WoodWorks

Cantilever Wood Diaphragm Webinar Series

A Design Example of a Wood Cantilever Diaphragm

Part 2-Shear Wall Design in Cantilever Diaphragm Structures

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

Course Description

Part 2 of this series will introduce an open front diaphragm design example that will be worked through in the remaining webinars. Topics addressed will include seismic force calculation and distribution, and preliminary shear wall design taking into account nominal shear wall stiffness. The impact of factors such as horizontal and torsional irregularities on force distribution to shear walls will be examined, and design of elements contributing to shear wall rotation and overturning will be discussed. The effect of gravity loads on shear walls will also be reviewed.

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.**

Cantilever Wood Diaphragm Webinar Series-Content

Webinar Part 1- Code Requirements and Relative Stiffness issues:

- Introduction
- Questions needing resolution
- Horizontal distribution of shear and stiffness issues
- 2015 SDPWS open-front requirements
- Review preliminary design assumptions

Webinar Part 2- Shear Wall Design in Cantilever Diaphragm Structures:

- Introduction to open-front example
- Calculation of seismic forces and distribution
- Preliminary shear wall design
- Nominal shear wall stiffness
- Verification of shear wall design

Webinar Part 3- Cantilever Diaphragm Design, Flexibility and Drift Checks :

- Diaphragm design
- Maximum diaphragm chord force
- Diaphragm flexibility
- Story drift

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

- Amplification of accidental torsion
- Redundancy
- Transverse direction design
- Multi-story shear wall effects

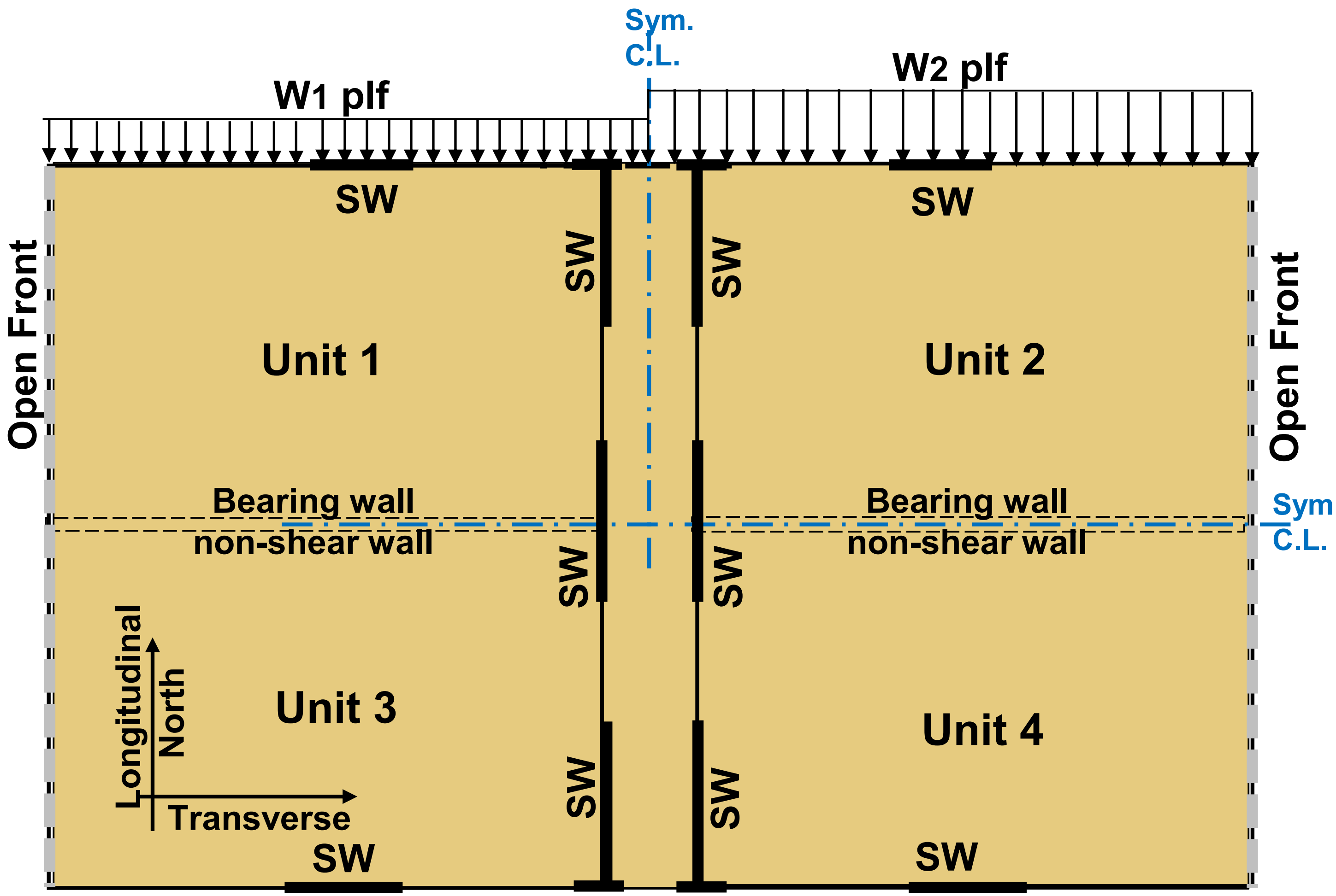
Content and Learning Objectives

Shear Wall Design:

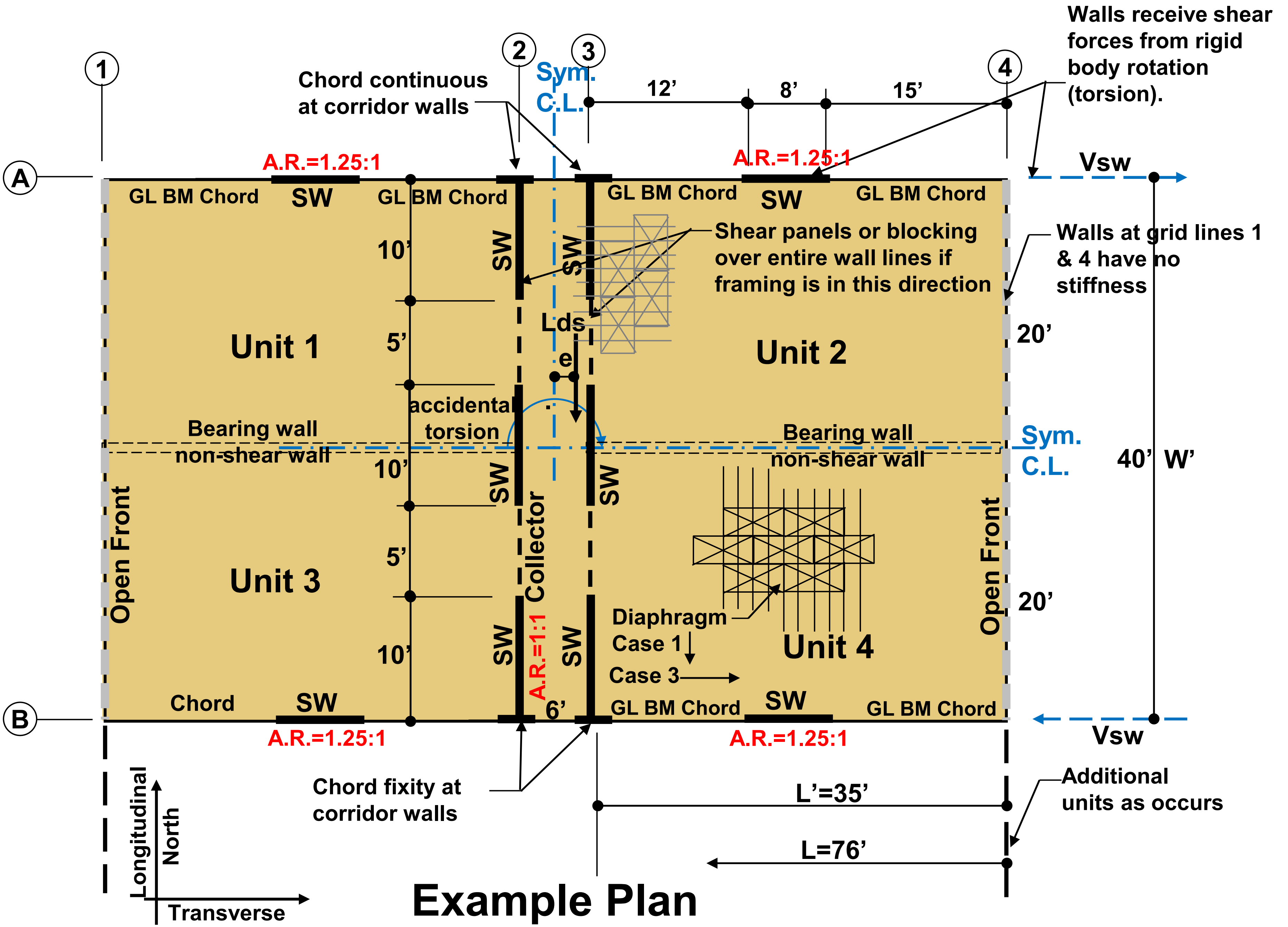
- **Introduction to open-front design example**
  The design example plan layout and goal of the example will be explained.
- **Calculation of seismic forces and distribution**
  The basic seismic forces and distribution to the shear walls will be covered.
- **Preliminary shear wall design**
  The basic shear wall construction will be chosen. Suggestions for improving the preliminary wall design to limit drift and reduce torsion will be discussed.
- **Nominal shear wall stiffness**
  A new approach for determining a single shear wall stiffness will be presented.
- **Verification of shear wall design**
  Verification of the wall capacity will be examined after the redistribution of forces are calculated using the nominal shear wall stiffness.

