9

Advanced RC Structures

Structural Wall 1

- Bearing Walls
- Shear Walls
- Flexural Strength
- Shear Strength

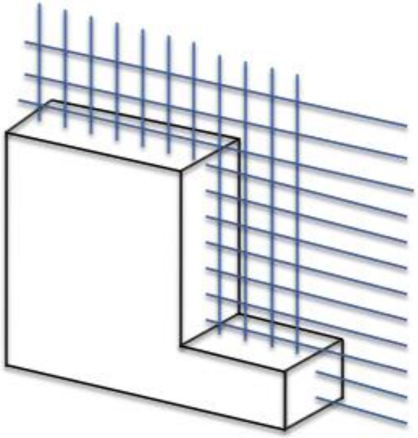
โดย ผศ.ดร.มงคล จิรวัชรเดช

SURANAREE UNIVERSITY OF TECHNOLOGY

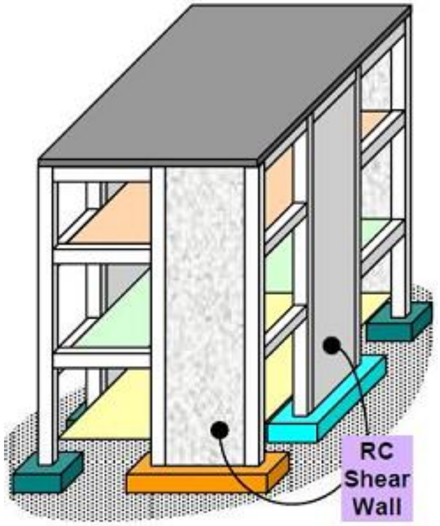
INSTITUTE OF ENGINEERING

SCHOOL OF CIVIL ENGINEERING

RC Structural Walls



- Known as shear walls
- Designed to resist lateral forces earthquake & wind



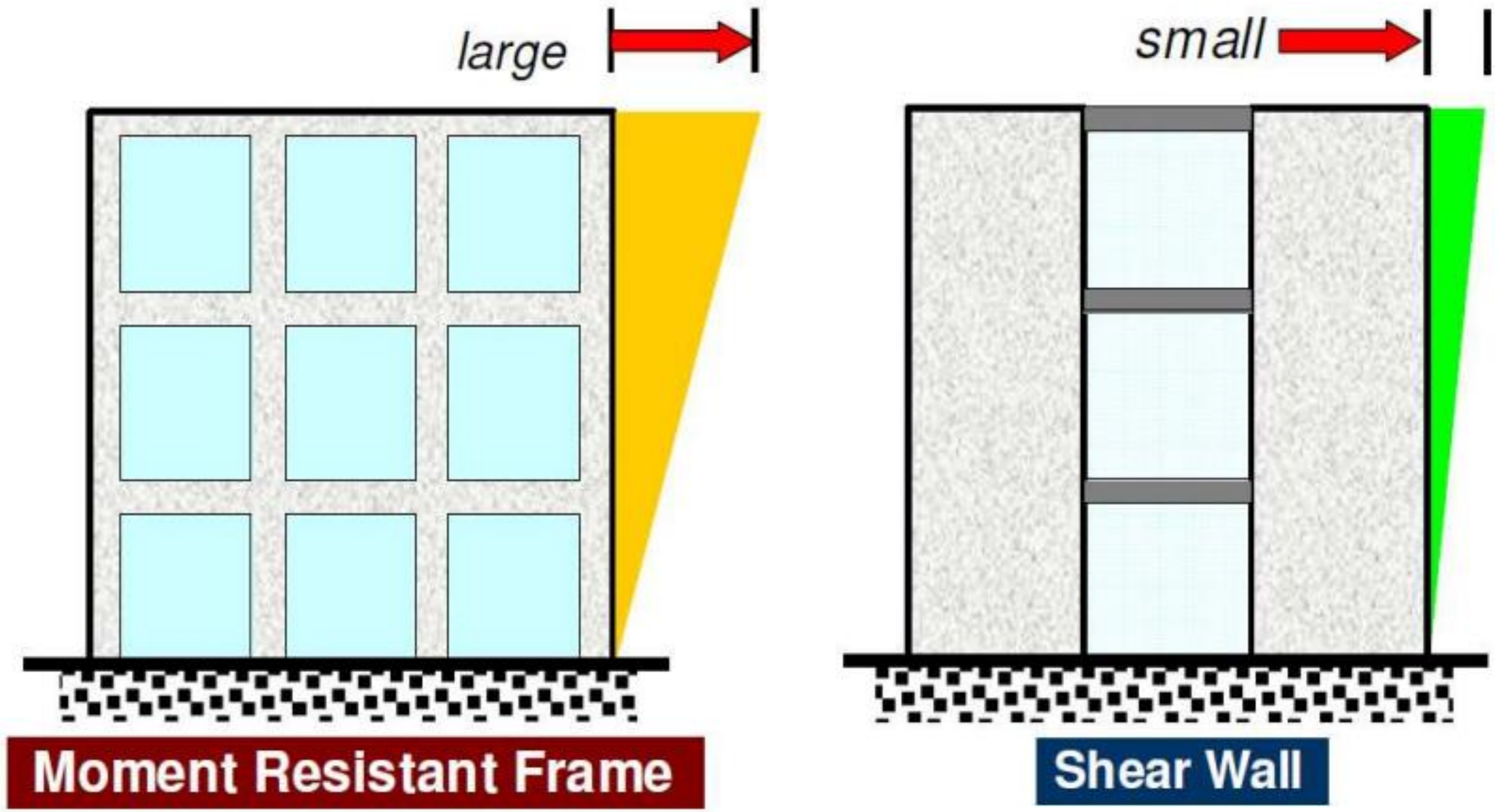
- Provided throughout entire height of building
- Using from 1960s for medium and high rise buildings (4 to 35 stories)

Advantages of Shear Walls

- Large strength and stiffness in the direction of orientation
- Significantly reduces lateral sway
- Easy construction and implementation
- Effective use of construction cost in minimizing earthquake damage

