
Structural Basics
Self-Certification Training Class
January 18-20, 2022
CHICAGO
Department of Buildings

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Introduction

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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

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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

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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**

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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)

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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	—

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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

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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

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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

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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

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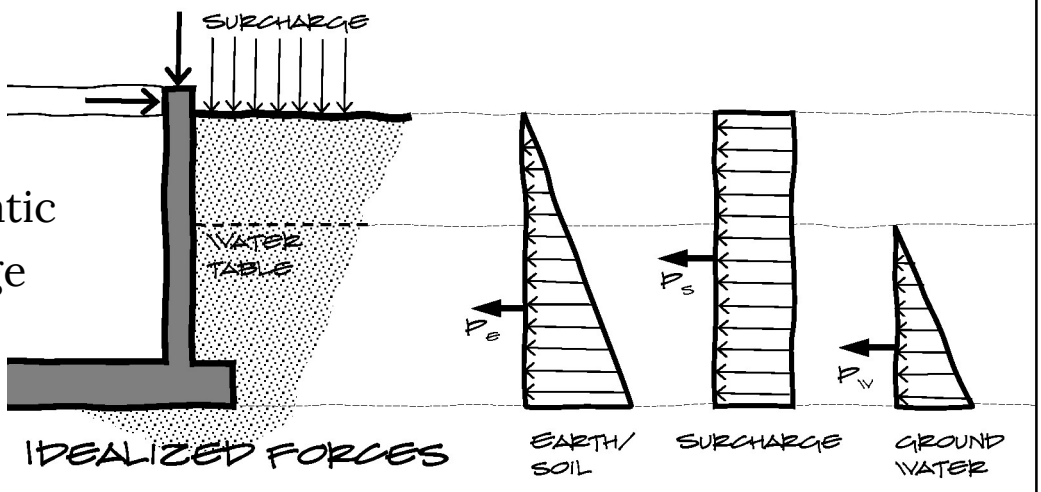
Lateral Soil Loads

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



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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	—

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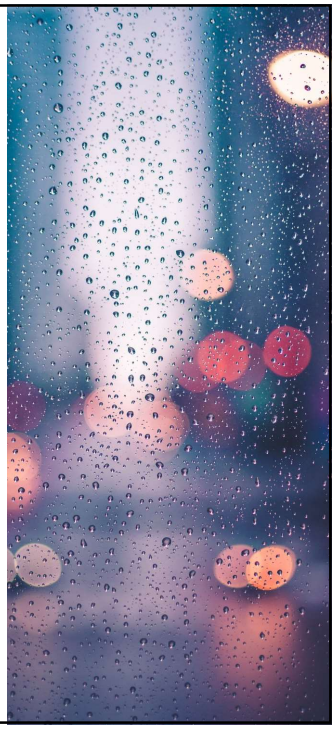
Rain and Ice Loads

- 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.



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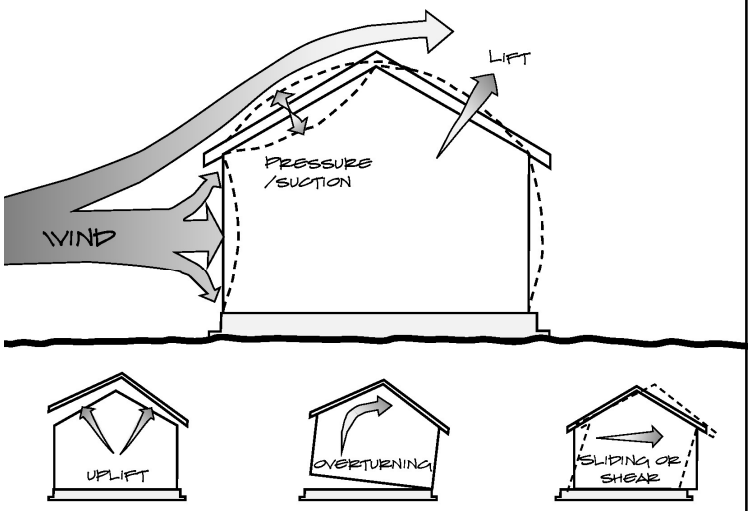
Wind Loads

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



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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.

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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)

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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.