Design Example- Longitudinal Direction

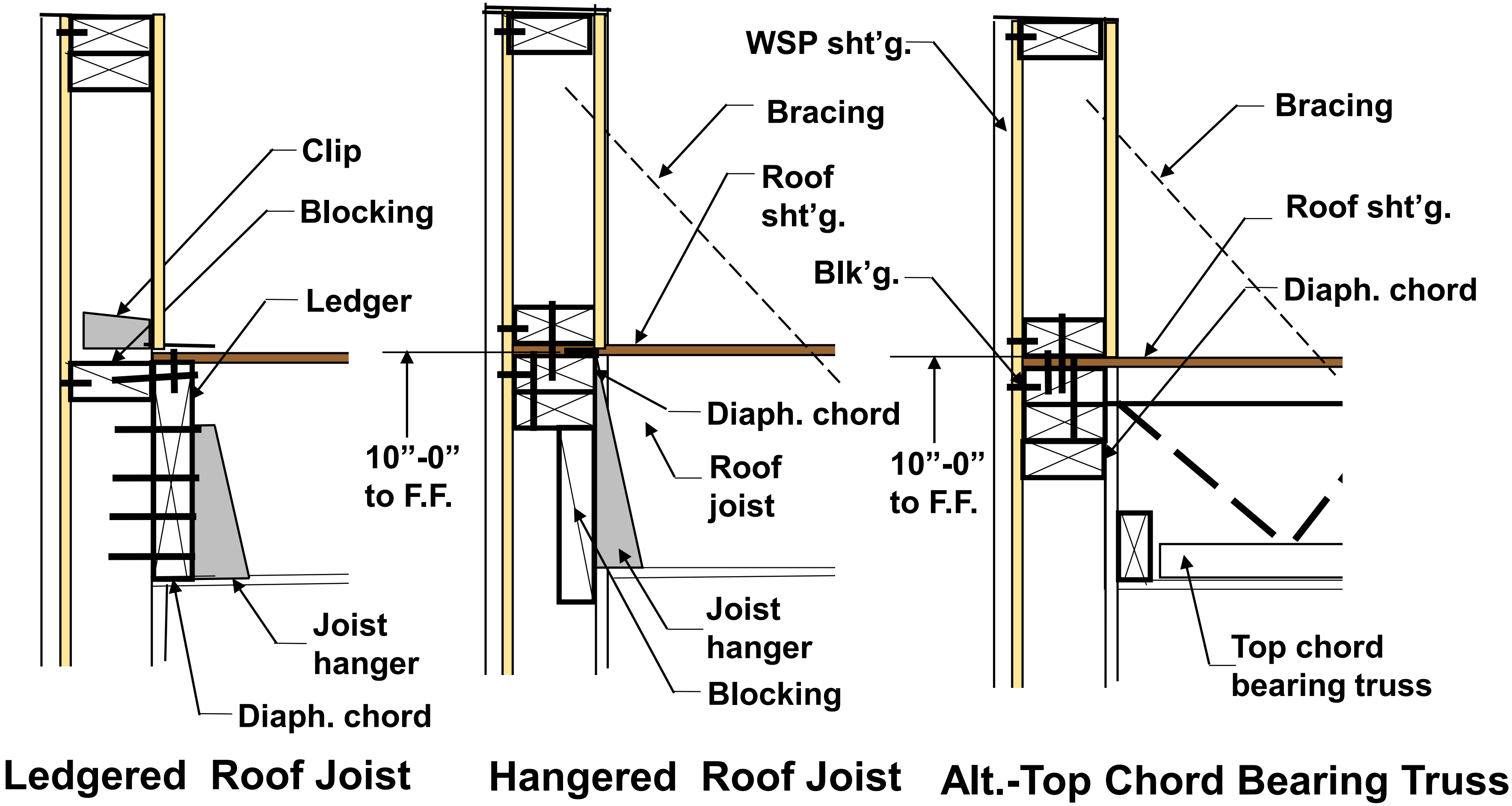
Example plan selected to provide maximum information on design issues



Disclaimer:
The following information is an open-front diaphragm example which is subject to further revisions and validation. The information provided is project specific, and is for informational purposes only. It is <u>not</u> intended to serve as recommendations or as the only method of analysis available.

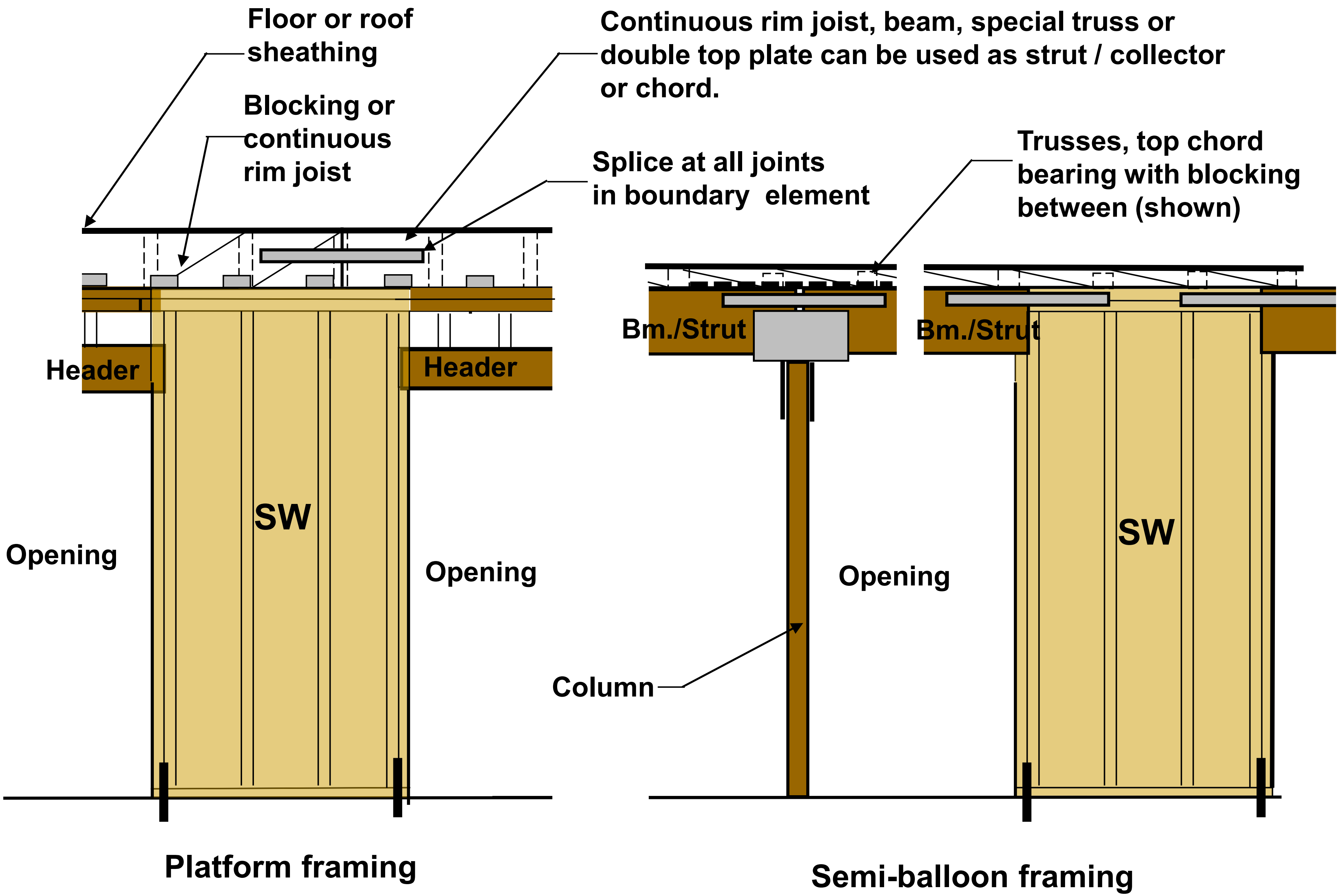


Example Plan

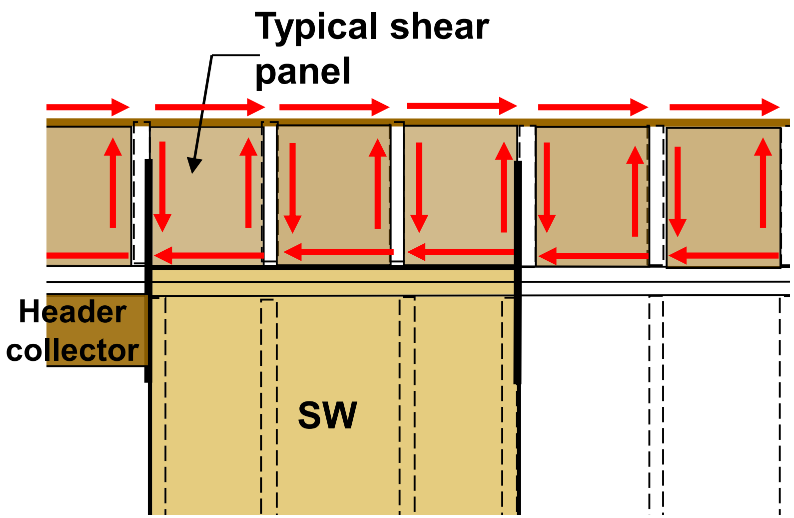


(Platform framing not shown)

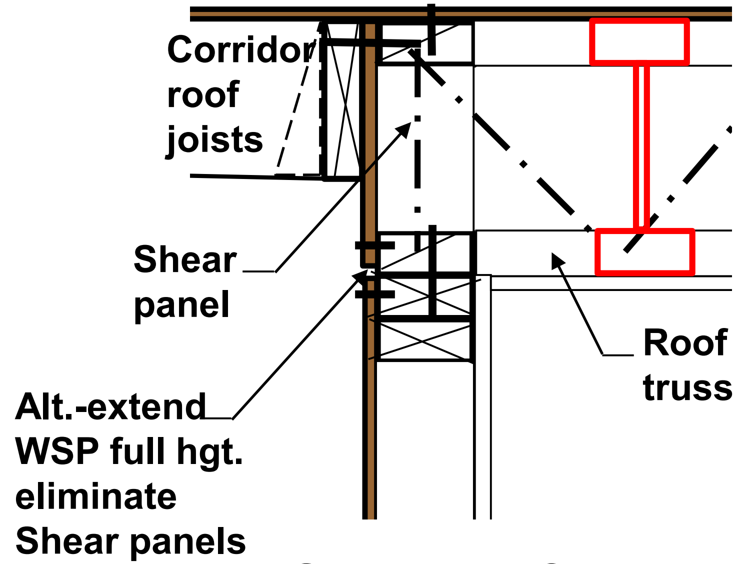
Typical Exterior Wall Sections



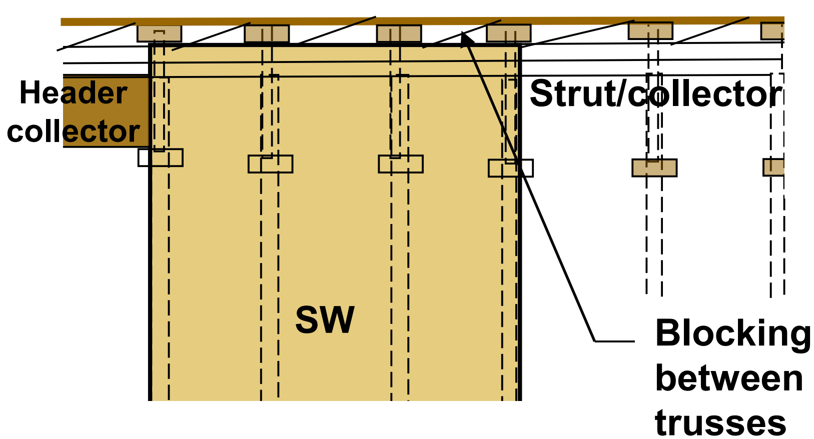
Typical Exterior Wall Elevations at Grid Lines A and B