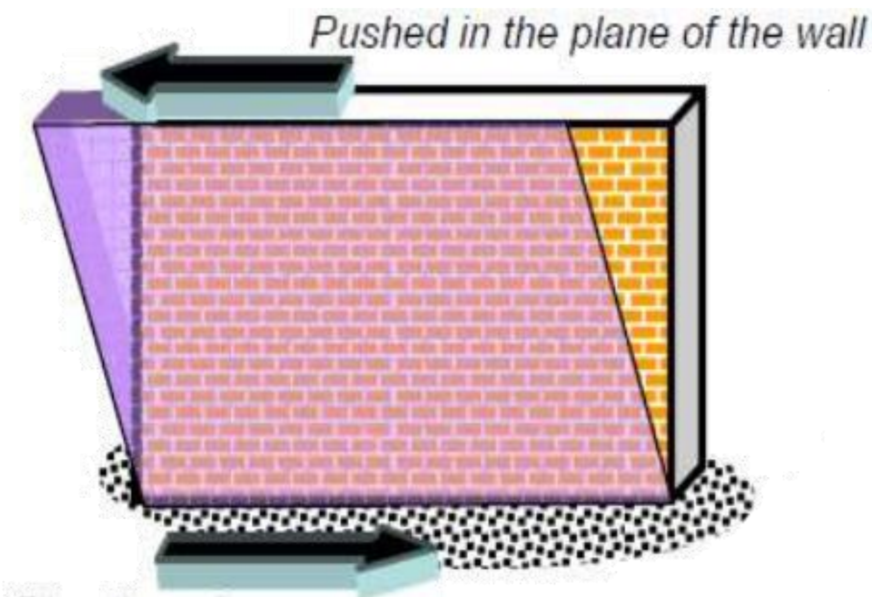
Advantages of Shear Walls

- Significantly reduces lateral sway



Strong & Weak Directions of the Walls

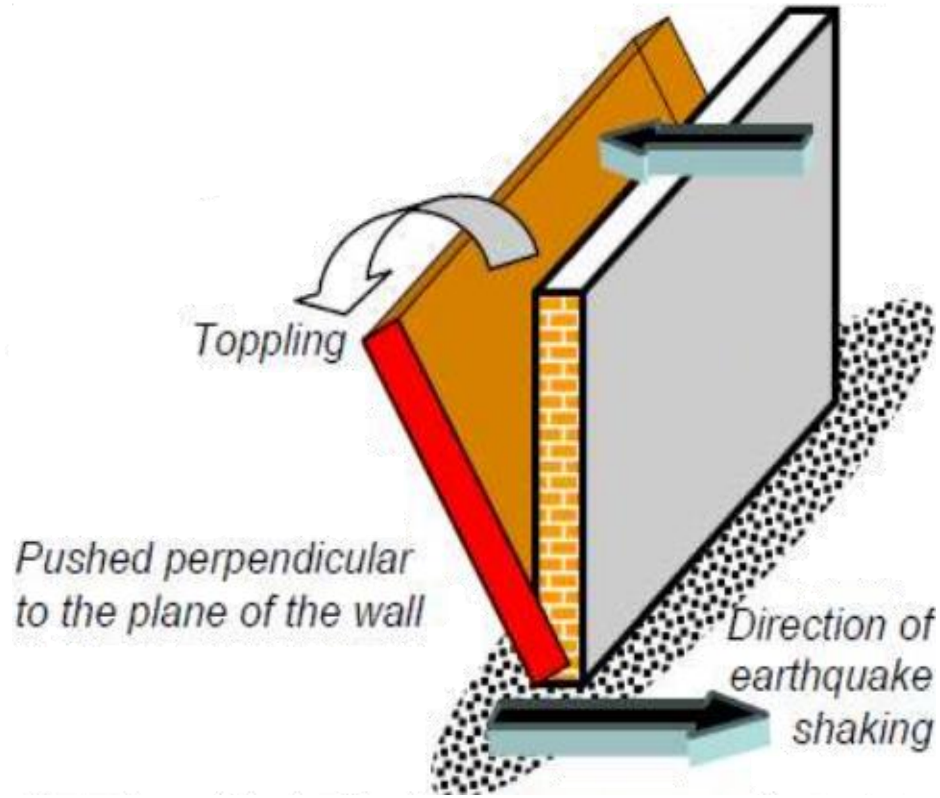
A wall topples down easily if pushed horizontally at the top in a direction perpendicular to its plane **(weak direction),** but offers much greater resistance if pushed along its length **(strong direction)**.



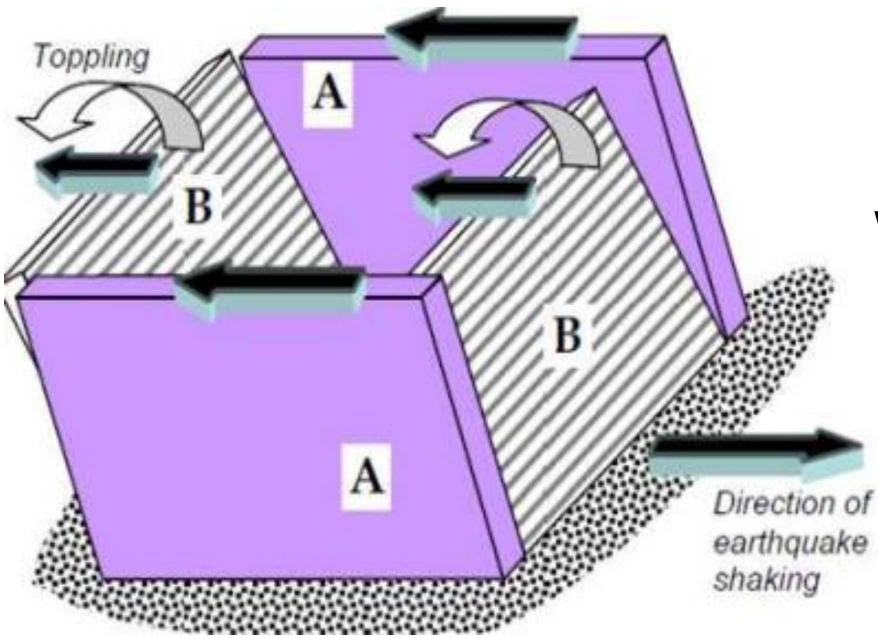
Direction of earthquake shaking

Strong Direction

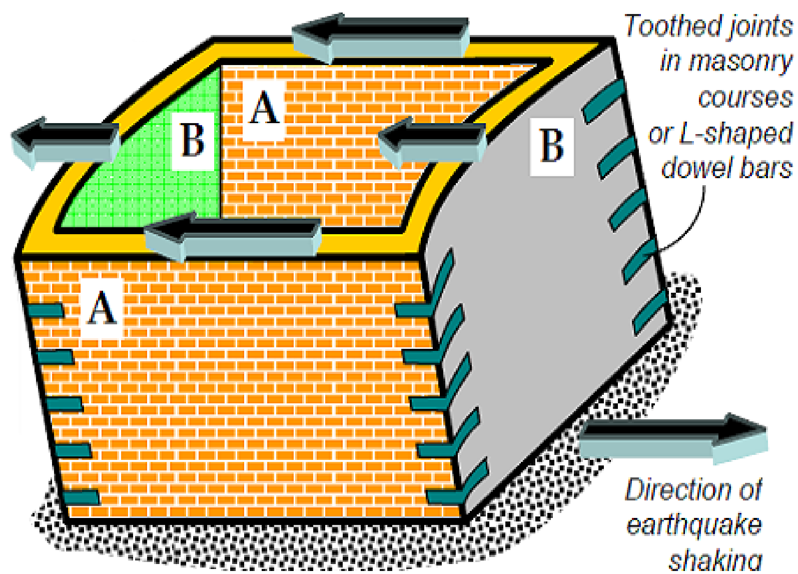
Weak Direction



Box behavior of the Walls



For the direction of earthquake shown, wall B tends to fail



Wall B properly connected to Wall A

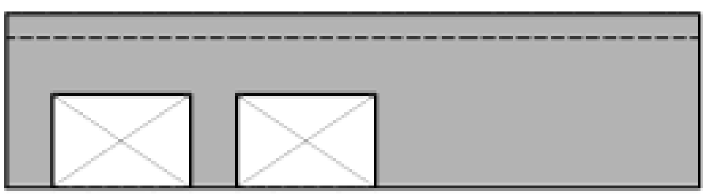
Wall A (loaded in strong direction)

supports Wall B (loaded in weak direction)

