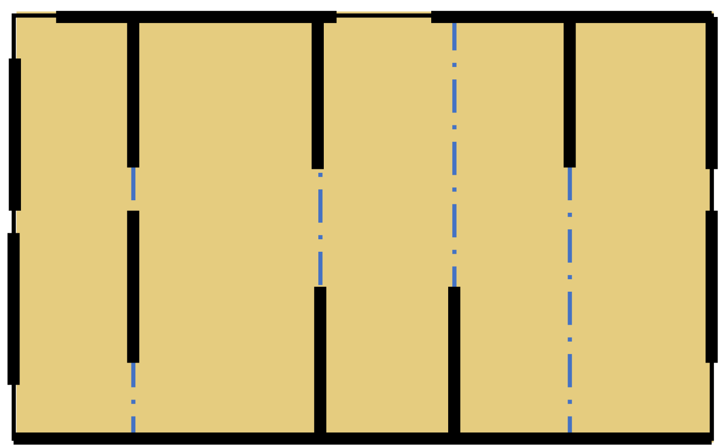


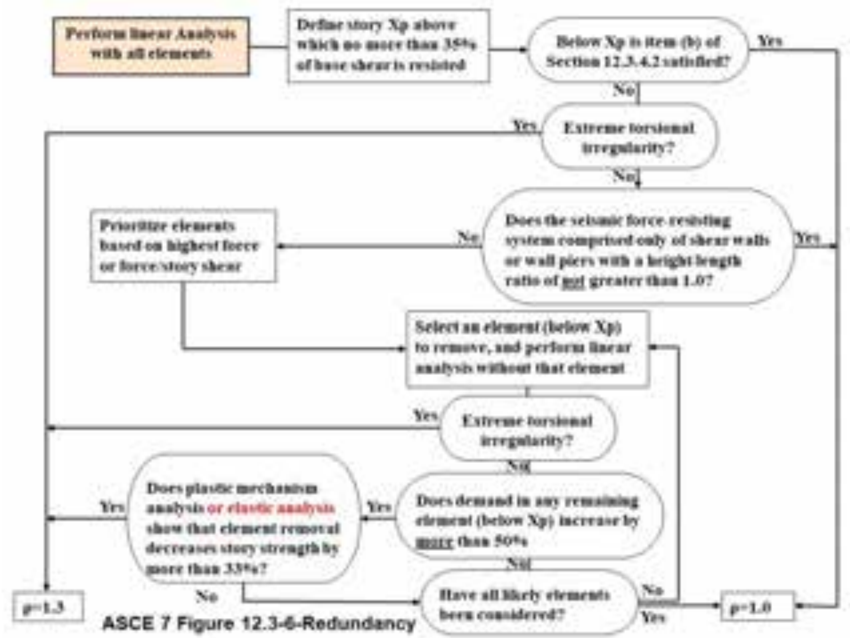
Verify Redundancy, ρ

Seismic- ρ=1.0, Ax=1.0

Redundancy

Seismic- ρ=1.0, Ax=1.0





ASCE 7-16 Redundancy Flow Chart
Figure C12.3-6

- **The application of rho relates directly to increasing the capacity of the walls only, or adding more walls.**
- **The rho factor has an effect of reducing R, for less redundant structures which increases the seismic demand**
- **Shear wall systems have been included in Table 12.3-3 so that either an adequate number of walls are included, or a proper redundancy factor has been applied.**

12.3.4.1 Conditions Where Value of ρ is 1.0. The value of ρ is permitted to equal 1.0 for the following:

2. **Drift calculation and P-delta effects.**

5. **Design of collector elements, splices, and their connections for which the seismic load effects including over-strength factor of section 12.4.3 are used.**

6. **Design of members or connections where seismic load effects including over -strength factor of section 12.4.3 are required for design.**

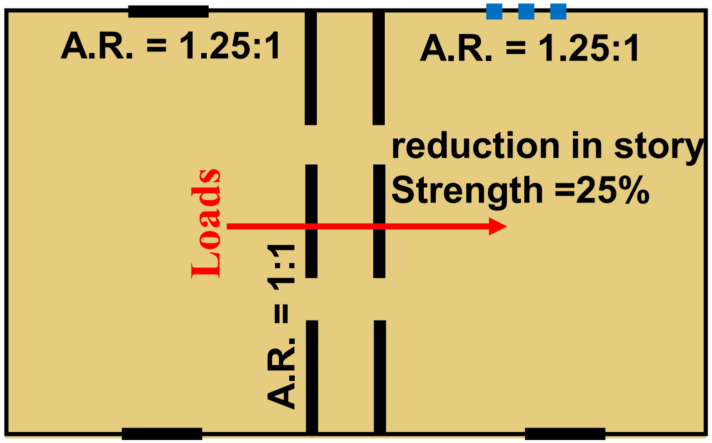
7. **Diaphragm loads, Fpx, determined using Eq. 12.10-1, including min. & max. values.**

12.3.4.2 Redundancy Factor, ρ, for Seismic Design Categories D through F.

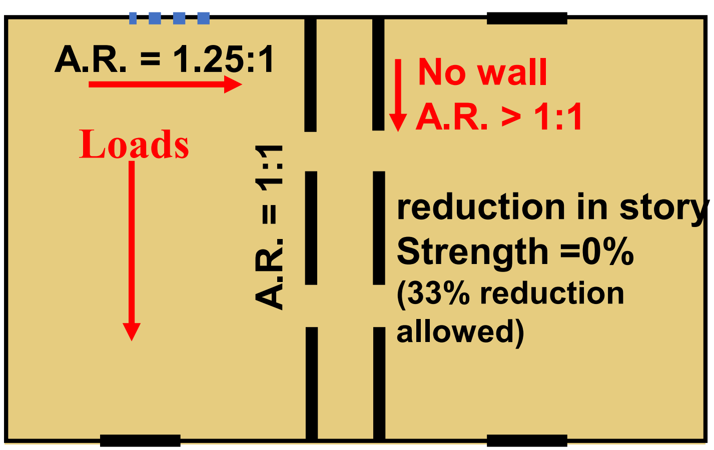
- **For structures assigned to Seismic Design Category D and having extreme torsional irregularity as defined in Table 12.3-1, Type 1b, ρ shall equal 1.3.**

- **For other structures assigned to Seismic Design Category D and for structures assigned to Seismic Design Categories E or F, ρ shall equal 1.3 unless one of the following two conditions (a. or b.) is met, whereby ρ is permitted to be taken as 1.0.**

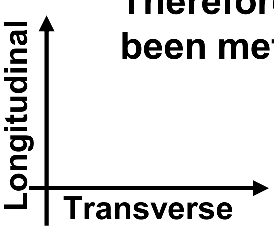
Let's check condition b. first



No. bays=2(8)(2)/10=3.2 bays
(But not all 4 sides)



Therefore condition "a" has been met and ρ=1.0.



b. Structures that are regular in plan at all levels ρ=1.0 provided:

- **SFRS consist of at least two bays of perimeter SFRS framing on each side of the structure in each orthogonal direction at each story resisting more than 35% of the base shear.**
- **The number of bays for a shear wall = Lsw / hsx, or 2Lsw / hsx, for light-frame construction.**