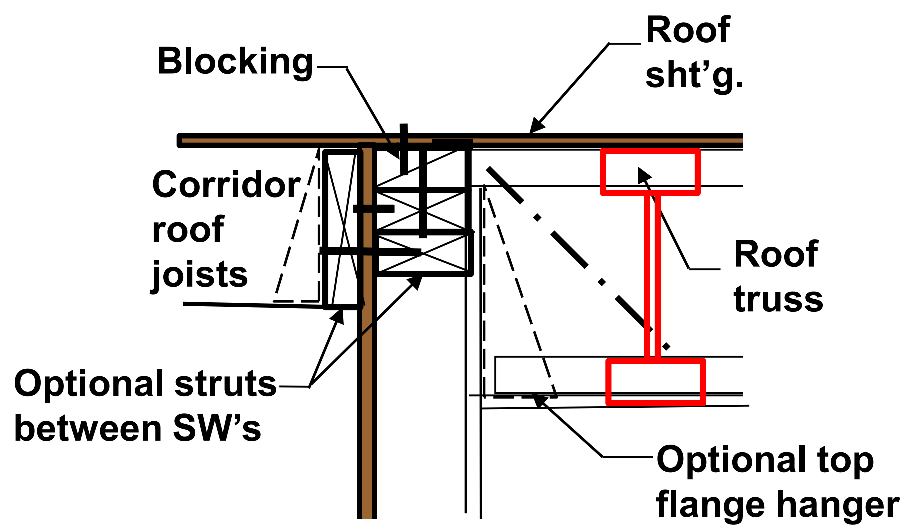
Platform Framing at Corridor



Section at Corridor



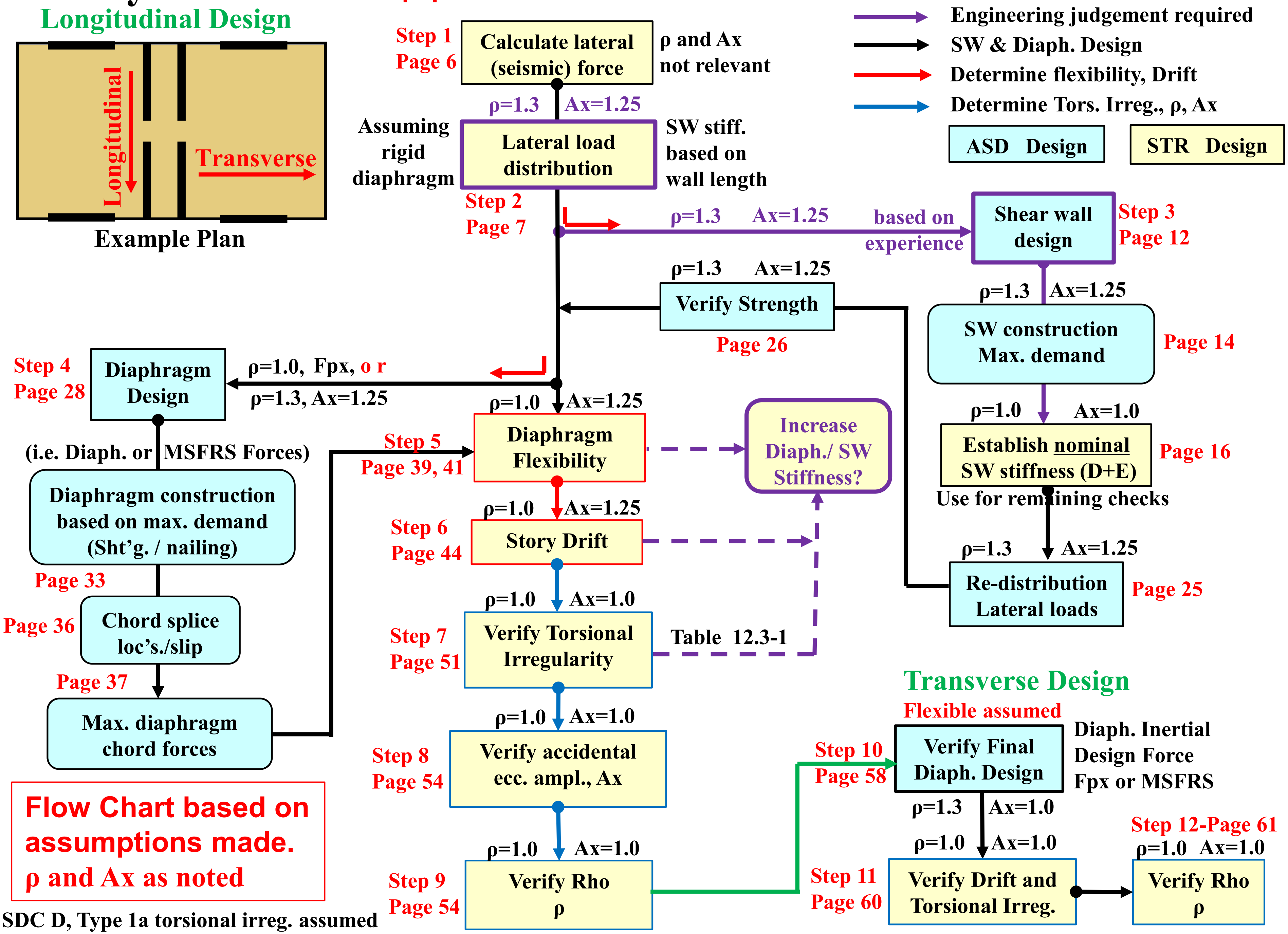
Semi-balloon Framing at Corridor



Section at Corridor
(Similar to example)

Typical Wall Sections at Corridor Walls

Analysis Flow- Not in paper



Typical Spreadsheet

	Requires Input

Rigid Diaphragm Analysis

Longitudinal Loading

Grid Line	kx	Ky	dx	dy	kd	kd^2	Fv		F_T	F_V+F_T
2	43.54		3		130.63	391.89	8874.0		-527.1	8346.9
3	43.54		3		130.63	391.89	8874.0		527.1	9401.1
A		25.14		20	502.74	10054.73			2028.5	2028.5
B		25.14		20	502.74	10054.73			-2028.5	-2028.5
Σ	87.09	50.27			J=	20893.23	17748			

Loads

δ_{SW}		
0.192	Rho=	1
0.216	Ax=	1.25
0.0807	Fy=	17748
-0.081	emin=	4.75
	T=Fe=	84303

Input ρ, Ax

Input or calculate base shear

Transverse Loading

Grid Line	kx	Ky	dx	dy	kd	kd^2	Fv		F_T	F_V+F_T
2	43.54		3		130.63	391.89			277.4	277.4
3	43.54		3		130.63	391.89			-277.4	-277.4
A		25.14		20	502.74	10054.73	8874.0		1067.6	9941.6
B		25.14		20	502.74	10054.73	8874.0		-1067.6	7806.4
Σ	87.09	50.27			J=	20893.23	17748.0			

Loads

Loads

0.006		
-0.006		
0.396	Fx=	17748
0.311	emin=	2.5
	T=Fe=	44370

Shear wall ρ=1.3, Ax=1.25
Torsion, Ax ρ=1.0, Ax=1.0
Flex/Drift ρ=1.0, Ax=1.25
Redundancy ρ=1.0, Ax=1.0

Use this load combination for defining Nominal Stiffness values, Keff. Then use those Keff values for all other analyses.

$$\delta_{sw\,4\text{-}term} = \frac{8vh^3}{EAb} + \frac{vh}{1000G_a} + \frac{h\Delta_a}{b}$$

Expected Dead + Seismic D+QE (other terms if "expected" gravity loads as per ASCE 41-13, equation 7-3) ρ=1.0, Ax=1.0

Nominal wall stiffness

Grid Line	SW	Ga	Rho	V on wall	v	T	C	Δ_a	$F_{c\perp}$	Crush.	Shrink	δ_B	δ_S	δ_{Rot}	δ_{SW}		K (k/in)
Calculate Stiffness of Walls on A & B using Transverse loading																	
A		37	1.0	7308.0	913.5	6390.85	13769.85	0.154	556.36	0.056	0.019	0.022	0.247	0.313	0.581	A	25.14
B		37	1.0	7308.0	913.5	6390.85	13769.85	0.154	556.36	0.056	0.019	0.022	0.247	0.313	0.581	B	25.14
Calculate Stiffness of Walls on 2 & 3 using Longitudinal loading																	25.14
2		30	1.0	7022.0	702.2	6391.13	8340.73	0.154	505.50	0.045	0.019	0.020	0.234	0.230	0.484	2	43.54
3		30	1.0	7022.0	702.2	6391.13	8340.73	0.154	505.50	0.045	0.019	0.020	0.234	0.230	0.484	3	43.54
V equal to revised wall force based on HD STR (design) capacity									625 Max.	Add stud							43.54

Calculate nominal stiffness by 3-term or 4-term deflection equation. K=F/δ

Longitudinal Analysis

Shear Walls LC7

LC7=0.726D+ρQE

Grid Line	SW	Ga	Rho	V on wall	v	T	C	$\delta_{SW=F/Keff}$
A & B	A,B	37	1.0	1014.3	126.8	-1229.16	4127.99	0.081
2	2	30	1.0	2782.3	278.2	2202.41	3617.82	0.192
3	3	30	1.0	3133.7	313.4	2572.30	3987.71	0.216

δsw=F/K

Shear Walls LC6

LC6=1.374D+ρQE+0.2S

Grid Line	SW	Ga	Rho	V on wall	v	T	C	$\delta_{SW=F/Keff}$
A & B	A,B	37	1.0	1014.3	126.8	-4085.04	7128.71	0.081
2	2	30	1.0	2782.3	278.2	1477.15	4305.90	0.192
3	3	30	1.0	3133.7	313.4	1847.03	4675.78	0.216

$$\delta_{Diaph\,Unif} = \frac{3vL'^3}{EAW'} + \frac{0.5v_{max}L'}{1000G_a} + \frac{\Sigma\Delta_c X_c}{W'}$$

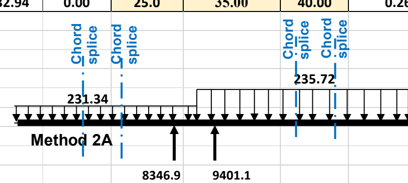
Diaphragm Deflection (STR)

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.
	1063.3	1158.3	3529.3	0.075	232.94	0.00	25.0	35.00	40.00	0.265	0.00	0.265
Nails Req'd=	4.70	5.13	15.62									
Use Nails =	8	16	24									
Slip=	0.023	0.012	0.025									

EA= 28050000, (2)2x6

Iincludes effects of sw's along chord line



W2	W1
233.53	233.53
2.19	-2.19
235.72	231.34

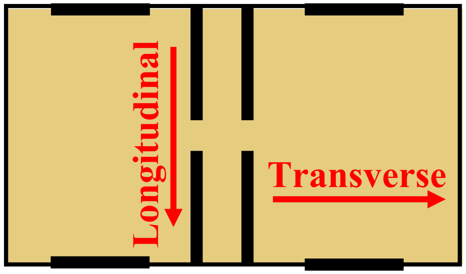
Diaphragm Deflection (STR)

