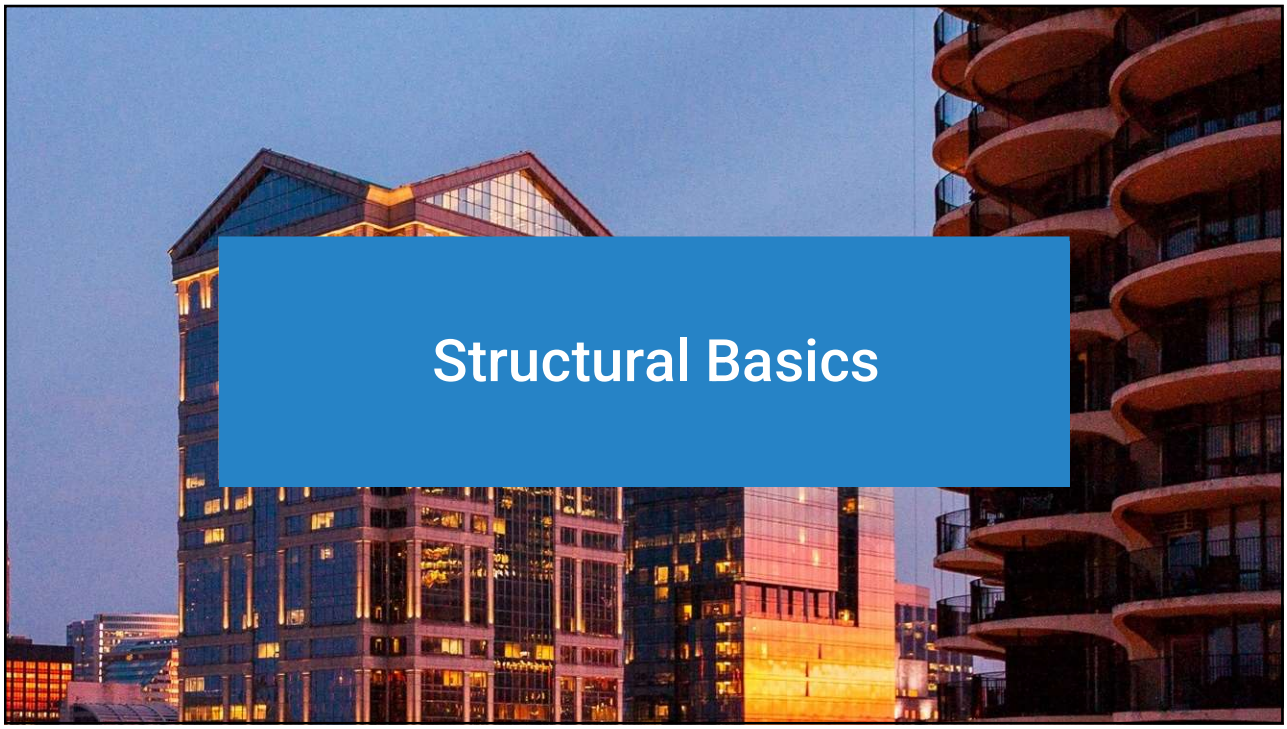


2

3

KEY CONCEPT

Structural Loads

- Design and construction account for various types of structural loads
  - Dead loads
  - Live loads
  - Environmental loads
- Provide continuous load path for both gravity loads and lateral loads

4

Dead Loads

- Loads that do not change significantly over time.
  - Weight of building structural components (walls, floor, roof, beams, columns, etc.)
  - Weight of building finishes (siding, roofing, flooring, etc.)
  - Weight of fixed permanent equipment (HVAC, plumbing, etc.)
- Determined by design professional based on known information about specified materials and systems

5

FOR EXAMPLE

Dead Load Breakdown from Structural Calculations

Roof Dead Load	Floor Dead Load
Framing Members = 3.0psf	Framing Members = 2.5psf
$^1/_2$" Sheathing = 1.5psf	$^3/_4$" Sheathing = 2.5psf
2 Layers Asphalt Shingles = 3.0psf	2" Lightweight Concrete = 16psf
12" Insulation = 3.6psf	Carpet & Pad = 1.0psf
$^5/_8$" Gypsum = 2.8psf	$^5/_8$" Gypsum = 2.8psf
Lights/Misc. = 1.2psf	Lights/Misc. = 1.2psf
Total Roof DL = 15.0psf	**Total Floor DL = 26.0psf**

6

Live Loads

- Loads that can or do change over time:
  - People (based on occupancy)
  - Movable objects (furniture, movable equipment, etc.)
- Code-specified minimums based on intended use of each room, space, or area (Table 1607.1)
- Classification is independent of classifications in Chapter 3 (Occupancy Classification) and Chapter 10 (Occupant Load)

7

CODE BOOK

Table 1607.1

OCCUPANCY OR USE	UNIFORM (psf)	CONCENTRATED (pounds)
1. Apartments (see residential)	—	—
2. Access floor systems Office use *Telecommunication equipment area*	 50 100	 2,000 2,000
3. Armories and drill rooms	150[n]	—
4. Assembly areas Dressing rooms Fixed seats (fastened to floor) Follow spot, projections and control rooms Lobbies Movable seats Stage floors Platforms (assembly) Other assembly areas	 40 60[m] 50 100[m] 100[m] 150[n] 100[m] 100[m]	—
5. *Porches, exterior balconies, decks* and similar structures[b] Accessible from a single *dwelling unit* All others	 60 100	 300[f] 300[f]
6. Catwalks	40	300
7. Cornices	60	—

OCCUPANCY OR USE	UNIFORM (psf)	CONCENTRATED (pounds)
23. Penal institutions Cell blocks Corridors	 40 100	—
24. Recreational uses: Bowling alleys, poolrooms and similar uses Dance halls and ballrooms Gymnasiums Ice skating rink Reviewing stands, grandstands and bleachers Roller skating rink Stadiums and arenas with fixed seats (fastened to floor)	 75[m] 100[m] 100[m] 250[n] 100[c, m] 100[m] 60[c, m]	—
25. Residential Group R-3, R-4 and R-5 occupancies Uninhabitable attics without storage[i] Uninhabitable attics with storage[i, j, k] All other areas Group R-1 and R-2 occupancies Private rooms and corridors serving	 10 20 40	—

8

CHICAGO AMENDMENT

Changes from pre-2019 Code

	Old	New
Telecommunication Equip. Area (Tech. Ctr.)	125	↓ 100
Assembly—projection and control rooms	60 or 100	↓ 50
Assembly—platforms other than stages	150	↓ 100
Porches, decks, balconies, and occupiable rooftops accessible from a single unit (incl. porch/deck on single-family home)	100	↓ 60
Public dining rooms in residential buildings	75	↑ 100
Parking garages	50	↓ 40

9

CHICAGO AMENDMENT

Changes from pre-2019 Code (continued)

	Old	New
Library corridors above 1st floor	100	↓ 80
Office building corridors above 1st floor	50	↑ 80
Correctional facility corridors above 1st floor	80	↑ 100
Assembly—bowling alleys, poolrooms, etc.	100	↓ 75
Assembly—ice skating rink	100	↑ 250
R-3, R-4, R-5 inaccessible attics	?	10
R-3, R-4, R-5 uninhabitable attics with storage	40	↓ 20
Retail, above 1st floor	100	↓ 75

10

KEY CONCEPT

Design Live Loads for Egress Components

Interior (except within dwelling)	
Exit access	var.
Exit access corridors	
Serving apts. only	40
All other	80-100
Exit access stairs	100
Exit stairs	100
Exit passageways	100
Exit discharge lobbies, etc.	100

Exterior (except single dwelling)	
Exit access	100
Stairs, porches	100
Exit discharge, egress court	100

Exterior (single dwelling)	
Porch, deck, balcony, or occupiable rooftop	60

11

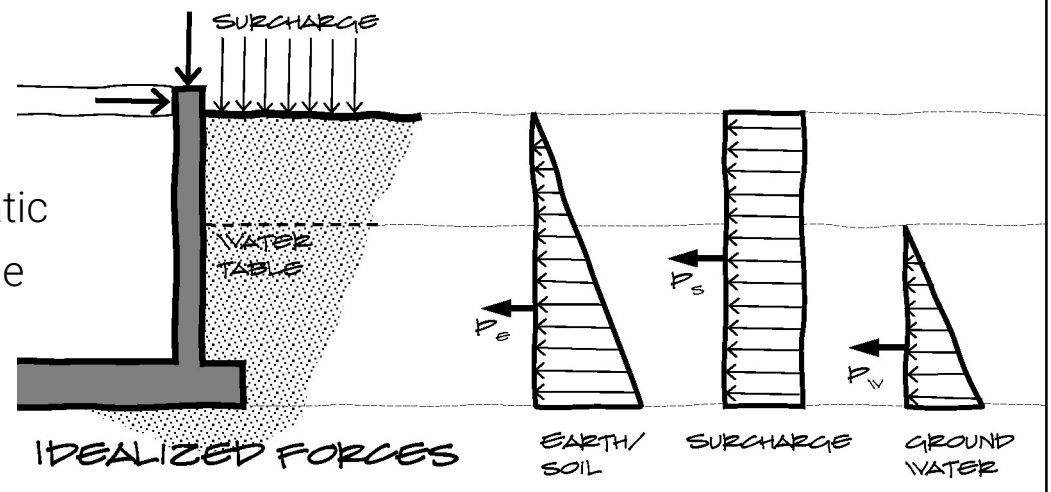
Snow Loads

- Designed for 50-year snow storm
- Chicago design ground snow load is 25 psf
- Roof snow load varies based on roof type (flat, sloped, etc.)
- Roofs must also be designed for snow drift and sliding snow

12

Lateral Soil Loads

- At-rest
- Active
- Passive
- Hydrostatic
- Surcharge



13

Soil Bearing Capacity

- Maximum load (per unit area) which soil can support without yielding. Typically specified by a geotechnical engineer, but (conservative) prescriptive values for small projects:

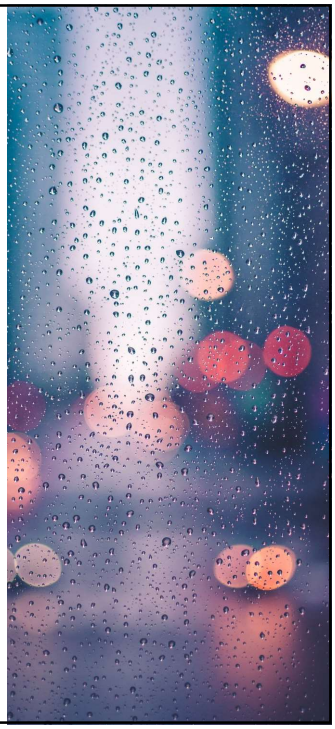
TABLE 1806.2(1)
PRESUMPTIVE LOAD-BEARING VALUES WITHOUT FULL GEOTECHNICAL INVESTIGATION

CLASS OF MATERIALS	VERTICAL FOUNDATION PRESSURE (psf)	LATERAL BEARING PRESSURE (psf/ft below natural grade)	LATERAL SLIDING RESISTANCE	
			Coefficient of friction[a]	Cohesion (psf)[b]
Sandy gravel and gravel (GW and GP)	3,000	200	0.35	—
Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000	150	0.25	—
Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500	100	—	130
Non-engineered fill	500	50	0.1	—

14

Rain and Ice Loads

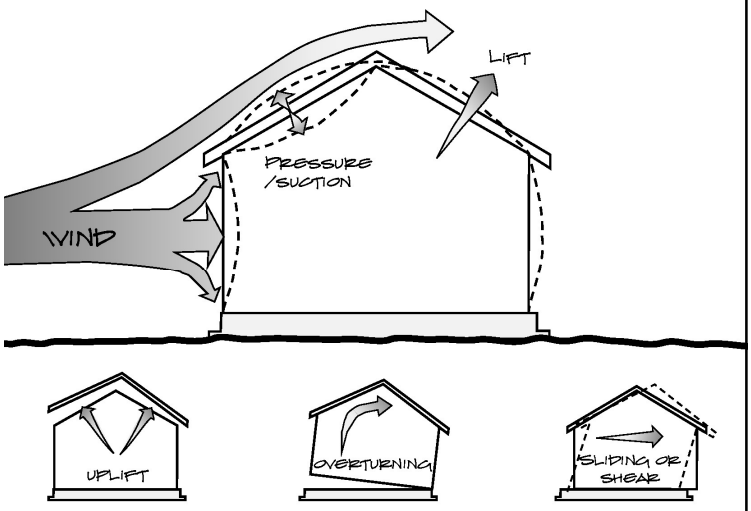
- Roofs must be designed to support rainwater if primary drainage is blocked.
- Ice-sensitive structures (cable structures, open catwalks and platforms, amusement rides, flagpoles, signs, etc.) must be designed for ice loads.



15

Wind Loads

- Wind pressure creates various types of forces on a structure:
  - Uplift
  - Overturning
  - Sliding
  - Shear
- Forces can be positive or negative



16

Wind Loads (continued)

- Wind loads for design of structure
- Wind loads for attachment of components and cladding:
  - Roof and wall coverings
  - Connections for framed members
  - Fastening methods for roof decking, etc.

17

Earthquake Loads

- In Chicago region, seismic risk is relatively low.
- Never any seismic requirements for:
  - Group R-3 and R-5 occupancies
  - Wood light-frame construction per. Sec. 2308 (3 stories or less)
  - Agricultural and storage structures with limited occupancy
- Most buildings have minimal design requirements (nothing to inspect for)
- Seismic design features may be required for critical facilities (police/fire, hospitals, utilities)

18

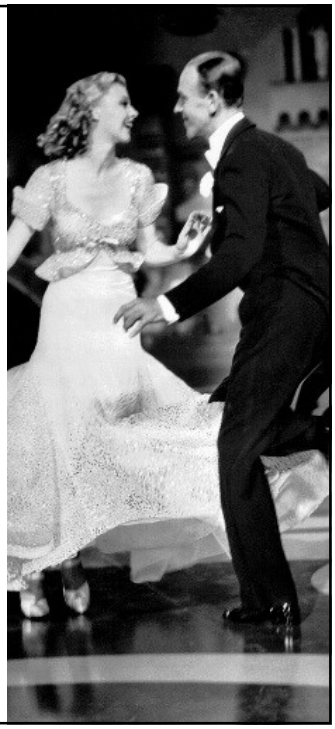
Load Combinations

- Direct combination of all loads at once is not probable or practical.
- Code doesn't require designing for full live load, snow load and wind load simultaneously.
- Designer must check several load combinations specified in code.

19

Concentrated vs. Uniform Loads

- Significant concentrated loads (heavy equipment, etc.) can have major effect on structural performance.
- Difference between being stepped on by a ballet slipper or a stiletto heel.



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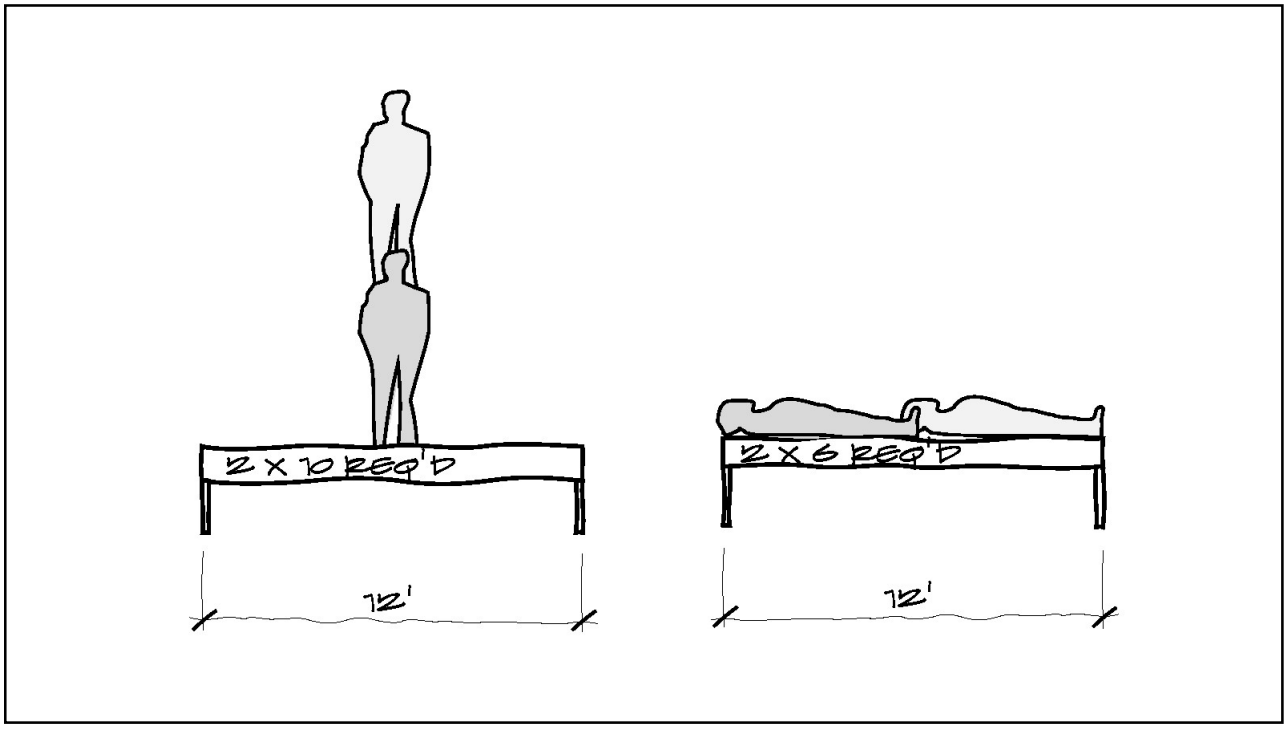

21

Complete Load Path

- Every structure must be designed to provide a "complete load path capable of transferring loads from their point of origin to the load-resisting elements." (Sec. 1604.4)
- Floor and roof loads must transfer to the ground.
- Gravity load path
- Lateral load path

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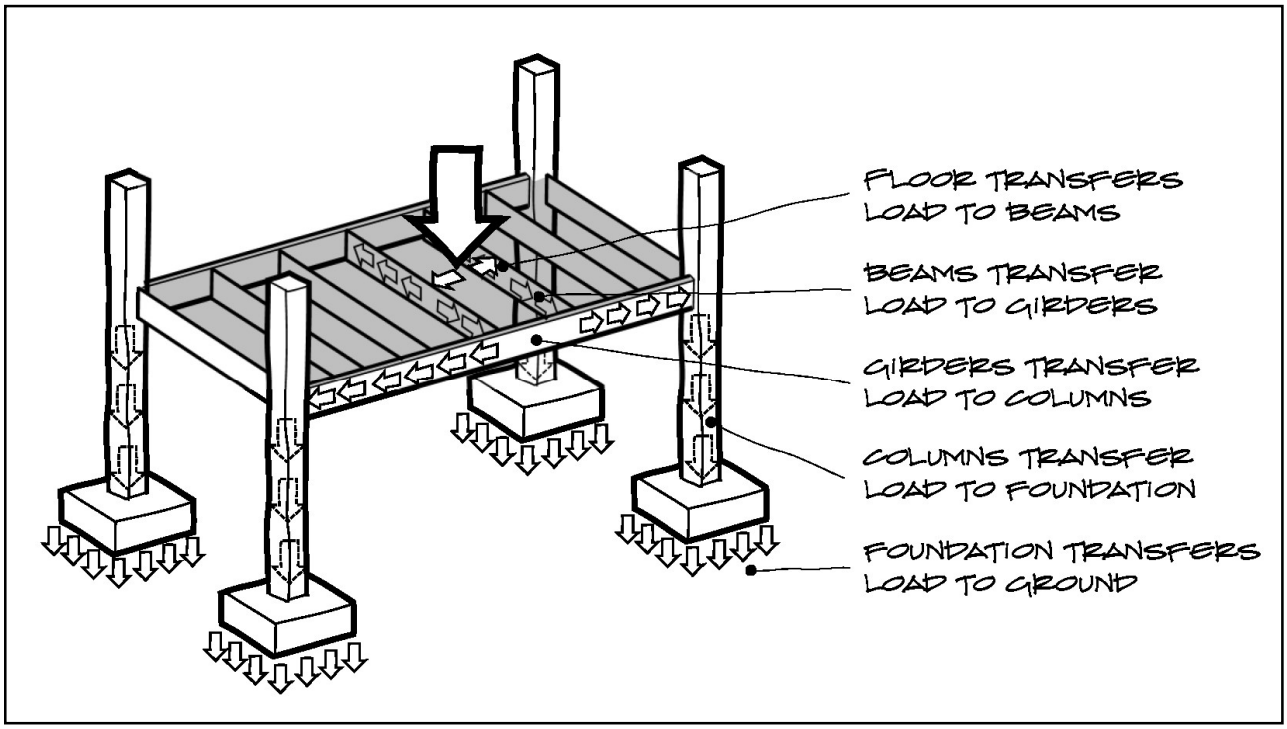
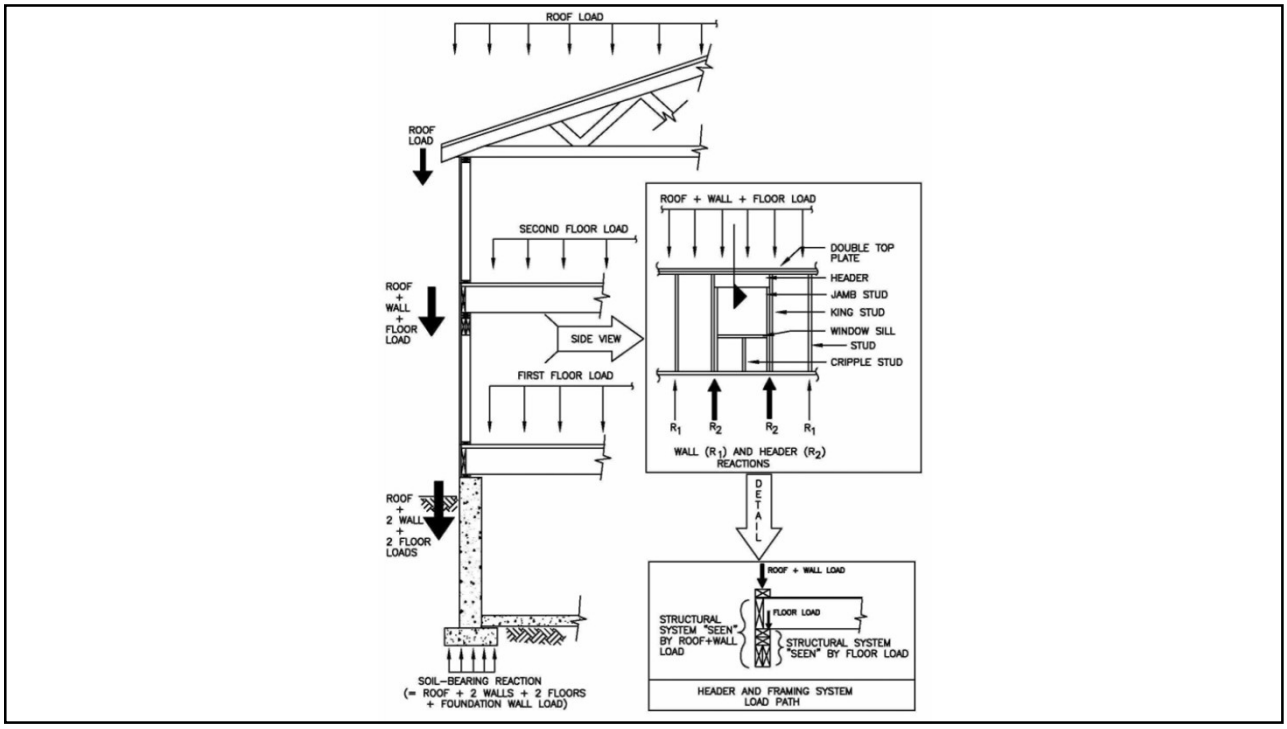
Gravity Load Path

- Addresses vertical loads
  - Dead loads
  - Live loads
  - Snow, rain, ice loads
  - Soil bearing capacity
- Check for weak links
- Field changes can compromise gravity load path

23


FLOOR TRANSFERS LOAD TO BEAMS
BEAMS TRANSFER LOAD TO GIRDERS
GIRDERS TRANSFER LOAD TO COLUMNS
COLUMNS TRANSFER LOAD TO FOUNDATION
FOUNDATION TRANSFERS LOAD TO GROUND

24


ROOF LOAD
ROOF LOAD
SECOND FLOOR LOAD
ROOF + WALL + FLOOR LOAD
SIDE VIEW
FIRST FLOOR LOAD
ROOF + 2 WALLS + 2 FLOOR LOADS
SOIL-BEARING REACTION (= ROOF + 2 WALLS + 2 FLOORS + FOUNDATION WALL LOAD)
ROOF + WALL + FLOOR LOAD
DOUBLE TOP PLATE
HEADER
JAMB STUD
KING STUD
WINDOW SILL
STUD
CRIPPLE STUD
R1 R2 R2 R1
WALL (R1) AND HEADER (R2) REACTIONS
DETAIL
ROOF + WALL LOAD
FLOOR LOAD
STRUCTURAL SYSTEM "SEEN" BY ROOF+WALL LOAD
STRUCTURAL SYSTEM "SEEN" BY FLOOR LOAD
HEADER AND FRAMING SYSTEM LOAD PATH