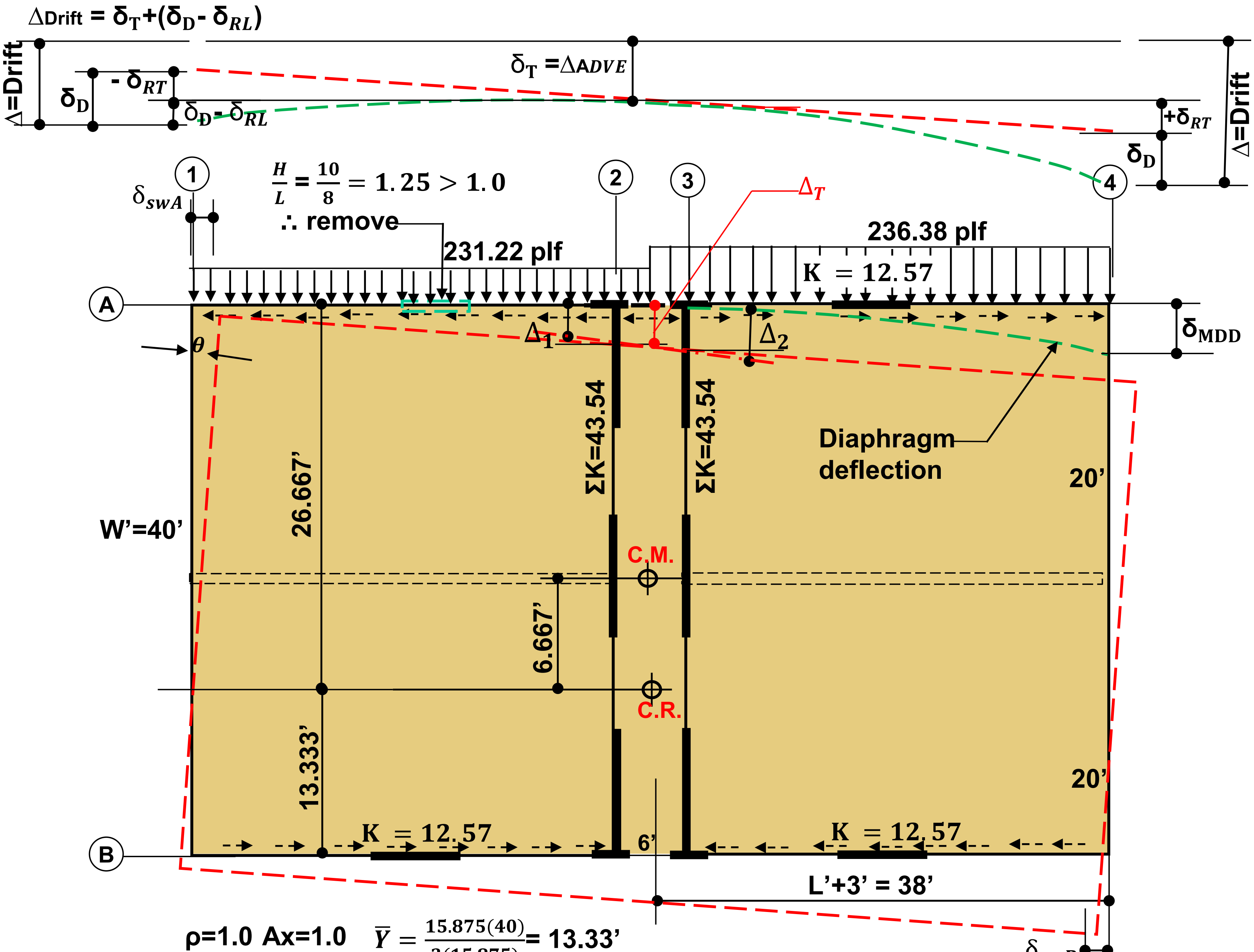
Although the plan is regular, in the longitudinal direction, there are no SFRS walls at all exterior wall lines. Therefore, the structure does not comply with condition "b", and condition "a" must be met.

Condition a.

Each story resisting more than 35% of the base shear in the direction of interest shall comply with Table 12.3-3.

Table 12.3-3.

- **Removing one wall segment with A.R. > 1:1 will not result in reduction in story strength > 33% limit.**
- **Removing 1 wall within any story will not result in extreme torsional irregularity, Type 1b.**

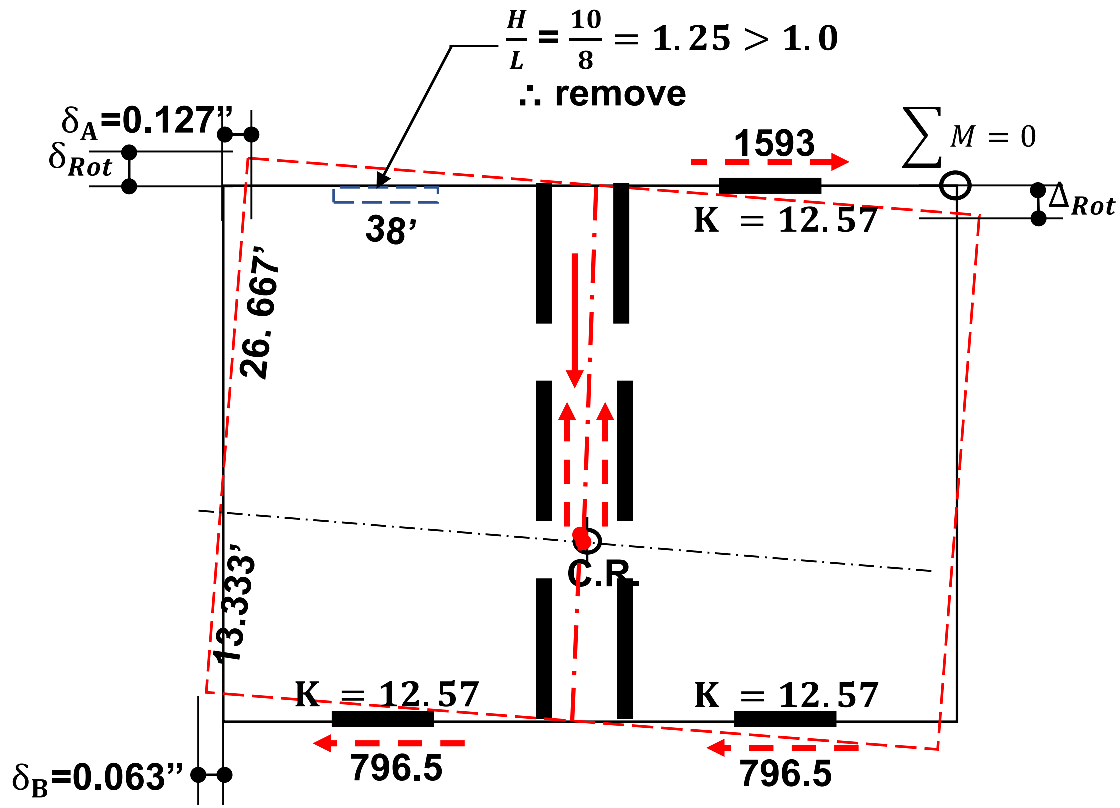

ΔDrift = δT+(δD- δRL)
Δ=Drift
δD
- δRT
δD- δRL
δT =ΔADVE
+δRT
δD
Δ=Drift
1
2
3
4
H/L = 10/8 = 1.25 > 1.0
∴ remove
δswA
ΔT
231.22 plf
236.38 plf
K = 12.57
A
δMDD
θ
Δ1
Δ2
ΣK=43.54
ΣK=43.54
Diaphragm deflection
20'
26.667'
W'=40'
C.M.
6.667'
C.R.
13.333'
20'
K = 12.57
K = 12.57
B
6'
L'+3' = 38'
ρ=1.0 Ax=1.0
Ȳ = 15.875(40) / 3(15.875) = 13.33'
δswB

Redundancy Study

Spreadsheet results

- δ_A= 0.127”
- δ_B= 0.063”
- δ_2= 0.190”
- δ_3= 0.218”
- Δ_{Diaph} L= 0.256”
- Δ_{Diaph} R= 0.260”

	Total
F_A	1595
F_B	1595
F_2	8263
F_3	9506



Check

$$\Delta_{Rot} = \frac{0.127(38)}{26.667} = 0.181”$$

$$\Delta_T = \frac{0.190+0.218}{2} = 0.204”$$

$$Drift_{\Delta_4} = \sqrt{(0.204 + 0.260 + 0.181)^2 + (0.127)^2} = 0.657”$$

$$Drift_1 = \sqrt{(0.204 + 0.256 - 0.181)^2 + (0.127)^2} = 0.307“$$

$$\Delta_{Aver} = \frac{0.657 + 0.307}{2} = 0.482“$$

0.657 < 1.4(0.482) = 0.674”, ∴ Horizontal torsional irregularity Type 1b does not exist in this direction and ρ = 1.0