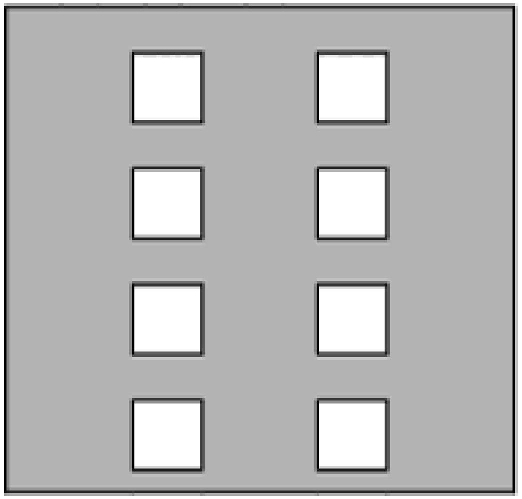
Shear Wall

Configurations in Buildings

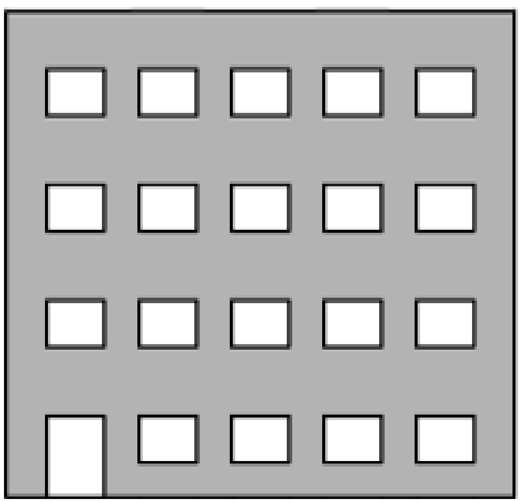
(a) Squat, shear–dominated wall, showing control joints