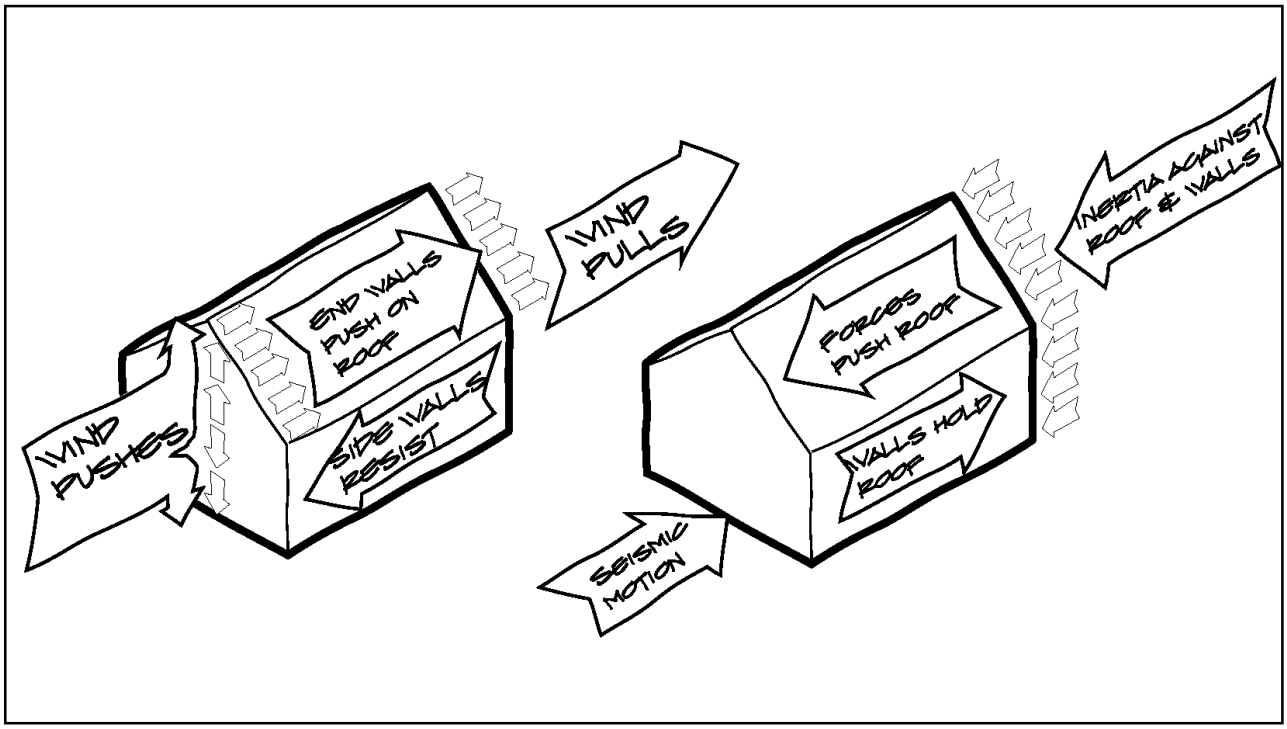
25

26

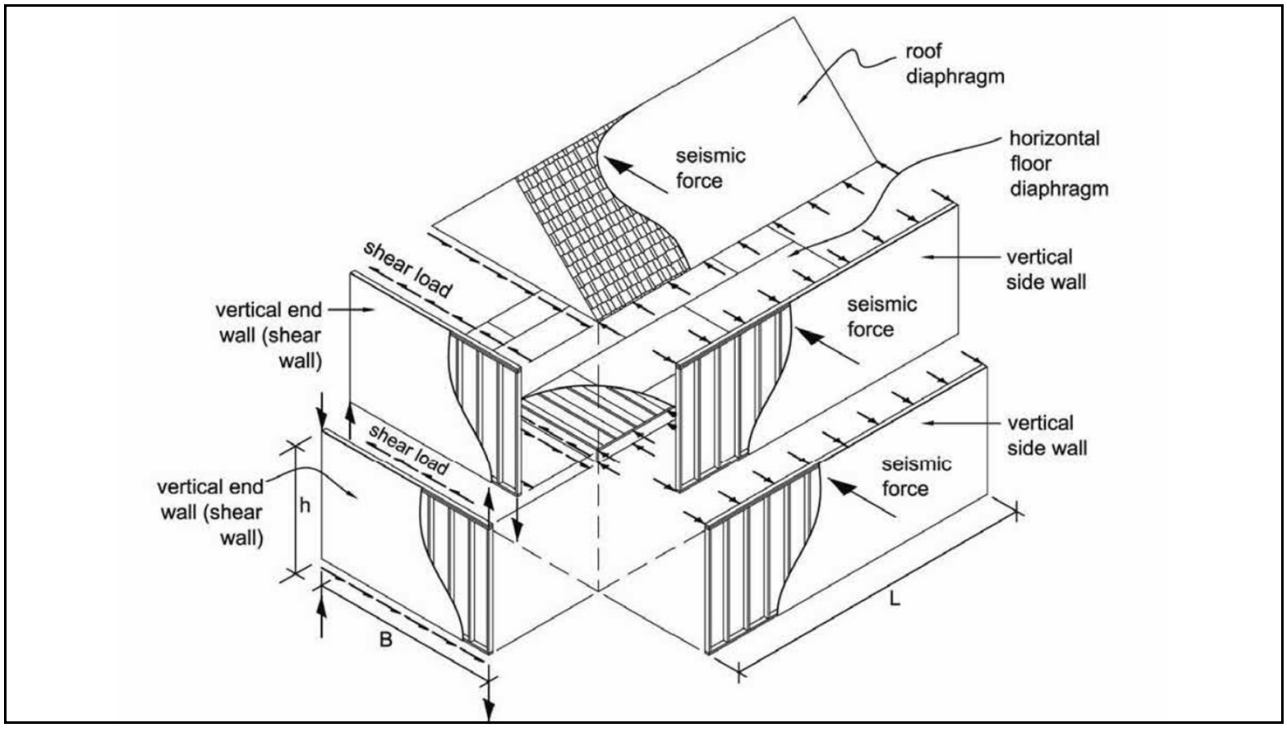
Lateral Load Path

- Addresses horizontal forces on structure:
  - Wind loads
  - Earthquake loads

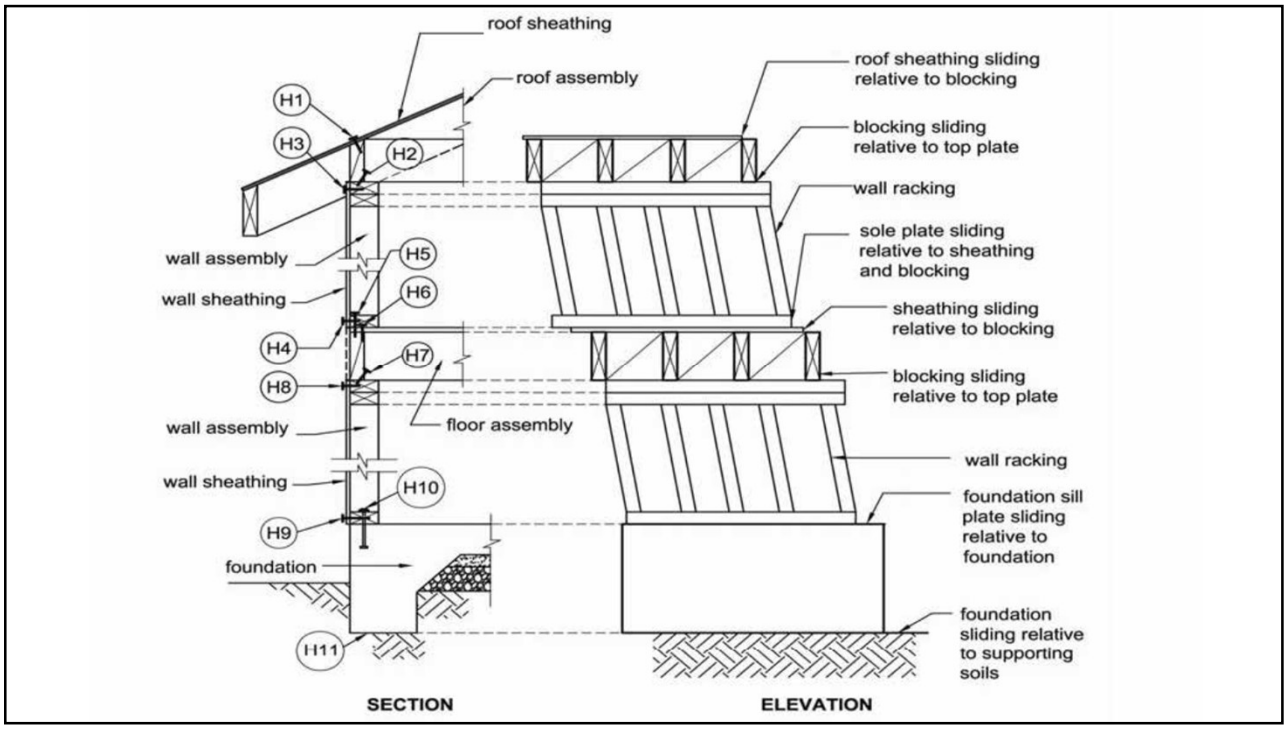
27


WIND PUSHES
END WALLS PUSH ON ROOF
SIDE WALLS RESIST
WIND PULLS
SEISMIC MOTION
FORCES PUSH ROOF
WALLS HOLD ROOF
INERTIA AGAINST ROOF & WALLS

28

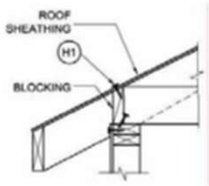
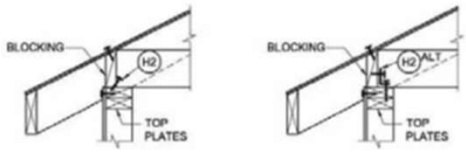
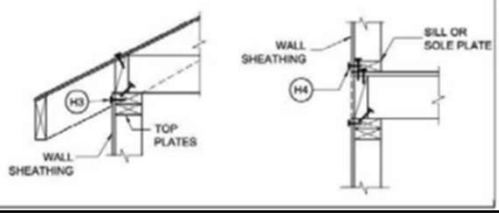

roof diaphragm
seismic force
horizontal floor diaphragm
vertical side wall
shear load
vertical end wall (shear wall)
seismic force
vertical side wall
shear load
vertical end wall (shear wall)
seismic force
h
B
L

29



30

Table 2-1 Load Path Connections for Horizontal Sliding

Item	Minimum Fastening per *IRC* Table R602.3(1) and Discussion	Illustration
H1	**Sheathing[a]** **Nailing[b]** 5/16" to ½" 8d common @ 6" 19/32" to 1" 8d common @ 6" 1 1/8" to 1 1/4" 10d common @ 6" • Resists roof sheathing sliding with respect to blocking below. • Six-inch nail spacing applies to supported sheathing edges and blocking. Twelve-inch spacing applies at other panel supports. • Rafter blocking is not always required by *IRC*; however, sheathing should be nailed to blocking where blocking is provided.	
H2	Three 8d box (0.113"x2 1/2") or three 8d common (0.131x2 1/2") toenails each block. • Resists rafter blocking sliding with respect to wall top plate. • **Use of angle clips in lieu of toenails is a recommended above-code measure.** • Rafter blocking is not always required by *IRC*; however, it should be fastened where provided.	
H3 & H4	**Sheathing[a]** **Nailing[b]** 5/16" to ½" 6d common @ 6" 19/32" to 1" 8d common @ 6" 1 1/8" to 1 1/4" 10d common @ 6" • Provides wall racking resistance. • Six-inch nail spacing applies to sheathing edges. Twelve-inch spacing applies at other studs.	

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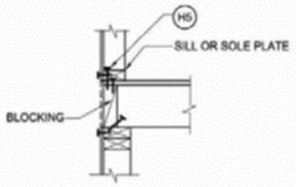
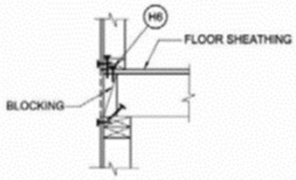
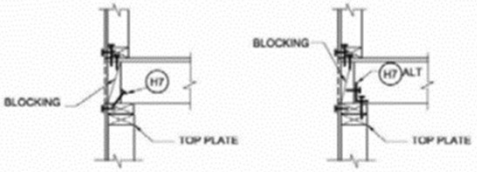
Item	Minimum Fastening per *IRC* Table R602.3(1) and Discussion	Illustration
H5	**At Braced Wall Panels** Three 16d box (0.135"x3$^1/_2$") or three 16d sinker (0.148x3$^1/_4$") face nails each 16 inches on center (space evenly). **Between Braced Wall Panels** One 16d box (0.135"x3$^1/_2$") or one 16d sinker (0.148x3$^1/_4$") face nail at 16 inches on center. • Resists wall sole plate sliding with respect to sheathing and blocking or rim joist below.	
H6	**Sheathing[a] Nailing[b]** 5/16" to ½" 6d common @ 6" 19/32" to 1" 8d common @ 6" 1$^1/_8$" to 1$^1/_4$" 10d common @ 6" • Resists floor sheathing sliding with respect to blocking below. • Six-inch nail spacing applies to supported sheathing edges and blocking. Twelve-inch spacing applies at other panel supports.	
H7	Three 8d box (0.113"x2$^1/_2$") or three 8d common (0.131x2$^1/_2$") toenails each block. • Resists joist blocking sliding with respect to wall top plate. • **Use of angle clips in lieu of toenails is a recommended above-code measure.**	

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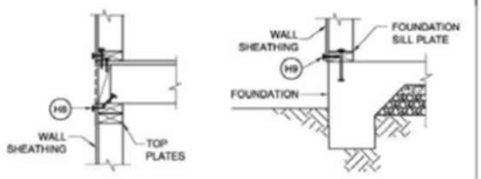
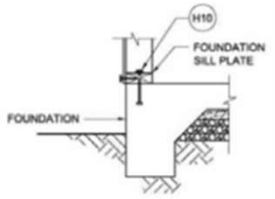
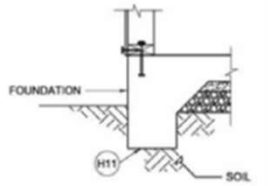
Item	Minimum Fastening (*IRC* Table R602.3(1) U.O.N.) & Discussion	Illustration
H8 & H9	**Sheathing[a] Nailing[b]** 5/16" to ½" 6d common @ 6" 19/32" to 1" 8d common @ 6" 1$^1/_8$" to 1$^1/_4$" 10d common @ 6" • Provides wall racking resistance. • Six-inch nail spacing applies to sheathing edges. Twelve-inch spacing applies at other studs.	
H10	Anchor bolts in accordance with *IRC* Sections R403.1.6 and R403.1.6.1. Steel plate washers in accordance with R602.11.1. Requirements vary by SDC. See Chapter 4 of this guide for further discussion. • Resists foundation sill plate sliding with respect to slab-on-grade or other foundation.	
H11	Foundation embedment in accordance with *IRC* Section 403.1.4 provides for development of lateral bearing and friction, which permits transfer of loads between the foundation and supporting soil. • Resists foundation sliding relative to soil (grade).	

a. Wood structural panel sheathing; see *IRC* Table R602.3(1) for other sheathing materials.
b. Common nail diameter and length: 6d: 0.113"x2", 8d: 0.131"x2-1/2", 10d: 0.148"x3".

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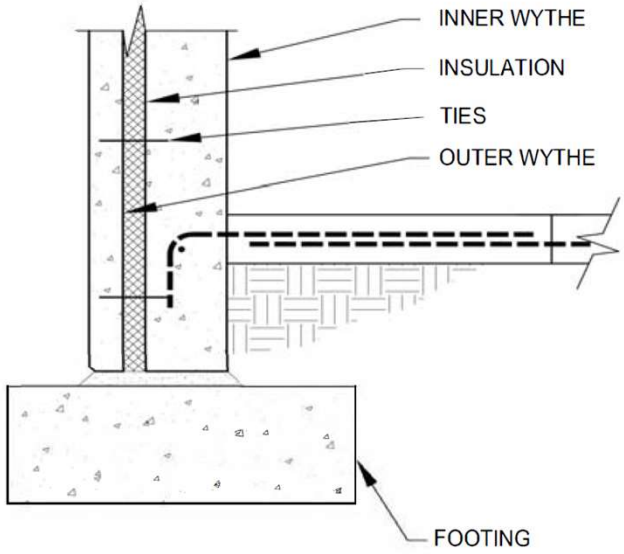

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Structural Risk Category

- Structural requirements vary based on risks associated with intended use(s) of building and importance that the structure remain unaffected by severe events
- Most buildings will be Risk Category II
- Larger buildings or heightened risks will be Risk Category III (large schools and assemblies)
- Essential or critical facilities are Risk Category IV (hospitals, police/fire, utilities)

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TABLE 1604.5
RISK CATEGORY OF BUILDINGS AND OTHER STRUCTURES

RISK CATEGORY	NATURE OF OCCUPANCY
I	*Structures* that represent a low hazard to human life in the event of failure, including but not limited to: • Agricultural *facilities*. • Minor storage *facilities*.
II	*Structures* except those listed in *Risk Categories* I, III and IV.
III	*Structures* that represent a substantial hazard to human life in the event of failure, including but not limited to: • *Buildings* containing one or more Group A occupancies with a combined *occupant load* in Group A occupancies greater than 1,000.[a] • *Buildings* containing Group E occupancies with an *occupant load* greater than 500.[a] • *Buildings* containing Group I-2, Condition 1 occupancies with 50 or more care recipients. • *Buildings* containing Group I-2, Condition 2 occupancies not having emergency surgery or emergency treatment *facilities*. • *Buildings* containing Group I-3 occupancies. • Any other *building* with an *occupant load* greater than 5,000.[a] • Power-generating stations, water treatment facilities for potable water, wastewater treatment *facilities* and other public utility *facilities* not included in *Risk Category* IV. • *Structures* not included in *Risk Category* IV containing quantities of toxic or explosive materials that exceed maximum allowable quantities per *control area* as given in Table 307.1(1) or 307.1(2) or per outdoor *control area* in accordance with the *Chicago Fire Prevention Code*; and are sufficient to pose a threat to the public if released.[b]
IV	*Structures* designated as *essential facilities*, including but not limited to: • *Buildings* containing Group I-2, Condition 2 occupancies having emergency surgery or emergency treatment *facilities*. • *Buildings* containing fire, rescue, ambulance and police stations and emergency vehicle garages. • *Buildings* containing earthquake, hurricane or other emergency shelters. • Designated emergency preparedness, communications and operations centers and other *facilities* required for emergency response. • Power-generating stations and other public utility *facilities* required as emergency backup facilities for *Risk Category* IV *structures*. • *Structures* containing quantities of highly toxic materials that: exceed maximum allowable quantities per control area as given in Table 307.1(2) or per outdoor control area in accordance with the *Chicago Fire Prevention Code*; and are sufficient to pose a threat to the public if released.[b] • Aviation control towers, air traffic control centers and emergency aircraft hangars. • *Structures* having critical public safety or national defense functions. • Water storage *facilities* and pump *structures* required to maintain water pressure for fire suppression.

a. *Occupant load* shall be determined in accordance with Table 1004.5.
b. Where *approved* by the *fire code official*, the classification of *structures* as *Risk Category* III or IV based on their quantities of toxic, highly toxic or explosive materials is permitted to be reduced to *Risk Category* II, provided that it can be demonstrated by a hazard assessment in accordance with Section 1.5.3 of ASCE 7 that a release of the *hazardous materials* is not sufficient to pose a threat to the public.

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Audience Q&A Session

ⓘ Start presenting to display the audience questions on this slide.

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Soils, Footings, Foundations

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KEY CONCEPT

Start with the soil . . .

- Most larger projects will require a geotechnical report to be submitted (and reviewed) with the permit application.
- Some small and medium sized projects may be permitted without a geotechnical report, but a report is required before construction. (And you can ask to see it.)
- A few small projects may never require a report. (sheds, private garages, etc.)

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Geotechnical Data

- No report required:
  - 1-story storage structures w/o basements ≤ 2,000 ft² (includes private garages)
  - Alterations and additions that do not cause increase of loads > 5% of existing foundation capacity
- Test pit by contractor before construction allowed:
  - Excavation ≤ 8 ft below ground level
  - Confirm soil type
  - Confirm water table height

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Geotechnical Data (continued)

- Geotechnical report (by engineer) not req'd for permit, but required before construction:
  - Excavation ≤ 8 ft below ground level
  - Ground area ≤ 16,000 ft²
  - Up to 4 stories above grade
- Geotechnical report (by engineer) required before permit issuance if exceeding these values or if design based on engineer provided or confirmed soil bearing capacity

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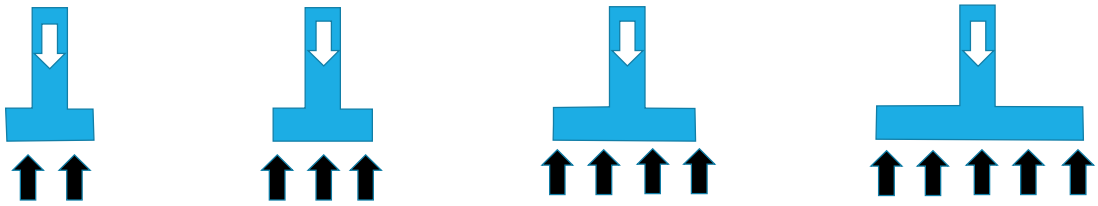
Allowable Soil Bearing Pressure

- Most conservative values if no engineer involved (Table 1806.2(1))
- Conservative values if no testing.
- Engineer may determine site-specific values with testing.
- Footing on non-engineered fill must be 6x footing on sandy gravel



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Types of Foundations

- Shallow Foundations
  - Spread or Strip Footings
- Deep Foundations
  - Drilled Piers
  - Piles

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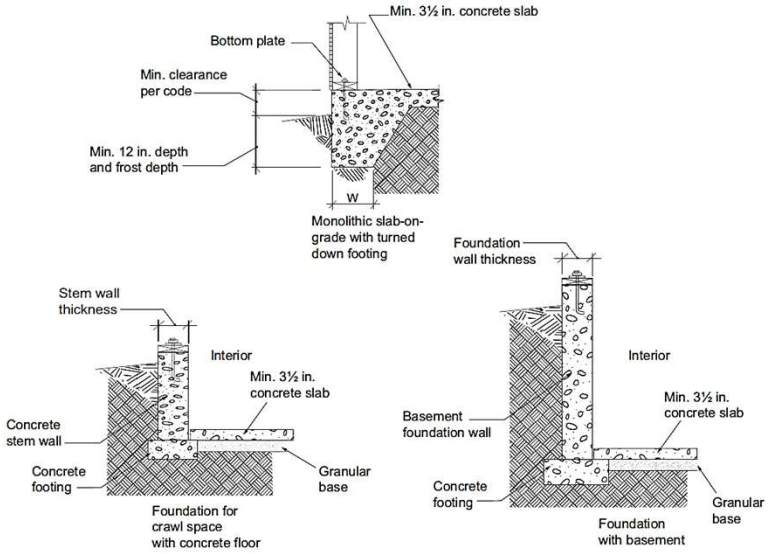
Typical Shallow Foundation Types



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Shallow Foundations – Spread or Strip Footings

1809.2 Supporting soils. *Shallow foundations* shall be built on undisturbed soil, compacted fill material or controlled low-strength material (CLSM). Compacted fill material shall be placed in accordance with Section 1804.5. CLSM shall be placed in accordance with Section 1804.6.

1809.3 Stepped footings. The top surface of footings shall be level. The bottom surface of footings shall be permitted to have a slope not exceeding one unit vertical in 10 units horizontal (10-percent slope). Footings shall be stepped where it is necessary to change the elevation of the top surface of the footing or where the surface of the ground slopes more than one unit vertical in 10 units horizontal (10-percent slope).

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Shallow Foundations – Spread or Strip Footings

1809.4 Depth and width of footings. The minimum depth of footings below the undisturbed ground surface shall be 12 inches (305 mm). Where applicable, the requirements of Section 1809.5 shall be satisfied. The minimum width of footings shall be 12 inches (305 mm).

1809.5 Frost protection. Except where otherwise protected from frost, foundations and other permanent supports of buildings and structures shall be protected from frost by one or more of the following methods:

1. Extending at least 42 inches (1067 mm) below final grade.
2. Constructing in accordance with ASCE 32.
3. Erecting on solid rock.