Shear wall Deflection

$$\delta_{SW} = \frac{F}{K}$$

Shear wall Nominal Stiffness

$$K = \frac{F}{\delta_{SW}}$$

Struts and Collectors-Seismic

Struts / collectors and their connections shall be designed in accordance with ASCE 7-16 sections:

12.10.2 SDC B - Collectors can be designed w/o over-strength
but not if they support discontinuous walls or frames.

12.10.2.1 SDC C thru F- Collectors and their connections, including connections to the vertical resisting elements require the over-strength factor of Section 12.4.3, except as noted:

Shall be the maximum of:

Same {
$\Omega_o F_x$ - Forces determined by ELF Section 12.8 or Modal Response Spectrum Analysis procedure 12.9

$\Omega_o F_{px}$ - Forces determined by Diaphragm Design Forces (Fpx), Eq. 12.10-1 or }

and

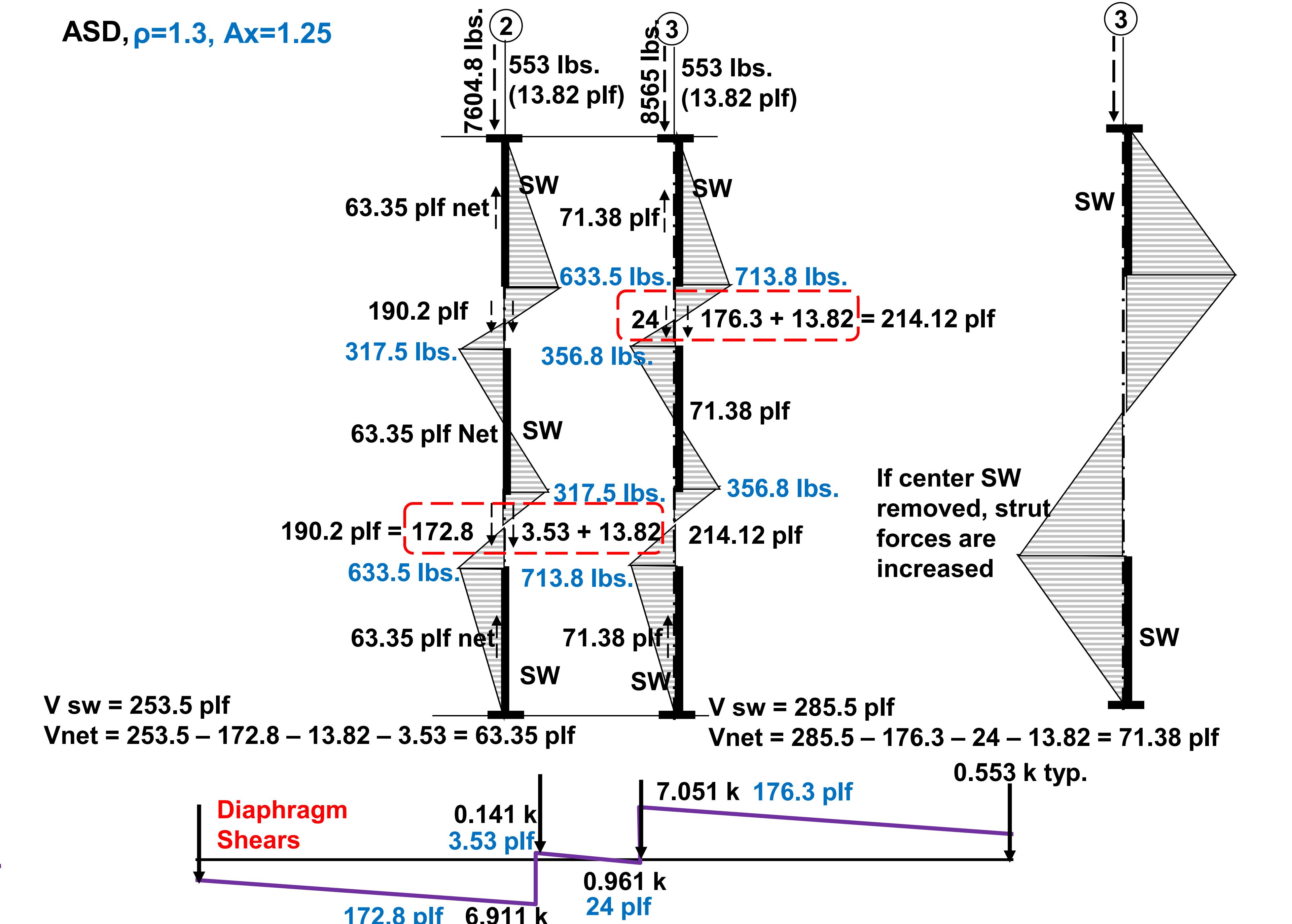
$F_{px\,min} = 0.2 S_{DS} I_e w_{px}$ - Lower bound seismic diaphragm design forces determined by Eq. 12.10-2 ($F_{px\,min}$) using the Seismic Load Combinations of section 12.4.2.3 (w/o over-strength)-do not require the over-strength factor.

$F_{px\,max} = 0.4 S_{DS} I_e w_{px}$- Upper bound seismic diaphragm design forces determined by Eq. 12.10-2 ($F_{px\,max}$) using the Seismic Load Combinations of section 12.4.2.3 (w/o over-strength)-do not require the over-strength factor.

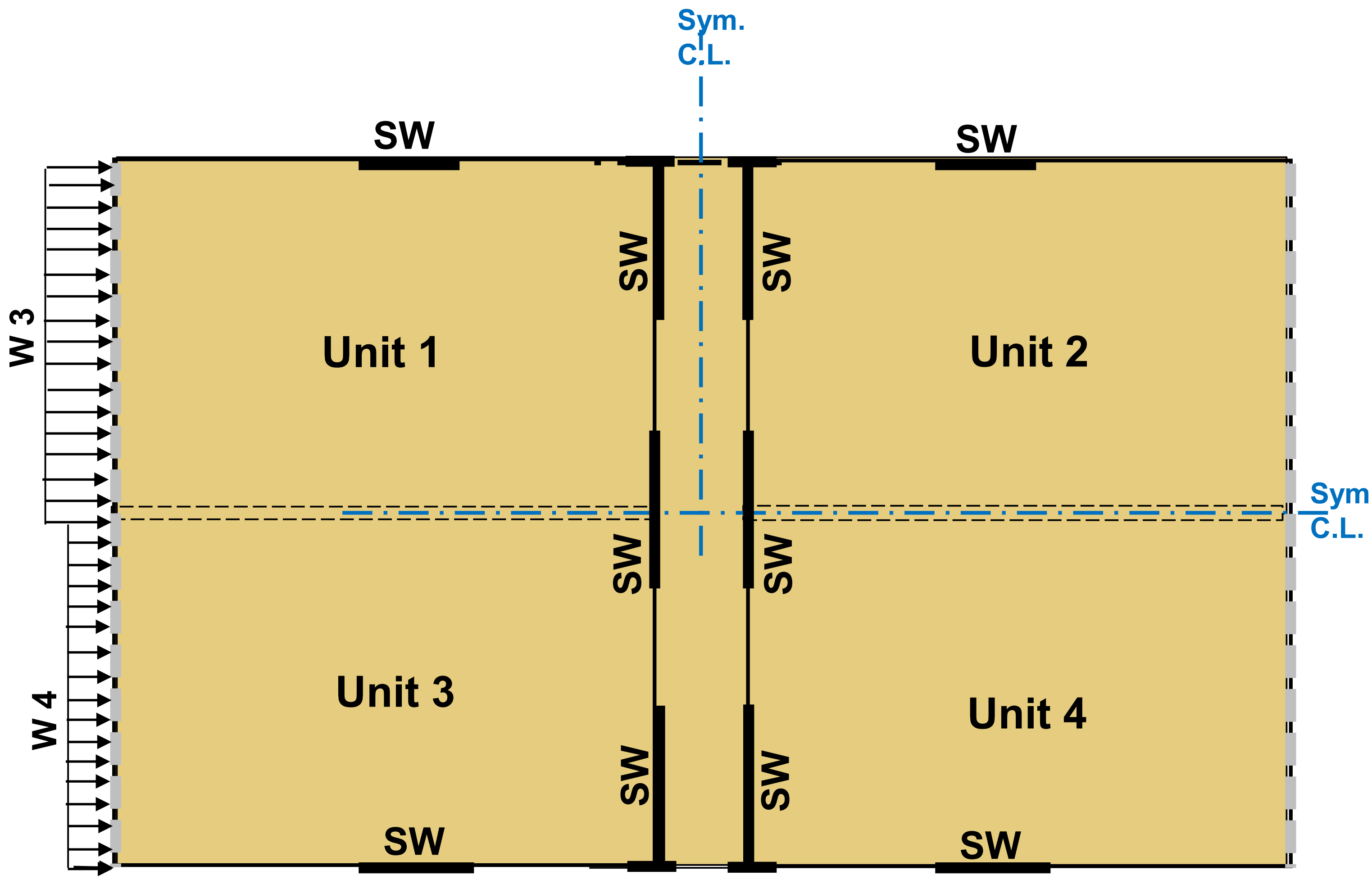
Exception:

1. In structures (or portions of structures) braced entirely by light framed shear walls, collector elements and their connections, including connections to vertical elements need only be designed to resist forces using the standard seismic force load combinations of Section 12.4.2.3 with forces determined in accordance with Section 12.10.1.1 (Diaphragm inertial Design Forces, F_{px}).

ASD, ρ=1.3, Ax=1.25

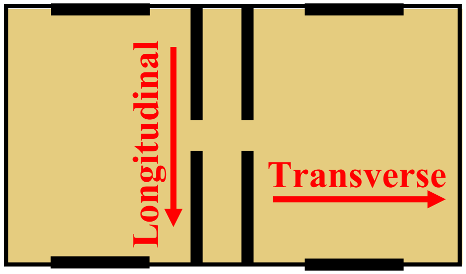


Design Example- Transverse Direction

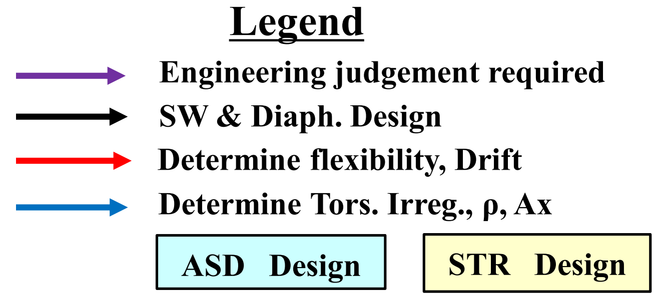


Analysis Flow

Longitudinal Design

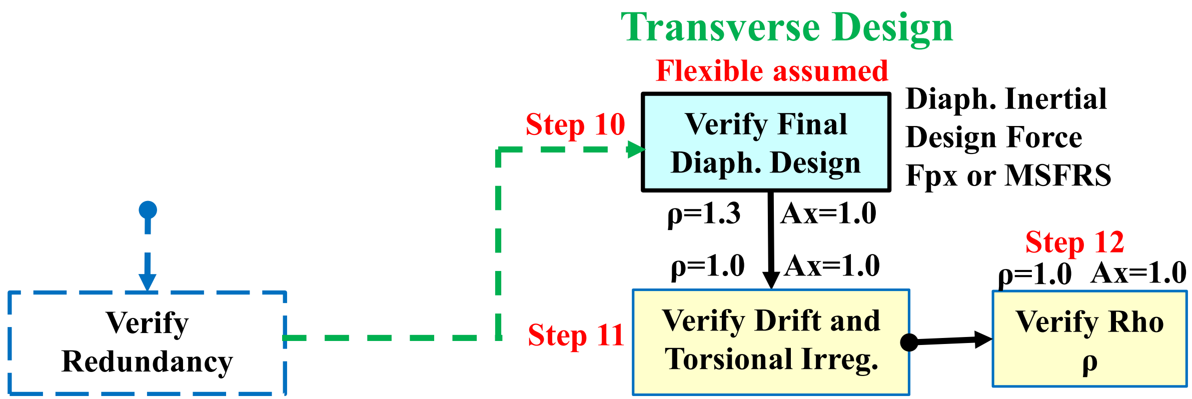


Example Plan



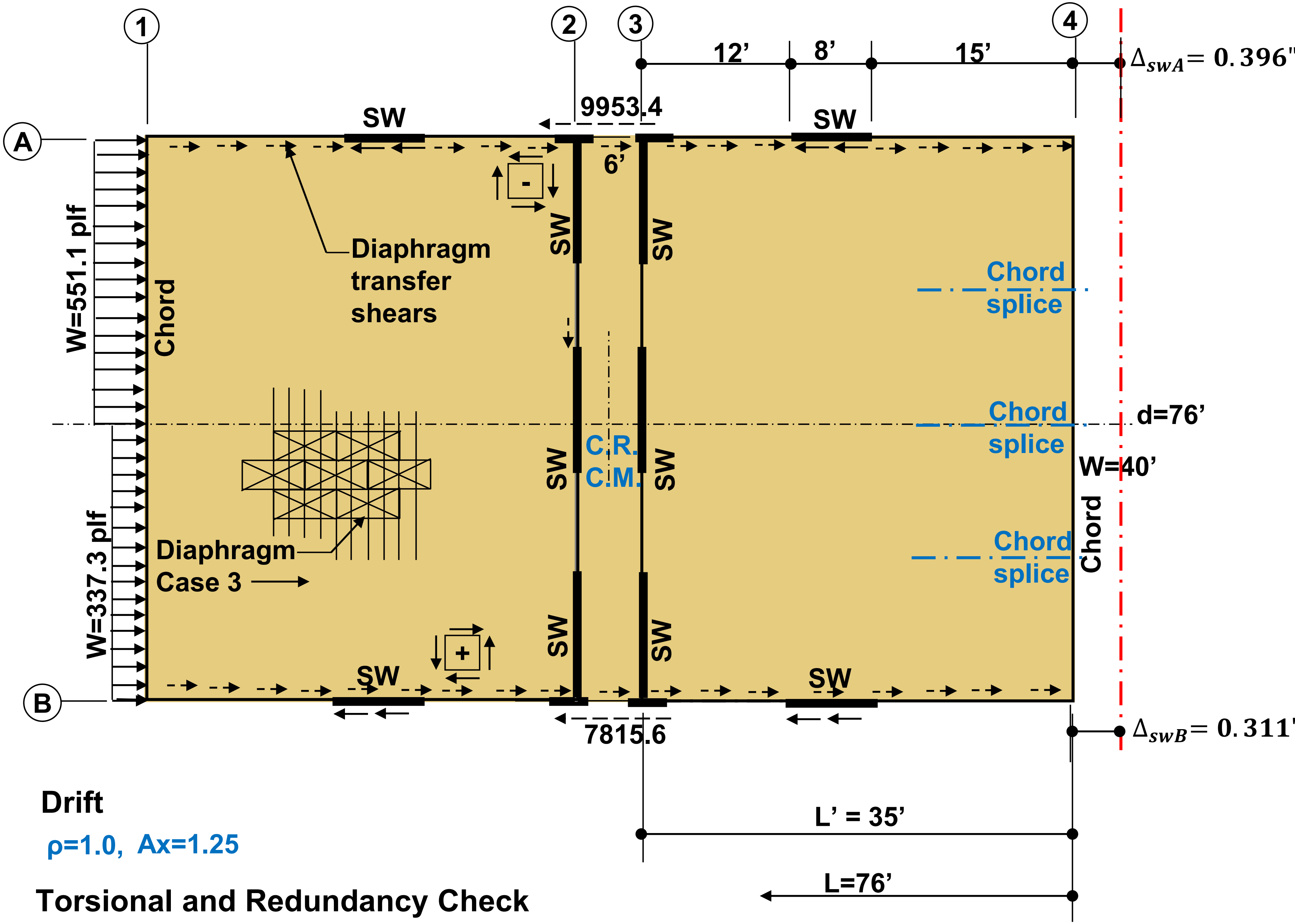
Transverse Design

Seismic- ρ=1.3, Ax=1.0



12.3.1.1- (c), Light framed construction, diaphragms meeting all the following conditions are allowed to be idealized as flexible:

1. All Light framed construction
2. Non-structural concrete topping ≤ 1 ½" over wood structural panels (WSP).
3. Each elements of the seismic line of vertical force-resisting system complies with the allowable story drift of Table 12.12-1



Drift

ρ=1.0, Ax=1.25

Torsional and Redundancy Check

ρ=1.0, Ax=1.0

Diaphragm Flexibility, Resulting numbers: ρ=1.0, Ax=1.25

W= 17769/76=444.1 plf (ASD)

V_A=9057.6 lbs.

$V_{max\ Diaph} = \frac{9057.6}{76}$ = 119.2 plf < 464 plf ∴ O.K

From spreadsheet (STR)

$\delta_{Diaph} = 0.066“$

$\Delta_{SW\ A} =$ 0.396”, $\Delta_{SW\ B} =$ 0.311”, $2x\Delta_{Average} = 0.707“$

0.066” < 0.707” ∴ Rigid diaphragm, as initially assumed.

Check Story Drift

$\rho = 1.0$ and $A_x = 1.25$

$C_d = 4$, $I_e = 1$

$\delta_{SWA} = 0.396$ in from spreadsheet

$$\delta_M = \frac{C_d \delta_{max}}{I_e} = \frac{4(0.396)}{1} = 1.58 \text{ in}$$

$0.020\ h_{sx} = 0.020(10)(12) = 2.4$ in > 1.58 in, ∴ Drift OK

Check for Torsional Irregularity ρ=1.0, Ax=1.0

Rigid diaphragm, ρ =1.0 and Ax = 1.0 as required by ASCE 7 Table 12.3-1

From spreadsheet

δ_{SWA}**=0.387"**

δ_{SWB}**=0.319"**

$\Delta_{Average} = \frac{0.387+0.319}{2} = 0.353"$ **From spreadsheet**

0.387 < 1.2(0.353) = 0.424", ∴ No torsional irregularity exists in this direction, as assumed.

Redundancy Check ρ=1.0, Ax=1.0

Table 12.3-3 Requirements

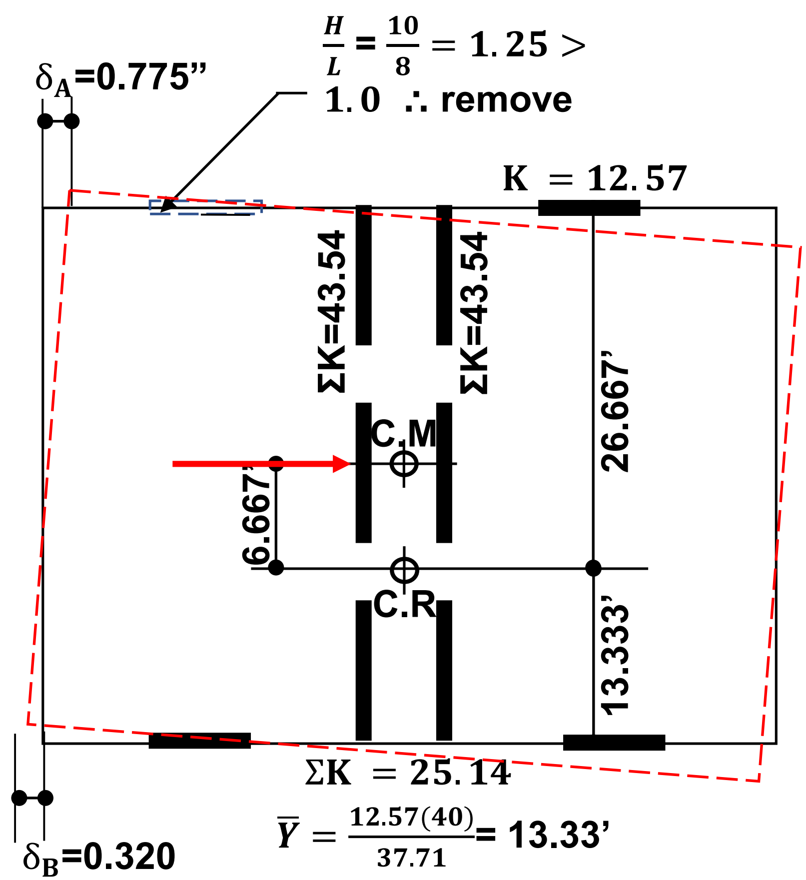
- **Removal of SW with H/L > 1.0**
  1. **Will not result in > 33% reduction in strength**
  2. **Will not result in extreme torsional irregularity**

- δ_A= 0.775"
- δ_B= 0.320"

$$\Delta_{Aver} = \frac{0.775+0.320}{2} = 0.547''$$

Only 25% decrease in story strength.

0.775" > 1.4(0.547)= 0.765" ∴ Type 1b ∴ ρ=1.3



Example Summary

Preliminary Assumptions Made:

- Diaphragm is rigid or semi-rigid in both directions. Correct
- Torsional irregularity Type 1a occurs in longitudinal direction, but not transverse, Correct
- A_x=1.25 assumed. Incorrect, Ax=1.121
- Horizontal irregularity Type 1b does not occur in either direction. Correct, however, when checking redundancy, it occurs in the transverse direction by the removal of 1 wall.
- No redundancy in both directions, ρ=1.3 Incorrect:
  - ρ = 1.0 Longitudinal
  - ρ = 1.3 Transverse

Other Design Requirements:

- Drift < allowable

Multi-Story, Stiffness Issues

Current Examples of Shear Wall Multi-story Effects and Mid-rise Analysis

Current Examples of Mid-rise Analysis-Traditional Method

- **Thompson Method-Woodworks Website**

  Webinar http://www.woodworks.org/education/online-seminars/

  Paper http://www.woodworks.org/wp-content/uploads/5-over-1-Design-Example.pdf

- **SEAOC/IBC Structural Seismic Design Manual, Volume 2. 2015. Structural Engineers Association of California. Sacramento, CA**

Current Examples of Mid-rise Analysis-Mechanics Based Approach

Not currently addressed or required by code

- **Shiotani/Hohbach Method-Woodworks Slide archive**
  http://www.woodworks.org/wp-content/uploads/HOHBACH-Mid-Rise-Shear-Wall-and-Diaphragm-Design-WSF-151209.pdf

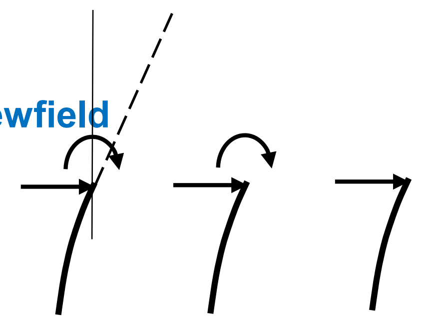
- **FPInnovations-Website NEW**
  "Seismic Analysis of Wood-Frame Buildings on Concrete Podium", Newfield