Lft. Cantilever

250.3	1930.1	3622.4	0.073	229.11	0.00	25.0	35.00	40.00	0.259	0.00	0.259
1.11	8.54	16.03									
8	16	24									
0.005	0.021	0.026									

Analysis Flow

Longitudinal Design



Example Plan

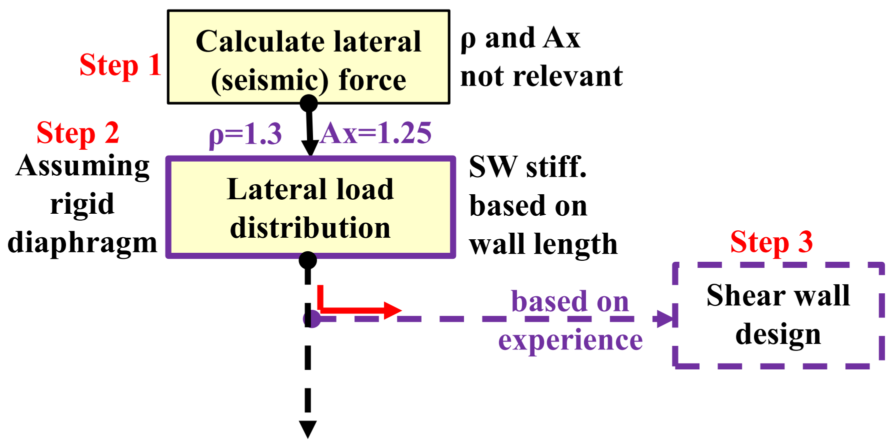
Legend

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

ASD Design | STR Design

Assumptions Made: Page 8

- Diaphragm is rigid or semi-rigid in both directions
- Torsional irregularity Type 1a occurs in longitudinal direction, but not transverse, Ax=1.25.
- Horizontal irregularity Type 1b does not occur in either direction.
- No redundancy in both directions, ρ=1.3



Force Distribution to Shear Walls

Seismic- ρ=1.3, Ax=1.25

Page 6,7

Basic Project Information

- Structure-Occupancy B, Office, Construction Type VB-Light framing:
  - Wall height=10’-Single story
  - L=76’, total length
  - W’=40’, width/depth
  - L’=35’, cantilever length (max.)
  - 6’ corridor width
- Roof DL (seismic)= 35.0 psf including wall/ partitions
- Wall DL = 13.0 psf (in-plane)
- Roof snow load = 25 psf > required roof LL=20 psf
- Roof (lateral)= roof + wall H/2 plus parapet

Lateral Load Calculations-Seismic

Calculate Seismic Forces -ASCE 7-16 Section 12.8 Equivalent Lateral Force Procedure, F_x

- **Risk category II**
- **Importance factor, I_e = 1.0**

Using USGS Seismic Design Map-Tool, 2015 NEHRP, 2016 ASCE 7-16:

- **Location-Tacoma, Washington**
- **Site class D-stiff soil**
- **Ss = 1.355 g, S1 = 0.468 g**
- **S_{DS} = 1.084 g, S_{D1} = 0.571 g**
- **Seismic Design Category (SDC) = D**

ASCE 7-16 Table 12.2-1, Bearing Wall System, A(15) light framed wood walls w/ WSP sheathing. R = 6.5, Ω_0=3, Cd=4, Maximum height for shear wall system=65'.

Seismic Force Calculation results:

$$C_s = \frac{S_{DS}}{\left(\frac{R}{I_e}\right)} = \textbf{0.167} \quad \textbf{short period controls} \qquad \textbf{12.8-2}$$

Basic lateral force MSFRS

V = C$_S$W = 0.167(35)(76)(40) = 17769 lbs. STR

17769(0.7) = 12438 lbs. ASD

Rigid Diaphragm Analysis- ρ=1.3, Ax=1.25

Initial wall stiffness will be based on wall length.

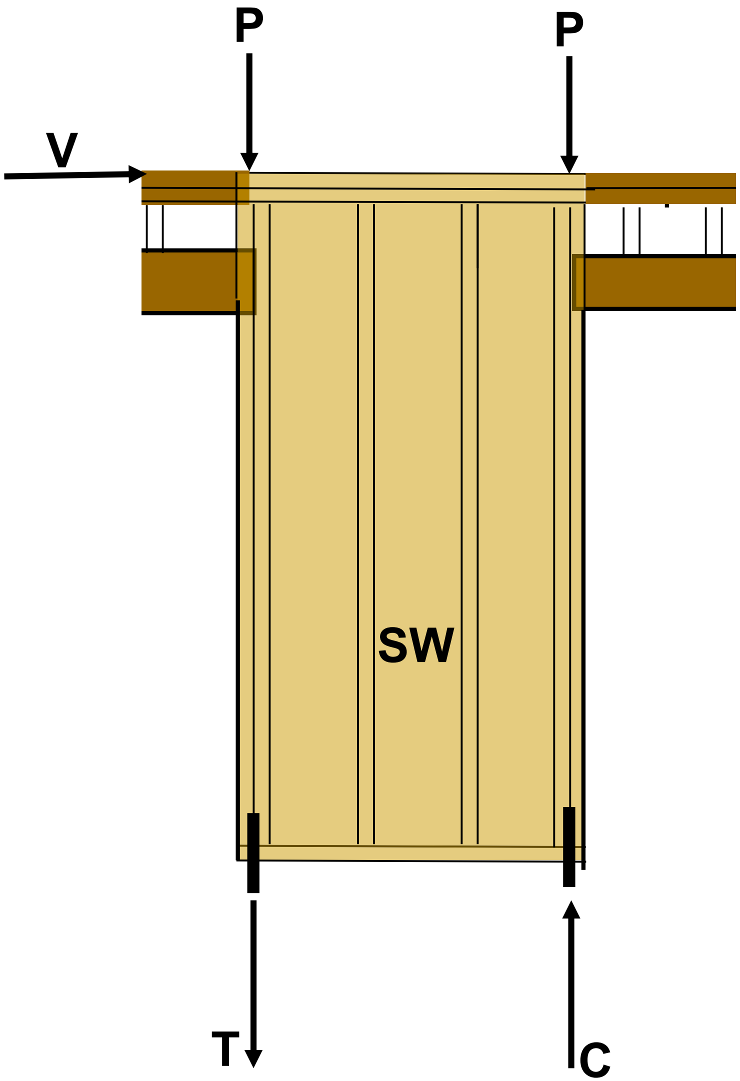
The final wall Nominal stiffness's are used for all final analysis checks.

RDA Equations

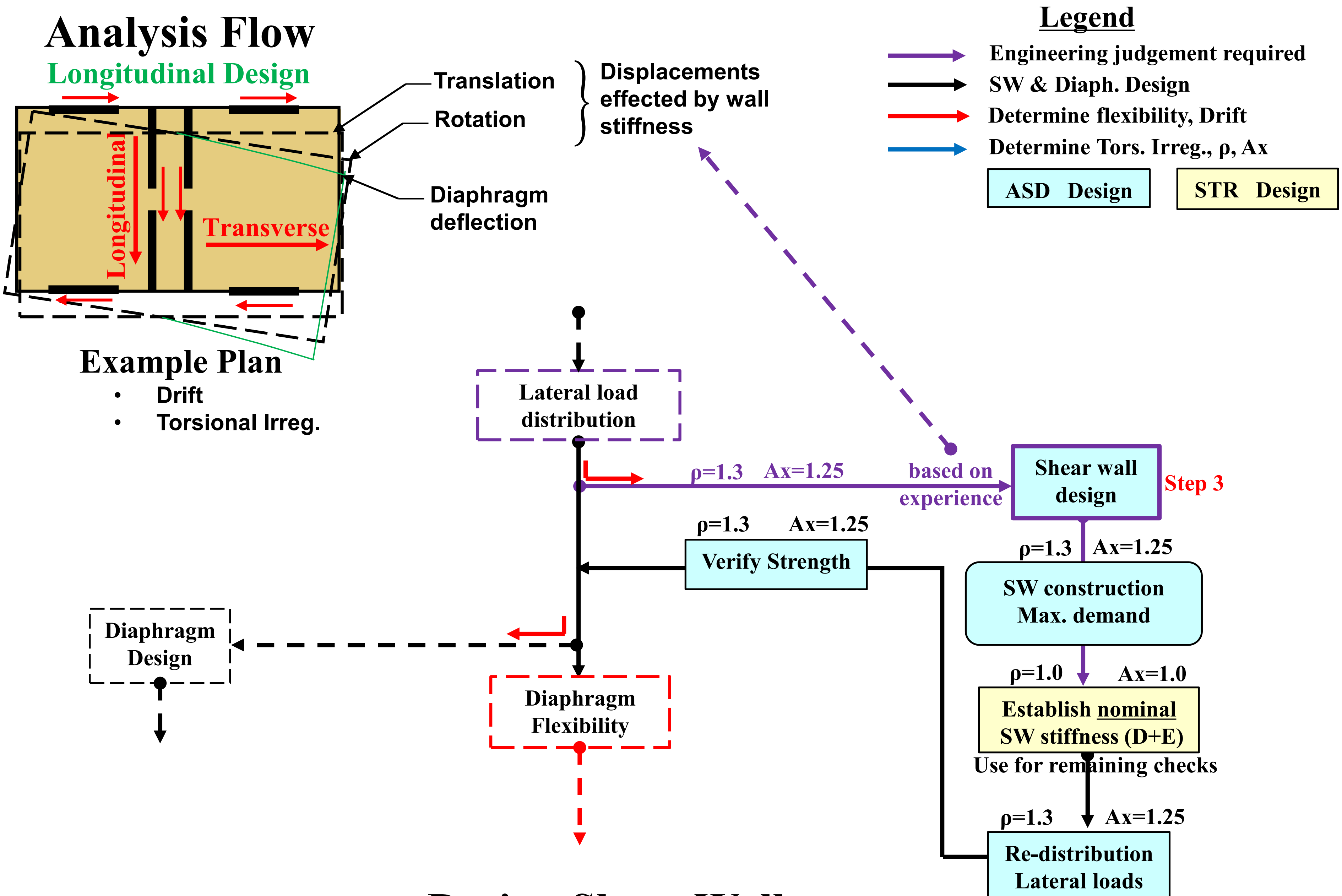
$$T = V(e)(Ax)(\rho) \text{ ft. lbs.} \qquad F_T = T\frac{kd}{\sum kd_x^2 + kd_y^2} \qquad F_{sw} = F_V + F_T$$

$$J = \sum kd_x^2 + kd_y^2 \qquad F_V = F_x\frac{k}{\sum k}$$

Preliminary Shear Wall Design



Analysis Flow



Design Shear Walls

Seismic- ρ=1.3, Ax=1.25

Preliminary Shear wall Design (ASD): ASCE 7-16 Section 2.3.6-Seismic

SW Design Checks

- Check aspect ratio, If A.R.>2:1, reduction is required per SDPWS Section 4.3.4. A.R. = 1.25:1< 3.5:1. Since the A.R. does not exceed 2:1, no reduction is required.