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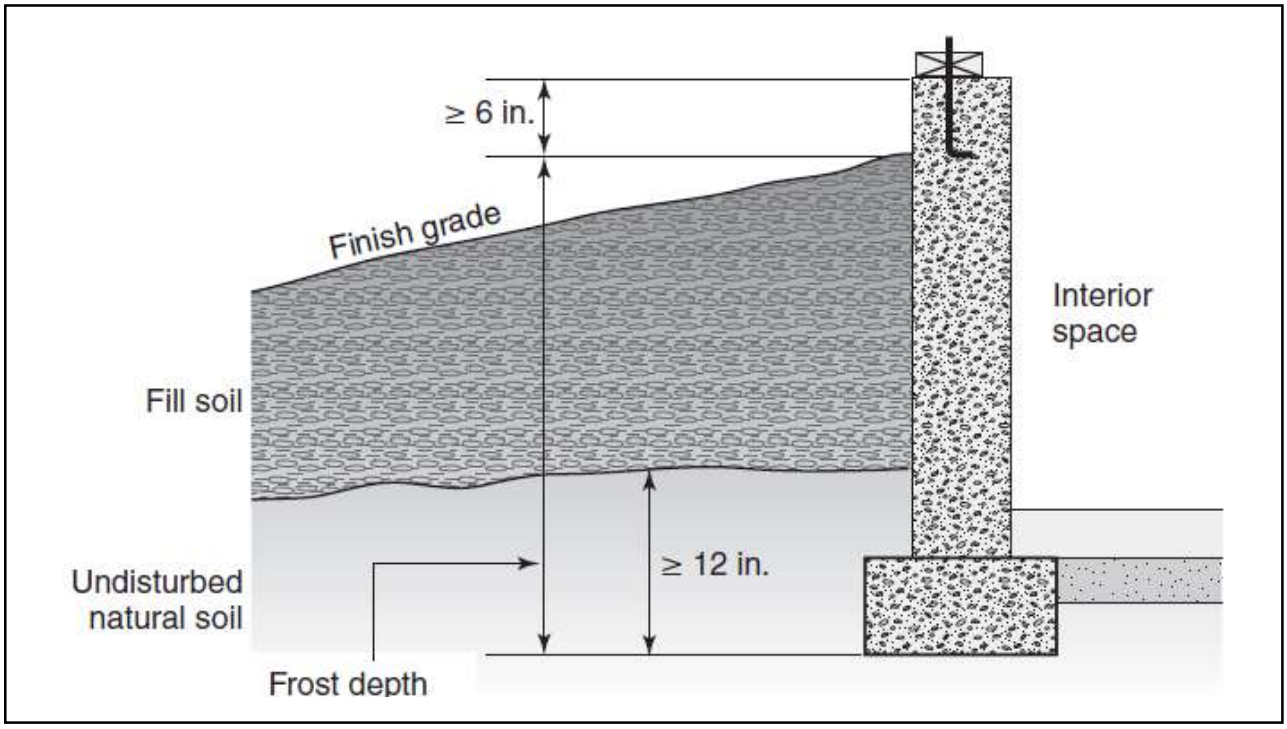

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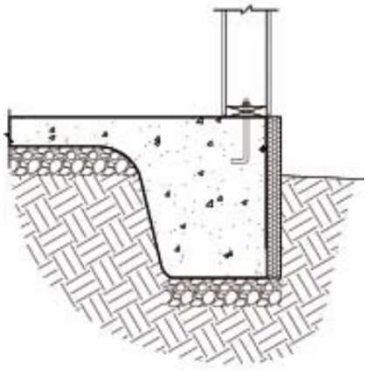
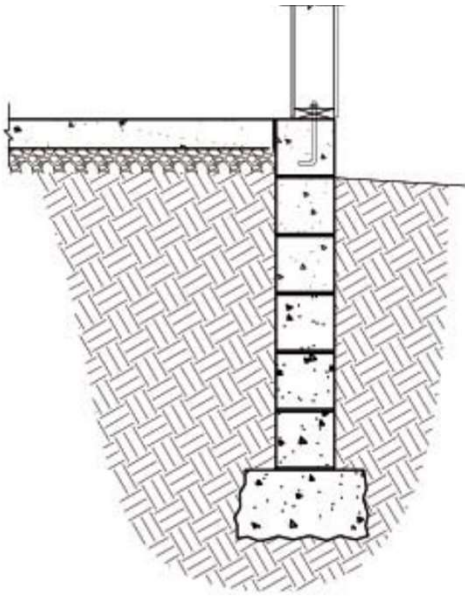
Frost Protected Shallow Foundation (ASCE 32)



Conventional Shallow Foundation



HUD Builder's Guide to Frost Protected Shallow Foundations

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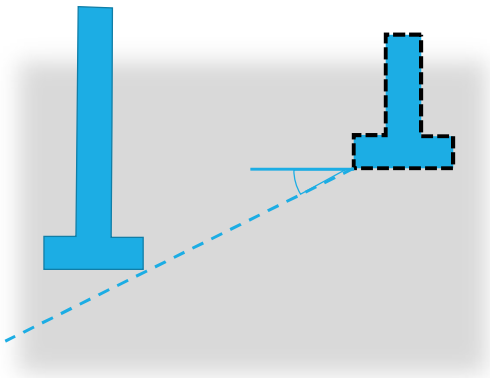
Shallow Foundations – Spread or Strip Footings

1809.6 Location of footings. Footings on granular soil shall be so located that the line drawn between the lower edges of adjoining footings shall not have a slope steeper than 30 degrees (0.52 rad) with the horizontal, unless the material supporting the higher footing is braced or retained or otherwise laterally supported or a greater slope has been properly established by engineering analysis.



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Shallow Foundations – Spread or Strip Footings

1809.7 Prescriptive footings for light-frame construction. Where a specific design is not provided, concrete or masonry-unit footings supporting walls of *light-frame construction* shall be permitted to be designed in accordance with Table 1809.7.

TABLE 1809.7
PRESCRIPTIVE FOOTINGS SUPPORTING WALLS OF LIGHT-FRAME CONSTRUCTION[a, b, c, d, e]

NUMBER OF FLOORS SUPPORTED BY THE FOOTING[f]	WIDTH OF FOOTING (inches)	THICKNESS OF FOOTING (inches)
1	12	6
2	15	6
3	18	8[g]

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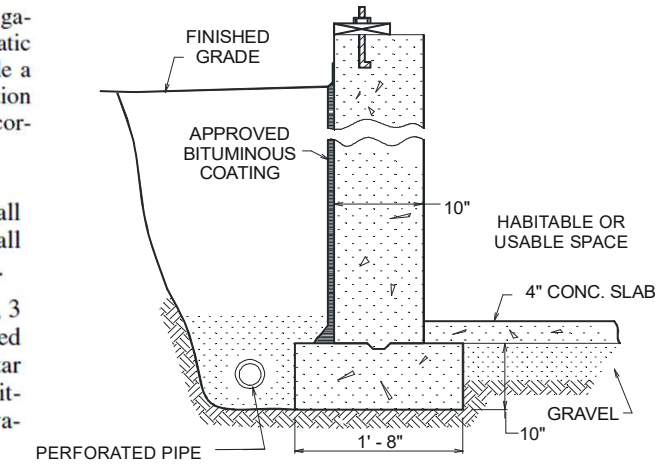
Foundation Drainage, Waterproofing and Dampproofing

1805.3 Waterproofing. Where the ground water investigation required by Section 1803.5.4 indicates that a hydrostatic pressure condition exists, and the design does not include a ground water control system as described in Section 1805.1.3, walls and floors shall be waterproofed in accordance with this section.

1805.2.2 Walls. Dampproofing materials for walls shall be installed on the exterior surface of the wall, and shall extend from the top of the footing to above ground level.

Dampproofing shall consist of a bituminous material, 3 pounds per square *yard* (16 N/m^2) of acrylic modified cement, $^1/_8$ inch (3.2 mm) coat of surface-bonding mortar complying with ASTM C887, any of the materials permitted for waterproofing by Section 1805.3.2 or other equivalent methods or materials.



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Foundation Drainage

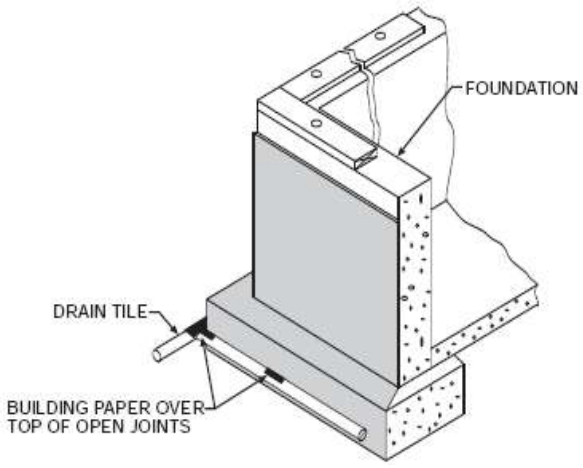
1805.4 Subsoil drainage system. Where a permanent hydrostatic pressure condition does not exist, dampproofing shall be provided and a granular base course shall be installed under the floor and a drain installed around the foundation perimeter. A subsoil drainage system designed and constructed in accordance with Section 1805.1.3 shall be deemed adequate for lowering the ground-water table.

1805.4.1 Floor base course. Floors of basements, except as provided for in Section 1805.1.1, shall be placed over a floor base course not less than 4 inches (102 mm) in thickness that consists of gravel or crushed stone containing not more than 10 percent of material that passes through a No. 4 (4.75 mm) sieve.

Exception: Where a *site* is located in well-drained gravel or sand/gravel mixture soils, a floor base course is not required.

1805.4.2 Foundation drain. A drain shall be placed at the perimeter of the foundation.

1805.4.3 Drainage discharge. The floor base course and foundation perimeter drain shall discharge by gravity or mechanical means into a drainage system that complies with the *Chicago Plumbing Code*.



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Shallow Foundation Inspections

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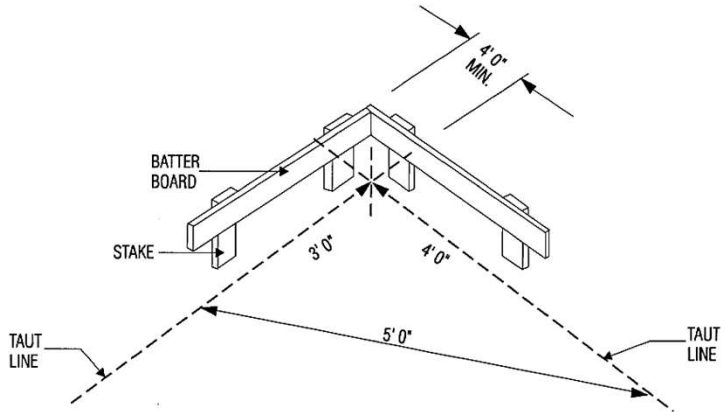
Marking Location of Construction



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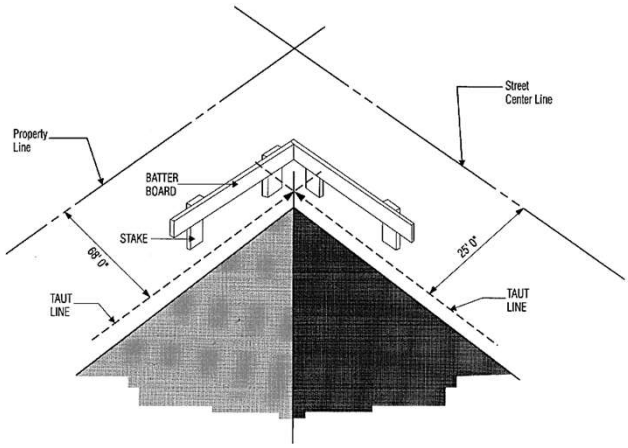
Marking Location of Construction



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Inspections

- By looking at the foundation plan, the inspector can check for the width, depth and spacing of the footing forms.
- The inspector can also check to see if there is a column footing form for each column shown on the foundation plan.

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City of Glendale, AZ, *What to Expect When You're Inspecting*

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TABLE 1808.8.2
MINIMUM CONCRETE COVER

FOUNDATION ELEMENT OR CONDITION	MINIMUM COVER
1. Shallow foundations	In accordance with Section 20.6 of ACI 318
2. Precast nonprestressed deep foundation elements Exposed to seawater Not manufactured under plant conditions Manufactured under plant control conditions	 3 inches 2 inches In accordance with Section 20.6.1.3.3 of ACI 318
3. Precast prestressed deep foundation elements Exposed to seawater Other	 2.5 inches In accordance with Section 20.6.1.3.3 of ACI 318
4. Cast-in-place deep foundation elements not enclosed by a steel pipe, tube or permanent casing	2.5 inches
5. Cast-in-place deep foundation elements enclosed by a steel pipe, tube or permanent casing	1 inch
6. Structural steel core within a steel pipe, tube or permanent casing	2 inches
7. Cast-in-place drilled shafts enclosed by a stable rock socket	1.5 inches

For SI: 1 inch = 25.4 mm.

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ACI 318 - Section 26.6.2

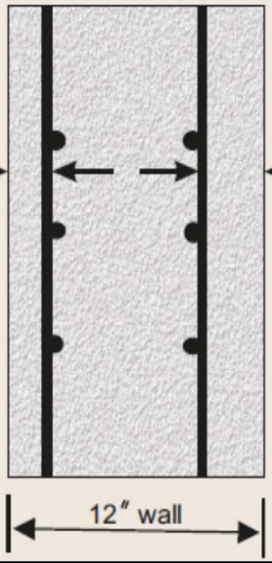
Tolerance is ½ in. but not to exceed $^1/_3$ specified cover

Inside face $^3/_4$″-clear

Outside face 1½″ clear

For outside face tolerance = ½″
1 in. cover is acceptable

For inside face:
tolerance = $^1/_3$ ($^3/_4$) = $^1/_4$ in.
½-in. cover is acceptable



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ACI 318 - Section 20.6.1.3

The amount of concrete cover specified for adequate protection is detailed in ACI 318 Section 20.6.1.3.

For quick reference, the specified cover for cast-in-place concrete with conventional reinforcing bars is summarized in Table 18.9.

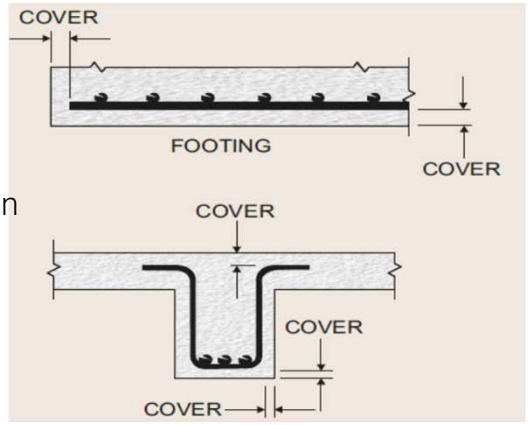

TABLE 18.9
CONCRETE COVER FOR REINFORCING BARS IN CAST-IN-PLACE CONCRETE

CONCRETE EXPOSURE		SPECIFIED COVER,* IN.
Cast against ground (without forms)		3
Exposed to weather or ground but cast against forms	#5 bar and smaller	$1\frac{1}{2}$
	Greater than #5 bar	2
Slabs and walls (no exposure)		$\frac{3}{4}$
Beams and columns (no exposure)		$1\frac{1}{2}$

*Measured cover ≥ minimum ± cover tolerance [AC1 318 Section 26.6.2.1(a)].

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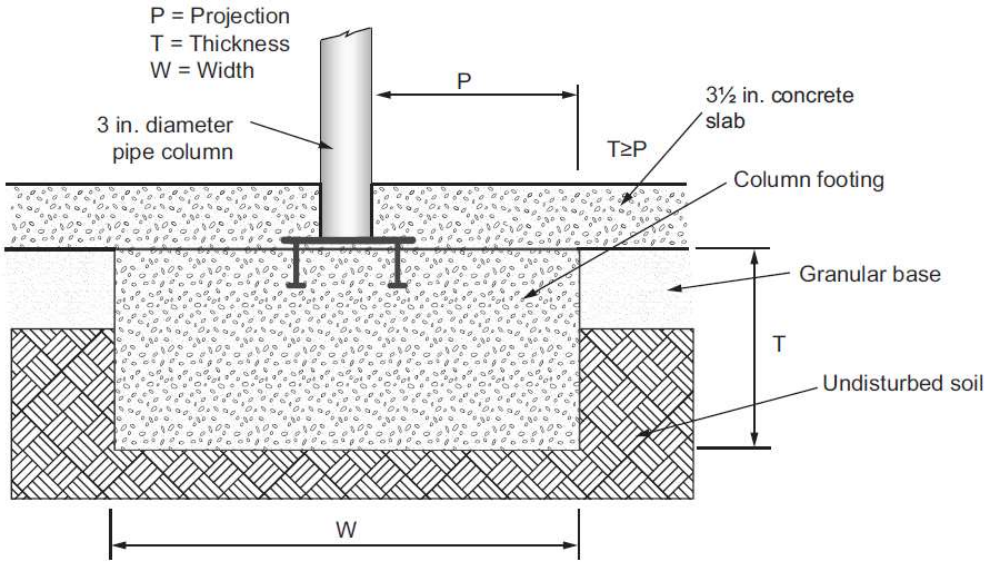
Column Footing Section



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QUESTION AND ANSWER

Shallow Foundations

The bottom of a footing shall be located a minimum of _____ inches below the undisturbed ground surface.

a. 6
b. 12
c. 15
d. 18

63

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QUESTION AND ANSWER

Shallow Foundations

The bottom of a footing shall be located a minimum of _____ inches below the undisturbed ground surface.

a. 6
b. 12
c. 15
d. 18

1809.4 Depth and width of footings. The minimum depth of footings below the undisturbed ground surface shall be 12 inches (305 mm). Where applicable, the requirements of Section 1809.5 shall be satisfied. The minimum width of footings shall be 12 inches (305 mm).

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QUESTION AND ANSWER

Shallow Foundations

The minimum concrete cover for reinforcing bars is _____ inches for concrete exposure cast against ground.

a. 1 ½
b. 2
c. 3
d. 4

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QUESTION AND ANSWER

Shallow Foundations

The minimum concrete cover for reinforcing bars is _____ inches for concrete exposure cast against ground.

a. 1 ½
b. 2
c. 3
d. 4

TABLE 18.9
CONCRETE COVER FOR REINFORCING BARS IN CAST-IN-PLACE CONCRETE

CONCRETE EXPOSURE		SPECIFIED COVER,* IN.
Cast against ground (without forms)		3
Exposed to weather or ground but cast against forms	#5 bar and smaller	$1^1/_2$
	Greater than #5 bar	2
Slabs and walls (no exposure)		$^3/_4$
Beams and columns (no exposure)		$1^1/_2$

*Measured cover ≥ minimum ± cover tolerance [AC1 318 Section 26.6.2.1(a)].

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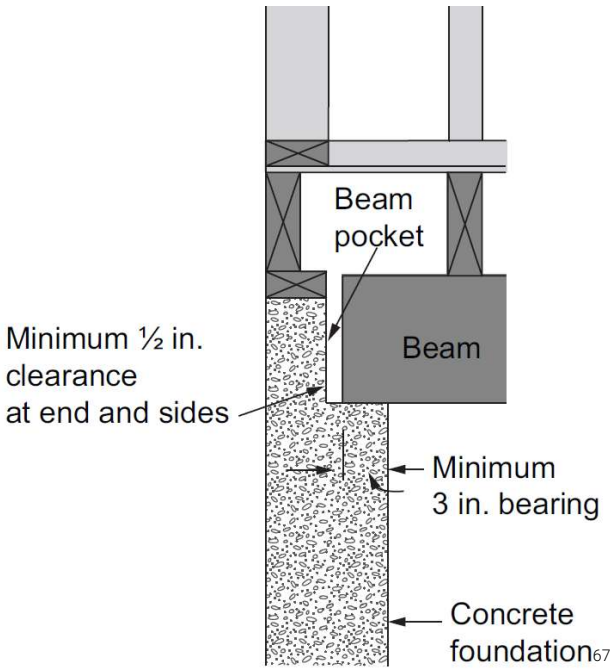
Beam Pocket



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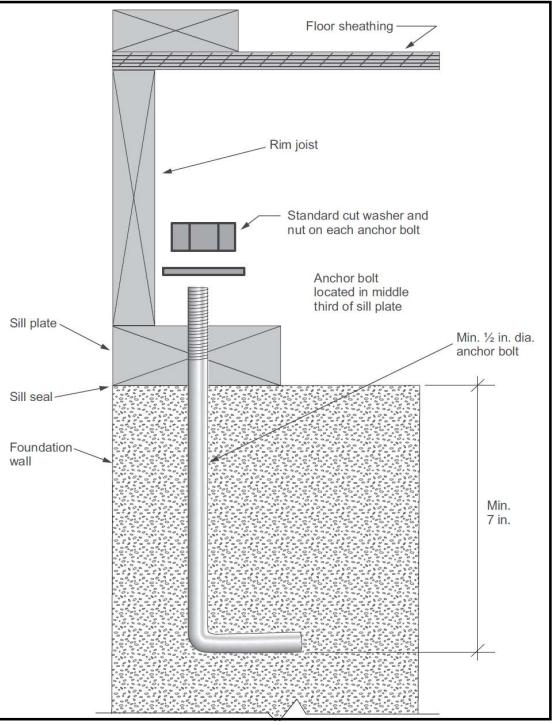
Anchor Bolts



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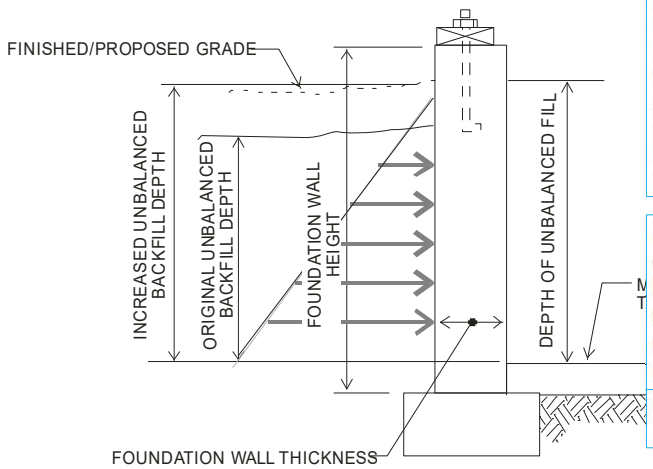
Foundation Wall Review

- Lateral loads increase with the depth of unbalanced fill.



1807.1.2 Unbalanced backfill height. Unbalanced backfill height is the difference in height between the exterior finish ground level and the lower of the top of the concrete footing that supports the foundation wall or the interior finish ground level. Where an interior concrete slab on grade is provided and is in contact with the interior surface of the foundation wall, the unbalanced backfill height shall be permitted to be measured from the exterior finish ground level to the top of the interior concrete slab.

1807.1.6.1 Foundation wall thickness. The thickness of prescriptively designed foundation walls shall be not less than the thickness of the wall supported, except that foundation walls of not less than 8-inch (203 mm) nominal width shall be permitted to support brick-veneered frame walls and 10-inch-wide (254 mm) cavity walls provided that the requirements of Section 1807.1.6.2 or 1807.1.6.3 are met.

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1807.1.6.2 Concrete foundation walls. Concrete foundation walls shall comply with the following:

1. The thickness shall comply with the requirements of Table 1807.1.6.2.
2. The size and spacing of vertical reinforcement shown in Table 1807.1.6.2 are based on the use of reinforcement with a minimum yield strength of 60,000 pounds per square inch (psi) (414 MPa). Vertical reinforcement with a minimum yield strength of 40,000 psi (276 MPa) or 50,000 psi (345 MPa) shall be permitted, provided that the same size bar is used and the spacing shown in the table is reduced by multiplying the spacing by 0.67 or 0.83, respectively.
3. Vertical reinforcement, where required, shall be placed nearest the inside face of the wall a distance, d, from the outside face (soil face) of the wall. The distance, d, is equal to the wall thickness, t, minus 1.25 inches (32 mm) plus one-half the bar diameter, d_b, [$d = t - (1.25 + d_b / 2)$]. The reinforcement shall be placed within a tolerance of $\pm\ ^3/_8$ inch (9.5 mm) where d is less than or equal to 8 inches (203 mm) or $\pm\ ^1/_2$ inch (12.7 mm) where d is greater than 8 inches (203 mm).
4. In lieu of the reinforcement shown in Table 1807.1.6.2, smaller reinforcing bar sizes with closer spacings that provide an equivalent cross-sectional area of reinforcement per unit length shall be permitted.
5. Concrete cover for reinforcement measured from the inside face of the wall shall be not less than $^3/_4$ inch (19.1 mm). Concrete cover for reinforcement measured from the outside face of the wall shall be not less than $1^1/_2$ inches (38 mm) for No. 5 bars and smaller, and not less than 2 inches (51 mm) for larger bars.
6. Concrete shall have a specified compressive strength, f'_c, of not less than 2,500 psi (17.2 MPa).
7. The unfactored axial load per linear foot of wall shall not exceed $1.2\,t\,f'_c$ where t is the specified wall thickness in inches.