- **2016 WCTE: A Comparative Analysis of Three Methods Used For Calculating Deflections For Multi-storey Wood Shear Walls: Grant Newfield, Jasmine B. Wang**

- **FPInnovations-Website**
  "A Mechanics-Based Approach for Determining Deflections of Stacked Multi-Storey Wood-Based Shear Walls", Newfield

- **Design Example: "Design of Stacked Multi-Storey Wood-Based Shear Walls Using a Mechanics-Based Approach ", Canadian Wood Council**

- **APEGBC Technical & Practice Bulletin Revised April 8, 2015**
  "5 and 6 Storey Wood Frame Residential Building Projects (Mid-Rise)"-Based on FPInnovations Mechanics Based Approach

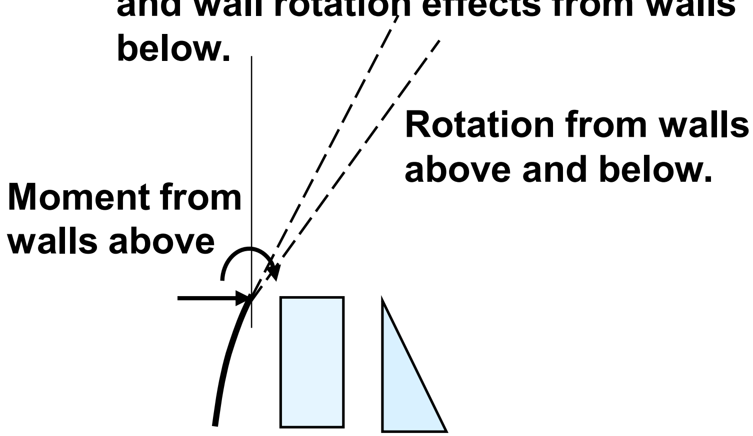


New Research and Analytical methods-Tall Shear Walls

Currently not addressed or required by code:
Engineering preference and/or judgement

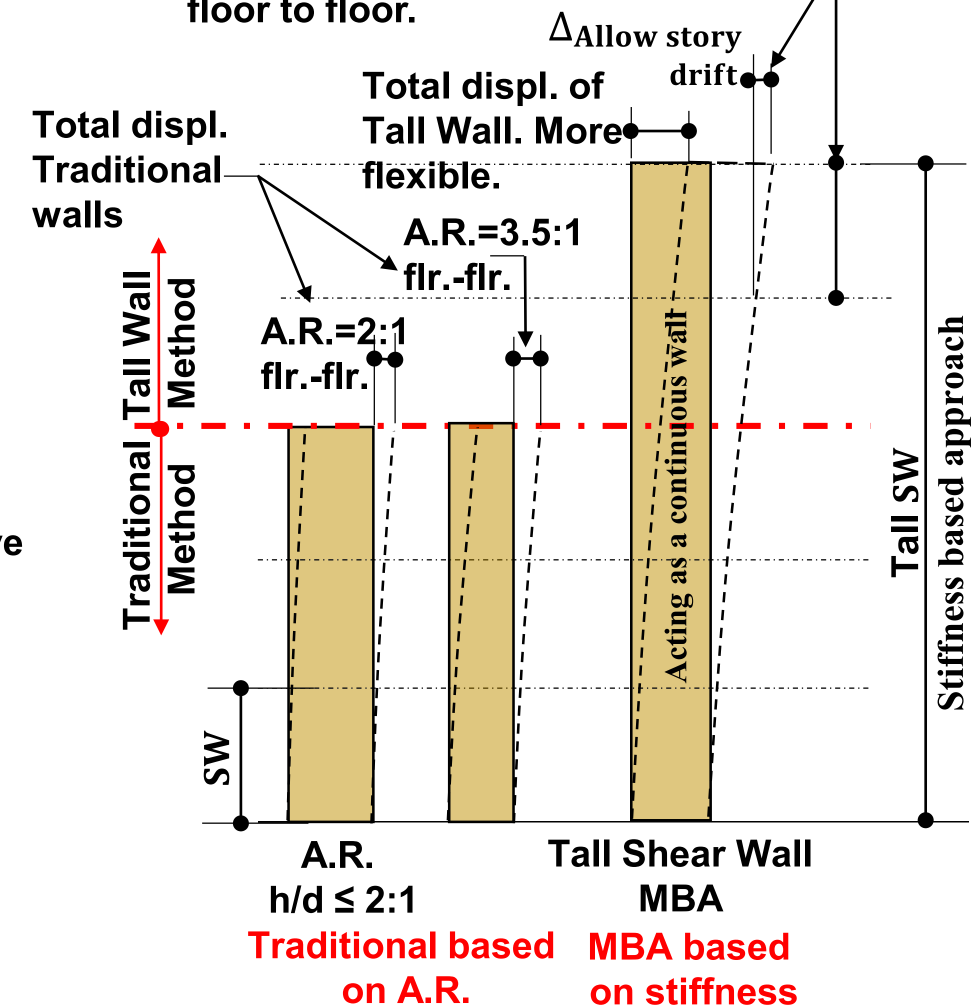
Testing shows that the traditional deflection equation is less accurate for walls with aspect ratios higher than 2:1.
(Dolan)

- Current research suggests that The traditional method of shear wall analysis might be more appropriate for low-rise structures.
- Multi-story walls greater than 3 stories should:
  - Consider flexure and wall rotation.
  - Rotation and moment from walls above and wall rotation effects from walls below.



$$\frac{\sum M_i H_i^2}{2(EI)_i} + \frac{\sum V_i (H^3)}{3(EI)_i}$$

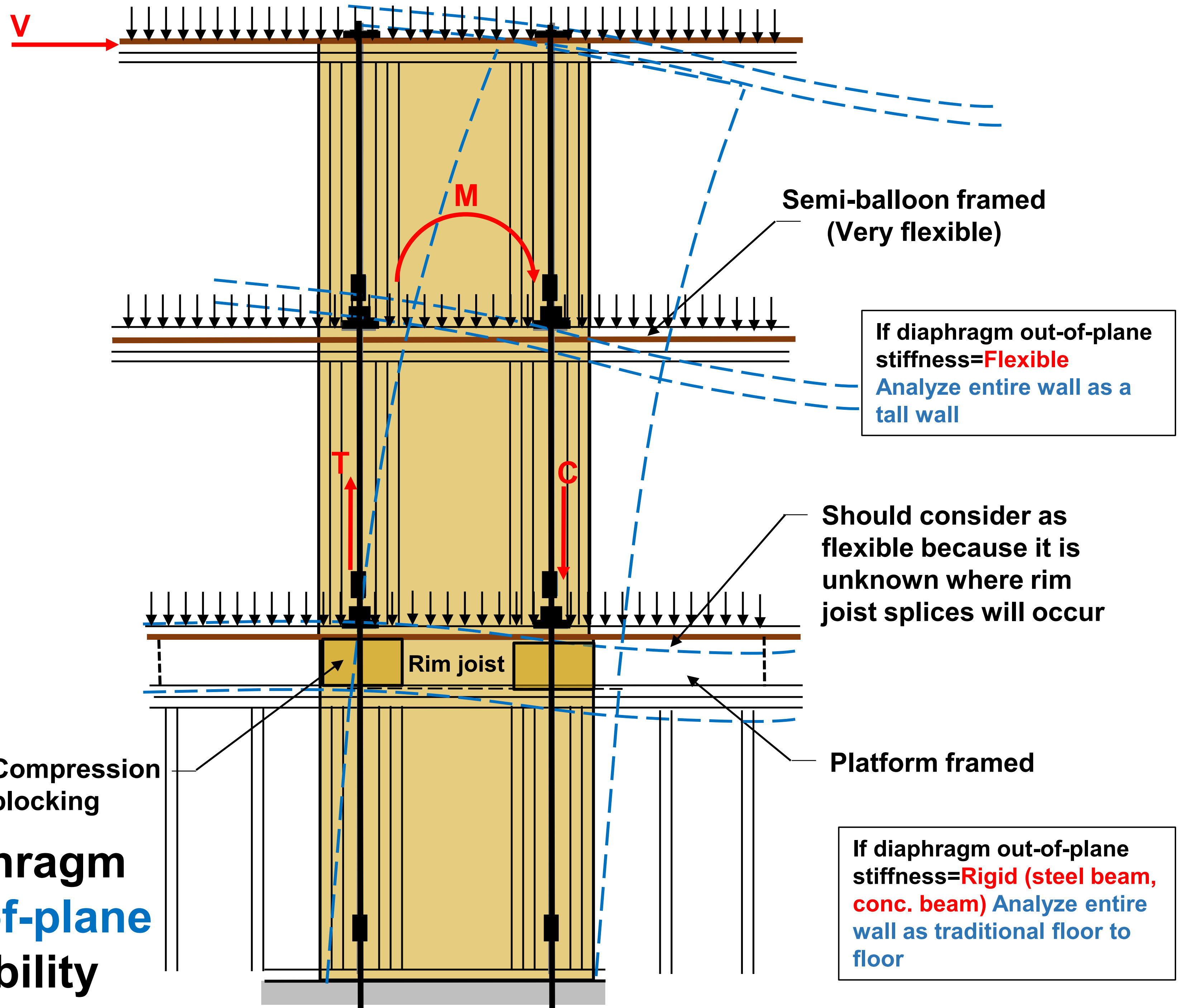
Allowable story drift for traditional and tall shear walls is checked floor to floor.