(b) Single line of resistance with disparate wall element stiffnesses



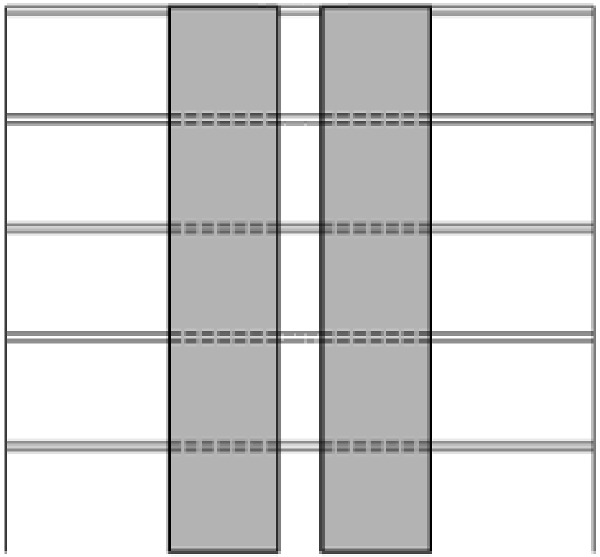
(c) Perforated wall – beam governed



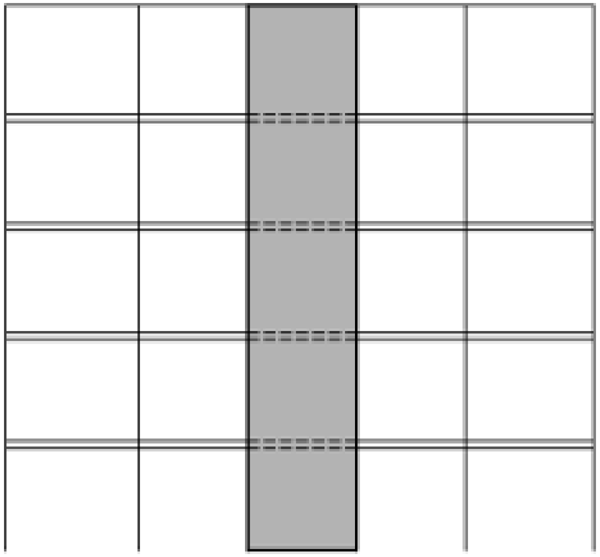
(d) Perforated wall – pier governed

Shear Wall

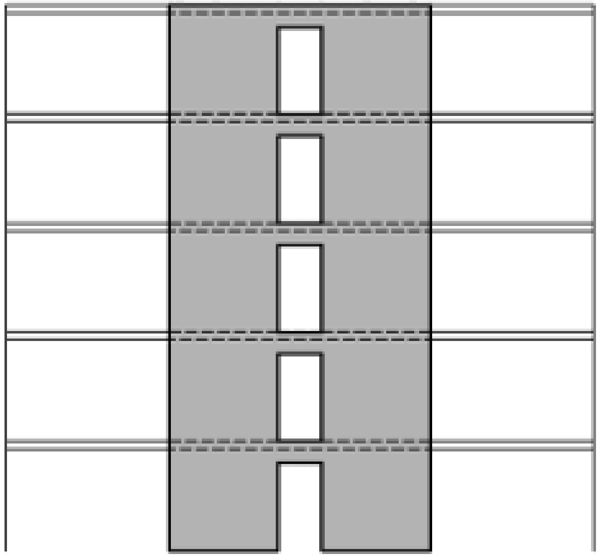
Configurations in Buildings



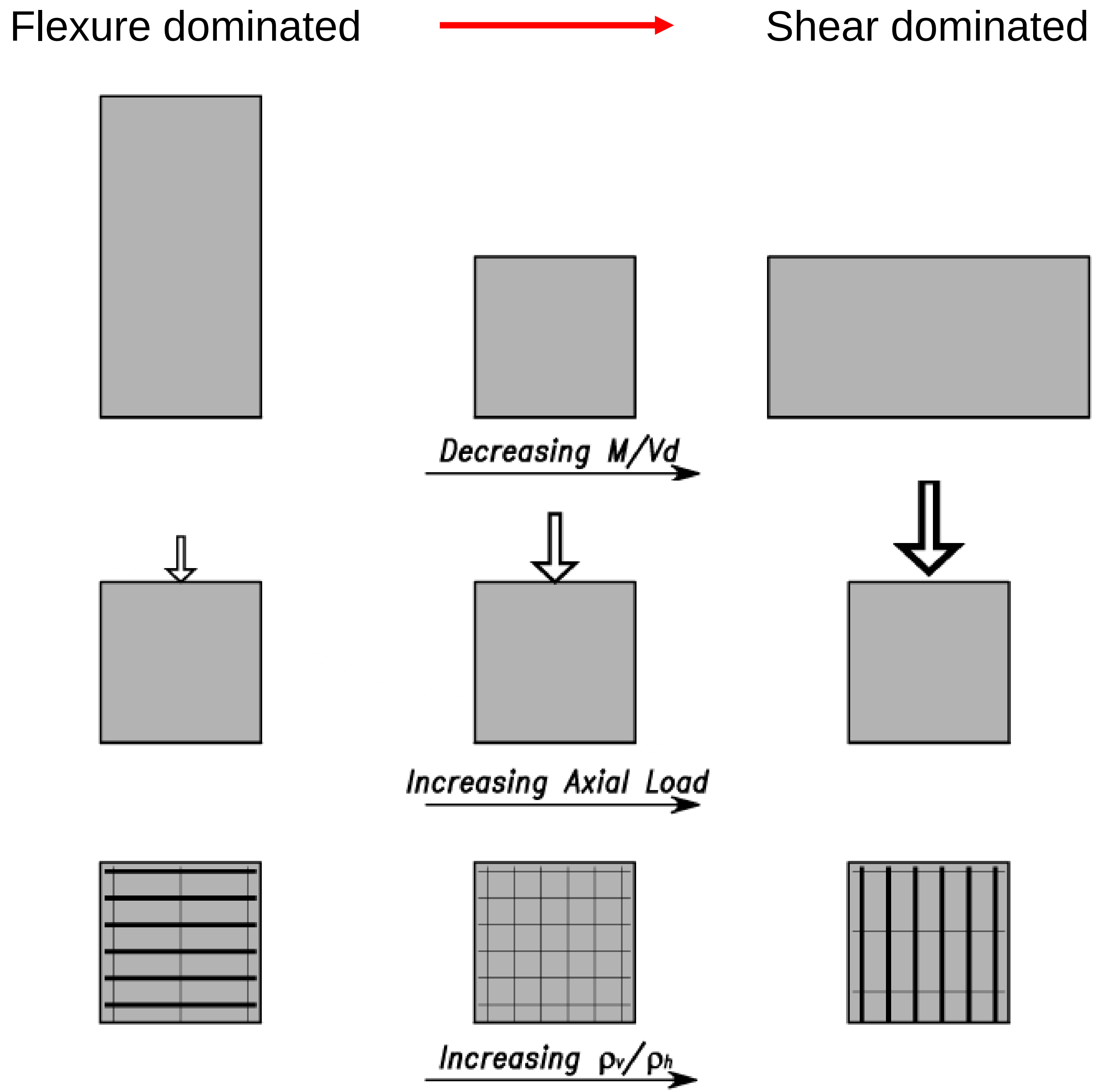
(f) Slab–coupled Wall



(e) Cantilever Wall

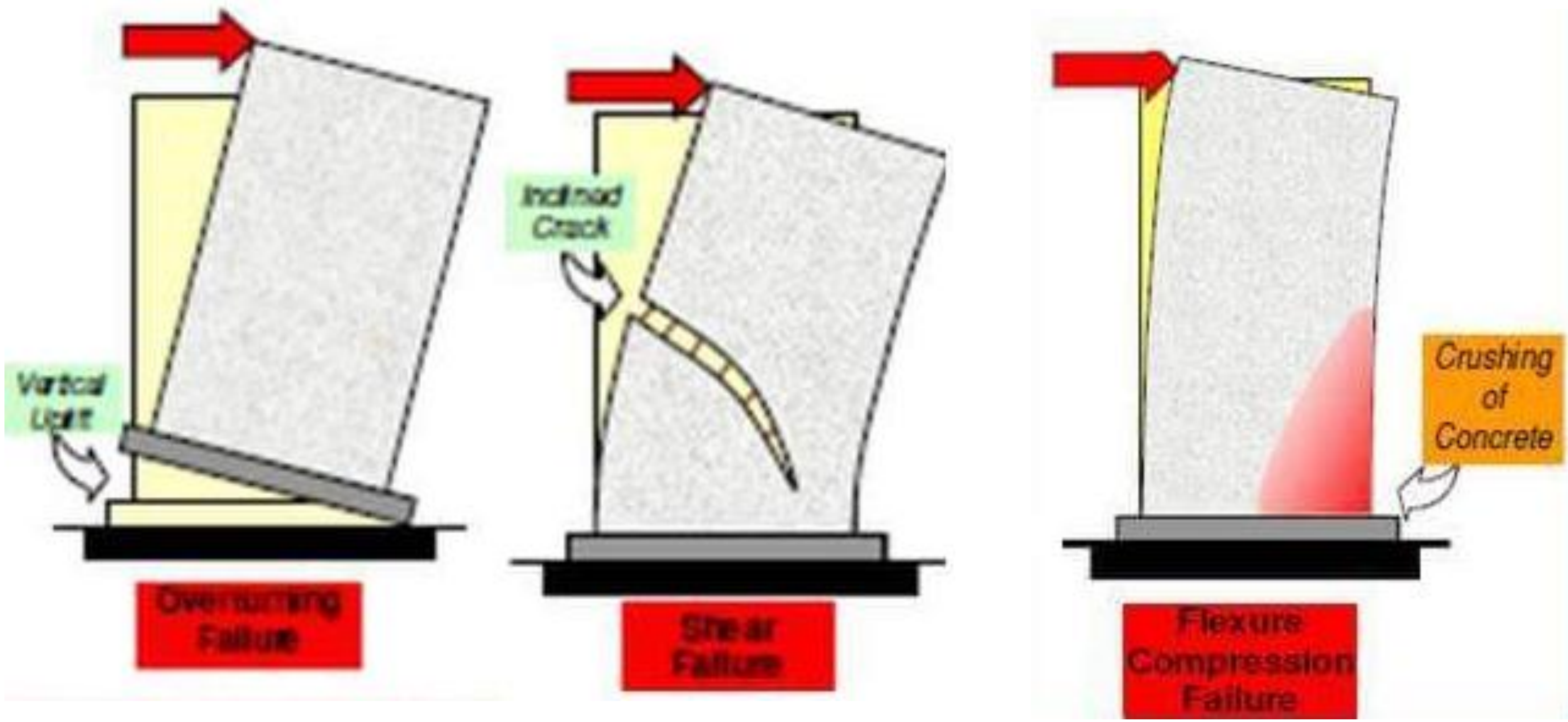


(g) Beam–coupled Wall



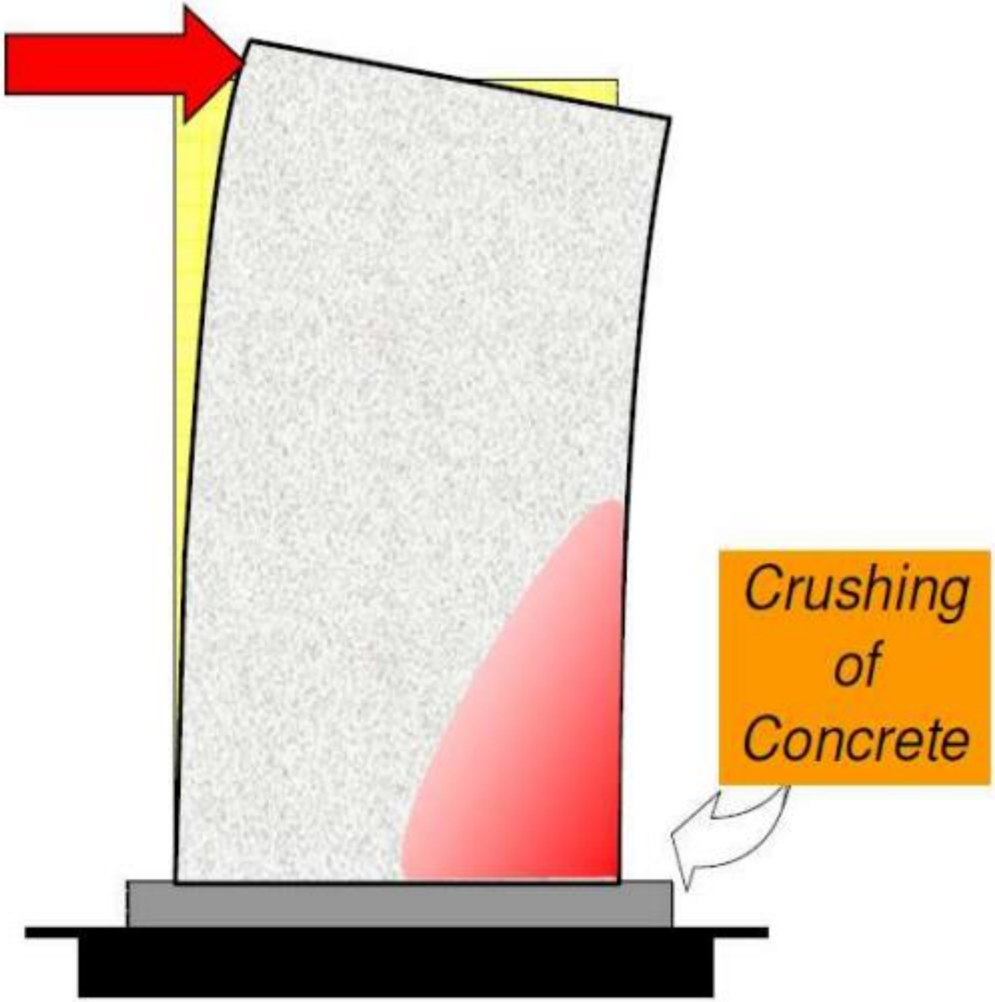
Flexure dominated
Shear dominated
Decreasing M/Vd
Increasing Axial Load
Increasing ρv/ρh