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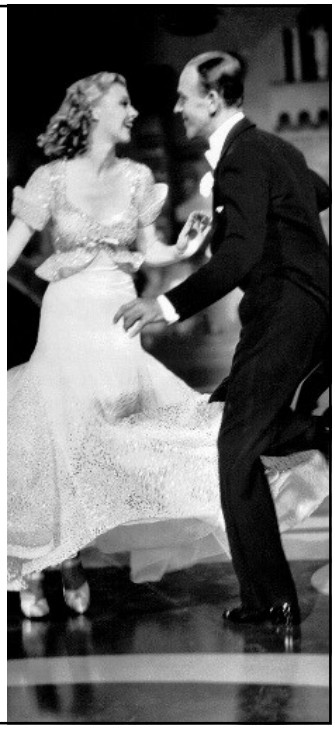
Concentrated vs. Uniform Loads

- 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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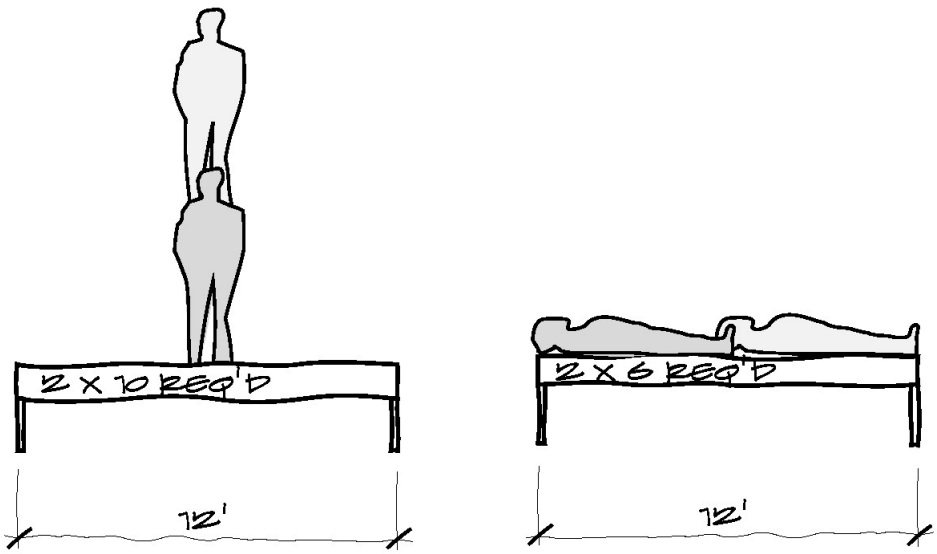

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Complete Load Path

- 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

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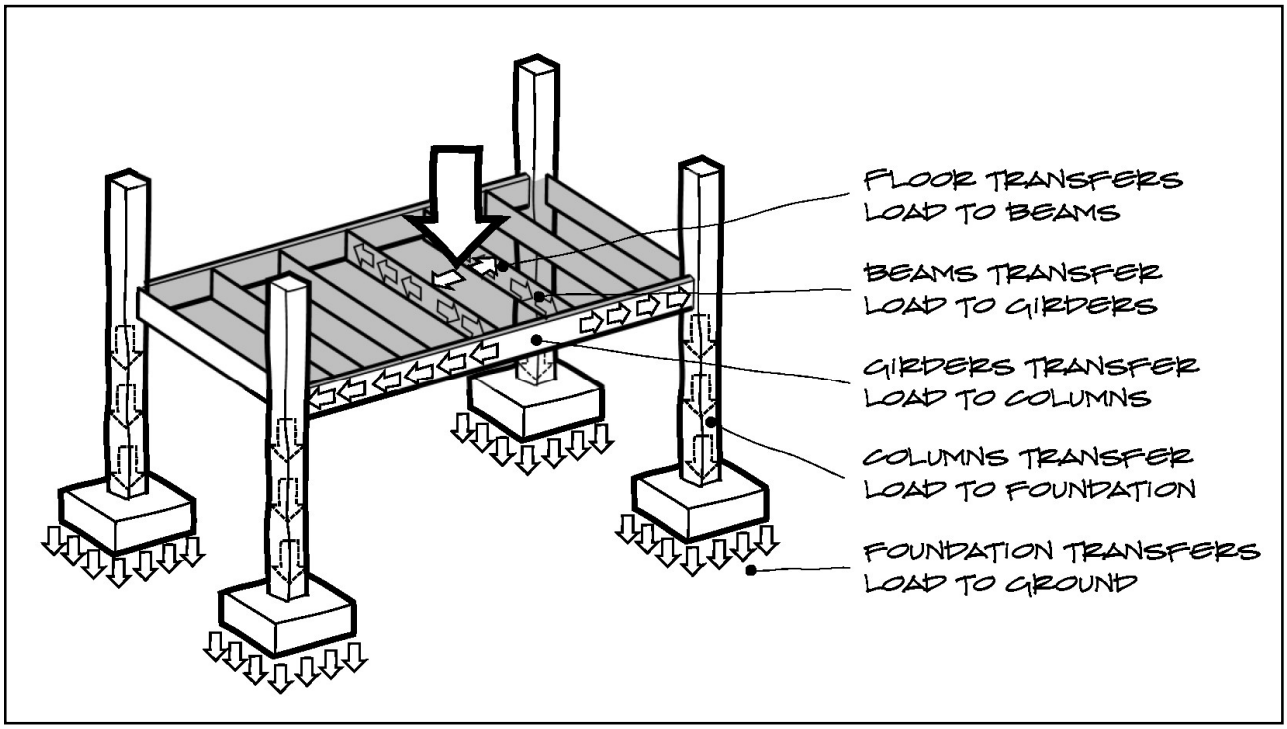
FLOOR TRANSFERS LOAD TO BEAMS
BEAMS TRANSFER LOAD TO GIRDERS
GIRDERS TRANSFER LOAD TO COLUMNS
COLUMNS TRANSFER LOAD TO FOUNDATION
FOUNDATION TRANSFERS LOAD TO GROUND