Floor to floor A.R.'s and Stiffness of Shear Walls

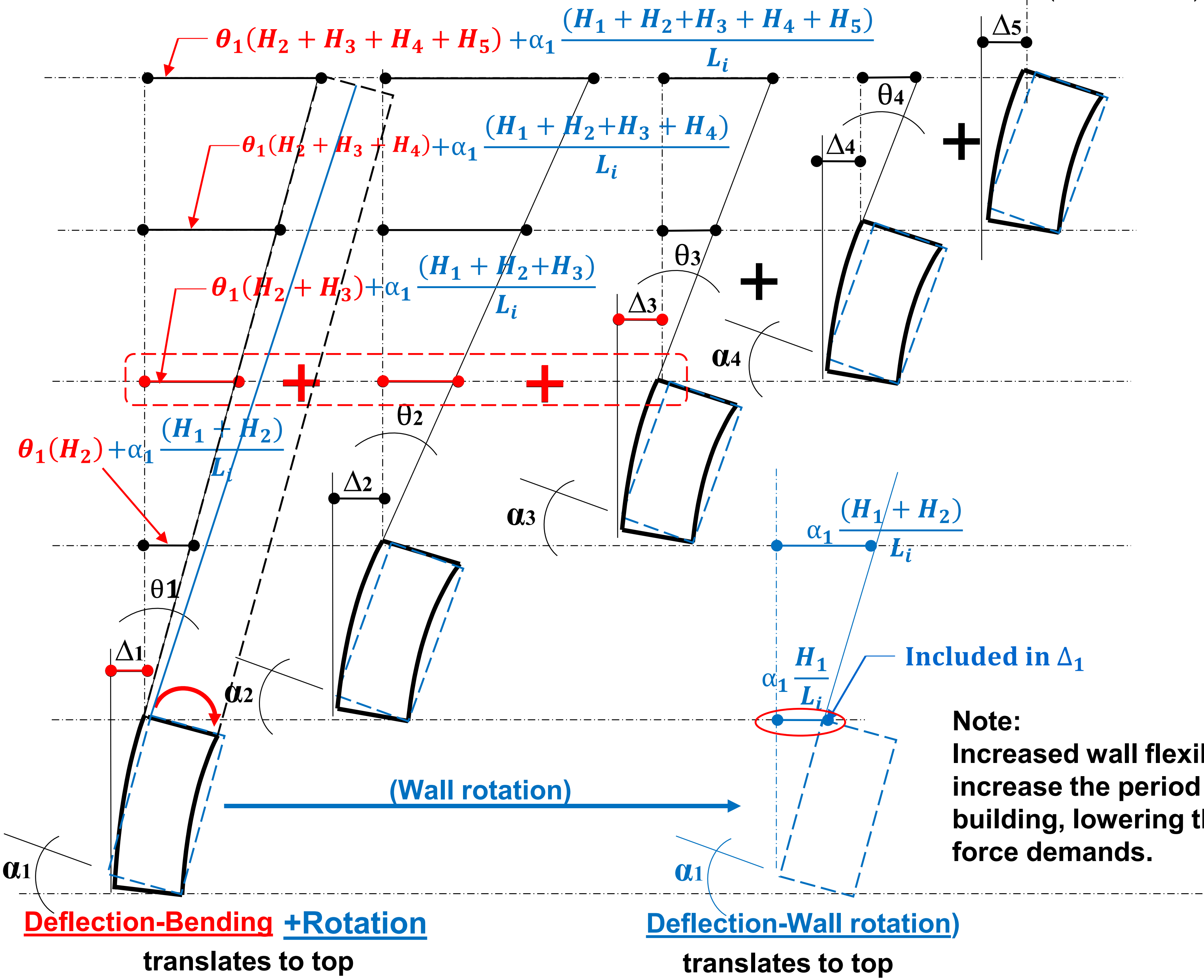
Not in example

Diaphragm out-of-plane Flexibility



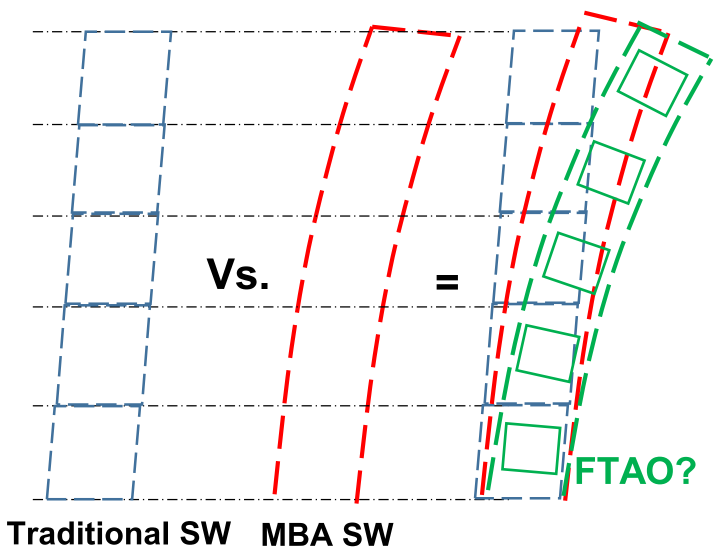
Tall Wall Deflection

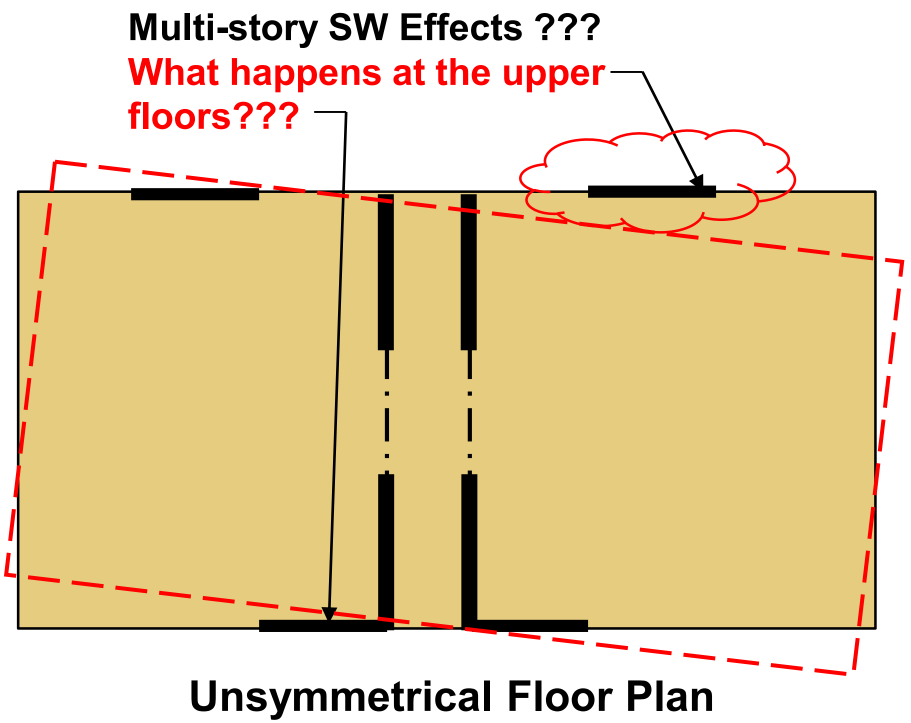
$$\Delta_i = \frac{\sum M_i H_i^2}{2(EI)_i} + \frac{\sum V_i (H^3)}{3(EI)_i} + \frac{V_i H_i}{G_{v,i} t_{v,i}} + 0.75 H_i e_{n,i} + \frac{H_i}{L_i} d_{a,i} + H_i \sum_{j=1}^{i-1}\left(\frac{M_j H_j}{(EI)_j} + \frac{V_j H_j^2}{2(EI)_j}\right) + H_i \sum_{j=1}^{i-1} \frac{d_{a,j}}{L_j}$$



Note:
Increased wall flexibility can increase the period of the building, lowering the seismic force demands.

Consideration of Shear Wall Multi-story Effects- Not in paper





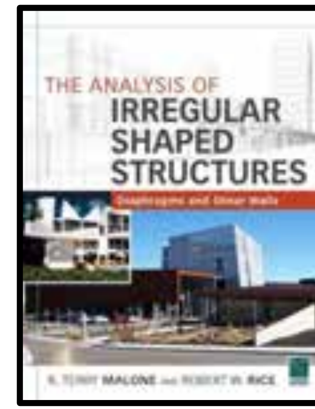
Question of the day:

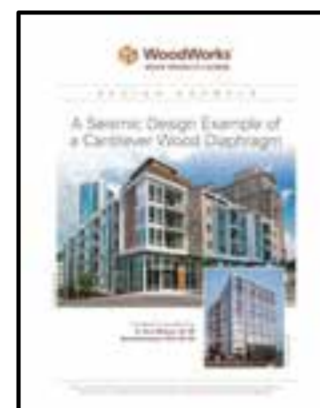
Reference Materials

- **The Analysis of Irregular Shaped Structures: Diaphragms and Shear Walls-Malone, Rice-Book published by McGraw-Hill, ICC**
- **Woodworks Presentation Slide Archives-Workshop-Advanced Diaphragm Analysis**
- **NEHRP (NIST) Seismic Design Technical Brief No. 10-Seismic Design of Wood Light-Frame Structural Diaphragm Systems: A Guide for Practicing Engineers**
- **SEAOC Seismic Design Manual, Volume 2**