Modes of Failure



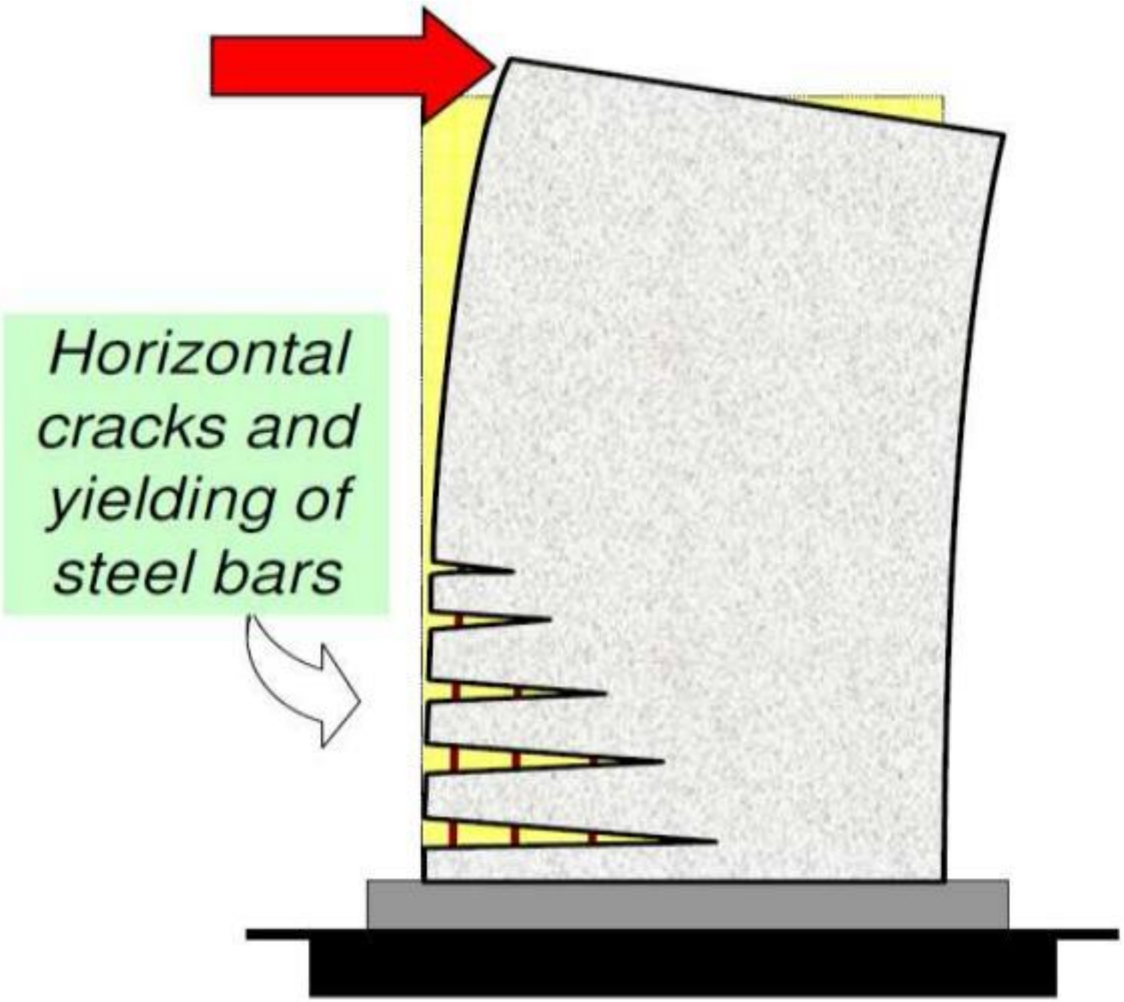
Undesirable Modes of Failure

Flexure Compression Failure



Desirable Modes of Failure

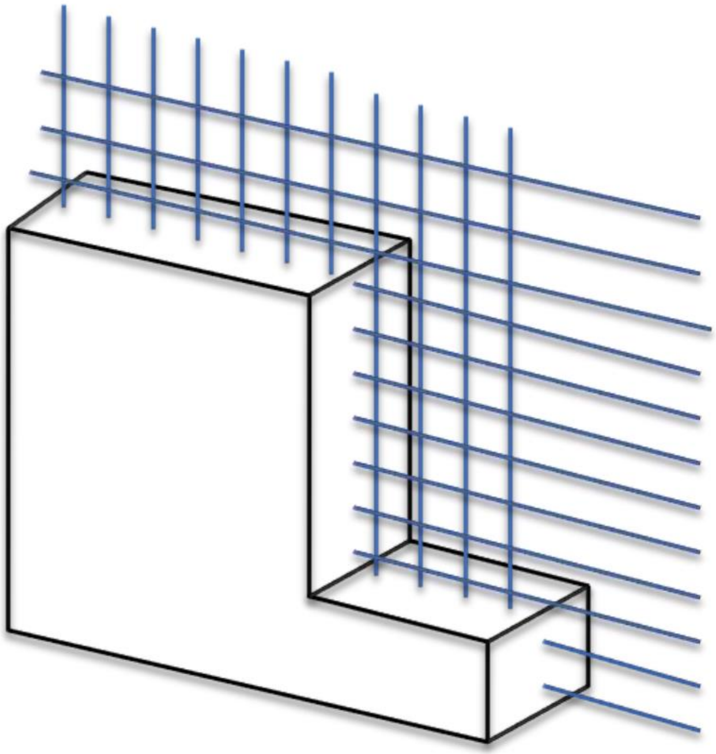
Flexure Tension Failure

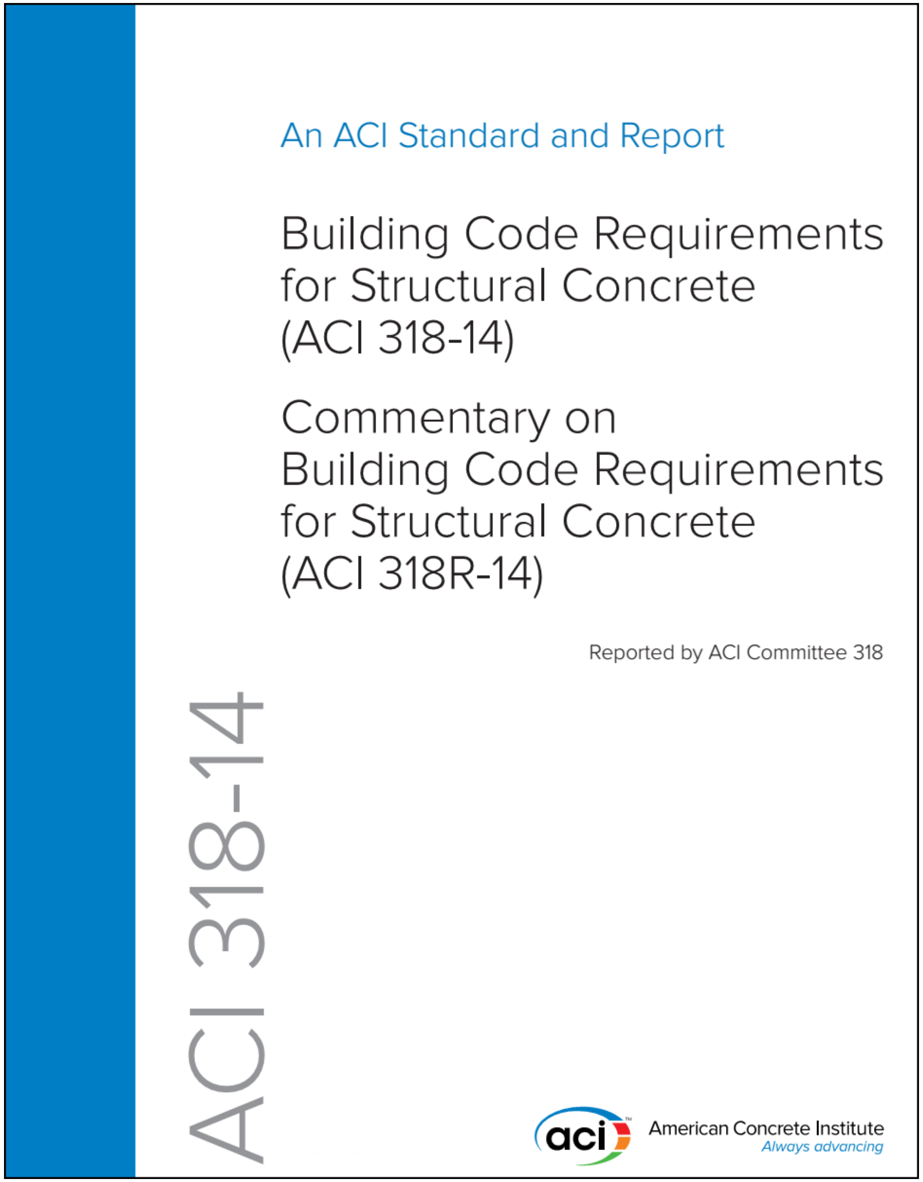


ACI 318 Building Code

CHAPTER 11

WALLS

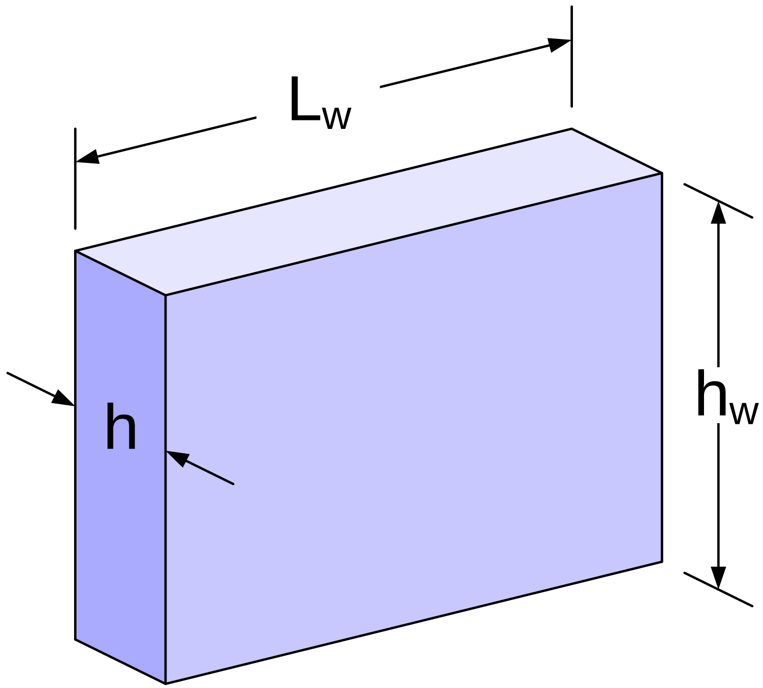




Definitions of Walls

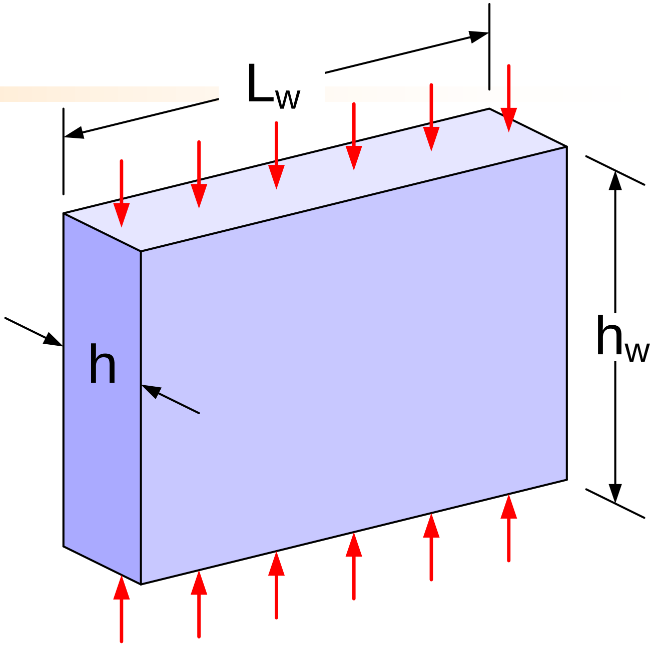
"**Wall** – a vertical element designed to carry axial load, lateral load, or both, with a horizontal length-to-thickness ratio greater than three, used to enclose or spate spaces."