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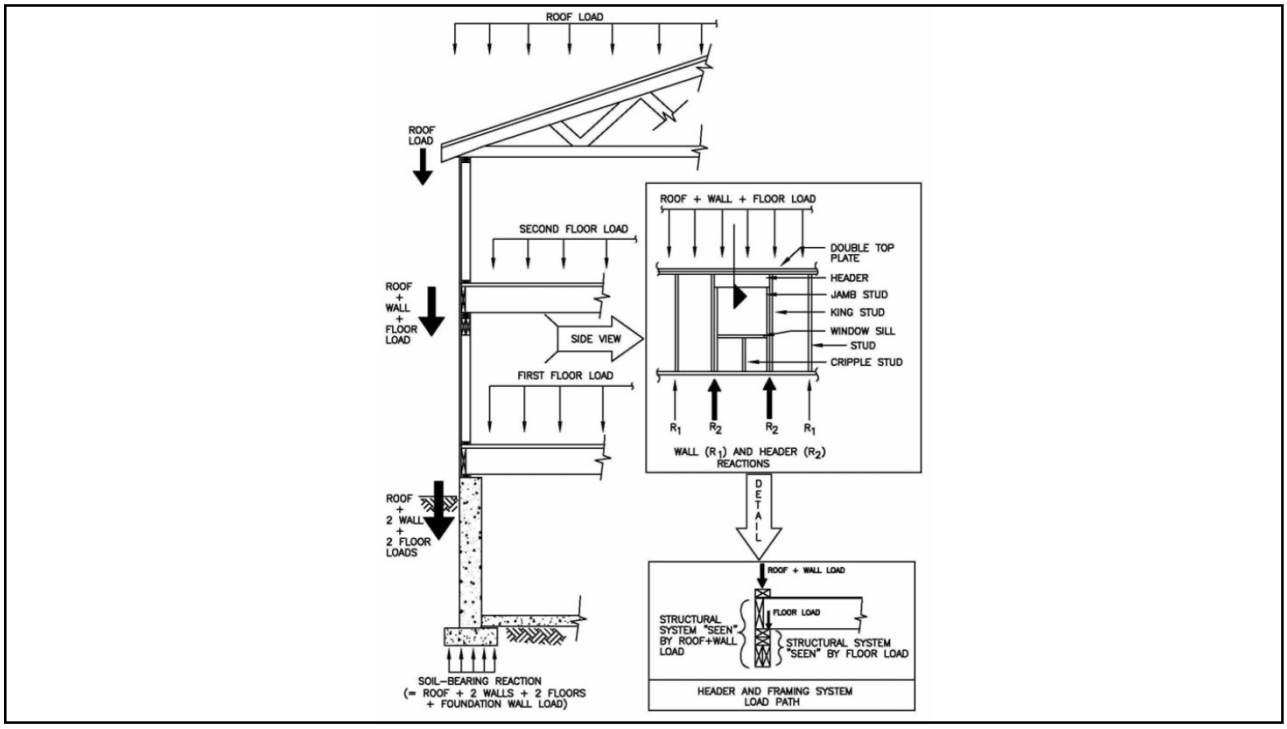
ROOF LOAD
ROOF LOAD
SECOND FLOOR LOAD
ROOF + WALL + FLOOR LOAD
SIDE VIEW
FIRST FLOOR LOAD
ROOF + 2 WALLS + 2 FLOOR LOADS
SOIL-BEARING REACTION (= ROOF + 2 WALLS + 2 FLOORS + FOUNDATION WALL LOAD)
DOUBLE TOP PLATE
HEADER
JAMB STUD
KING STUD
WINDOW SILL
STUD
CRIPPLE STUD
R_1 R_2 R_2 R_1
WALL (R_1) AND HEADER (R_2) 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