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1807.1.6.3 Masonry foundation walls. Masonry foundation walls shall comply with the following:

1. The thickness shall comply with the requirements of Table 1807.1.6.3(1) for *plain masonry* walls or Table 1807.1.6.3(2), 1807.1.6.3(3) or 1807.1.6.3(4) for masonry walls with reinforcement.
2. Vertical reinforcement shall have a minimum yield strength of 60,000 psi (414 MPa).
3. The specified location of the reinforcement shall equal or exceed the effective depth distance, d, noted in Tables 1807.1.6.3(2), 1807.1.6.3(3) and 1807.1.6.3(4) and shall be measured from the face of the exterior (soil) side of the wall to the center of the vertical reinforcement. The reinforcement shall be placed within the tolerances specified in TMS 602, Article 3.4.B.11, of the specified location.
4. Grout shall comply with Section 2103.3.
5. Concrete masonry units shall comply with ASTM C90.
6. Clay masonry units shall comply with ASTM C652 for hollow brick, except compliance with ASTM C62 or ASTM C216 shall be permitted where solid masonry units are installed in accordance with Table 1807.1.6.3(1) for *plain masonry*.
7. Masonry units shall be laid in running bond and installed with Type M or S mortar in accordance with Section 2103.2.1.
8. The unfactored axial load per linear foot of wall shall not exceed $1.2\,t\,f'_m$ where t is the specified wall thickness in inches and f'_m is the specified compressive strength of masonry in pounds per square inch.
9. Not less than 4 inches (102 mm) of solid masonry shall be provided at girder supports at the top of hollow masonry unit foundation walls.

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Concrete Compressive Strength

TABLE 1808.8.1
MINIMUM SPECIFIED COMPRESSIVE STRENGTH f'_c OF CONCRETE OR GROUT

FOUNDATION ELEMENT OR CONDITION	SPECIFIED COMPRESSIVE STRENGTH, f'_c
1. Foundations for structures assigned to Seismic Design Category A, B or C	2,500 psi
2a. Foundations for Group R or U occupancies of *light-frame construction*, two stories or less in height, assigned to Seismic Design Category D	2,500 psi
2b. Foundations for other structures assigned to Seismic Design Category D	3,000 psi
3. Precast nonprestressed driven piles	4,000 psi
4. *Drilled shafts* and auger cast piles	4,000 psi
5. *Micropiles*	4,000 psi
6. Precast prestressed driven piles	5,000 psi

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FOR EXAMPLE

Prescriptive Foundation Wall Design

Conditions:

BUILDING: 1 story light frame construction with concrete basement foundation wall

UNBALANCED FILL height against foundation wall as indicated

SOIL CONDITIONS: Gravelly clay (CL) – 60 psf per foot of depth lateral soil pressure

DESIGN FOUNDATION WALL: Provide “Minimum thickness”

75

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Prescriptive Example 1

Maximum Wall Height: 10 ft

Maximum Unbalanced Backfill Height: 6 ft

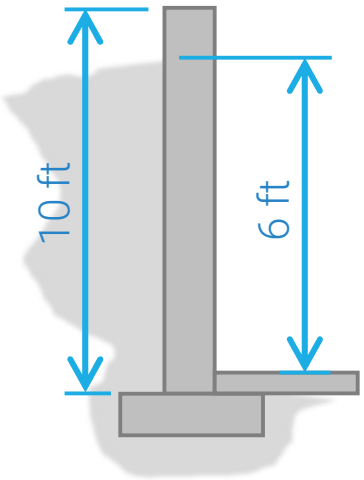

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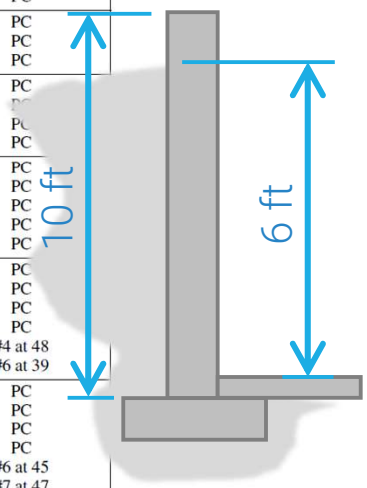
TABLE 1807.1.6.2
CONCRETE FOUNDATION WALLS[b,c]

MAXIMUM WALL HEIGHT (feet)	MAXIMUM UNBALANCED BACKFILL HEIGHT[a] (feet)	MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)		
		Design lateral soil load[a] (psf per foot of depth)		
		60		
		Minimum wall thickness (inches)		
		7.5	9.5	11.5
5	4	PC	PC	PC
	5	PC	PC	PC
6	4	PC	PC	PC
	5	PC	PC	PC
	6	PC	PC	PC
7	4	PC	PC	PC
	5	PC	PC	PC
	6	#5 at 48	PC	PC
	7	#6 at 48	PC	PC
8	4	PC	PC	PC
	5	PC	PC	PC
	6	#5 at 43	PC	PC
	7	#6 at 43	PC	PC
	8	#6 at 32	#6 at 44	PC
9	4	PC	PC	PC
	5	PC	PC	PC
	6	#5 at 39	PC	PC
	7	#6 at 38	#5 at 37	PC
	8	#7 at 39	#6 at 39	#4 at 48
	9[d]	#7 at 31	#7 at 41	#6 at 39
10	4	PC	PC	PC
	5	PC	PC	PC
	6	#5 at 37	PC	PC
	7	#6 at 35	#6 at 48	PC
	8	#7 at 35	#7 at 47	#6 at 45
	9[d]	#6 at 22	#7 at 37	#7 at 47
	10[d]	#6 at 22	#7 at 30	#7 at 38

Prescriptive Example 1



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Prescriptive Example 1

	Minimum wall thickness (inches)		
	7.5	9.5	11.5
4	PC	PC	PC
5	PC	PC	PC
6	#5 at 37	PC	PC
7	#6 at 35	#6 at 48	PC
8	#7 at 35	#7 at 47	#6 at 45
9[d]	#6 at 22	#7 at 37	#7 at 47
10[d]	#6 at 22	#7 at 30	#7 at 38

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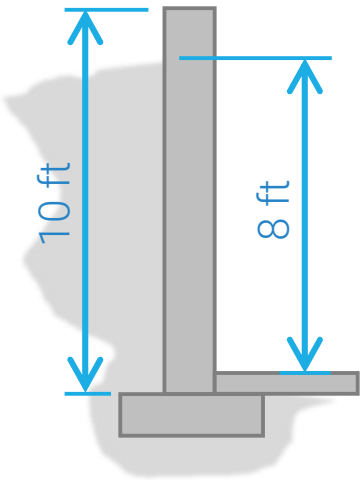
Prescriptive Example 2

Maximum Wall Height: 10 ft

Maximum Unbalanced Backfill Height: 8 ft



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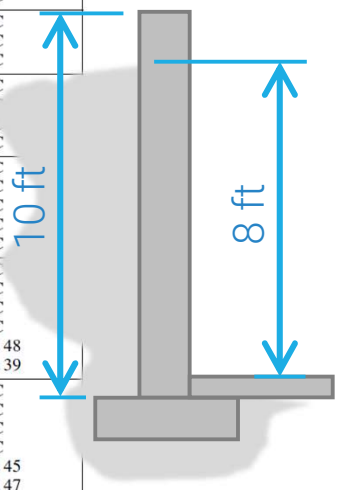
Prescriptive Example 2

TABLE 1807.1.6.2
CONCRETE FOUNDATION WALLS[b,c]

MAXIMUM WALL HEIGHT (feet)	MAXIMUM UNBALANCED BACKFILL HEIGHT[a] (feet)	MINIMUM VERTICAL REINFORCEMENT-BAR SIZE AND SPACING (inches)		
		Design lateral soil load[a] (psf per foot of depth)		
		60		
		Minimum wall thickness (inches)		
		7.5	9.5	11.5
5	4	PC	PC	PC
	5	PC	PC	PC
6	4	PC	PC	PC
	5	PC	PC	PC
	6	PC	PC	PC
7	4	PC	PC	PC
	5	PC	PC	PC
	6	#5 at 48	PC	PC
	7	#6 at 48	PC	PC
8	4	PC	PC	PC
	5	PC	PC	PC
	6	#5 at 43	PC	PC
	7	#6 at 43	PC	PC
	8	#6 at 32	#6 at 44	PC
9	4	PC	PC	PC
	5	PC	PC	PC
	6	#5 at 39	PC	PC
	7	#6 at 38	#5 at 37	PC
	8	#7 at 39	#6 at 39	#4 at 48
	9[d]	#7 at 31	#7 at 41	#6 at 39
10	4	PC	PC	PC
	5	PC	PC	PC
	6	#5 at 37	PC	PC
	7	#6 at 35	#6 at 48	PC
	8	#7 at 35	#7 at 47	#6 at 45
	9[d]	#6 at 22	#7 at 37	#7 at 47
	10[d]	#6 at 22	#7 at 30	#7 at 38



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Prescriptive Example 2

	Minimum wall thickness (inches)		
	7.5	9.5	11.5
4	PC	PC	PC
5	PC	PC	PC
6	#5 at 37	PC	PC
7	#6 at 35	#6 at 48	PC
8	#7 at 35	#7 at 47	#6 at 45
9[d]	#6 at 22	#7 at 37	#7 at 47
10[d]	#6 at 22	#7 at 30	#7 at 38

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Deep Foundations – Drilled Piers

- Piers are drilled into the ground and are used to transfer superstructure loads to deeper soils which are stronger or not subject to shrinking and swelling.
- The design and construction of drilled piers are found in Section 1810.

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Deep Foundations – Drilled Piers

1810.3.2.1 Concrete. Where concrete is cast in a steel pipe or where an enlarged base is formed by compacting concrete, the maximum size for coarse aggregate shall be $^{3}/_{4}$ inch (19.1 mm). Concrete to be compacted shall have a zero slump.

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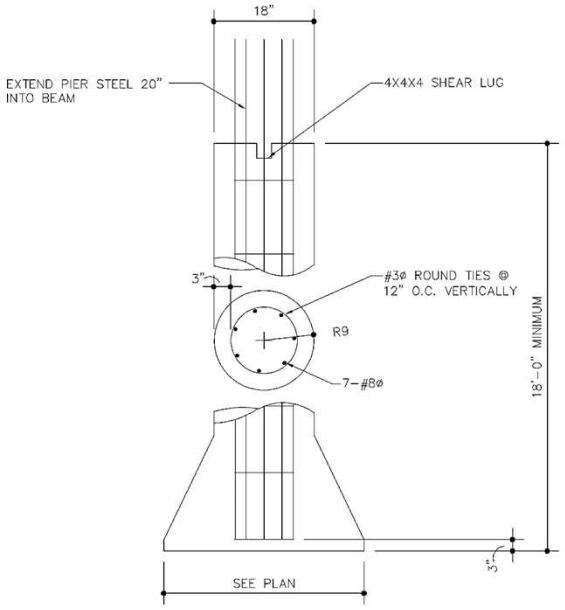
Deep Foundations – Drilled Piers

- Upward or downward loads can be transferred to the soil through skin friction along the shaft or through bearing at the end of the pier.
- Bells can be located at the end of the pier to increase the end bearing area.



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Deep Foundations – Piles

- Piles are driven (pounded) into the ground to transfer superstructure loads to deeper soils.
- The design and construction of piles is covered in Section 1810.

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Deep Foundations – Piles


Piles can be made of timber, steel or pre-cast concrete.

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Deep Foundations – Piles


1810.3.2.4 Timber. Timber *deep foundation* elements shall be designed as piles or poles in accordance with ANSI/AWC NDS. Round timber elements shall conform to ASTM D25. Sawn timber elements shall conform to DOC PS-20.

1810.3.5.2.3 Micropiles. *Micropiles* shall have a nominal diameter of 12 inches (305 mm) or less.

1810.3.2.3 Steel. Structural steel H-piles and structural steel sheet piling shall conform to the material requirements in ASTM A6. Steel pipe piles shall conform to the material requirements in ASTM A252. Fully welded steel piles shall be fabricated from plates that conform to the material requirements in ASTM A36, ASTM A283, ASTM A572, ASTM A588 or ASTM A690.

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Deep Foundations – Helical Piles

- Unlike other piles, helical piles are "screwed" into the ground.
- The design and construction of helical piles is covered in Section 1810.3.1.5

1810.3.1.5 Helical piles. *Helical piles* shall be designed and manufactured in accordance with accepted engineering practice to resist all stresses induced by installation into the ground and service loads.

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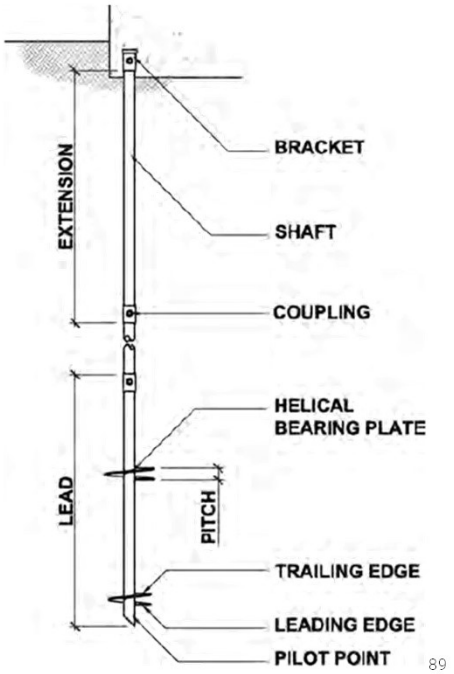
Helical Pile Foundations

- Helical piles are manufactured items that are installed by rotating into the ground.

Basic helical pile



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Audience Q&A Session

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Floor Construction

Photo courtesy steelconstruction.info

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Wood Construction

2302.1 General. The design of structural elements or systems, constructed partially or wholly of wood or wood-based products, shall be in accordance with one of the following methods:

1. *Allowable stress design* in accordance with Sections 2304, 2305 and 2306.
2. *Load and resistance factor design* in accordance with Sections 2304, 2305 and 2307.
3. *Conventional light-frame construction* in accordance with Sections 2304 and 2308.
4. AWC WFCM in accordance with Section 2309.
5. The design and construction of log structures in accordance with the provisions of ICC 400.

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Wood Construction

2302.1 General. The design of structural elements or systems, constructed partially or wholly of wood or wood-based products, shall be in accordance with one of the following methods:

1. *Allowable stress design* in accordance with Sections 2304, 2305 and 2306.
2. *Load and resistance factor design* in accordance with Sections 2304, 2305 and 2307.

Engineered

3. *Conventional light-frame construction* in accordance with Sections 2304 and 2308.
4. AWC WFCM in accordance with Section 2309.
5. The design and construction of log structures in accordance with the provisions of ICC 400.

Prescriptive

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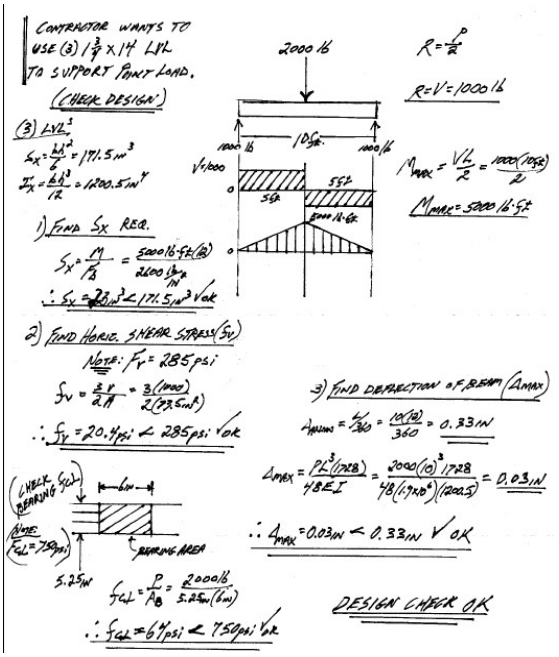
Engineered Design

- When special concentrated loads or unique structural designs are supported by headers, actual loads should be calculated by a competent designer.

Design Stresses

Grade	Orientation	G Shear Modulus of Elasticity (psi)	E Modulus of Elasticity (psi)	E_{min} Adjusted Modulus of Elasticity[1] (psi)	F_b Flexural Stress[2] (psi)	F_t Tension Stress[3] (psi)	$F_{c\perp}$ Compression Perpendicular to Grain[4] (psi)	F_{cII} Compression Parallel to Grain (psi)	F_v Horizontal Shear Parallel to Grain (psi)	SG Equivalent Specific Gravity[5]
TimberStrand® LSL										
1.3E	Beam/Column	81,250	1.3×10^6	660,750	1,700	1,075	680	1,400	400	0.50[6]
	Plank	81,250	1.3×10^6	660,750	1,900[7]	1,075	435	1,400	310	0.50[6]
1.55E	Beam	96,875	1.55×10^6	787,915	2,325	1,070[8]	690	2,650	310[9]	0.50[6]
Microllam® LVL										
1.9E	Beam	118,750	1.9×10^6	965,710	2,600	1,555	750	2,510	285	0.50
Parallam® PSL										
1.8E and 2.1E	Column	112,500	1.8×10^6	914,880	2,400[10]	1,755	425[10]	2,510	190[10]	0.50
2.0E[11]	Beam	125,000	2.0×10^6	1,016,535	2,900	2,025	750	2,900	290	0.50



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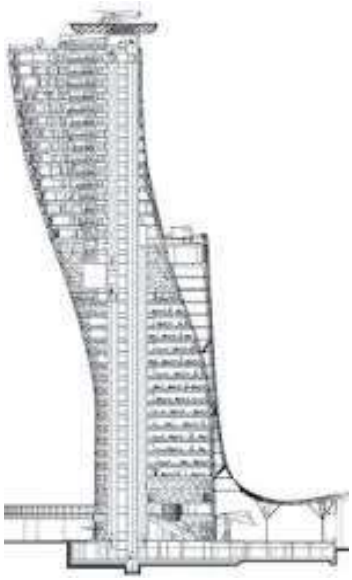
Prescriptive Design????



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Prescriptive Design

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Wood Markings

2303.1.1 Sawn lumber. Sawn lumber used for load-supporting purposes, including end-jointed or edge-glued lumber, machine stress-rated or machine-evaluated lumber, shall be identified by the *grade mark* of a lumber grading or inspection agency accredited by an *accreditation body* that complies with DOC PS 20 or *approved* equivalent. Grading practices and identification shall comply with rules published by an agency certified in accordance with the procedures of DOC PS 20 or *approved* equivalent procedures.

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Wood Markings

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Conventional Light-Frame Construction

2308.1 General. The requirements of this section are intended for *conventional light-frame construction*. Other construction methods are permitted to be used, provided that a satisfactory design is submitted showing compliance with other provisions of this code. Interior nonload-bearing partitions, ceilings and curtain walls of *conventional light-frame construction* are not subject to the limitations of Section 2308.2.

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Conventional Light-Frame Construction

- Maximum 3 stories
- Maximum 11’-7” Floor-to-floor height
- Maximum 10’-0” stud height
- Only allowed for occupancies with live load of 40 psf or less (residential)

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Wood Joist and Girder Review Steps

1. Check joist spans.
2. Check wood girder and header spans in exterior bearing walls.
3. Check wood girder and header spans in interior bearing walls.
4. Check floor framing under bearing walls.
5. Check joists for minimum bearing.
6. Check lateral support of joists.
7. Check framing around floor openings.
8. Check design of wood floor trusses.
9. Check for draftstopping.

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Conventional Light-Frame Construction

2308.4.2 Floor joists. Floor joists shall comply with this section.

2308.4.2.1 Span. Spans for floor joists shall be in accordance with Table 2308.4.2.1(1) or 2308.4.2.1(2) or the AWC STJR.

2308.4.2.4 Notches and holes. Notches on the ends of joists shall not exceed one-fourth the joist depth. Notches in the top or bottom of joists shall not exceed one-sixth the depth and shall not be located in the middle third of the span. Holes bored in joists shall not be within 2 inches (51 mm) of the top or bottom of the joist and the diameter of any such hole shall not exceed one-third the depth of the joist.

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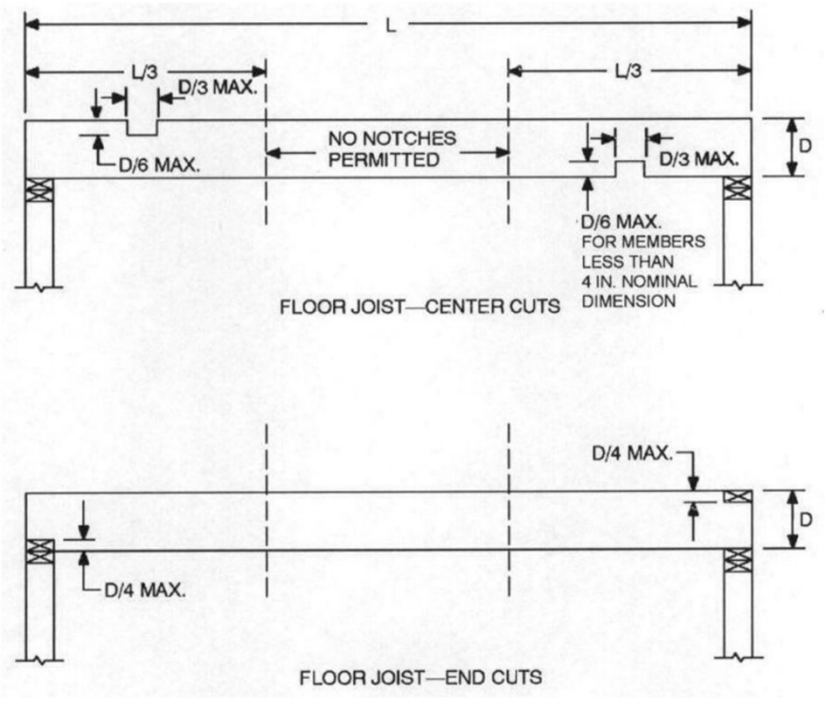

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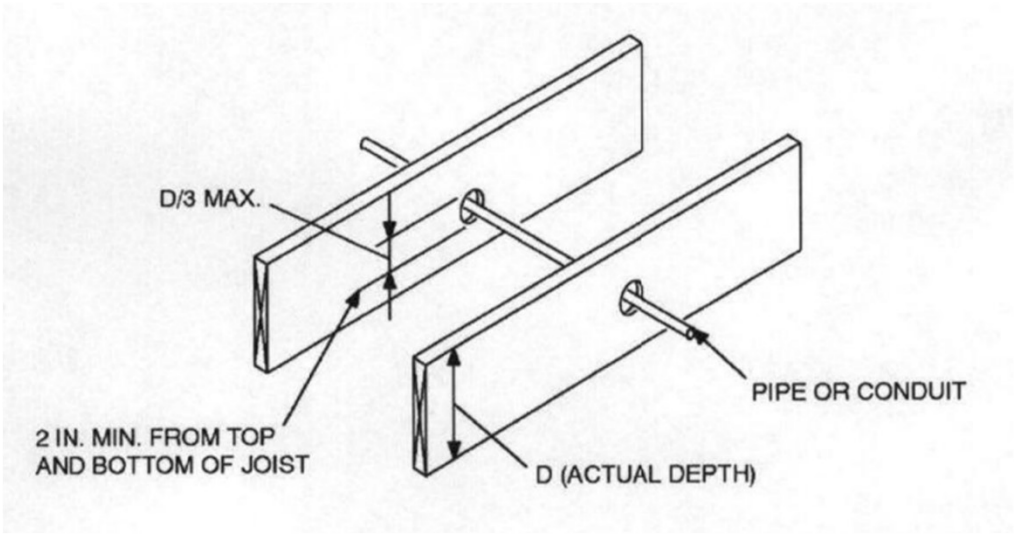

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Joist Spans

TABLE 2308.4.2.1(2)
FLOOR JOIST SPANS FOR COMMON LUMBER SPECIES
(Residential living areas, live load = 40 psf, [illegible]0)

JOIST SPACING (inches)	SPECIES AND GR		DEAD LOAD = 10 psf				DEAD LOAD = 20 psf			
			2 x 6	2 x 8	2 x 10	2 x 12	2 x 6	2 x 8	2 x 10	2 x 12
			Maximum floor joist spans							
			(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)
12	[illegible]ir-Larch	SS	11-4	15-0	19-1	23-3	11-4	15-0	19-1	23-3
	Douglas Fir-Larch	#1	10-11	14-5	18-5	22-0	10-11	14-2	17-4	20-1
	Douglas Fir-Larch	#2	10-9	14-2	17-9	20-7	10-6	13-3	16-3	18-10
	Douglas Fir-Larch	#3	8-8	11-0	13-5	15-7	7-11	10-0	12-3	14-3
	Hem-Fir	SS	10-9	14-2	18-0	21-11	10-9	14-2	18-0	21-11
	Hem-Fir	#1	10-6	13-10	17-8	21-6	10-6	13-10	16-11	19-7
	Hem-Fir	#2	10-0	13-2	16-10	20-4	10-0	13-1	16-0	18-6
	Hem-Fir	#3	8-8	11-0	13-5	15-7	7-11	10-0	12-3	14-3
	Southern Pine	SS	11-2	14-8	18-9	22-10	11-2	14-8	18-9	22-10
	Southern Pine	#1	10-9	14-2	18-0	21-11	10-9	14-2	16-11	20-1
	Southern Pine	#2	10-3	13-6	16-2	19-1	9-10	12-6	14-9	17-5
	Southern Pine	#3	8-2	10-3	12-6	14-9	7-5	9-5	11-5	13-6
	Spruce-Pine-Fir	SS	10-6	13-10	17-8	21-6	10-6	13-10	17-8	21-6
	Spruce-Pine-Fir	#1	10-3	13-6	17-3	20-7	10-3	13-3	16-3	18-10
	Spruce-Pine-Fir	#2	10-3	13-6	17-3	20-7	10-3	13-3	16-3	18-10
	Spruce-Pine-Fir	#3	8-8	11-0	13-5	15-7	7-11	10-0	12-3	14-3

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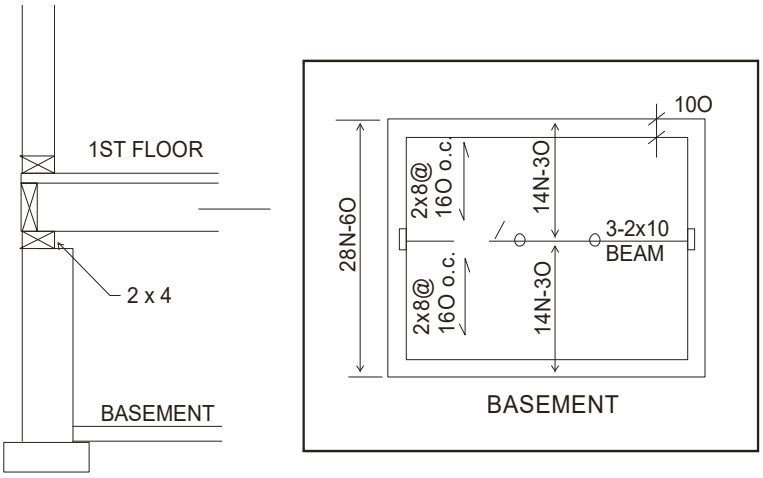
Check Floor Joist Spans



NOTES:
- JOISTS TO BE DOUGLAS-FIR-LARCH NO. 2 OR BETTER
- FIRST FLOOR: LIVE LOAD = 40 PSF
  DEAD LOAD = 10 PSF.