- Wall shear: $V_{sw\ A,\ B} = \frac{V_{wall\ line}}{2}$ Lbs. each wall segment, $v_s = \frac{V_{wall}}{L_{wall}}$ plf

- Select over-turning anchor-capacity > demand.

- Calculate actual anchor slip, $\text{slip} = \frac{\text{Max slip at capacity(T)}}{\text{Strength capacity}}$

- Determine shear wall chord properties:

  2x6 DF-L no. 1 framing used throughout.
  E = 1,700,000 psi, wall studs @ 16" o.c.

  EA= 42,075,000 lbs. at grid line A,B = (3)2x6 D.F., KD, studs @16" o.c. boundary elem.

  EA= 28,050,000 lbs. at grid line 2,3 = (2)2x6 D.F., KD, studs @16" o.c. boundary elem.

- Calculate wall deflection

- **Shear Wall Deflection-calculated using:**

Traditional 4 term deflection equation

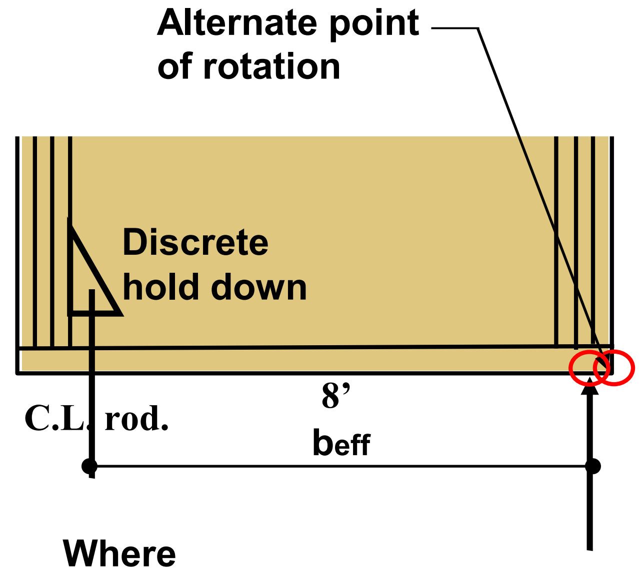
$$\delta_{SW} = \frac{8vh^3}{EAb} + \overbrace{\frac{vh}{G_v t_v} + 0.75he_n}^{\text{SDPWS combines}} + \frac{h\Delta_a}{\text{beff}} \qquad \text{C4.3.2-1}$$

Bending

Shear

Nail slip

Rod elongation (Wall rotation)



SDPWS 3 term deflection equation

$$\delta_{SW} = \frac{8vh^3}{EAb} + \frac{vh}{1000G_a} + \frac{h\Delta_a}{\text{beff}} \qquad \text{4.3-1 Alt.}$$

Bending

Apparent shear stiffness
- Nail slip
- Panel shear deformation

Vertical elongation
- Device elongation
- Rod elongation

Where

v=wall unit shear (plf)

h=wall height (ft.)

beff =Wall rotation width (ft.)

b=Wall width (ft.)

Ga=apparent shear stiffness (k/in.)

Δ_a=Sum of vertical displacements at anchorage and boundary members (in.)

Note:

Calculate wall deflection as: $\delta_{sw\ A,B} = \frac{F}{k}$

after Nominal stiffness has been established

Causes of Wall Rotation

- Hold downs = pre-manufactured bucket style with screw attachments Same H.D used at all SW locations
  - Manuf. table gives Allowable ASD hold down capacity and displacement at capacity (ESR Reports)
  - Displacement at hold down = $\frac{T(Allow.Displ)}{ASD\ Capacity}$
  - Min. wood attachment thickness = 3” per table

- Sill plate shrinkage:

Dimensional change = 0.0025 inches per inch of cross-sectional dimension for every 1 percent change in MC.

Shrinkage = (0.0025)(D)(Starting MC - End MC)

Where: D is the dimension of the member in the direction under consideration, in this case the thickness of a wall plate.

- **Sill plate crushing:**

  $F'_{c\perp}$ **values in AWC 2018 NDS section 4.2.6 are based on 0.04" deformation/crushing limit for a steel plate bearing on wood.**

  Adjustment factor = 1.75 for parallel to perpendicular grain wood to wood contact.

  Boundary values for bearing perpendicular to grain stresses and crushing-D.F.

  $F_{c\perp 0.02} = 0.73F'_{c\perp}$ **= 0.73(625) = 456.3 psi**

  $F_{c\perp 0.04} = F'_{c\perp}$ **= 625 psi**

  When $f_{c\perp} \leq F_{c\perp 0.02}$"

  $$\Delta_{crush} = 0.02\left(\frac{f_{c\perp}}{F_{c\perp 0.02}}\right)$$

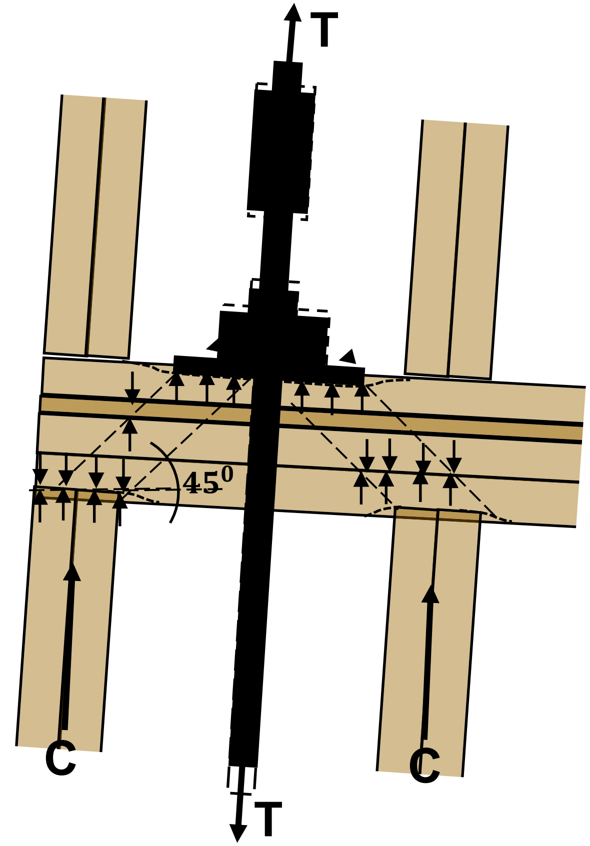
  When $F_{c\perp 0.02}" \leq f_{c\perp} \leq F_{c\perp 0.04}"$

  $$\Delta_{crush} = 0.04 - 0.02\left(\frac{1-\frac{f_{c\perp}}{F_{c\perp 0.04}"}}{0.27}\right)$$

  When $f_{c\perp} > F_{c\perp 0.04}"$

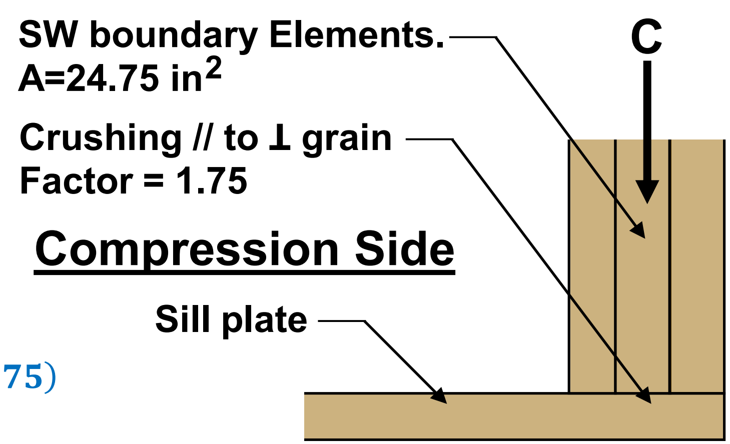
  $$\Delta_{crush} = 0.04\left(\frac{f_{c\perp}}{F_{c\perp 0.04}}\right)^3$$

  If $f_{c\perp} = \left(\frac{C}{A_{chord}}\right) < 456.3\text{ psi},\ Crushing = 0.02\left(\frac{fc\perp}{456.3}\right)(1.75)$