"**Structural wall** – a wall proportioned to resisted combinations of shears, moments and axial forces in the plane of the wall. A shear wall is a structural wall."

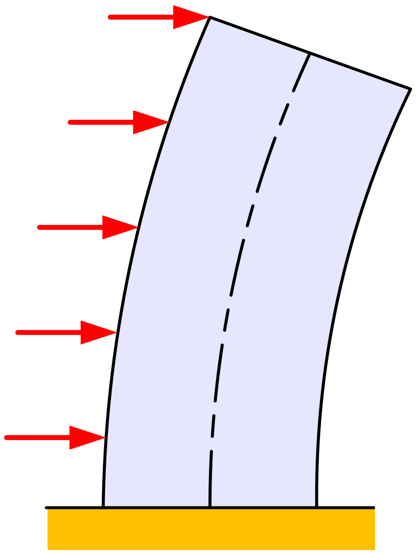


$$\frac{L_w}{h} > 3.0$$

Types of Walls



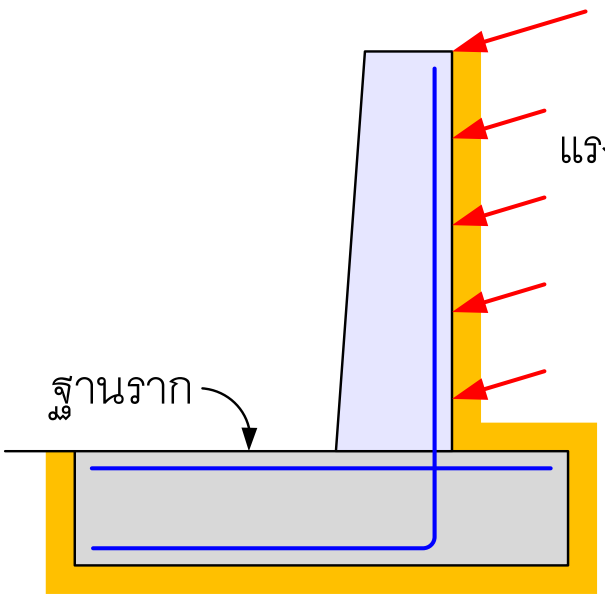
(a) Bearing walls – wall that are laterally supported and braced by the rest of the structure that resist primarily in-plane vertical loads acting downward on the top of the wall.