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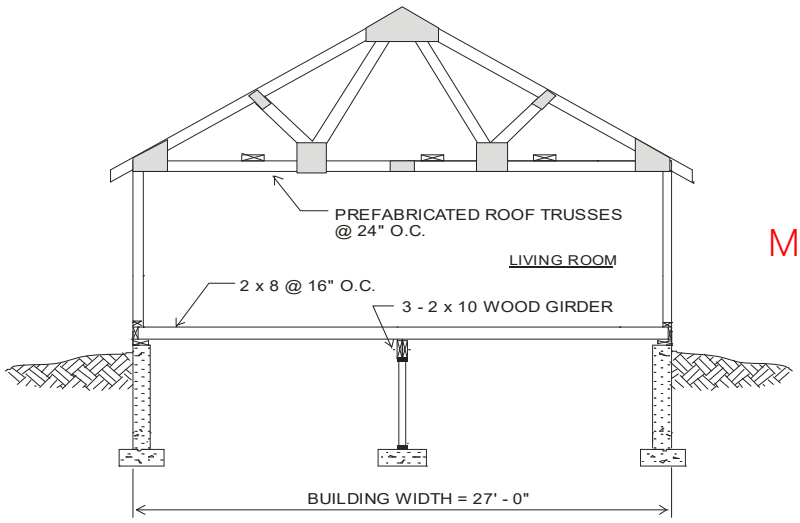
FOR EXAMPLE

Wood Joist and Girder Review



Max Span?

NOTE: GIRDERS ARE S-P-F NO. 2 OR BETTER

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Girder Spans and Header Spans for Interior Bearing Walls

TABLE 2308.4.1.1(2)
HEADER AND GIRDER SPANS[a, b] FOR INTERIOR BEARING WALLS
(Maximum spans for Douglas fir-larch, hem-fir, Southern pine and spruce-pine-fir and required number of jack studs)

HEADERS AND GIRDERS SUPPORTING	SIZE	BUILDING WIDTH[c] (feet)					
		12		24		36	
		Span[e]	NJ[d]	Span[e]	NJ[d]	Span[e]	NJ[d]
One floor only	2-2 × 4	4-1	1	2-10	1	2-4	1
	2-2 × 6	6-1	1	4-4	1	3-6	1
	2-2 × 8	7-9	1	5-5	1	4-5	2
	2-2 × 10	9-2	1	6-6	2	5-3	2
	2-2 × 12	10-9	1	7-7	2	6-3	2
	3-2 × 8	9-8	1	6-10	1	5-7	1
	3-2 × 10	11-5	1	8-1	1	6-7	2
	3-2 × 12	13-6	1	9-6	2	7-9	2
	4-2 × 8	11-2	1	7-11	1	6-5	1
	4-2 × 10	13-3	1	9-4	1	7-8	1
	4-2 × 12	15-7	1	11-0	1	9-0	2
Two floors	2-2 × 4	2-7	1	1-11	1	1-7	1
	2-2 × 6	3-11	1	2-11	2	2-5	2
	2-2 × 8	5-0	1	3-8	2	3-1	2
	2-2 × 10	5-11	2	4-4	2	3-7	2
	2-2 × 12	6-11	2	5-2	2	4-3	3
	3-2 × 8	6-3	1	4-7	2	3-10	2
	3-2 × 10	7-5	1	5-6	2	4-6	2

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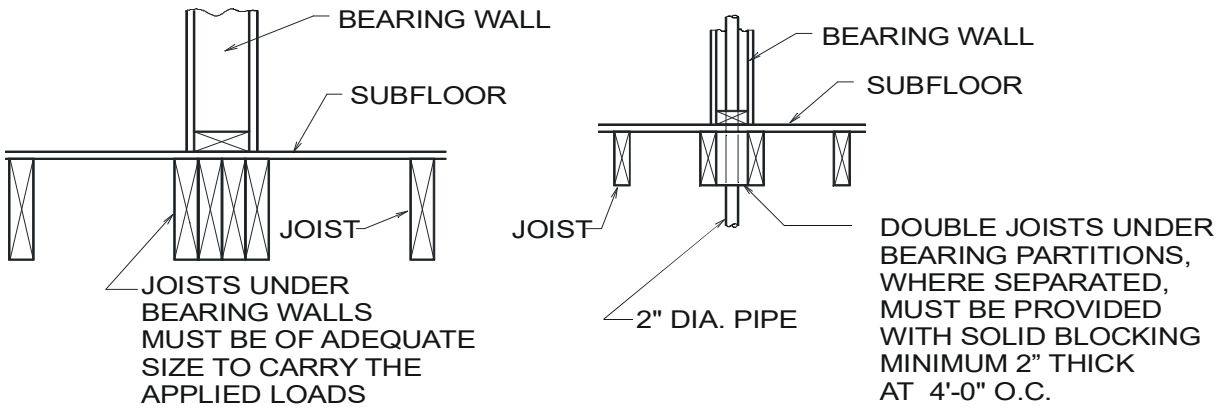
Double Joists at Bearing Wall



For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

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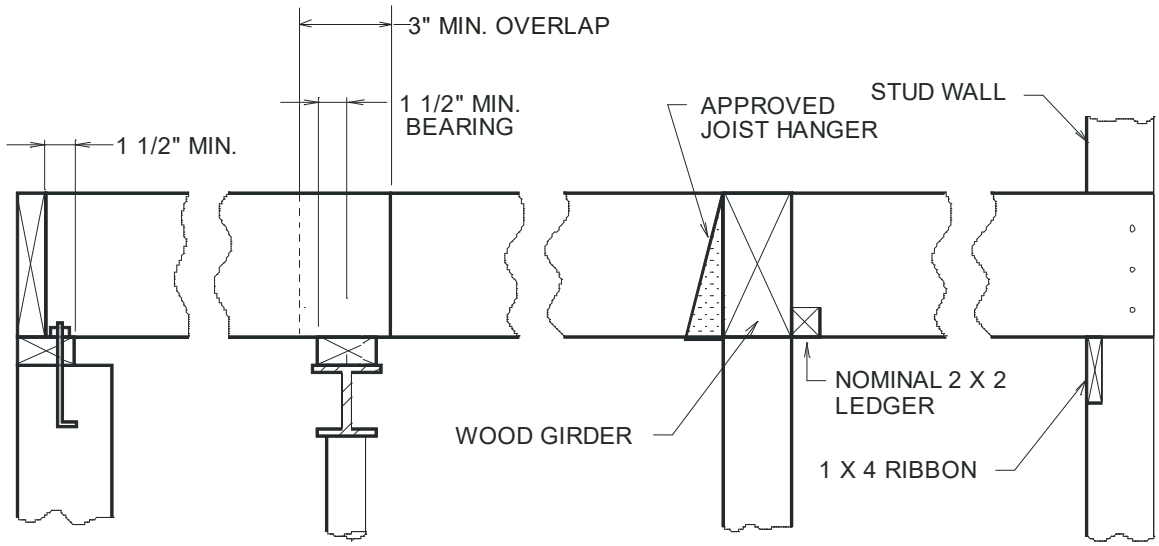
Wood Joist, Beam or Girder Bearing



For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

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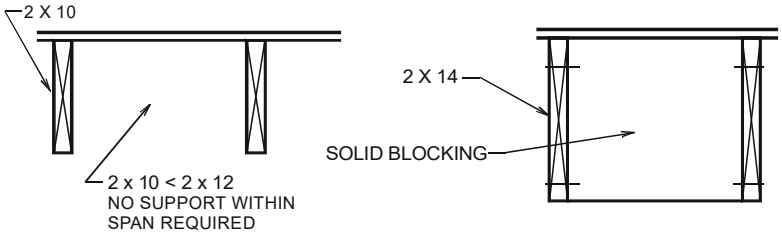
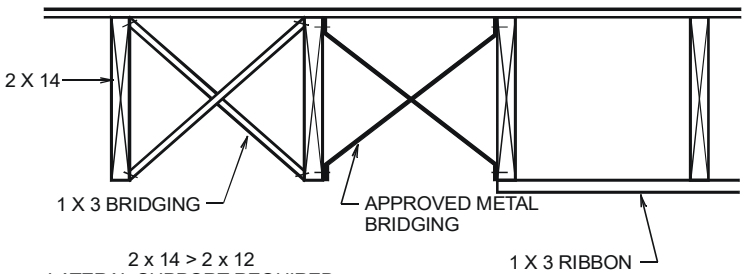
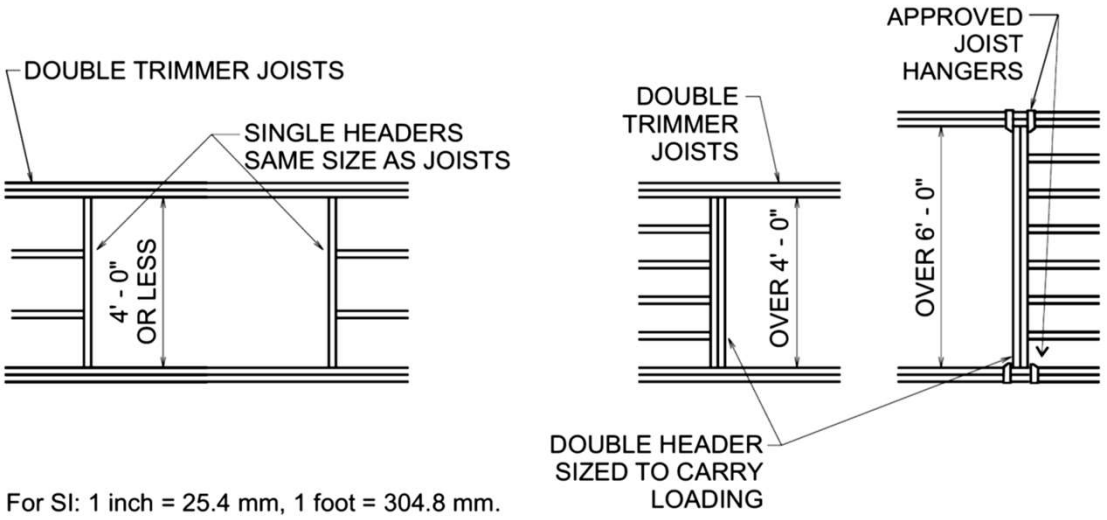
Lateral Restraint of Supports and Bridging of Joists





111

Framing of Openings



For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

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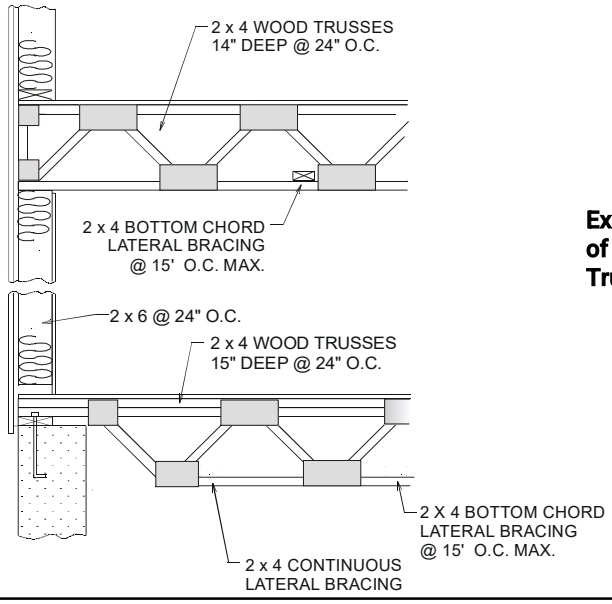
Wood Floor Trusses



Examples of Floor Truss Bracing

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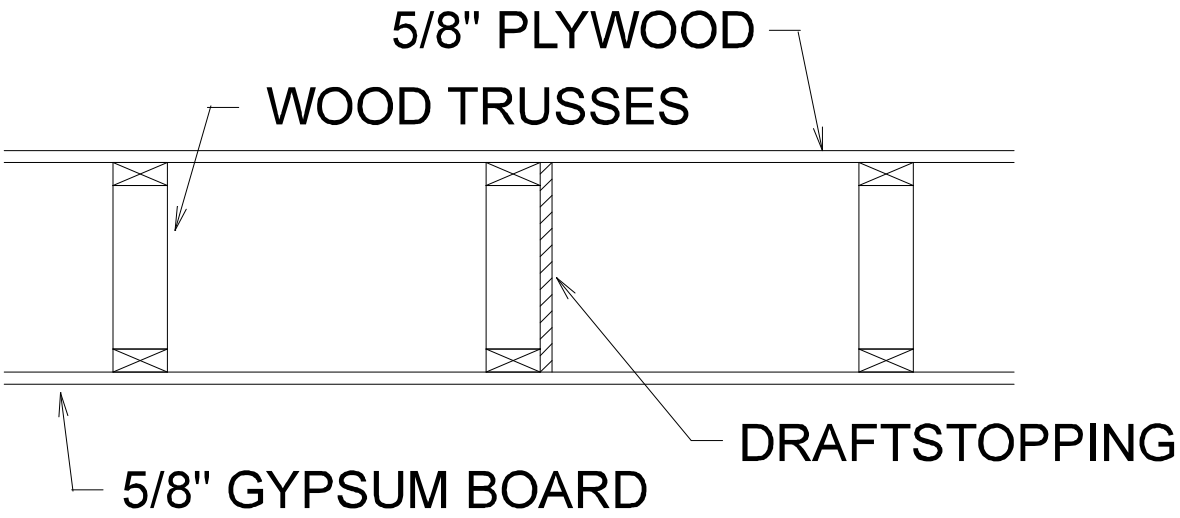
Draftstopping in Floor Trusses



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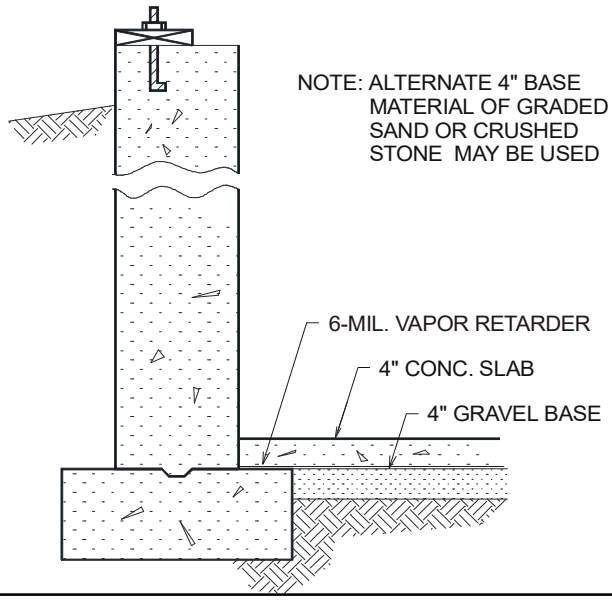
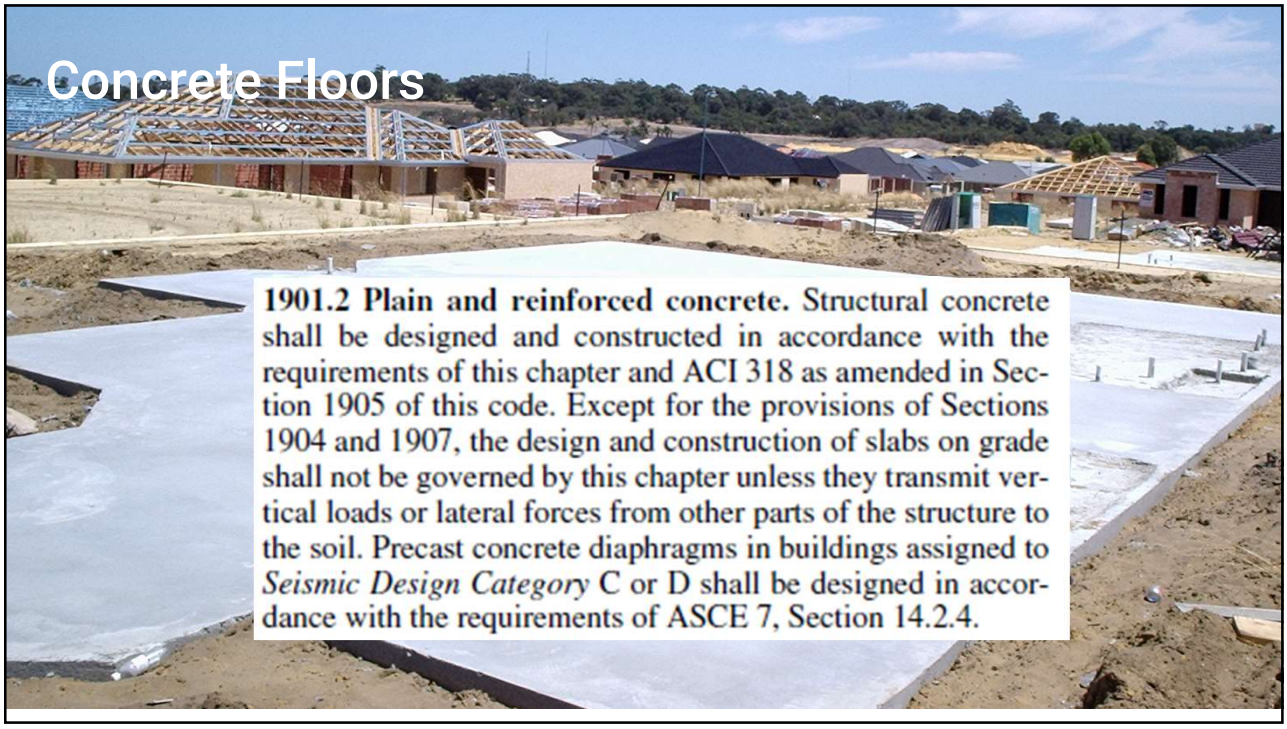
Concrete Floors



115


Concrete Floors

116


Concrete Floors
1901.2 Plain and reinforced concrete. Structural concrete shall be designed and constructed in accordance with the requirements of this chapter and ACI 318 as amended in Section 1905 of this code. Except for the provisions of Sections 1904 and 1907, the design and construction of slabs on grade shall not be governed by this chapter unless they transmit vertical loads or lateral forces from other parts of the structure to the soil. Precast concrete diaphragms in buildings assigned to *Seismic Design Category* C or D shall be designed in accordance with the requirements of ASCE 7, Section 14.2.4.

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Minimum Slab Requirements

1907.1 General. The thickness of concrete floor slabs supported directly on the ground shall be not less than $3^1/_2$ inches (89 mm). A 6-mil (0.006 inch; 0.15 mm) polyethylene vapor retarder with joints lapped not less than 6 inches (152 mm) shall be placed between the base course or subgrade and the concrete floor slab, or other equivalent methods or materials shall be used to retard vapor transmission through the floor slab.

Exception: A vapor retarder is not required:

1. For detached structures accessory to occupancies in Groups R-3 or R-5, such as garages, utility buildings or other unheated facilities.
2. For unheated storage rooms having an area of less than 70 square feet (6.5 m^2) and carports attached to occupancies in Groups R-3 and R-5.
3. For buildings of other occupancies where migration of moisture through the slab from below will not be detrimental to the intended occupancy of the building.
4. For driveways, walks, patios and other flatwork that will not be enclosed at a later date.
5. Where *approved* based on local site conditions.

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Audience Q&A Session

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Wall Construction

X

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Exterior Walls

Chapter 14 provides requirements for the materials and construction creating finished exterior surfaces of a building that result in:

- Minimum permitted weather resistance
- Minimum permitted fire performance

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Exterior Walls

Development of new methods and materials available for application to exterior walls for protection against weather and exposure provide options for:

- Different appearances
- Improved insulating quality
- Fire-resistance

The code has developed prescriptive and performance regulations to control these aspects and the types and thicknesses of exterior wall coverings.

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Exterior Wall Coverings

TABLE 1404.2
MINIMUM THICKNESS OF WEATHER COVERINGS

COVERING TYPE	MINIMUM THICKNESS (inches)
Adhered masonry veneer	
Architectural cast stone	0.75
Other	0.25
Aluminum siding	0.019
Anchored masonry veneer	
Stone (natural)	2.0
Architectural cast stone	1.25
Other	2.0
Cold-rolled copper[d]	0.0216 nominal
Copper shingles[d]	0.0162 nominal
Exterior plywood (with sheathing)	0.313
Exterior plywood (without sheathing)	See Section 2304.6
Fiber cement lap siding	0.25[c]
Fiber cement panel siding	0.25[c]
Fiberboard siding	0.5
Glass-fiber reinforced concrete panels	0.375
Hardboard siding[c]	0.25
High-yield copper[d]	0.0162 nominal
Marble slabs	1
Particleboard (with sheathing)	See Section 2304.6
Particleboard (without sheathing)	See Section 2304.6
Porcelain tile	0.25
Steel (corrosion resistant)	0.0149
Structural glass	0.344
Stucco or exterior cement plaster	
Three-coat work over:	
Metal plaster base	0.875[b]
Unit masonry	0.625[b]
Cast-in-place or precast concrete	0.625[b]
Two-coat work over:	
Unit masonry	0.5[b]
Cast-in-place or precast concrete	0.375[b]
Terra cotta (anchored)	1
Terra cotta (adhered)	0.25
Vinyl siding	0.035
Wood shingles	0.375
Wood siding (without sheathing)[a]	0.5

a. Wood siding of thicknesses less than 0.5 inch shall be placed over sheathing that conforms to Section 2304.6.
b. Exclusive of texture.
c. As measured at the bottom of decorative grooves.
d. 16 ounces per square foot for cold-rolled copper, 12 ounces per square foot for copper shingles and high-yield copper.

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Combustible Materials on the Exterior Side of Exterior Walls

- The code requires walls to be noncombustible for buildings of construction Types I, II, III and IV, in order to limit the fuel load.

1405.1.1 Types I, II, III and IV construction. On buildings of Types I, II, III and IV construction, *exterior wall coverings* shall be permitted to be constructed of combustible materials, complying with the following limitations:

1. Combustible *exterior wall coverings* shall not exceed 10 percent of an *exterior wall* surface area where the *fire separation distance* is 15 feet (4572 mm) or less.
2. Combustible *exterior wall coverings* shall be limited to 40 feet (12 192 mm) in height above *grade plane*.
3. [Reserved]
4. Wood veneers shall comply with this section and Section 1404.5.

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Fire Separation and Combustible Covering (Except Type V Construction)

1405.1.1.1.1 Fire separation 15 feet or less. Where installed on *exterior walls* having a *fire separation distance* of 15 feet (4572 mm) or less, combustible *exterior wall coverings* shall not exhibit sustained flaming as defined in NFPA 268.

1405.1.1.1.2 Fire separation greater than 15 feet. For *fire separation distances* greater than 15 feet (4572 mm), any *exterior wall covering* shall be allowed that has been exposed to a reduced level of incident radiant heat flux in accordance with the NFPA 268 test method without exhibiting sustained flaming. The minimum *fire separation distance* required for the *exterior wall covering* shall be determined from Table 1405.1.1.1.2 based on the maximum tolerable level of incident radiant heat flux that does not cause sustained flaming of the *exterior wall covering*.