Tension Side

If cont. tie rod

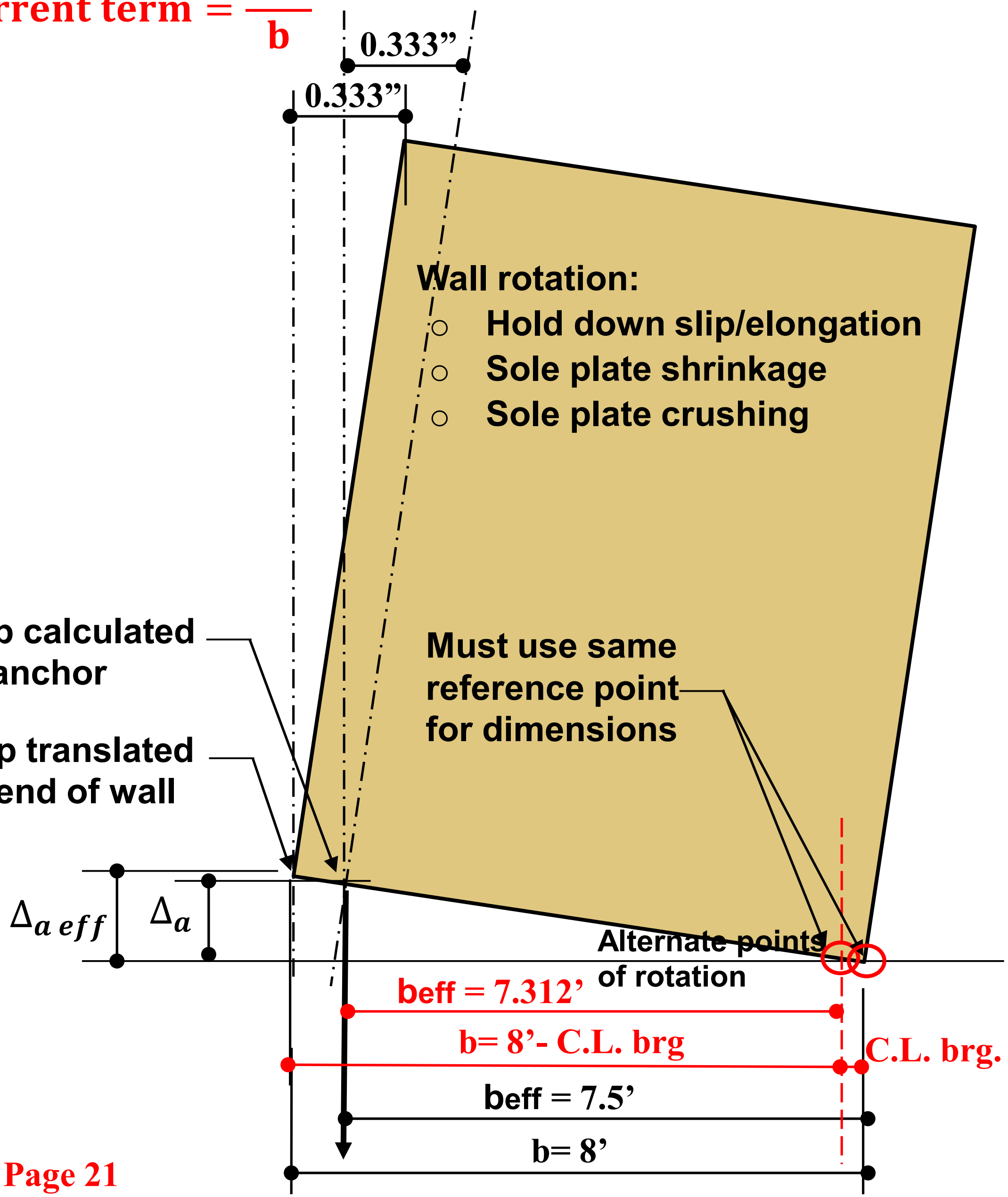


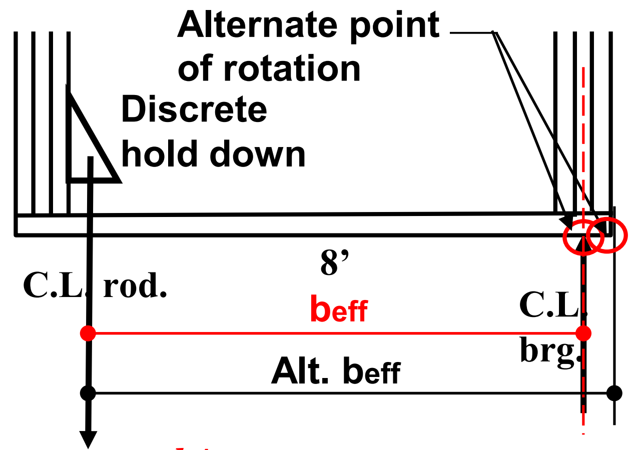
Compression Side

Shear Wall Rotation

Proposed nomenclature of next edition of SDPWS

Current term $= \dfrac{h\Delta_a}{b}$





$$SW_{rot} = \frac{h\Delta_a}{\text{beff}} \quad or \quad SW_{rot} = \frac{h\Delta_{a\,eff}}{b}$$

Where

h=wall height (ft.)

beff =Wall rotation arm (ft.)

b=Wall width (ft.)

$\Delta_{a\,eff}$=Sum of vertical displacements at anchorage (in.)

Δ_a=Sum of vertical displacements at tension edge of wall

$\Delta_a = 0.25''$

$$\Delta_{a\,eff} = \frac{0.25(8)}{7.5} = 0.267''$$

$$SW_{rot} = \frac{10(0.25)}{7.5} = 0.333''$$

$$SW_{rot} = \frac{10(0.267)}{8} = 0.333''$$

Load Combinations (ASD):

LC8 = $1.152D + 0.7\rho Q_E$

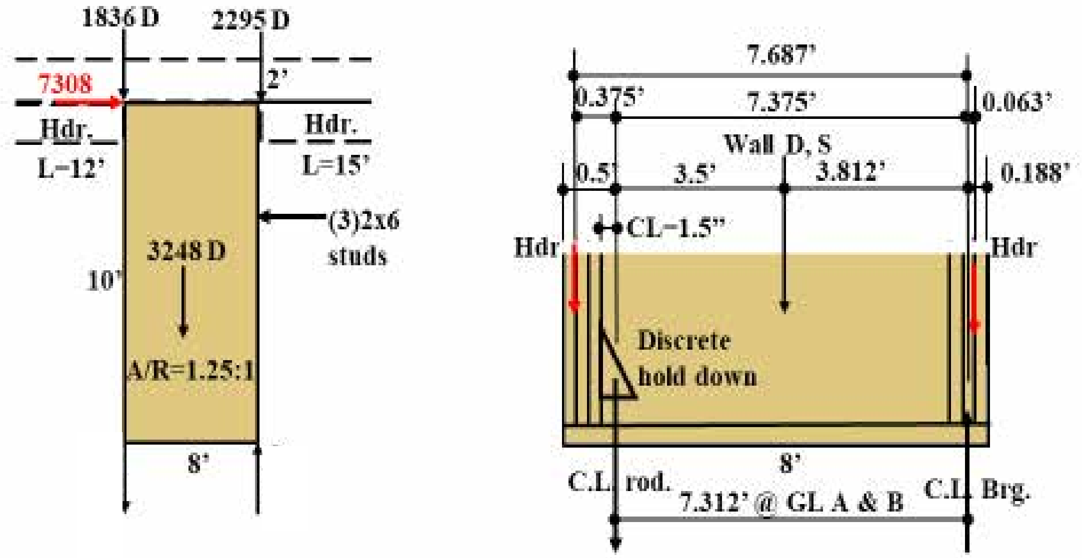
LC9 = $1.114D + 0.525\rho Q_E + 0.75S$

LC10 = $0.448D + 0.7\rho Q_E$

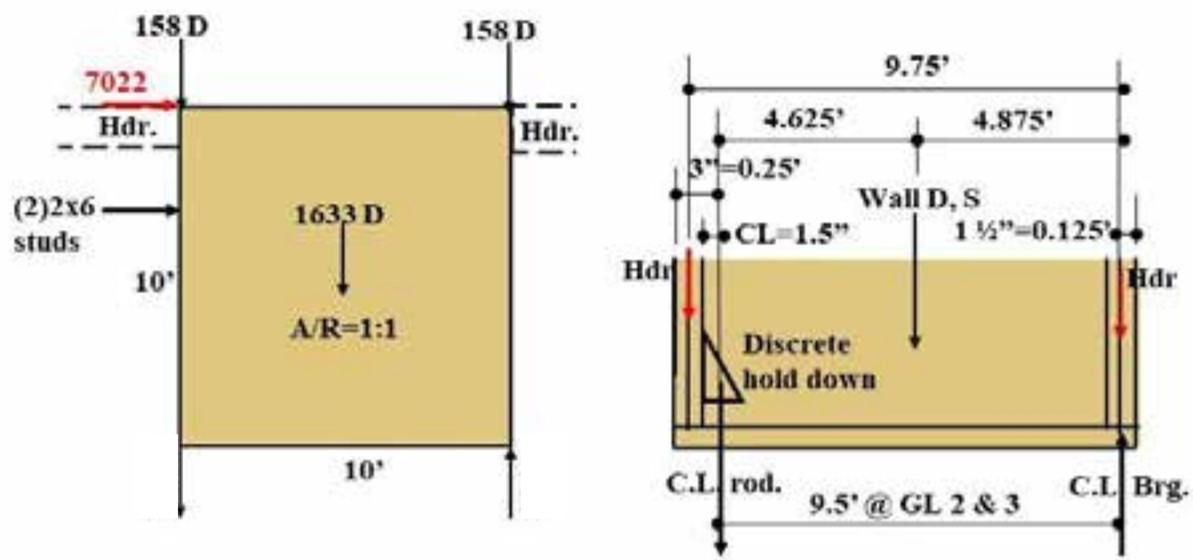
Full dead loads shown, 1.0D

Adding Gravity Loads to SW's

- Can have a significant impact on horizontal shear wall deflections and stiffness.
- Results in wall stiffness ($K = F/\delta$) relationships which are non-linear with the horizontal loading applied.



Shear Walls Along Grid Lines A and B
Design Dimensions



Shear Walls Along Grid Lines 2 and 3
Design Dimensions

Based on initial Relative Wall Stiffness's, ASD, ρ=1.3, Ax=1.25 –by wall lengths

Longitudinal Direction, e=4.75', T = 76806.5 ft. lbs.

SW Line	Ky k/in	Kx k/in	Dx Ft.	Dy Ft.	Kd	Kd^2	Fv Lbs.	F_T Lbs.	Total Lbs.
A	-------	16	--------	20	320	6400	0	1842.4	1842.4
B	-------	16	--------	20	320	6400	0	-1842.4	-1842.4
2	30	--------	3	--------	90	270	8084.9	-518.2	7566.7
3	30	--------	3	--------	90	270	8084.9	518.2	8603.1

Corridor Walls at Grid lines A & B Walls

ΣKy=60 ΣKx=32

J=16169.8

Transverse Direction, e=2.5', T = 40424.5 ft. lbs.

SW Line	Ky k/in	Kx k/in	Dx Ft.	Dy Ft.	Kd	Kd^2	Fv Lbs.	F_T Lbs.	Total Lbs.
A	-------	16	--------	20	320	6400	8084.9	969.7	9054.6
B	-------	16	--------	20	320	6400	8084.9	-969.7	7115.2
2	30	--------	3	--------	90	270	0	-272.7	-272.7
3	30	--------	3	--------	90	270	0	272.7	272.7

Corridor Walls at Grid lines A & B Walls

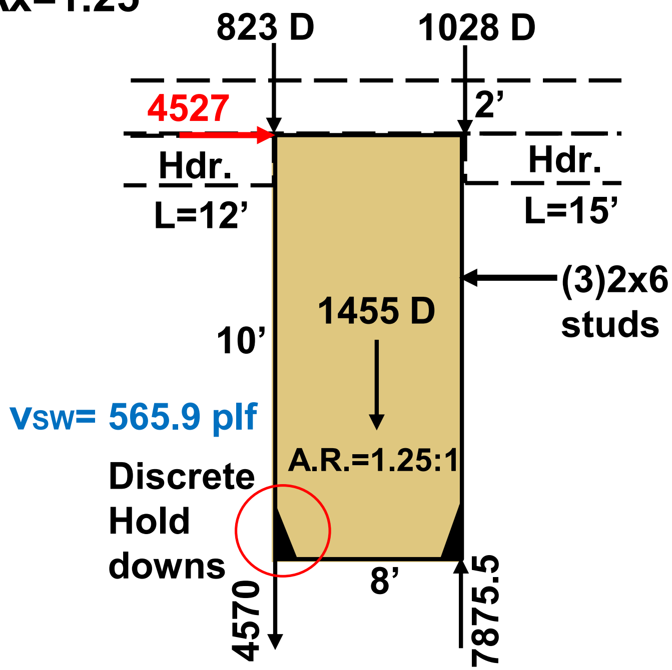
ΣKy=60 ΣKx=32

J=16169.8

Preliminary Shear Wall Design-Distribution based on wall lengths

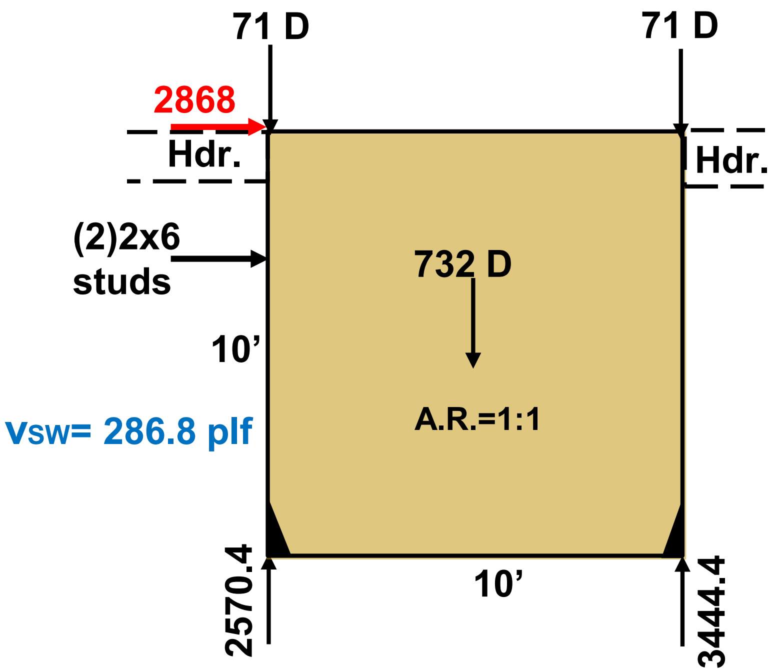
ASD Load Combination: LC10 = $0.448D+0.7\rho Q_E$