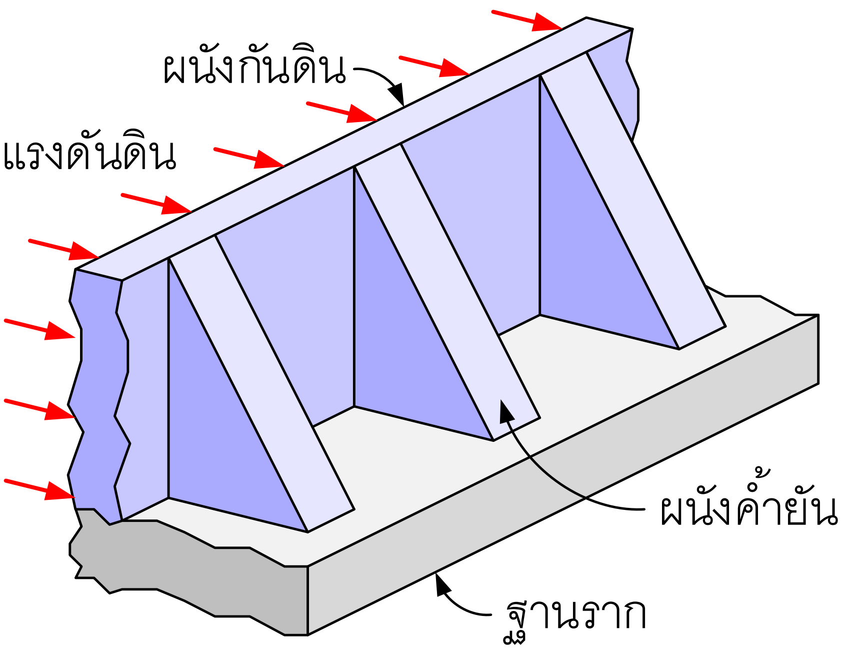


(b) Shear walls – wall that primarily resist lateral loads due to wind or earthquakes acting on the building are called shear walls or structural walls.

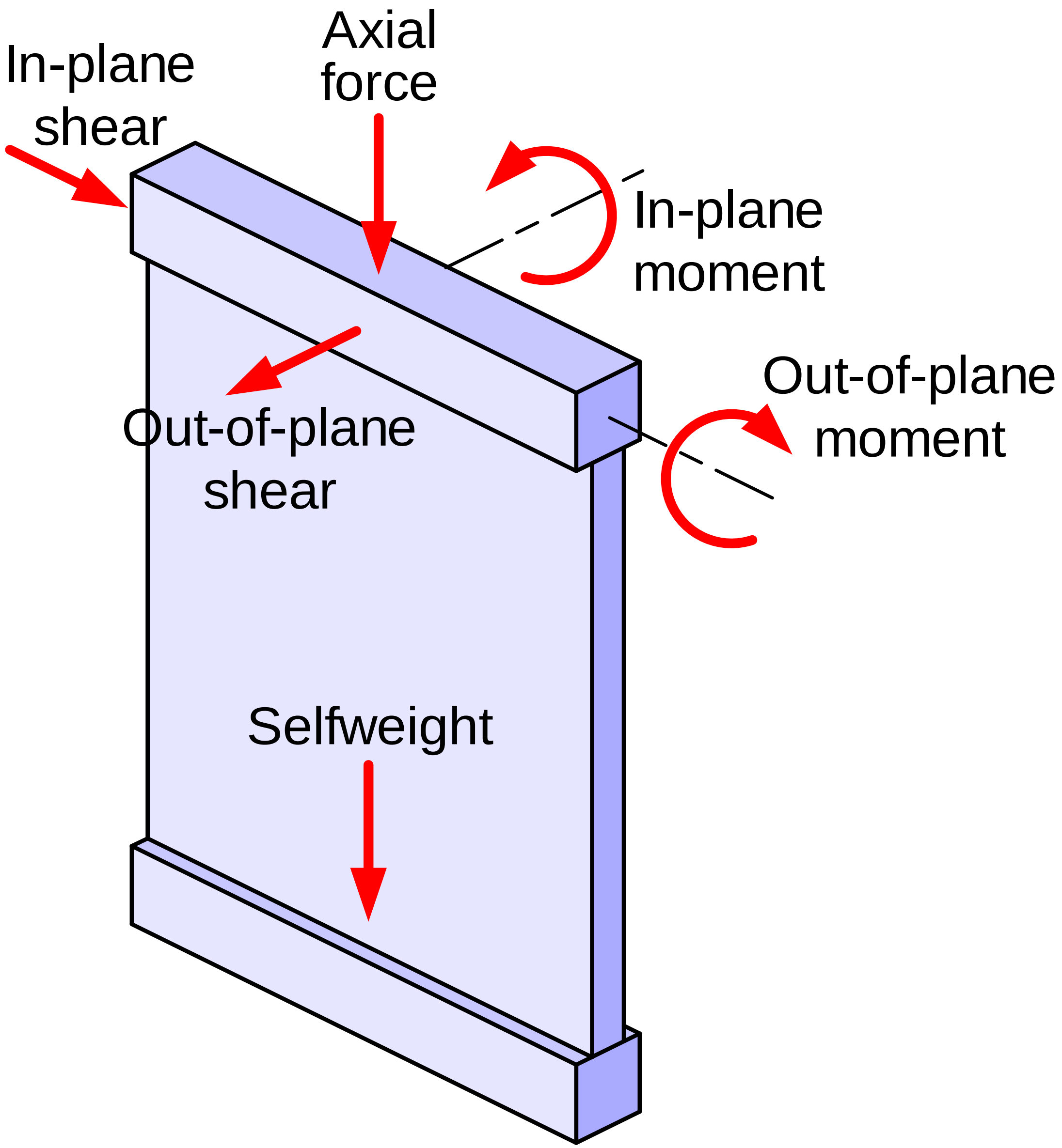
Types of Walls

(c) Nonbearing walls – wall that do not support gravity in-plane loads other than their weight. These walls may resist shears and moments due to pressures or loads acting on one or both sides of the wall. Examples are basement walls and retaining walls used to resist lateral soil pressures.





Forces on Wall



Design Strength

For each applicable factored load combination, design strength at all section shall satisfy

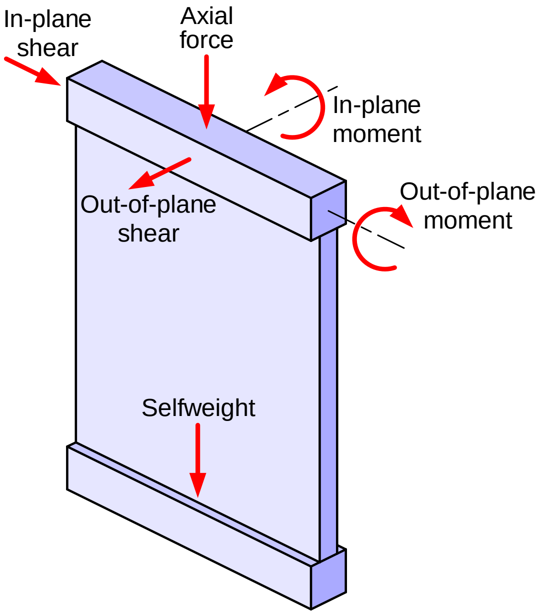
$$\phi S_n \geq U$$

Including (a), (b) and (c). Interaction between axial load and moment shall be considered.