TABLE 1405.1.1.1.2
MINIMUM FIRE SEPARATION FOR COMBUSTIBLE EXTERIOR WALL COVERINGS

FIRE SEPARATION DISTANCE (feet)	TOLERABLE LEVEL INCIDENT RADIANT HEAT ENERGY (kW/m^2)
greater than 15	5.9
17	5.5
18	5.2
19	4.9
20	4.6
21	4.4
22	4.1
23	3.9
24	3.7
25	3.5

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Prescriptive vs. Engineered Wood Walls

1. What is the purpose of a wall?
2. Prescriptive braced wall panels
3. Engineered shear walls
   - Segmented Shear Walls
   - Shear Walls with Openings (Force Transfer)
   - Perforated Shear Walls

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Wood stud sizing

2308.5 Wall construction. Walls of *conventional light-frame* construction shall be in accordance with this section.

2308.5.1 Stud size, height and spacing. The size, height and spacing of studs shall be in accordance with Table 2308.5.1.

TABLE 2308.5.1
SIZE, HEIGHT AND SPACING OF WOOD STUDS[c]

STUD SIZE (inches)	BEARING WALLS				NONBEARING WALLS	
	Laterally unsupported stud height[a] (feet)	Supporting roof and ceiling only	Supporting one floor, roof and ceiling	Supporting two floors, roof and ceiling	Laterally unsupported stud height[a] (feet)	Spacing (inches)
		Spacing (inches)				
2 × 3[b]	—	—	—	—	10	16
2 × 4	10	24	16	—	14	24
3 × 4	10	24	24	16	14	24
2 × 5	10	24	24	—	16	24
2 × 6	10	24	24	16	20	24

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm.

a. Listed heights are distances between points of lateral support placed perpendicular to the plane of the wall. Increases in unsupported height are permitted where justified by an analysis.

b. Shall not be used in exterior walls.

c. Utility-grade studs shall not be spaced more than 16 inches on center or support more than a roof and ceiling, or exceed 8 feet in height for exterior walls and load-bearing walls or 10 feet for interior nonload-bearing walls.

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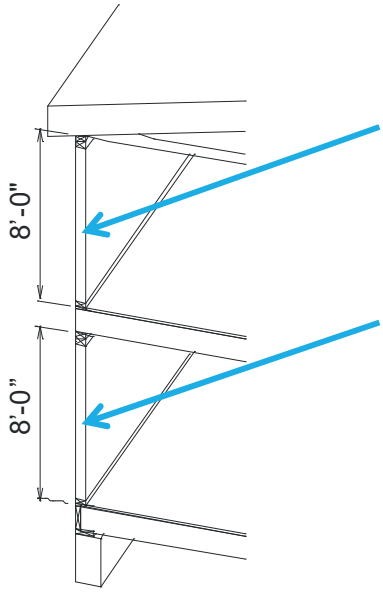
Wood Wall Construction Review

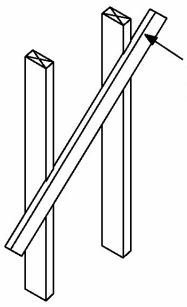


Proposed	Minimum Required
1. Support roof and ceiling only:	
2 x 4 @ 16" o.c. No. 2	2 x 4 @ 24" o.c. No. 3, Standard or stud grade 2 x 4 @ 16" o.c. utility grade
2. Supporting one floor roof and ceiling:	
2 x 4 @ 16" o.c. No. 2	2 x 4 @ 16" o.c. No. 3, Standard or stud grade

3. Compare *proposed* and *required* to determine code Compliance.

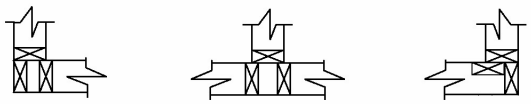
128

Framing Details



APPLY APPROVED SHEATHING OR BRACE EXTERIOR WALLS WITH 1 IN. BY 4 IN. BRACES LET INTO STUDS AND PLATES AND EXTENDING FROM BOTTOM PLATE TO TOP PLATE, OR OTHER APPROVED METAL STRAP DEVICES INSTALLED IN ACCORDANCE WITH THE MANUFACTURER'S SPECIFICATIONS. SEE SECTION R602.10.

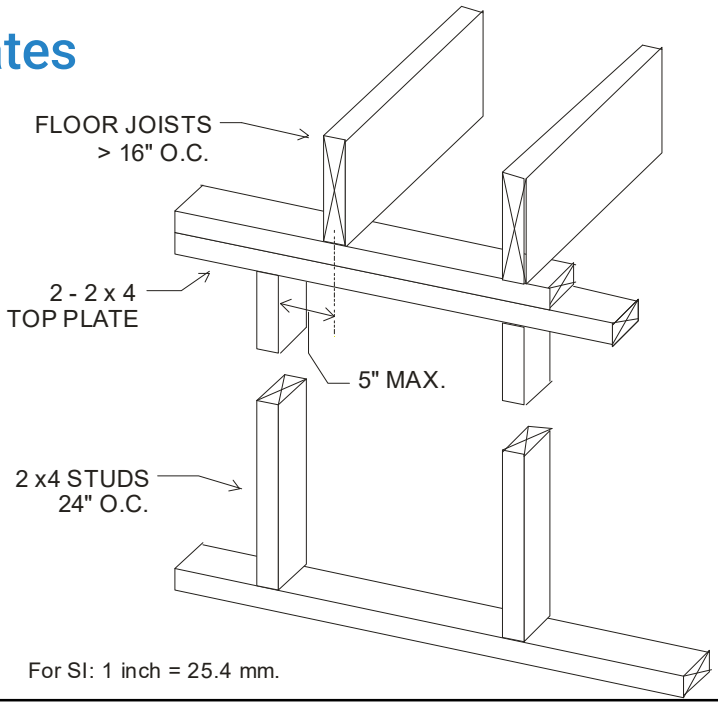
CORNER AND PARTITION POSTS



NOTE: A THIRD STUD AND/OR PARTITION INTERSECTION BACKING STUDS SHALL BE PERMITTED TO BE OMITTED THROUGH THE USE OF WOOD BACKUP CLEATS, METAL DRYWALL CLIPS OR OTHER APPROVED DEVICES THAT WILL SERVE AS ADEQUATE BACKING FOR THE FACING MATERIALS.

129

Top Plates

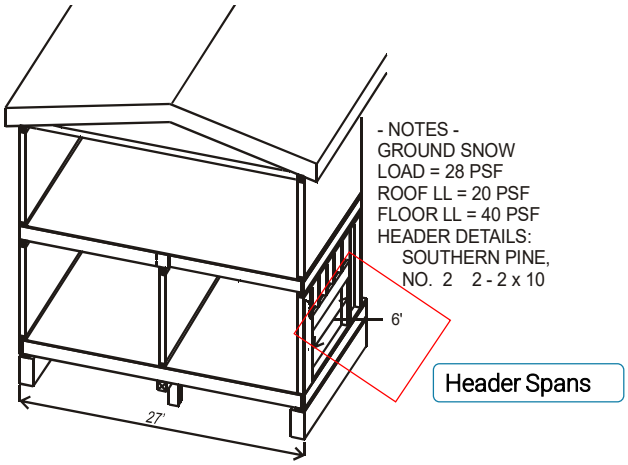


130

FOR EXAMPLE

Openings in Exterior Bearing Walls

What is the maximum header span (2- 2x10) permitted for this example?

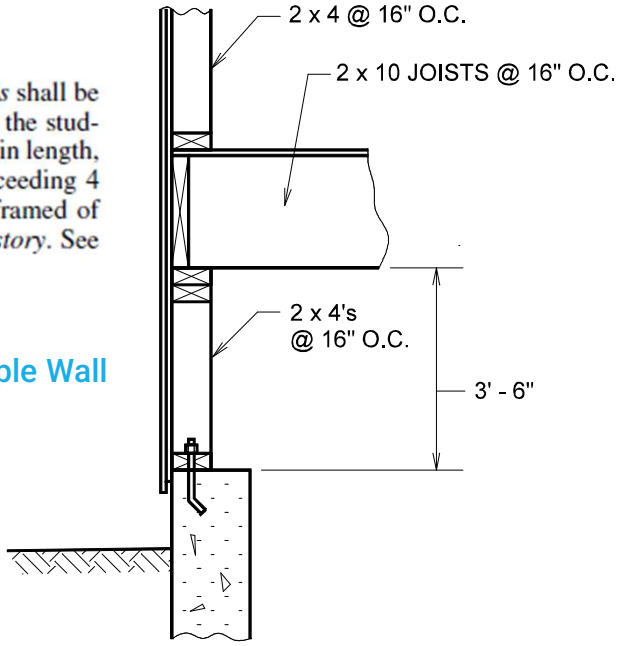


131

Cripple Walls

2308.5.6 Cripple walls. Foundation *cripple walls* shall be framed of studs that are not less than the size of the studding above and not less than 14 inches (356 mm) in length, or shall be framed of solid blocking. Where exceeding 4 feet (1219 mm) in height, such walls shall be framed of studs having the size required for an additional *story*. See Section 2308.6.6 for *cripple wall* bracing.

Cripple Wall



132

What is the purpose of wall sheathing?

Wall sheathing resists loads that act horizontally.

- Wind
- Earthquake
- Fluid

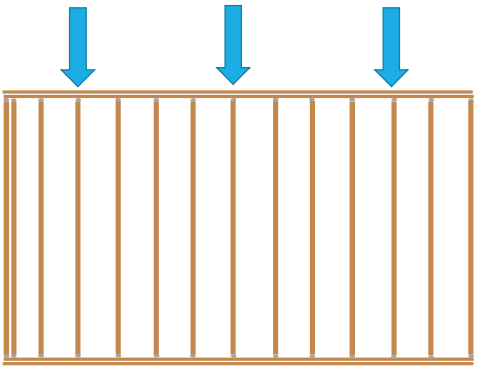
These loads are called 'lateral loads.'

133

Vertical Loads

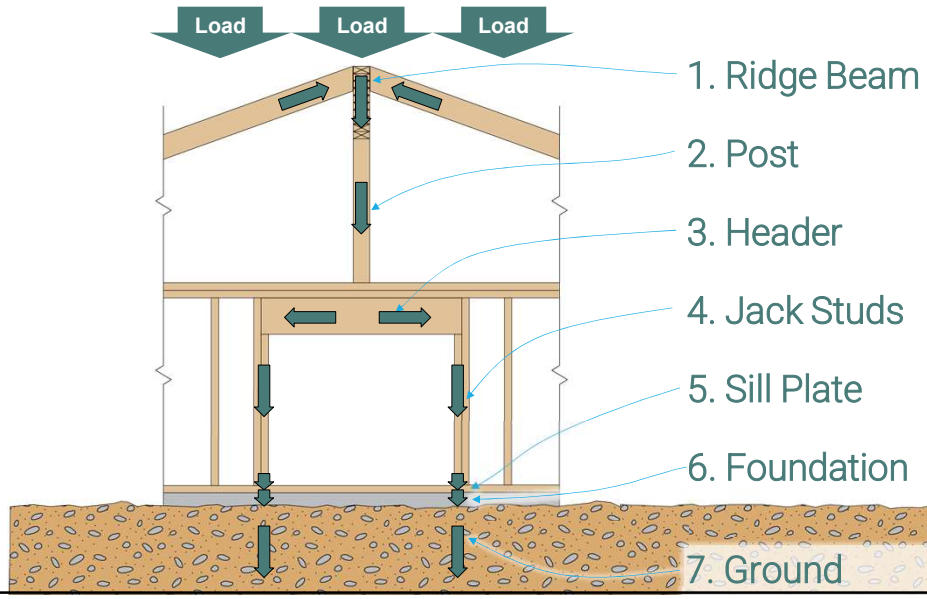
Wall sheathing does not resist vertical (gravity) loads.

Vertical loads are resisted by studs, top and bottom plates, headers and columns – the 'framing'.



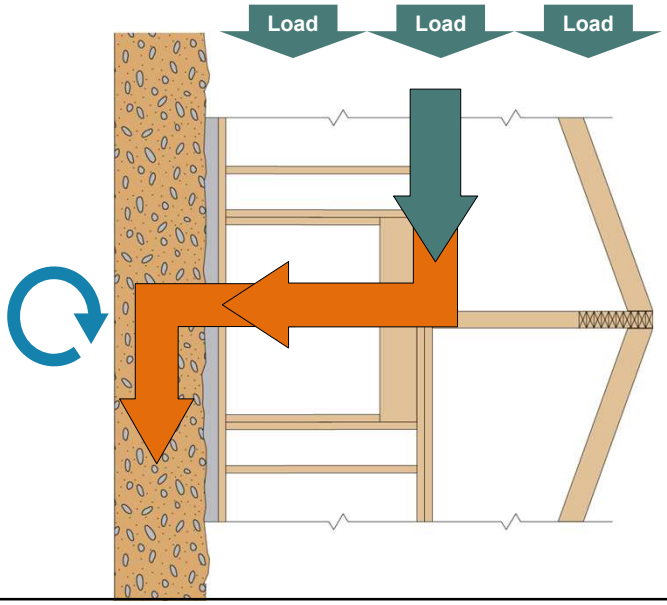
134

Vertical (Gravity) Load Path



135

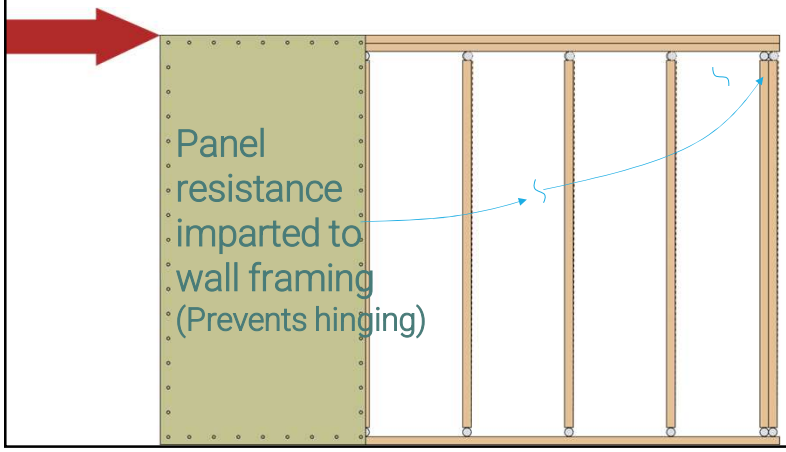
Lateral (Sideways) Load Path



136

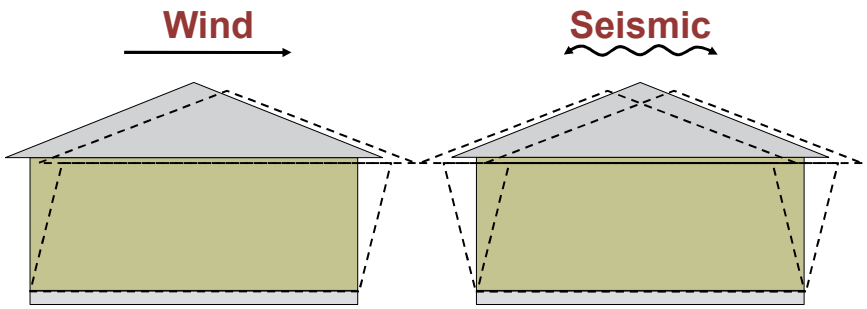
Lateral Loads

Wall sheathing resists loads that act horizontally.



137

Lateral Forces



Force =
Pressure x Area

Force =
Mass x Acceleration

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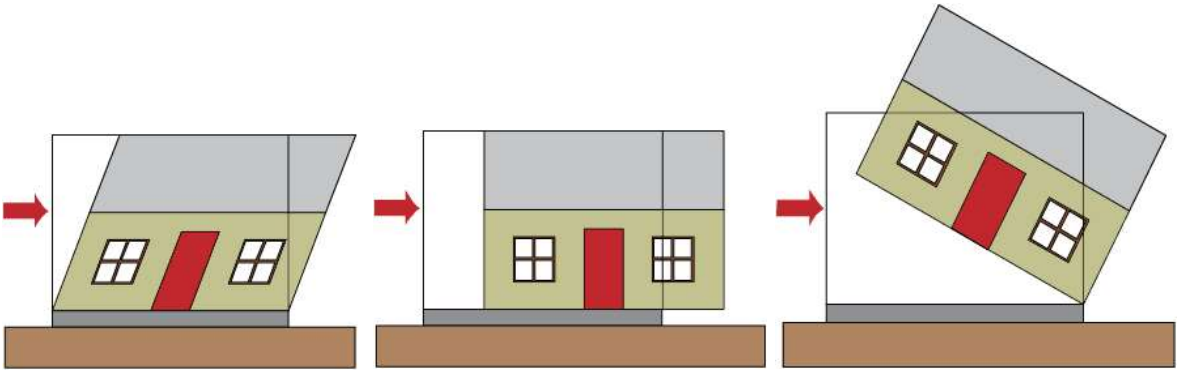
Lateral Force Effects

Racking

Base Shear

Overturning



Resisted by Bracing

Resisted by Anchors

Resisted by hold-downs &
Dead Load

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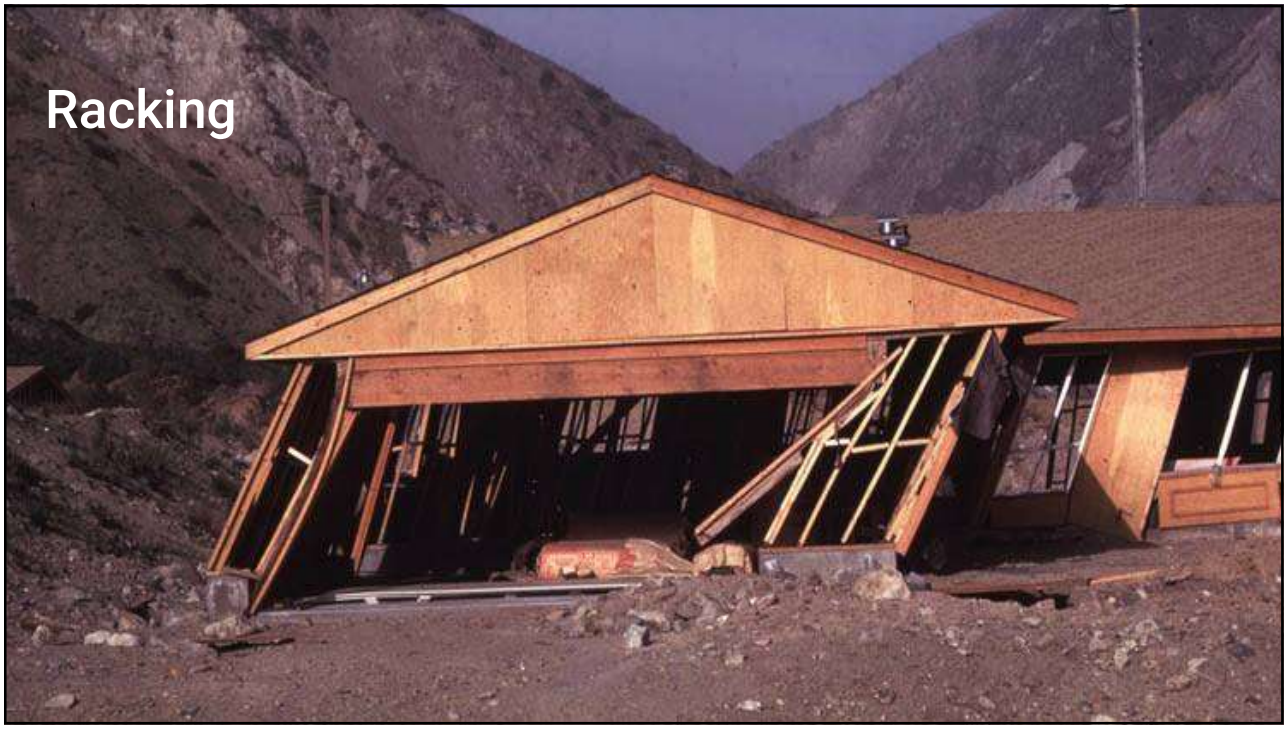
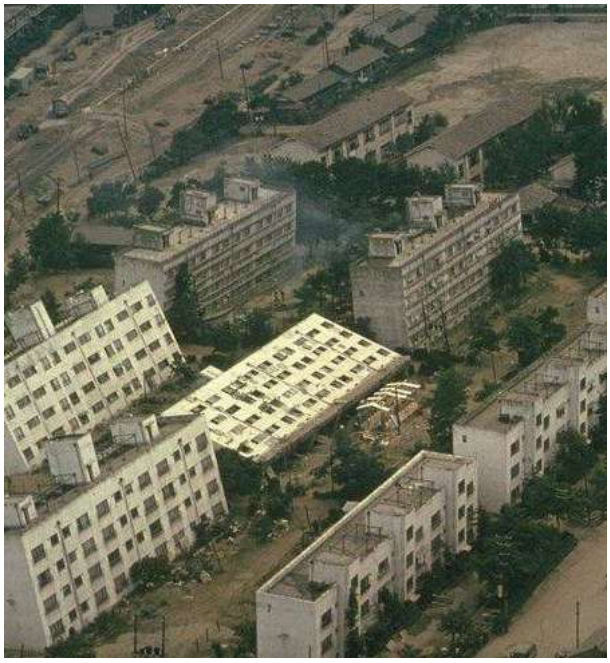


140

141



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Resisting Lateral Forces

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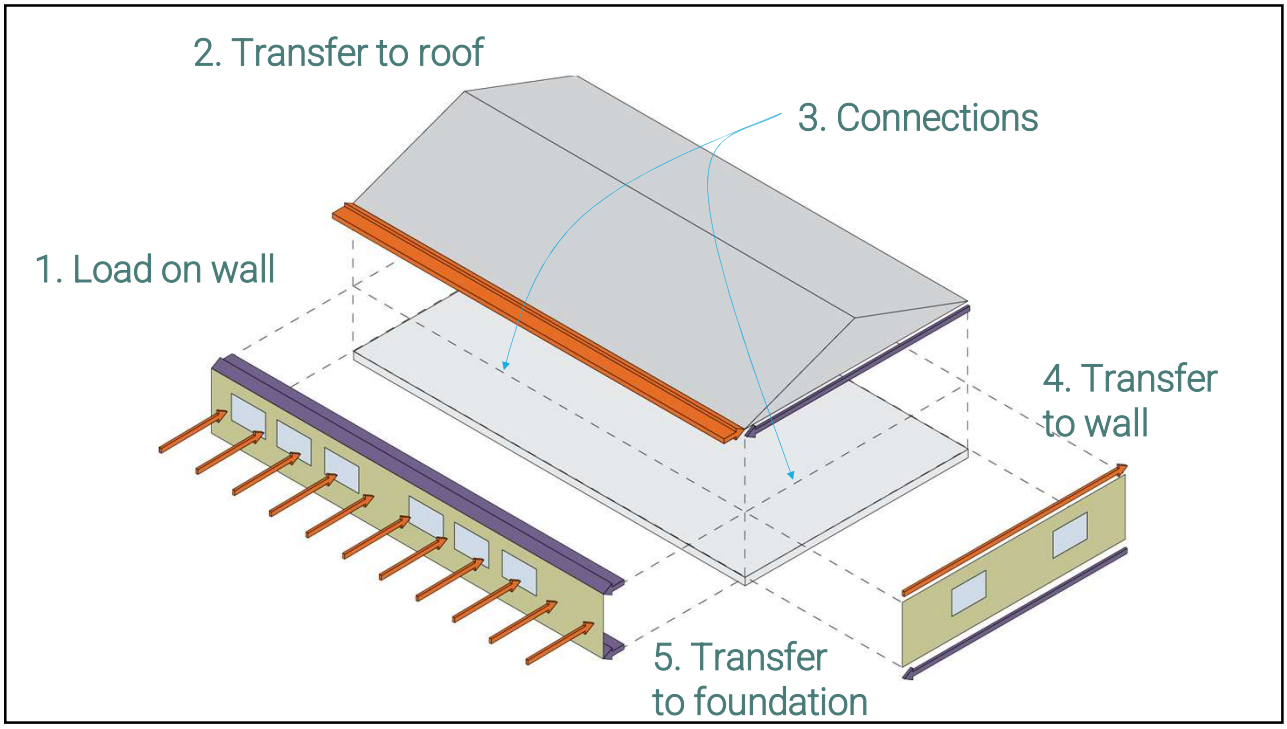
2. Transfer to roof
3. Connections
1. Load on wall
4. Transfer to wall
5. Transfer to foundation

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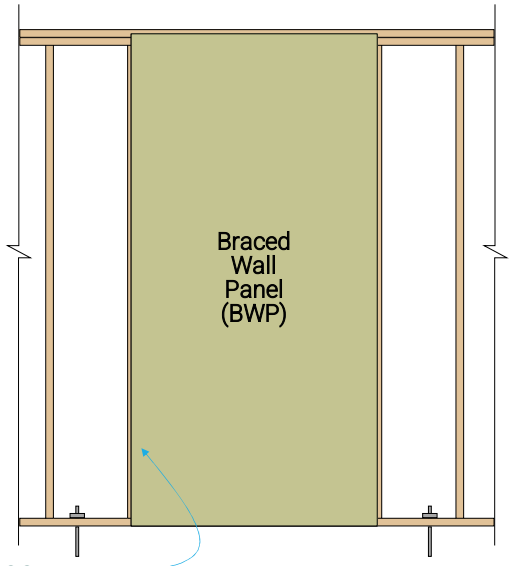
Prescriptive Braced Wall Panels

Conventional Light-frame Construction

- IBC Section 2308
- No engineering required
- Typically without hold-downs
- 3 stories maximum
- Residential loading



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Wall Bracing

2308.6 Wall bracing. Buildings shall be provided with exterior and interior *braced wall lines* as described in Sections 2308.6.1 through 2308.6.10.2.