ρ=1.3, Ax=1.25



Shear Walls Along Grid Lines A and B

Transverse Loading



Shear Walls Along Grid Lines 2 and 3

Longitudinal Loading

Calculated results by wall length

$V_{SW\ A,B}$ = 565.9 plf

$V_{SW\ 2,3}$ = 286.8 plf

Shear Wall Capacity-Wood Based Panels

Blocked

Table 4.3A Nominal Unit Shear Capacities for Wood-Framed Shear Walls

Wood Based Panels[4]																			
Sheathing Material	Minimum Nominal Panel Thickness (in.)	Minimum Fastener Penetration In Framing Member or Blocking (in.)	Fastener Type & Size Nail (common or Galvanized box)	A Seismic: Panel Edge Fastener Spacing (in.)												B Wind: Panel Edge Fastener Spacing (in.)			
				6 (plf) (kips/in.)			4 (plf) (kips/in.)			3 (plf) (kips/in.)			2 (plf) (kips/in.)			6 (plf)	4 (plf)	3 (plf)	2 (plf)
				Vs	Ga OSB	Ga PLY	Vs	Ga OSB	Ga PLY	Vs	Ga OSB	Ga PLY	Vs	Ga OSB	Ga PLY	Vw	Vw	Vw	Vw
Wood[4,5] Structural Panels-Sheathing	15/32	1-3/8	8d	520	13	10	760	19	13	980	25	15	1280	39	20	730	1065	1370	1790
	15/32			620	22	14	920	30	17	1200	37	19	1540	52	23	870	1290	1680	2155
	19/32	1-1/2	10d	680	19	13	1020	26	16	1330	33	18	1740	48	28	950	1430	1860	2435

Increasing stiffness to account for drift, torsion, etc. requires engineering judgement.

$SW_{A,B}$: Use 15/32" OSB w/ 10d@3" o.c., v_s= (1200)/2 = 600 plf, Ga=37

$SW_{2,3}$: Use 15/32" OSB w/ 10d@4" o.c., v_s= (920)/2 = 460 plf, Ga=30

Maximum tension force, T= 4570 lbs.- Use HD=4565 lbs. (0.1% under-check later)

ASD, Δa=0.114" @ capacity

STR, Δa=0.154" @ capacity

Determination of Nominal Wall Stiffness

Combining Rigid Diaphragm Analysis & shear wall deflection calculations is problematic due to non-linearities, which can effect the distribution of loads to the shear walls and will effect the shear wall deflections. This can lead to a different set of stiffness values that may not be consistent.

Whenever changing:

- **Load combinations**
- **Vertical or lateral loads,**
- **Direction of loading**
- **Redundancy, or**
- **Accidental torsion**

Requires an Iterative search for the point of convergence, which is not practical for multi-story structures.

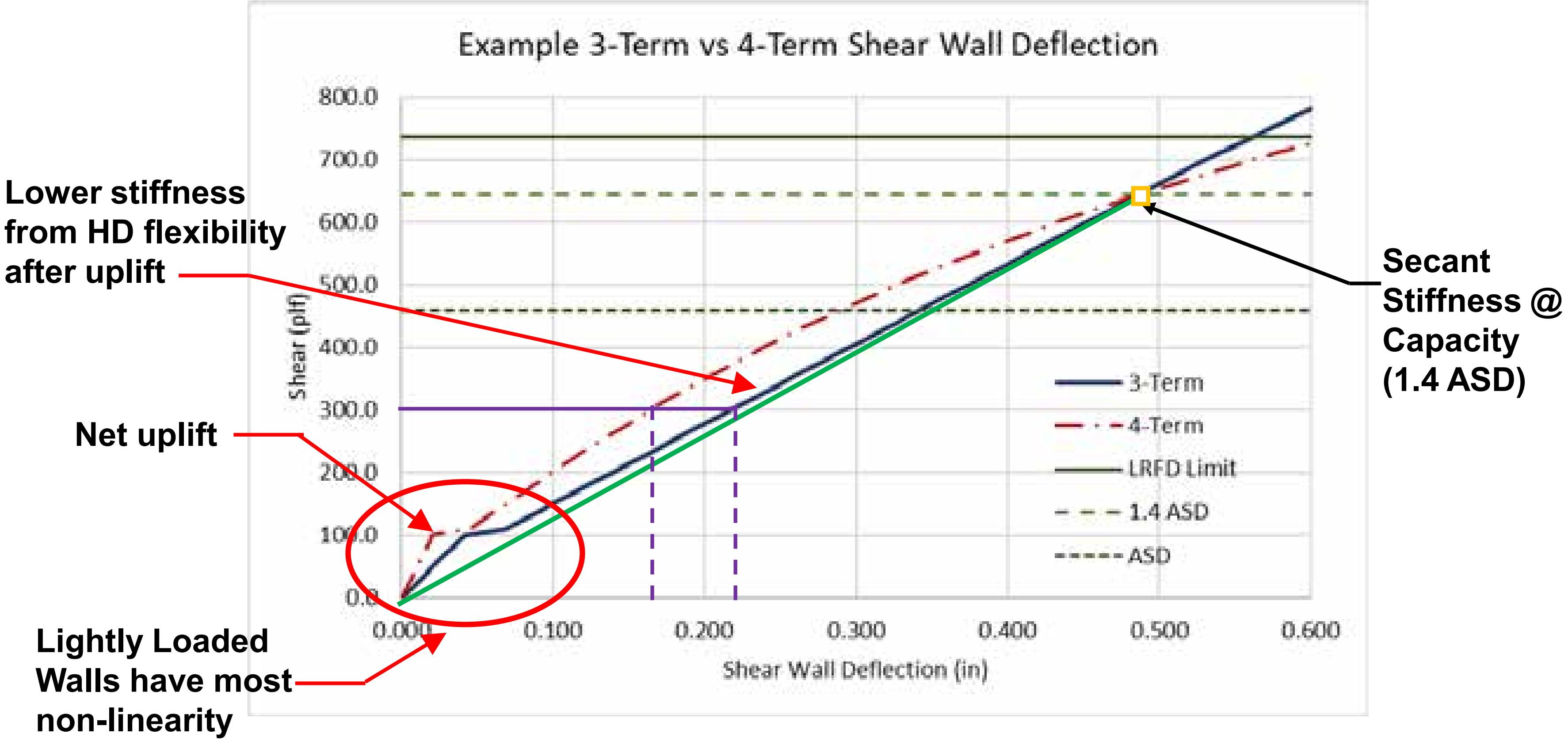
Sources of non-linearities:

- **Hold-down slip at uplift (e.g. shrinkage gap)**
- **Hold-down system tension and elongation**
- **Compression crushing. Non-linear in NDS**
- **Shrinkage**
- **4-term deflection equation**

Since deflection is "non-linear"…. the stiffness can vary with the loading, even when using 3-term deflection equation.

LATERAL Load for Shear Wall Deflection & Stiffness Calculations

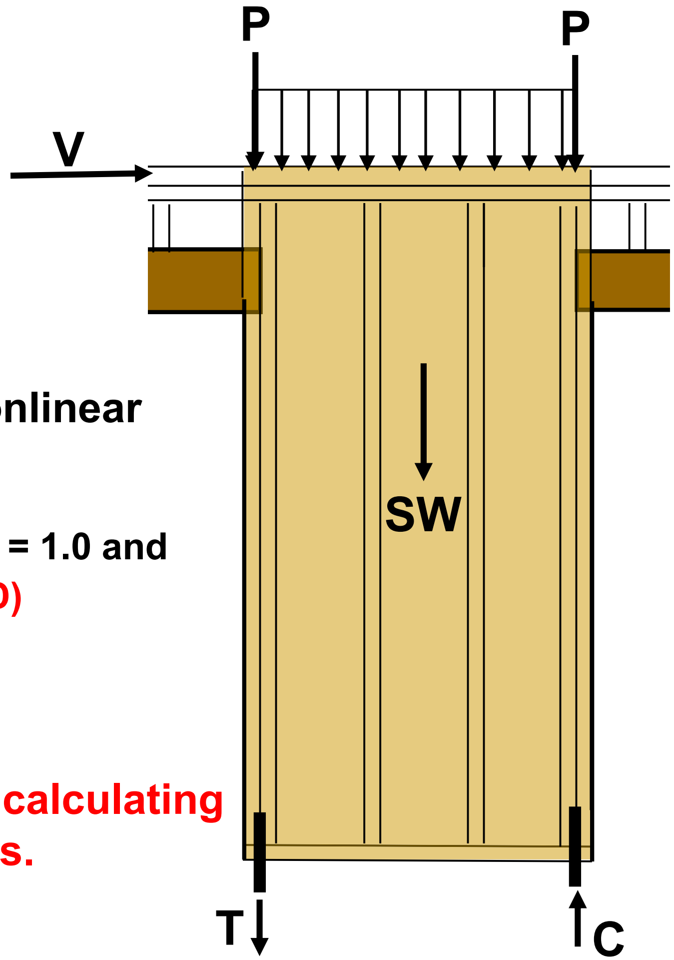
- **3-term equation is a linear simplification of the 4-term equation, calibrated to match the applied load at 1.4 ASD.**
- **This simplification removes the non-linear behavior of e_n.**
- **Similar approach can be used to remove non-linear effects of Δ_a by calculating the wall stiffness at strength level capacity of the wall, not the applied load.**



Method allows having only one set of nominal stiffness values.