(a) $\phi P_n \geq P_u$

(b) $\phi M_n \geq M_u$

(c) $\phi V_n \geq V_u$



Minimum Wall Thickness

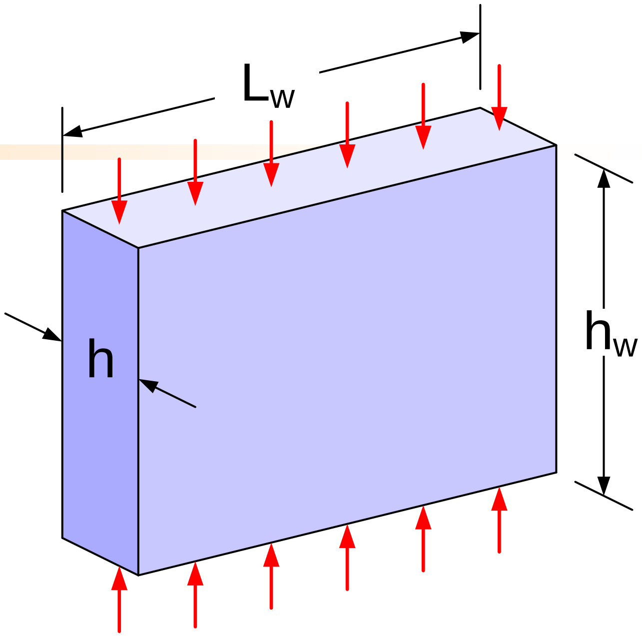
Minimum wall thickness shall be in accordance with Table 11.3.1.1.

Thinner walls are permitted if adequate strength and stability can be demonstrated by structural analysis.

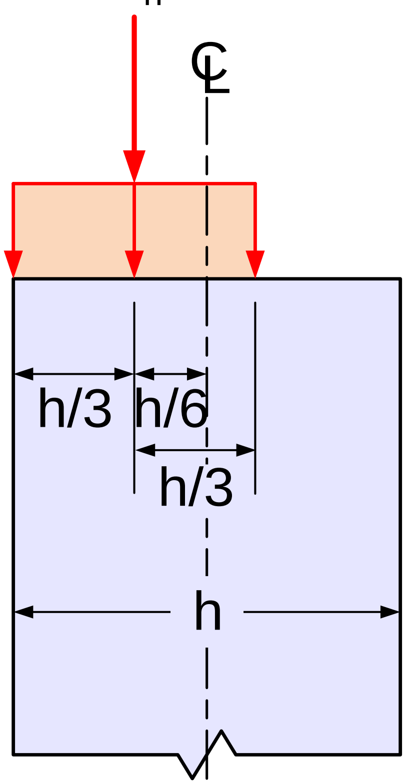
Table 11.3.1.1 – Minimum wall thickness h

Wall Type	Minimum thickness h	
Bearing[1]	Greater of	10 cm
		1/25 the lesser of unsupport length and unsupported height
Nonbearing	Greater of	10 cm
		1/30 the lesser of unsupport length and unsupported height
Exterior basement and foundation[1]	19 cm	

Bearing Walls



Walls used primarily to support gravity loads are subjected to axial load and moment due to eccentricity of **1/6** wall thickness.



$$P_n = 0.85 f'_c \times \frac{2}{3} h \times L_w = 0.567 f'_c \times h \times L_w$$

$$\phi P_n = 0.55 \phi f'_c A_g \left[1 - \left(\frac{k L_c}{32 h} \right)^2 \right]$$

ACI Eq. (11.5.3.1)

where $\phi = 0.70$

L_c = Length of compression member measured center-to-center of the joints

Table 11.5.3.2—Effective length factor *k* for walls

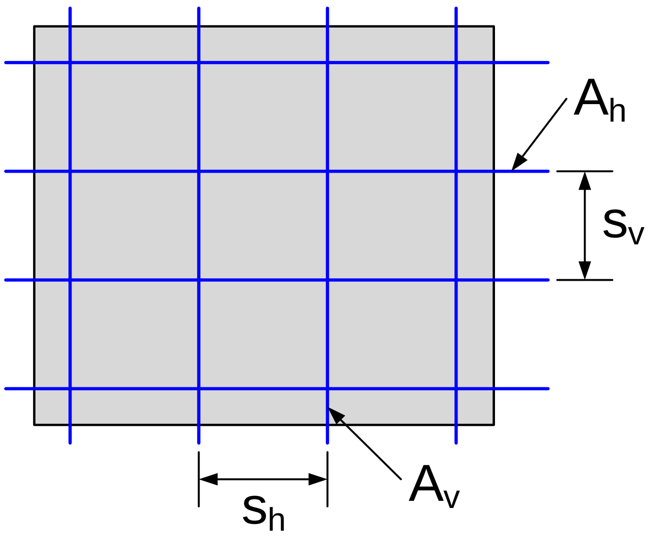
Boundary conditions	*k*
Walls braced top and bottom against lateral translation and:	
(a) Restrained against rotation at one or both ends (top, bottom, or both)	0.8
(b) Unrestrained against rotation at both ends	1.0
Walls not braced against lateral translation	2.0

Minimum Reinforcement

For DB16 or smaller bars with $f_y \geq 4{,}000$ kg/cm^2:

Vertical steel : $s_{h,max} = A_v / (0.0012h)$

Horizontal steel : $s_{v,max} = A_h / (0.0020h)$



EAXAMPLE-1 : Compute the Capacity of a Bearing Wall

A wall with a height of 4.8 m and a length of 7.5 m supports a uniform factored gravity load of 60 t/m. Is a 20 cm thick wall adequate if f'_c = 240 kg/cm^2? If so, select reinforcement for the wall.

(1) Check wall minimum thickness

$$h_{min} = 480/25 = 19.2 \text{ cm} < 20 \text{ cm} \quad \textbf{OK}$$

(2) Compute strength of 1-m-wide strip of wall

$$\phi P_n = 0.55 \phi f'_c A_g \left[1 - \left(\frac{k L_c}{32 h} \right)^2 \right]$$

$$= 0.55 \times 0.7 \times 0.24 \times 20 \times 100 \left[1 - \left(\frac{1.0 \times 480}{32 \times 20} \right)^2 \right]$$

$$= 80.9 \text{ t/m} > 60 \text{ t/m} \quad \textbf{OK}$$

(3) Select Reinforcement

For wall thickness $<$ 25 cm, ACI allows one layer or "curtain" reinforcement.

Max. spacing $= 3h = 3(20) = 60$ cm > 50 cm → $S_{max} = 50$ cm

Select DB12 one layer ($A_v = 1.13$ cm^2)

Vertical steel : $s_{h,max} = A_v / (0.0012h) = 1.13 / (0.0012 \times 20) = 47.1$ cm

USE DB12 @ 0.45 m

Horizontal steel : $s_{v,max} = A_h / (0.0020h) = 1.13 / (0.0020 \times 20) = 28.3$ cm

USE DB12 @ 0.25 m