2308.6.1 Braced wall lines. For the purpose of determining the amount and location of bracing required along each *story* level of a building, *braced wall lines* shall be designated as straight lines through the building plan in both the longitudinal and transverse direction and placed in accordance with Table 2308.6.1 and Figure 2308.6.1. *Braced wall line* spacing shall not exceed the distance specified in Table 2308.6.1. In structures assigned to *Seismic Design Category* D or E, *braced wall lines* shall intersect perpendicularly to each other.

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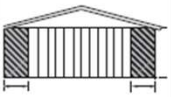
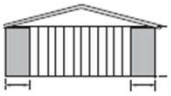
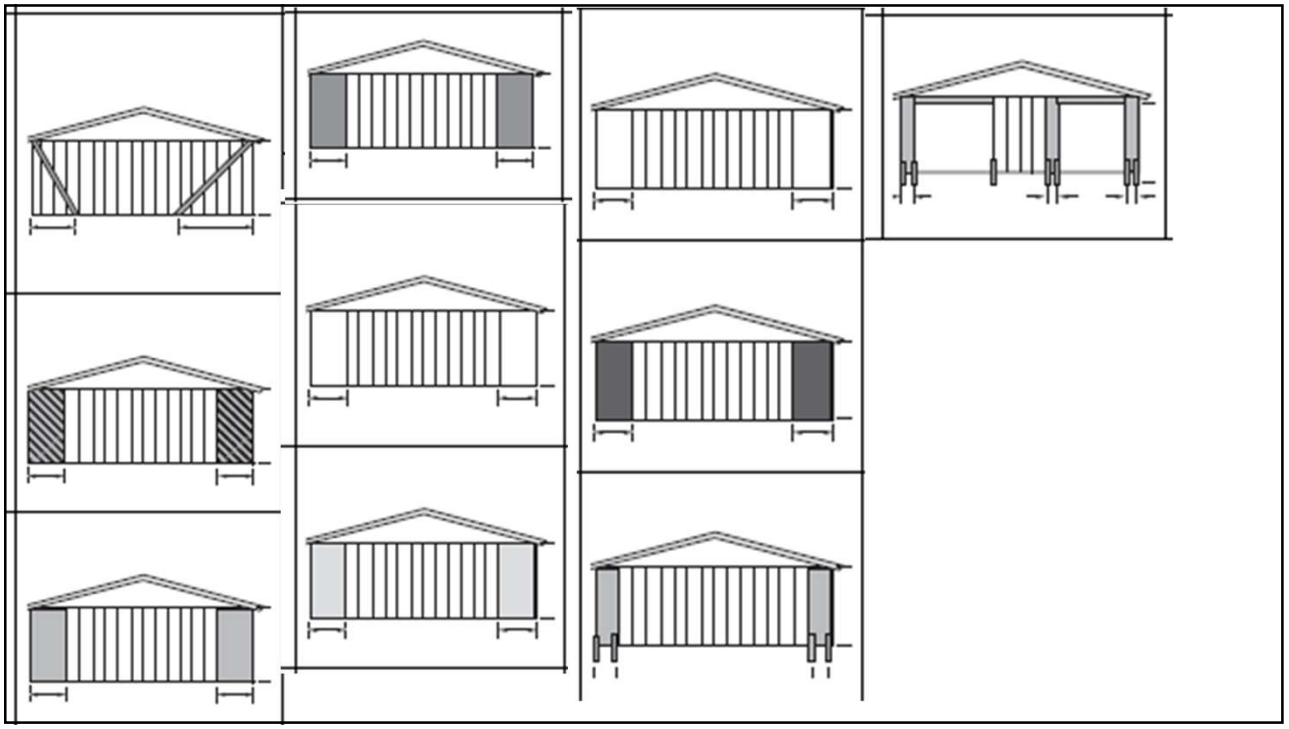
Bracing Methods

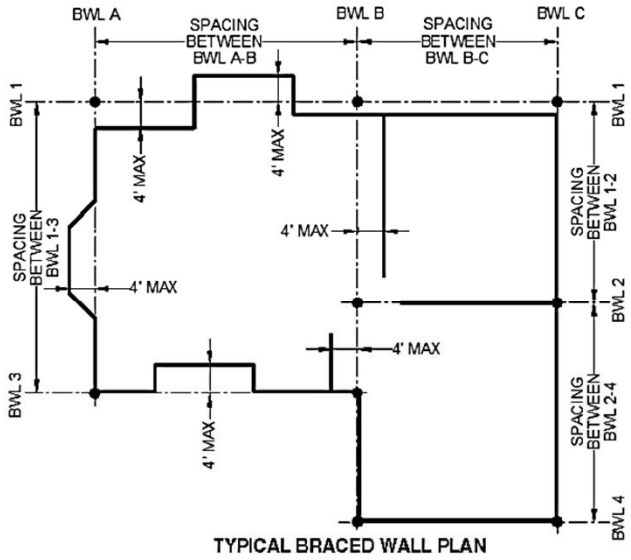
TABLE 2308.6.3(1)
BRACING METHODS

METHODS, MATERIAL	MINIMUM THICKNESS	FIGURE	CONNECTION CRITERIA[a]	
			Fasteners	Spacing
LIB[a] Let-in-bracing	1″ × 4″ wood or approved metal straps attached at 45° to 60° angles to studs at maximum of 16″ o.c.		Table 2304.10.1	Wood: per stud plus top and bottom plates
			Metal strap: installed in accordance with manufacturer's recommendations	Metal strap: installed in accordance with manufacturer's recommendations
DWB Diagonal wood boards	3/4″ thick (1″ nominal) × 6″ minimum width to studs at maximum of 24″ o.c.		Table 2304.10.1	Per stud
WSP *Wood structural panel*	3/8″ in accordance with Table 2308.6.3(2) or 2308.6.3(3)		Table 2304.10.1	6″ edges 12″ field

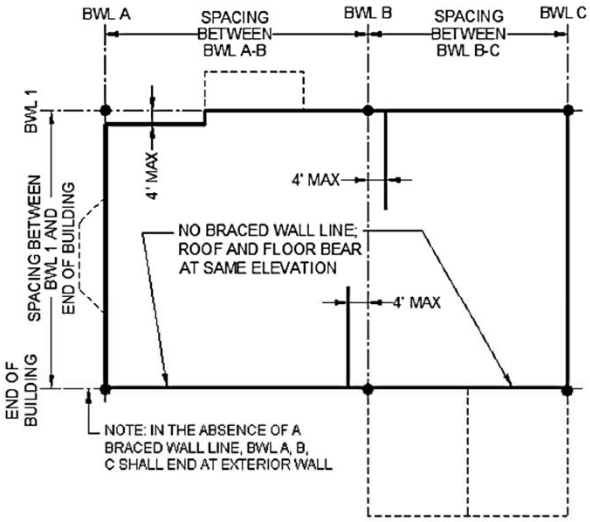
148



149



TYPICAL BRACED WALL PLAN



TYPICAL UPPER FLOOR BRACED WALL PLAN

For SI: 1 foot = 304.8 mm.

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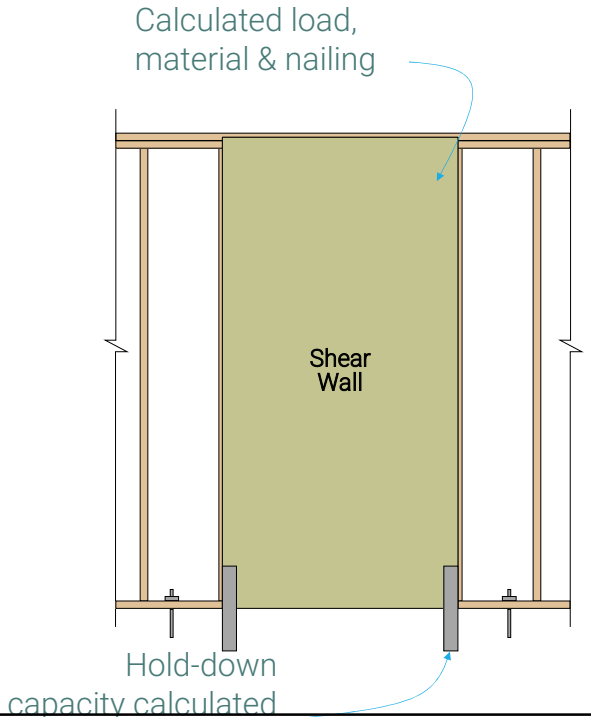
Engineered Shear Walls

A shear wall is the portion of a wall line that is designed to resist lateral forces.

Applications

- Any building size/shape
- Wind – no limit
- SDC – no limit
- Calculations required

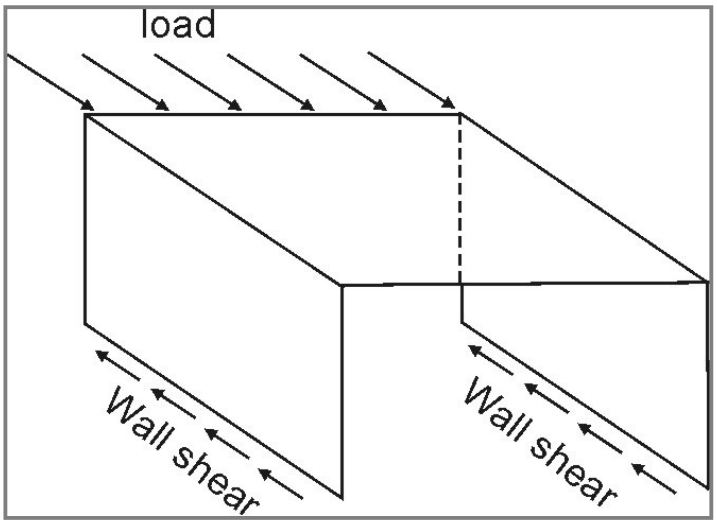
Typically <u>with</u> hold-downs



151

Shear Walls

- Are vertical cantilevered diaphragms
- Resist lateral forces of shear in the diaphragm
- Resist compression and tension in the boundary members.



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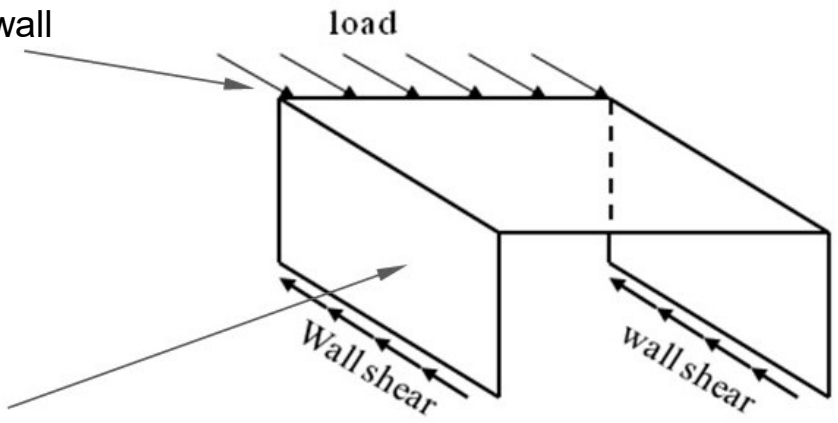
Shear Walls

Out-of-plane – the wall the wind pushes is loaded out-of-plane

In-plane – walls resisting the wind load (side walls) are loaded in-plane



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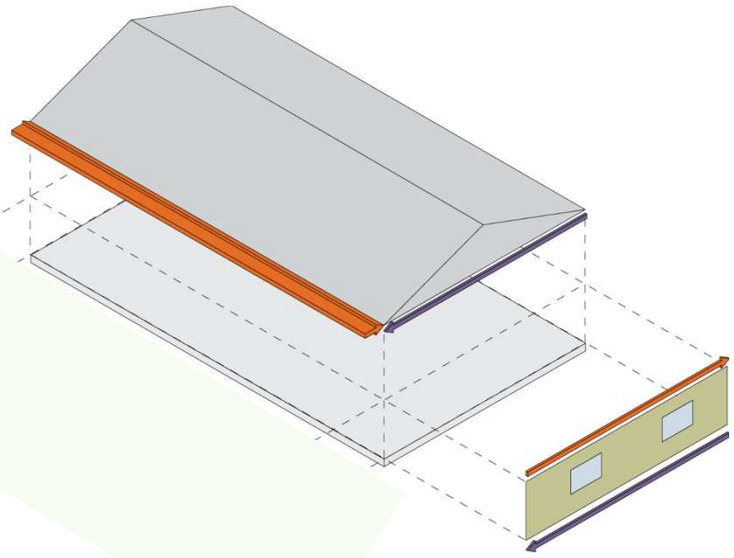
Shear walls transfer loads from roof and floor diaphragms to the story below

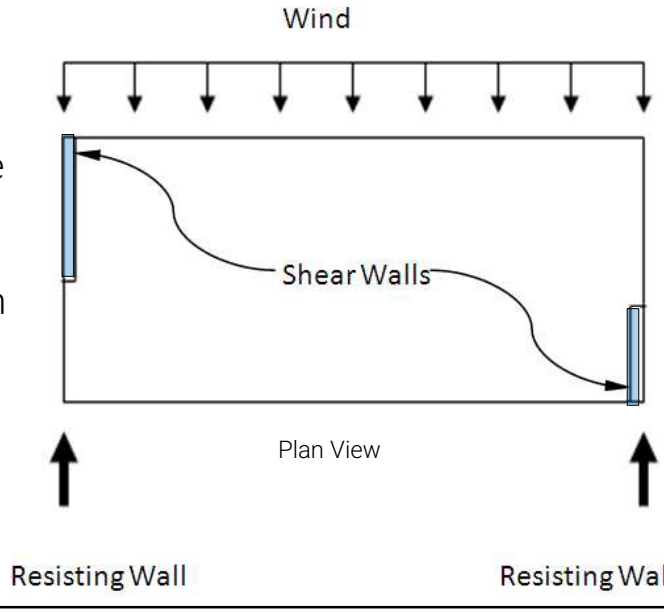


155

Shear Wall Loads

1. Wind pushes against the wall.
2. WSP sheathing spans from the foundation to the top plate on the wind wall, distributing half the wind load to the foundation and half the load to the roof or floor diaphragm.
3. The diaphragm distributes the load to the shear walls.

Loading of the shear wall = Load Path



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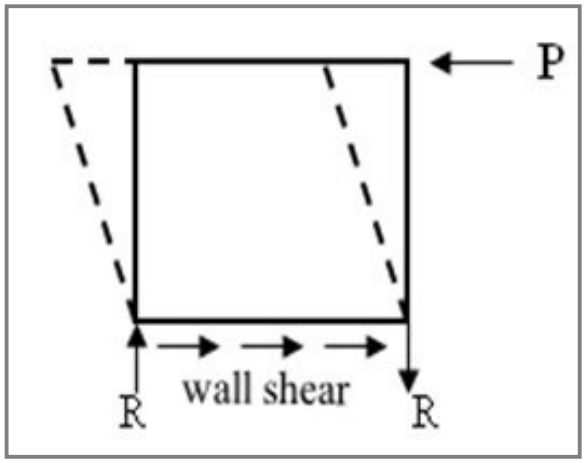
Shear Walls – Deformation

- In-plane shear walls resist loads by racking.
- A shear wall becomes trapezoidal in shape.



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Steel Construction

- Through Chapter 22, the code requires that materials used in the design of structural steel members conform to designated national standards.
- This code governs the design and use of steel materials using the specifications and standards of the American Institute of Steel Construction (AISC), the American Iron and Steel Institute (AISI), the Steel Joist Institute (SJI) and the American Society of Civil Engineers (ASCE).

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Steel Construction

Steel is a noncombustible material commonly associated with Type I and II construction; however, it is permitted to be used and commonly found in all types of construction.

There are two main families of steel members:

- The first is hot-rolled structural shapes and members that are made up of a combination of rolled shapes and plates,
- The second is composed of sections that are cold formed from steel sheets, strips, plates or flat bars in roll-forming machines, or by bending in brake-press operations.

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Properties of Steel

Alloying elements

- Manganese – increases strength and hardness
- Nickel – increases toughness, harden ability, and corrosion resistance
- Chromium – improves harden ability and abrasion resistance. (A chromium content greater than 4% classes steel as stainless or heat resisting.)
- Copper – improves corrosion resistance.

161

Properties of Steel

- The following are used to provide protection and a fire-resistance rating:
  - Plaster
  - Gypsum
  - Wallboard
  - Spray-applied materials

162

Structural Masonry

2101.2 Design methods. Masonry shall comply with the provisions of TMS 402, TMS 403 or TMS 404 as well as applicable requirements of this chapter.

- Requirements based on classification of the building or nature of occupancy
- Exceptions based on design strength and type of occupancy (nonessential buildings, etc.)
- Level I and Level II Masonry Inspections, based on design.

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Masonry Inspection Key Points

Pre-Construction Activities:

- Strength Tests of Masonry Prisms (at least 28 days prior to Masonry Construction)

During Masonry Construction:

- Cell Cleanliness and Cleanouts
- Steel Reinforcement Cleanliness
- Lap Length, Size, Spacing, Number, Placement of Reinforcement
- Monitor Grout Placement and Sample for Strength Tests
- Sample Block for each Type for Compressive Strength Testing

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Masonry Inspection Key Points

- Blocks are approved for use prior to construction, by compressive strength tests in approved laboratory.

2103.1 Masonry units. Concrete *masonry units*, clay or shale *masonry units*, *stone masonry units*, *glass unit masonry* and *AAC masonry units* shall comply with Article 2.3 of TMS 602. Architectural *cast stone* shall conform to ASTM C1364 and TMS 504. Calcium silicate-based *masonry units* shall conform to ASTM C73 or C744. Adhered manufactured *stone masonry* veneer units shall conform to ASTM C1670.

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Masonry Inspection Key Points

- Measuring spacing between vertical steel reinforcement
- Visual inspection of steel reinforcement to check for placement, size, etc.

2111.4.1 Vertical reinforcing. For fireplaces with chimneys up to 40 inches (1016 mm) wide, four No. 4 continuous vertical bars, anchored in the foundation, shall be placed in the concrete between wythes of solid masonry or within the cells of hollow unit masonry and grouted in accordance with Section 2103.3. For fireplaces with chimneys greater than 40 inches (1016 mm) wide, two additional No. 4 vertical bars shall be provided for each additional 40 inches (1016 mm) in width or fraction thereof.

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Masonry Inspection Key Points

- Vertical Steel placement
- Check cell cleanliness (i.e., no mortar protrusions beyond the allowable limit, or debris to clog cells)

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Masonry Inspection Key Points

- Cell cleanouts prior to grout placement
- Cleanout after grout placement shows grout made it to the bottom of cell

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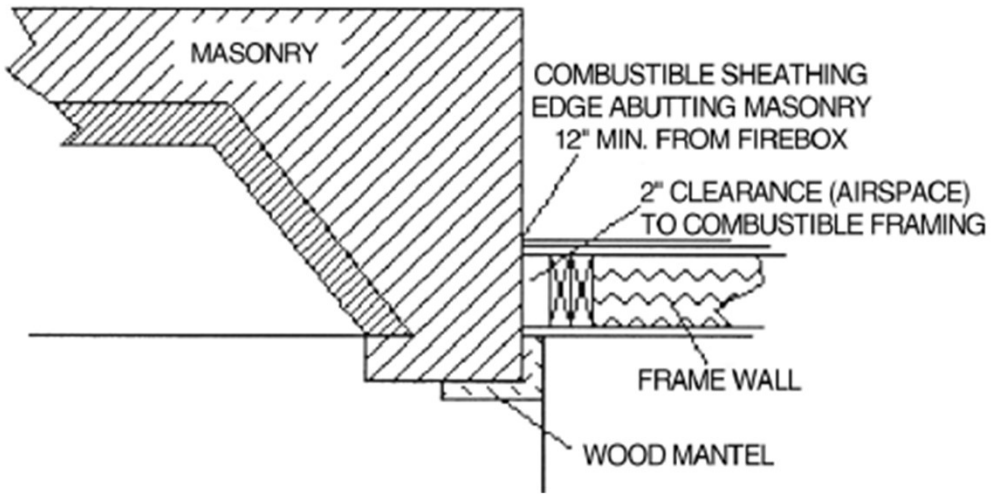
Masonry Chimneys



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Gypsum Board And Plaster

- Gypsum board and plaster represent the most common interior and exterior finish materials in the building industry.
- Gypsum board and plaster products represent a line of building products that are manufactured under the control of industry standards. The building inspector only needs to verify that the appropriate product has been used and properly installed for the intended use and location.
- Therefore, Chapter 25 deals primarily with quality-control-related issues with regards to material specifications and installation requirements.

170

Gypsum Wallboard

- Preparation
  - Ensure all previous work has been completed in conformance with reviewed plans
- Materials
  - Inspect for conformance to specifications
  - Carton or board must have a label indicating the manufacturer's name

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Gypsum Fasteners

- Gypsum panel application
  - Single-layer application
  - Double-layer application
  - Fastening methods
    - Single nailing
    - Double nailing
    - Adhesive nail-on
    - Screw attachment
    - Adhesive attachment

2508.6.4 Fasteners. Fasteners used for the attachment of *gypsum board* or *gypsum panel products* to a horizontal diaphragm ceiling shall be as defined in Table 2508.6. Fasteners shall be spaced not more than 7 inches (178 mm) on center at all supports, including perimeter blocking, and not more than $^{3}/_{8}$ inch (9.5 mm) from the edges and ends of the *gypsum board* or *gypsum panel product*.

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Gypsum Wallboard Shear

TABLE 2508.6
SHEAR CAPACITY FOR HORIZONTAL WOOD-FRAME GYPSUM BOARD DIAPHRAGM CEILING ASSEMBLIES

MATERIAL	THICKNESS OF MATERIAL (MINIMUM) (inches)	SPACING OF FRAMING MEMBERS (inches)	SHEAR VALUE[a,b] (PLF OF CEILING)	MIMIMUM FASTENER SIZE
Gypsum board or *gypsum panel product*	$^{1}/_{2}$	16 o.c.	90	5d cooler or wallboard nail; $1^{5}/_{8}$-inch long; 0.086-inch shank; $^{15}/_{64}$-inch head[c]
Gypsum board or *gypsum panel product*	$^{1}/_{2}$	24 o.c.	70	5d cooler or wallboard nail; $1^{5}/_{8}$-inch long; 0.086-inch shank; $^{15}/_{64}$-inch head[c]

For SI: 1 inch = 25.4 mm, 1 pound per foot = 14.59 N/m.

a. Values are not cumulative with other horizontal diaphragm values and are for short-term wind or seismic loading. Values shall be reduced 25 percent for normal loading.

b. Values shall be reduced 50 percent in *Seismic Design Categories D*.

c. $1^{1}/_{4}$-inch, No. 6 Type S or W screws are permitted to be substituted for the listed nails.

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Gypsum Wallboard

- When inspecting wallboard construction, pay attention to:
  - Framing
  - Suspended grillage
  - Base layer
  - Face layer
  - Fasteners

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slido

Audience Q&A Session

ⓘ Start presenting to display the audience questions on this slide.

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Ceiling and Roof Construction

Photo courtesy Ken DeMuth

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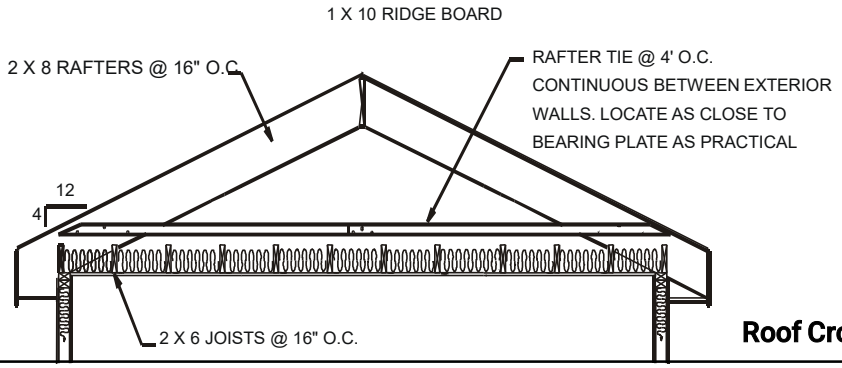
Roof & Ceiling Framing

- The framing details required in Section 2308 apply to roofs having a slope of not less than three units vertical in 12 units horizontal (25-percent slope). Where the roof slope is less than three units vertical in 12 units horizontal (25-percent slope), members supporting rafters and ceiling joists such as ridge board, hips and valleys shall be designed as beams.