- **Woodworks-The Analysis of Irregular Shaped Diaphragms (paper). Complete Example with narrative and calculations.**

  http://www.woodworks.org/wp-content/uploads/Irregular-Diaphragms_Paper1.pdf

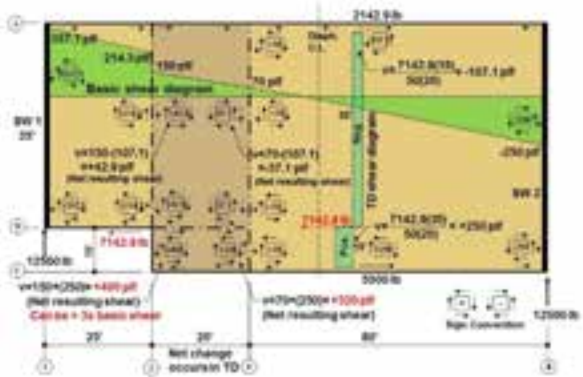
- **Woodworks-Guidelines for the Seismic Design of an Open-Front Wood Diaphragm (paper). Complete Example**





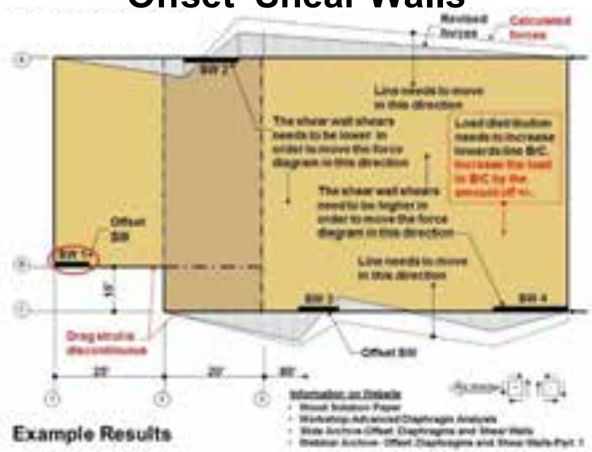
Method of Analysis and Webinar References

Offset Diaphragms



https://vimeo.com/woodproductscouncil/review/114574994/b64da97f09

Offset Shear Walls



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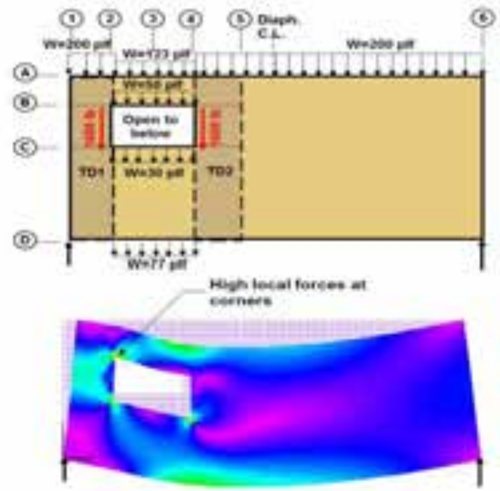
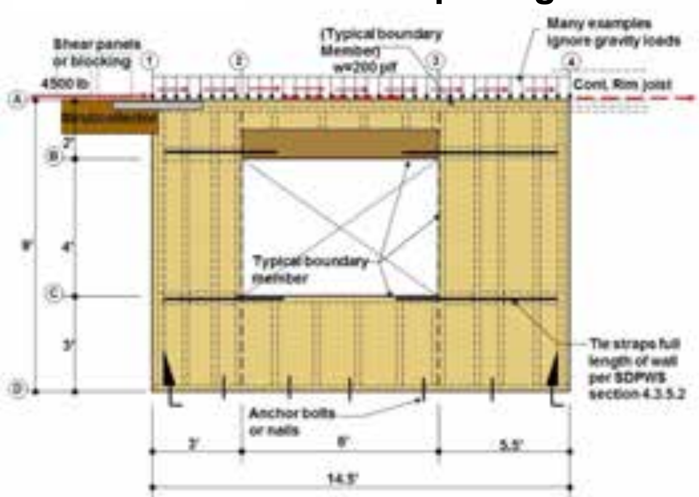
Diaphragms Openings



https://vimeo.com/woodproductscouncil/review/212986898/17ca94ef6f

Shear Walls with Openings



https://vimeo.com/woodproductscouncil/review/217888849/e3018a496a

Mid-rise Design Considerations

https://vimeo.com/woodproductscouncil/review/220727334/516f37ce1e

<u>Information on Website:</u> Presentation Slide Archives, Workshops, White papers, research reports

Questions?

This concludes Woodworks Presentation on:

Part 4-Torsional Irregularity, Other Design Checks, and Final Comments

Your comments and suggestions are valued. They will make a difference.

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Thank You