Objective:

Use a single rational vertical and lateral load combination to calculate deflections and Nominal shear wall stiffness.



Gravity Loads:

A simplification of gravity loads are applied similar to nonlinear procedures in ASCE 41-13 in ASCE 41-13 Eq. 7-3.

For this *Single-Story* Example we used 1.0D, using ρ = 1.0 and Ax = 1.0. Vertical seismic loading not included. ($E_V=0.2S_{DS}D$)

For multi-story buildings, suggest 1.0D+ αL as in ASCE 7-16 Section 16.3.2- Nonlinear analysis

Results in single vertical loading condition to use when calculating shear wall deflections and nominal shear wall stiffnesses.

Proposing:

1. Stiffness calculated using 3-term eq. and LC 1.0D+Qe, with ρ=1.0 and Ax=1.0.
2. Use stiffness calculated at 100% Maximum Seismic Design Capacity of the Wall for all Load Combinations and Drift Checks from RDA using 3 term equation.
3. Use nominal stiffness for all other analysis checks, calculating wall deflection,
$$\delta_{SW} = \frac{F}{K}$$
4. Maximum wall capacity =max. allow. Shear (nailing) or HD capacity whichever is less.

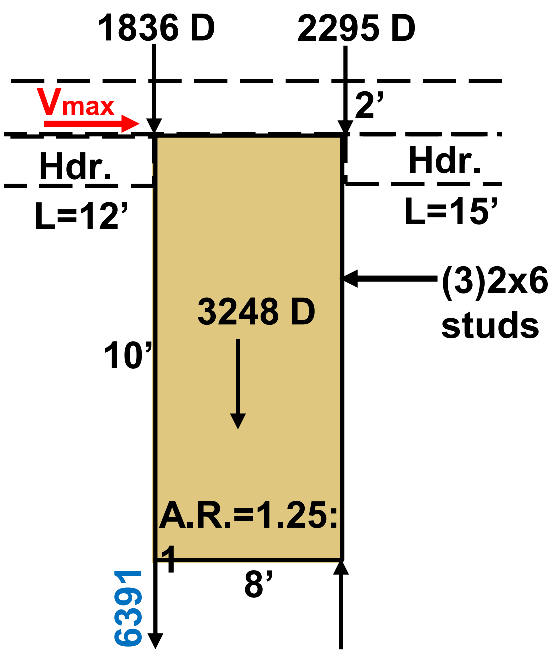
Nominal Shear Wall Stiffness's (STR) ρ=1.0, Ax=1.0

Load Combination: 1.0D + Q_E

Grid Line	Ga	V on wall	v	T	C	Δ_a	$F_{c\perp}$	Crush.	Shrink	δ_B	δ_S	δ_{Rot}	δ_{SW}
Calculate Stiffness of Walls on A & B using LRFD Capacity													
A	37	7308.0	913.5	6391	13770	0.154	556.36	0.056	0.019	0.022	0.247	0.313	0.581
B	37	7308.0	913.5	6391	13770	0.154	556.36	0.056	0.019	0.022	0.247	0.313	0.581
Calculate Stiffness of Walls on 2 & 3 using LRFD Coading													
2	30	7022.0	702.2	6391	8341	0.154	505.50	0.045	0.019	0.020	0.234	0.230	0.484
3	30	7022.0	702.2	6391	8341	0.154	505.50	0.045	0.019	0.020	0.234	0.230	0.484

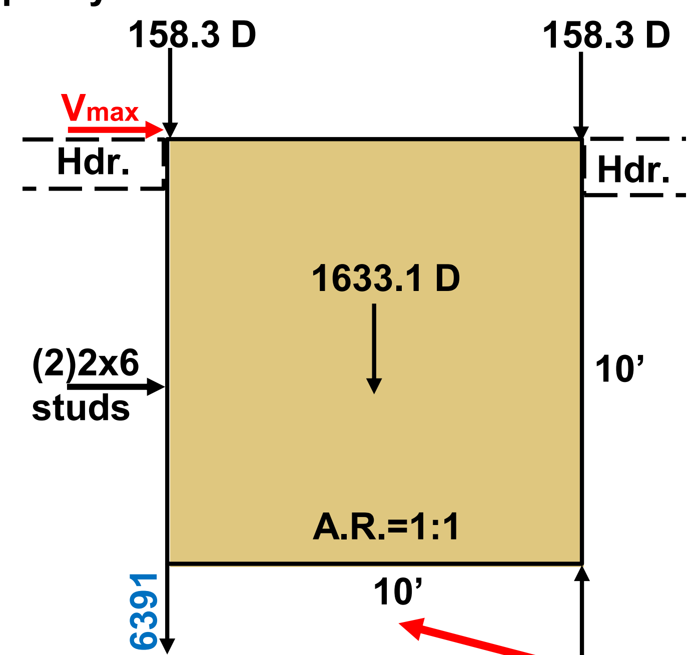
Wall Capacity based on hold down

	K (k/in)
A	25.14
B	25.14
Aver.=	25.14
2	43.54
3	43.54
Aver.=	43.54



Shear wall Grid A and B
Trib. = 10'

Transverse Loading
Nominal Strength



Shear wall Grid 2 and 3
Trib. = 2'

Longitudinal Loading
Nominal Strength

Max. capacity check (STR):

$\text{Shear}_{A,B}$= 0.8(1200)(8)=7680 lbs.
$\text{Shear}_{2,3}$= 0.8(920)(10)=7360 lbs.

$\text{H.D.}_{A,B,2,3}$=6391 lbs.(STR), Δa=0.154"

Set tension force=H.D. cap. and solve for allowable V at top of wall.

V max. A,B= 7308 lbs. controls
V max. 2,3= 7022 lbs. controls

Verification of Wall Strength (ASD)

Based on selected wall construction and Nominal Wall Stiffness

Longitudinal Direction, e=4.75', T = 76806.5 ft. lbs. ρ=1.3, Ax=1.25

SW Line	Ky k/in	Kx k/in	Dx Ft.	Dy Ft.	Kd	Kd^2	Fv Lbs.	FT Lbs.	Total Lbs.	
A	-------	25.14	--------	20	502.8	10056	0	1848.1	1848.1	Walls at Grid lines A & B
B	-------	25.14	--------	20	502.8	10056	0	-1848.1	-1848.1	
2	43.54	--------	3	--------	130.62	391.86	8084.9	-480.1	7604.8	Corridor Walls
3	43.54	--------	3	--------	130.62	391.86	8084.9	480.1	8565.0	

ΣKy=87.08 ΣKx=50.28

J=20895.72

Transverse Direction – e=2.5', T = 40424.5 ft. lbs. ρ=1.3, Ax=1.25

SW	Ky k/in	Kx k/in	Dx Ft.	Dy Ft.	Kd	Kd^2	Fv Lbs.	FT Lbs.	Total Lbs.	
A	-------	25.14	--------	20	502.8	10056	8084.9	972.7	9057.6	Walls at Grid lines A & B
B	-------	25.14	--------	20	502.8	10056	8084.9	-972.7	7112.2	
2	43.54	--------	3	--------	130.62	391.86	0	252.7	252.7	Corridor Walls
3	43.54	--------	3	--------	130.62	391.86	0	-252.7	-252.7	

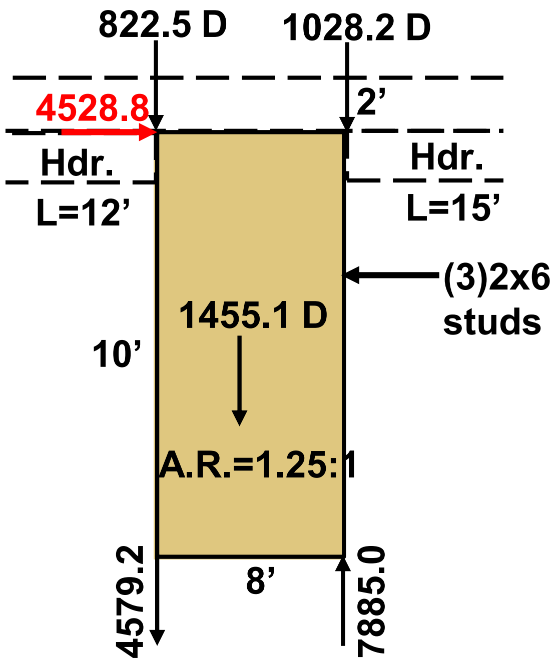
ΣKy=87.08 ΣKx=50.28

J=20895.72

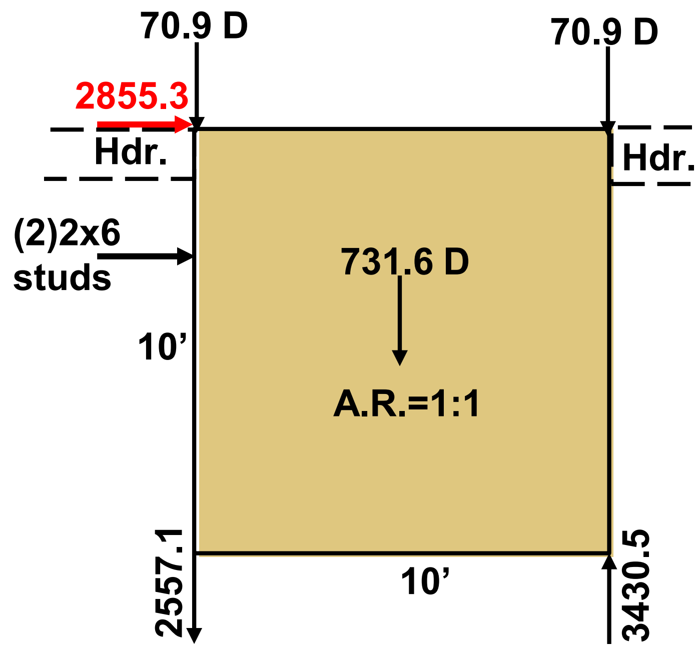
Nominal stiffness values used

ASD Load Combination: LC10 $0.448D + 0.7\rho Q_E$

$\rho=1.3$, $Ax=1.25$



Shear wall Grid A and B



Shear wall Grid 3

Shear Walls Along Grid Lines A and B
Transverse Loading- Nominal Strength

Shear Walls Along Grid Lines 2 and 3
Longitudinal Loading- Nominal Strength

$$vs = \frac{4528.8}{8} = 566.1 \text{ plf} < 600 \text{ plf allowed} \therefore \text{o.k.}$$

T= 4579.2 lbs. ≈ 4565 lbs. allowed, 0.3% over
∴ hold down o.k. –check later

$$vs = \frac{2855}{10} = 285.5 \text{ plf.} < 460 \text{ plf allowed} \therefore \text{o.k.}$$

T = 2557.1 lbs. < 4565 lbs. allowed
∴ hold down o.k.

Questions?

This concludes Woodworks Presentation on:

Part 2-Shear Wall Design in Cantilever Diaphragm Structures

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

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Thank You