Roof Cross Section

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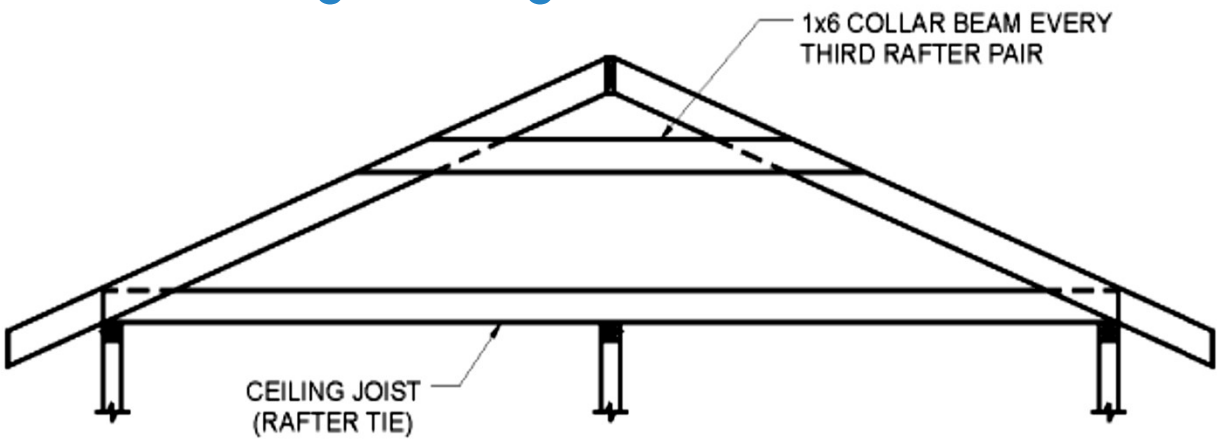
Roof & Ceiling Framing



COLLAR BEAMS AND CEILING JOISTS PREVENT LATERAL SPREADING OF THE ROOF SYSTEM DUE TO GRAVITY AND WIND LOADS.

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Ceiling Joist Spans

TABLE 2308.7.1(1)
CEILING JOIST SPANS FOR COMMON LUMBER SPECIES
(Uninhabitable attics without storage, live load = 10 psf, L/Δ = 240)

CEILING JOIST SPACING (inches)	SPECIES AND GRADE		DEAD LOAD = 5 psf			
			2 × 4	2 × 6	2 × 8	2 × 10
			Maximum ceiling joist spans			
			(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)
12	Douglas Fir-Larch	SS	13-2	20-8	Note a	Note a
	Douglas Fir-Larch	#1	12-8	19-11	Note a	Note a
	Douglas Fir-Larch	#2	12-5	19-6	25-8	Note a
	Douglas Fir-Larch	#3	10-10	15-10	20-1	24-6
	Hem-Fir	SS	12-5	19-6	25-8	Note a
	Hem-Fir	#1	12-2	19-1	25-2	Note a
	Hem-Fir	#2	11-7	18-2	24-0	Note a
	Hem-Fir	#3	10-10	15-10	20-1	24-6
	Southern Pine	SS	12-11	20-3	Note a	Note a
	Southern Pine	#1	12-5	19-6	25-8	Note a
	Southern Pine	#2	11-10	18-8	24-7	Note a
	Southern Pine	#3	10-1	14-11	18-9	22-9

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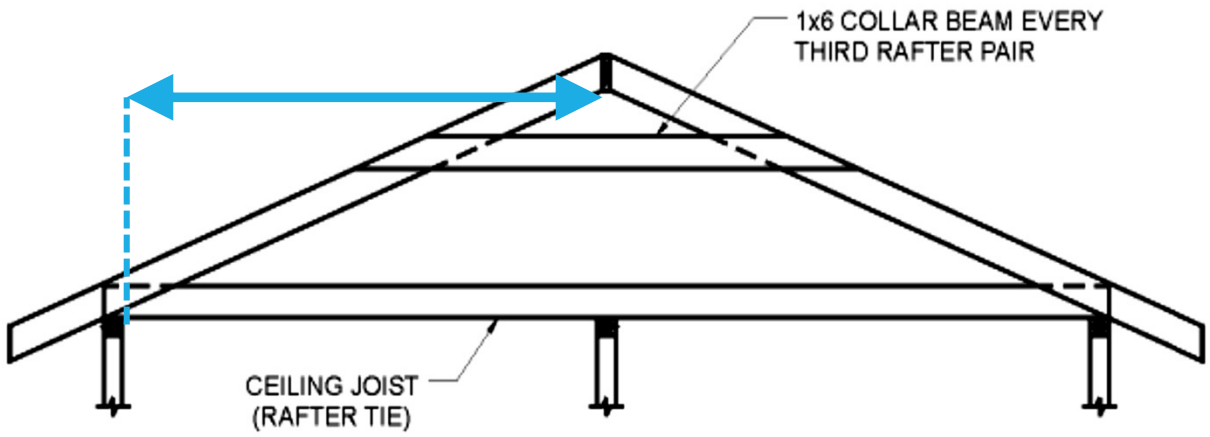
Rafter Spans



COLLAR BEAMS AND CEILING JOISTS PREVENT LATERAL SPREADING OF THE ROOF SYSTEM DUE TO GRAVITY AND WIND LOADS.

180

Rafter Spans

TABLE 2308.7.2(5)
RAFTER SPANS FOR COMMON LUMBER SPECIES
(Ground snow load = 30 psf, ceiling attached to rafters, L/Δ = 240)

RAFTER SPACING (inches)	SPECIES AND GRADE		DEAD LOAD = 10 psf					DEAD LOAD = 20 psf				
			2 × 4	2 × 6	2 × 8	2 × 10	2 × 12	2 × 4	2 × 6	2 × 8	2 × 10	2 × 12
			Maximum rafter spans[a]									
			(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)	(ft. - in.)
12	Douglas Fir-Larch	SS	9-1	14-4	18-10	24-1	Note b	9-1	14-4	18-10	24-1	Note b
	Douglas Fir-Larch	#1	8-9	13-9	18-2	22-9	Note b	8-9	13-2	16-8	20-4	23-7
	Douglas Fir-Larch	#2	8-7	13-6	17-5	21-4	24-8	8-5	12-4	15-7	19-1	22-1
	Douglas Fir-Larch	#3	7-1	10-5	13-2	16-1	18-8	6-4	9-4	11-9	14-5	16-8
	Hem-Fir	SS	8-7	13-6	17-10	22-9	Note b	8-7	13-6	17-10	22-9	Note b
	Hem-Fir	#1	8-5	13-3	17-5	22-2	25-9	8-5	12-10	16-3	19-10	23-0
	Hem-Fir	#2	8-0	12-7	16-7	21-0	24-4	8-0	12-2	15-4	18-9	21-9
	Hem-Fir	#3	7-1	10-5	13-2	16-1	18-8	6-4	9-4	11-9	14-5	16-8
	Southern Pine	SS	8-11	14-1	18-6	23-8	Note b	8-11	14-1	18-6	23-8	Note b
	Southern Pine	#1	8-7	13-6	17-10	22-3	Note b	8-7	13-5	17-0	19-11	23-7
	Southern Pine	#2	8-3	12-11	16-4	19-5	22-10	7-8	11-7	14-8	17-4	20-5
	Southern Pine	#3	6-7	9-9	12-4	15-0	17-9	5-11	8-9	11-0	13-5	15-10
	Spruce-Pine-Fir	SS	8-5	13-3	17-5	22-3	Note b	8-5	13-3	17-5	22-3	Note b
	Spruce-Pine-Fir	#1	8-3	12-11	17-0	21-4	24-8	8-3	12-4	15-7	19-1	22-1

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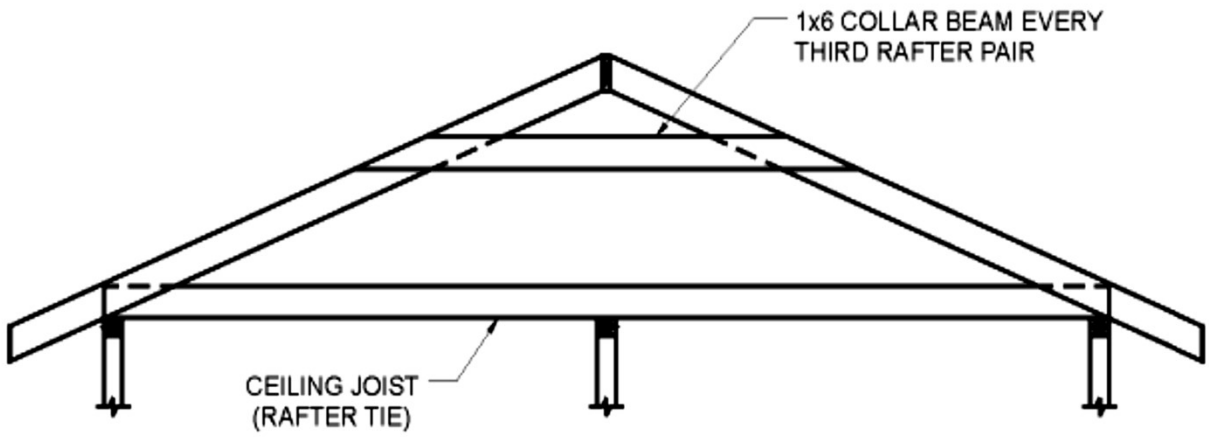
Roof & Ceiling Framing



COLLAR BEAMS AND CEILING JOISTS PREVENT LATERAL SPREADING OF THE ROOF SYSTEM DUE TO GRAVITY AND WIND LOADS.

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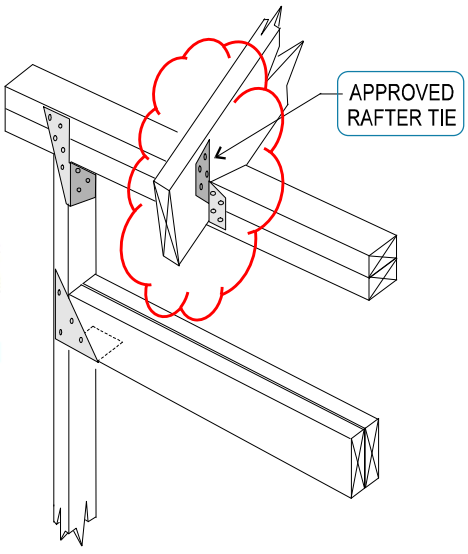
Wind Uplift

2308.7.5 Wind uplift. The roof construction shall have rafter and truss ties to the wall below. Resultant uplift loads shall be transferred to the foundation using a continuous load path. The rafter or truss to wall connection shall comply with Tables 2304.10.1 and 2308.7.5.



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Wind Uplift

TABLE 2308.7.5
REQUIRED RATING OF UPLIFT CONNECTORS (pounds)[a, b, c, e, f, g, h]

NOMINAL DESIGN WIND SPEED, V_{asd} [i]	ROOF SPAN (feet)							OVERHANGS (pounds/feet)[d]
	12	20	24	28	32	36	40	
85	-72	-120	-145	-169	-193	-217	-241	-38.55
90	-91	-151	-181	-212	-242	-272	-302	-43.22

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 mile per hour = 1.61 km/hr, 1 pound = 0.454 Kg, 1 pound/foot = 14.5939 N/m.

a. The uplift connection requirements are based on a 30-foot mean roof height located in Exposure B. For Exposure C or D and for other mean roof heights, multiply the loads by the following adjustment coefficients:

	Mean Roof Height (feet)									
EXPOSURE	15	20	25	30	35	40	45	50	55	60
B	1.00	1.00	1.00	1.00	1.05	1.09	1.12	1.16	1.19	1.22
C	1.21	1.29	1.35	1.40	1.45	1.49	1.53	1.56	1.59	1.62
D	1.47	1.55	1.61	1.66	1.70	1.74	1.78	1.81	1.84	1.87

b. The uplift connection requirements are based on the framing being spaced 24 inches on center. Multiply by 0.67 for framing spaced 16 inches on center and multiply by 0.5 for framing spaced 12 inches on center.

c. The uplift connection requirements include an allowance for 10 pounds of dead load.

d. The uplift connection requirements do not account for the effects of overhangs. The magnitude of the loads shall be increased by adding the overhang loads found in the table. The overhang loads are based on framing spaced 24 inches on center. The overhang loads given shall be multiplied by the overhang projection and added to the roof uplift value in the table.

e. The uplift connection requirements are based on wind loading on end zones as defined in Figure 28.5-1 of ASCE 7. Connection loads for connections located a distance of 20 percent of the least horizontal dimension of the building from the corner of the building are permitted to be reduced by multiplying the table connection value by 0.7 and multiplying the overhang load by 0.8.

f. For wall-to-wall and wall-to-foundation connections, the capacity of the uplift connector is permitted to be reduced by 100 pounds for each full wall above. (For example, if a 500-pound rated connector is used on the roof framing, a 400-pound rated connector is permitted at the next floor level down).

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Fire Classification—Roof Covering and Roof Assemblies

TABLE 1505.1[a, b]
MINIMUM ROOF COVERING CLASSIFICATION
FOR TYPES OF CONSTRUCTION

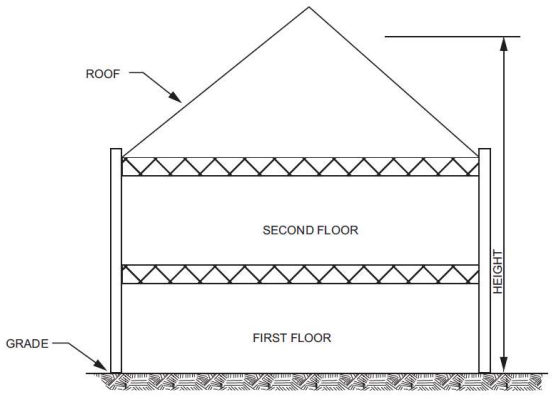
IA	IB	IIA	IIB	IIIA	IIIB	IV	VA	VB
B	B	B	B	B	C[c]	B	B	C[c]

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2.

a. Unless otherwise required due to the location of the building within a fire district in accordance with Appendix D.

b. Class C *roof coverings* shall be allowed on *buildings* of Group R-3, R-4, R-5 and Group U occupancies, where there is a minimum *fire-separation distance* of 6 feet measured from the leading edge of the roof.

c. *Buildings* that are not more than two *stories above grade plane* and having not more than 6,000 square feet of projected roof area and where there is a minimum 10-foot *fire separation distance* from the leading edge of the roof to an *abutting property line* on all sides of the *building*, shall be allowed to have roofs of *fire-retardant-treated wood* shingles and shakes constructed in accordance with Section 1505.6 or No. 1 cedar or redwood shakes and No. 1 shingles constructed in accordance with Section 1505.7.



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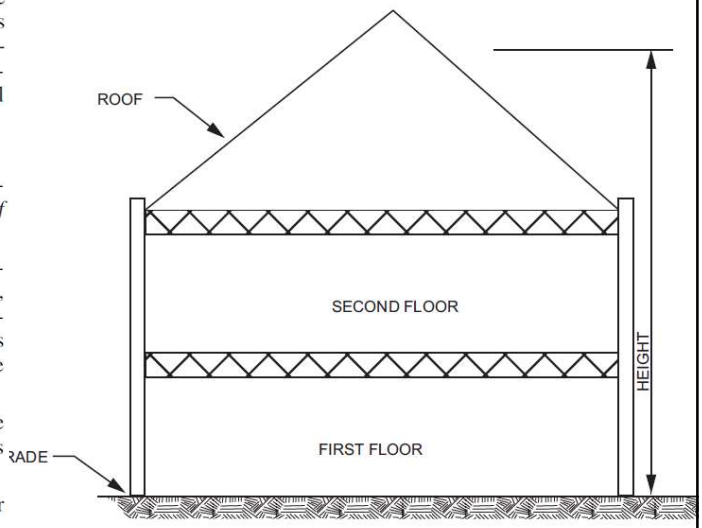
Fire Classification—Roof Assemblies

1505.2 Class A roof assemblies. Class A roof assemblies are those that are effective against severe fire test exposure. Class A roof assemblies and *roof coverings* shall be *listed* and identified as Class A by an *approved agency*. Class A roof assemblies shall be permitted for use in buildings or structures of all types of construction.

Exceptions:

1. Class A roof assemblies include those with coverings of brick, masonry or an exposed concrete *roof deck*.
2. Class A roof assemblies also include ferrous or copper shingles or sheets, metal sheets and shingles, clay or concrete roof tile or slate installed on noncombustible decks or ferrous, copper or metal sheets installed without a *roof deck* on noncombustible framing.
3. Class A roof assemblies include minimum 16 ounce per square foot (0.0416 kg/m^2) copper sheets installed over combustible *roof decks*.
4. Class A roof assemblies include slate installed over ASTM D226, Type II *underlayment* over combustible *roof decks*.



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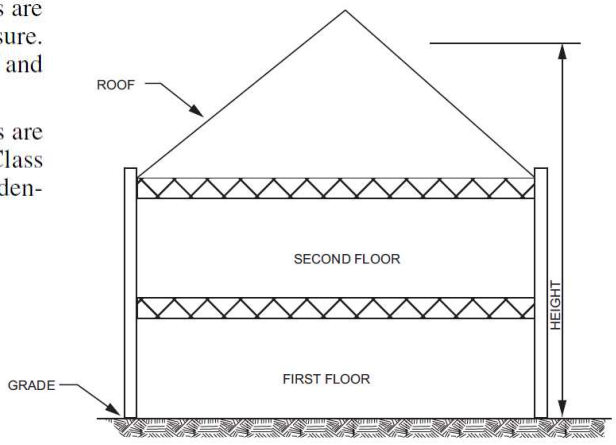
Fire Classification—Roof Assemblies

1505.3 Class B roof assemblies. Class B roof assemblies are those that are effective against moderate fire-test exposure. Class B roof assemblies and *roof coverings* shall be *listed* and identified as Class B by an *approved agency*.

1505.4 Class C roof assemblies. Class C roof assemblies are those that are effective against light fire-test exposure. Class C roof assemblies and *roof coverings* shall be *listed* and identified as Class C by an *approved agency*.



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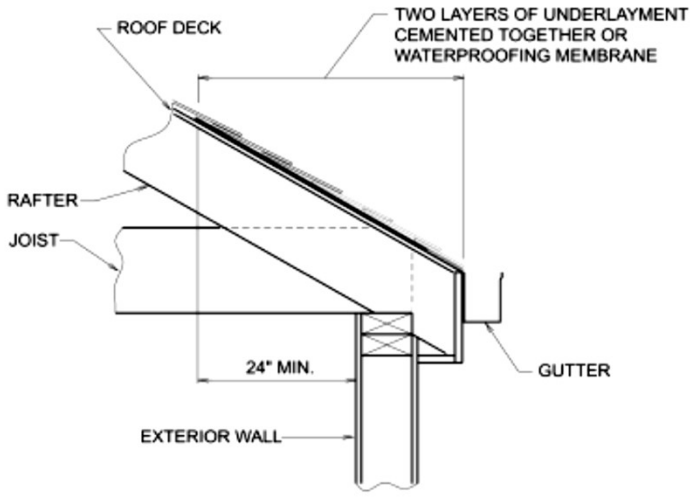
Underlayment



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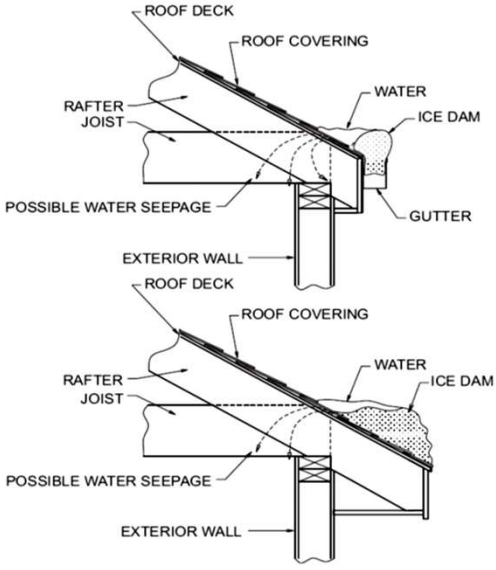
Possible Water Damage at Ice Dams

1507.1.2 Ice barriers. At eaves, an ice barrier shall be installed for asphalt shingles, *metal roof shingles*, mineral-surfaced roll roofing, slate and slate-type shingles, wood shingles and wood shakes. The ice barrier shall consist of not less than two layers of *underlayment* cemented together, or a self-adhering polymer modified bitumen sheet shall be used in place of normal *underlayment* and extend from the lowest edges of all roof surfaces to a point not less than 24 inches (610 mm) inside the exterior wall line of the building.

Exception: Detached accessory structures that do not contain conditioned floor area.



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Underlayment

TABLE 1507.1.1(1)
UNDERLAYMENT TYPES

ROOF COVERING	SECTION	INSTALLATION STANDARD
Asphalt shingles	1507.2	ASTM D226 Type I or II ASTM D4869 Type I, II, III or IV ASTM D6757
Clay and concrete tiles	1507.3	ASTM D226 Type II ASTM D2626 Type I ASTM D6380 Class M mineral surfaced roll roofing
Metal panels	1507.4	Manufacturer's instructions
Metal roof shingles	1507.5	ASTM D226 Type I or II ASTM D4869 Type I, II, III or IV
Mineral-surfaced roll roofing	1507.6	ASTM D226 Type I or II ASTM D4869 Type I, II, III or IV
Slate shingles	1507.7	ASTM D226 Type II ASTM D4869 Type III or IV
Wood shingles	1507.8	ASTM D226 Type I or II ASTM D4869 Type I, II, III or IV
Wood shakes	1507.9	ASTM D226 Type I or II ASTM D4869 Type I, II, III or IV
Photovoltaic shingles	1507.17	ASTM D226 Type I or II ASTM D4869 Type I, II, III or IV ASTM D6757

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Underlayment

TABLE 1507.1.1(2)
UNDERLAYMENT APPLICATION

ROOF COVERING	SECTION	INSTALLATION STANDARD
Asphalt shingles	1507.2	For roof slopes from two units vertical in 12 units horizontal (2:12), up to four units vertical in 12 units horizontal (4:12), *underlayment* shall be two layers applied as follows: Apply a 19-inch strip of *underlayment* felt parallel to and starting at the eaves. Starting at the eave, apply 36-inch-wide sheets of *underlayment*, overlapping successive sheets 19 inches. End laps shall be 4 inches and shall be offset by 6 feet. Distortions in the *underlayment* shall not interfere with the ability of the shingles to seal. For roof slopes of four units vertical in 12 units horizontal (4:12) or greater, *underlayment* shall be one layer applied as follows: *underlayment* shall be applied shingle fashion, parallel to and starting from the eave and lapped 2 inches, Distortions in the *underlayment* shall not interfere with the ability of the shingles to seal. End laps shall be 4 inches and shall be offset by 6 feet.
Clay and concrete tile	1507.3	For roof slopes from two and one-half units vertical in 12 units horizontal ($2^1/_2$:12), up to four units vertical in 12 units horizontal (4:12), *underlayment* shall be not fewer than two layers applied as follows: Starting at the eave, a 19-inch strip of *underlayment* shall be applied parallel with the eave. Starting at the eave, a 36-inch-wide strip of *underlayment* felt shall be applied, overlapping successive sheets 19 inches. End laps shall be 4 inches and shall be offset by 6 feet. For roof slopes of four units vertical in 12 units horizontal (4:12) or greater, *underlayment* shall be one layer applied as follows: *Underlayment* shall be applied shingle fashion, parallel to and starting from the eave and lapped 2 inches. End laps shall be 4 inches and shall be offset by 6 feet.
Metal roof panels	1507.4	Apply in accordance with the manufacturer's installation instructions
Metal roof shingles	1507.5	
Mineral-surfaced roll roofing	1507.6	
Slate shingles	1507.7	

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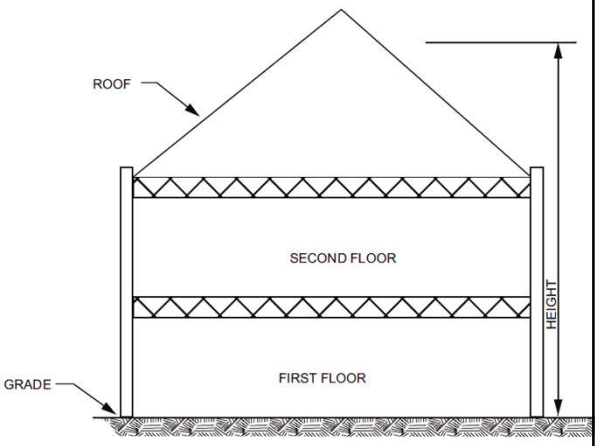
Roof Insulation

[BF] TABLE 1508.2
MATERIAL STANDARDS FOR ROOF INSULATION

Cellular glass board	ASTM C552
Composite boards	ASTM C1289, Type III, IV, V or VII
Expanded polystyrene	ASTM C578
Extruded polystyrene	ASTM C578
Fiber-reinforced gypsum board	ASTM C1278
Glass-faced gypsum board	ASTM C1177
High-density polyisocyanurate board	ASTM C1289, Type II, Class 4
Mineral fiber insulation board	ASTM C726
Perlite board	ASTM C728
Polyisocyanurate board	ASTM C1289, Type I or II
Wood fiberboard	ASTM C208, Type II



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