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Lateral Load Path

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

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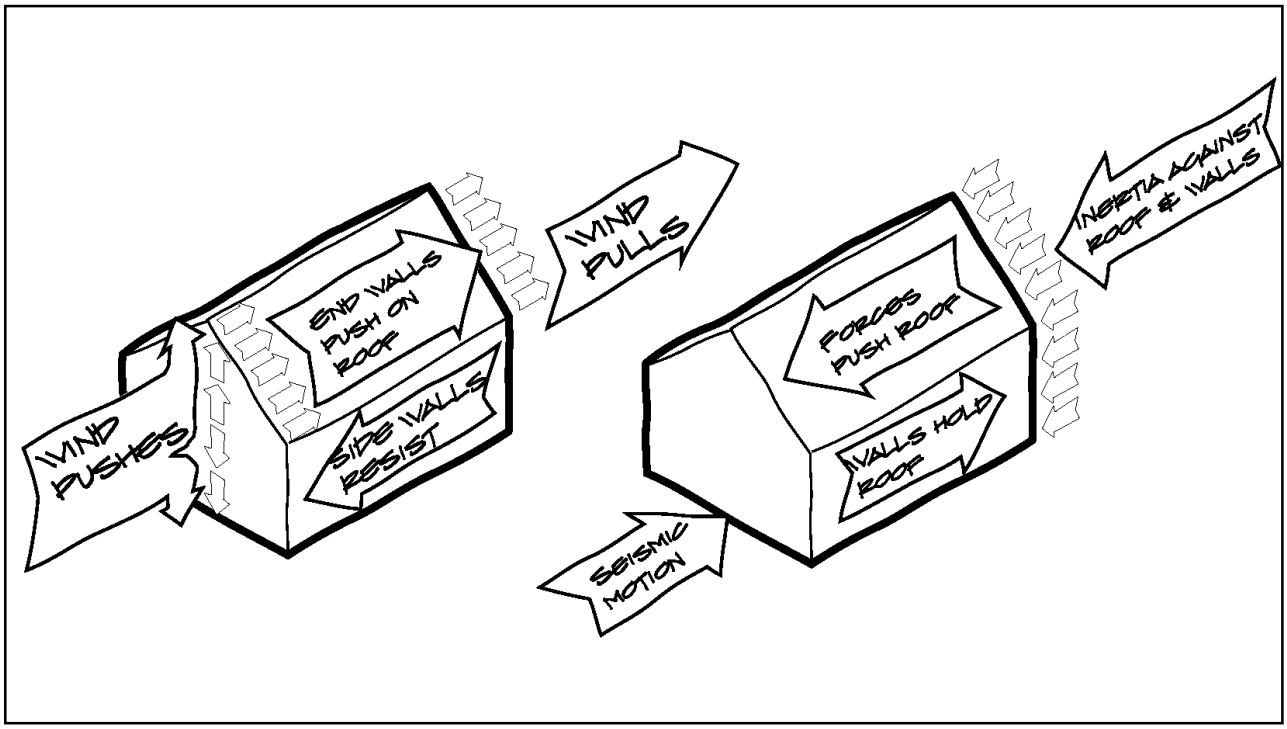
WIND PUSHES
END WALLS PUSH ON ROOF
SIDE WALLS RESIST
WIND PULLS
FORCES PUSH ROOF
WALLS HOLD ROOF
INERTIA AGAINST ROOF & WALLS
SEISMIC MOTION

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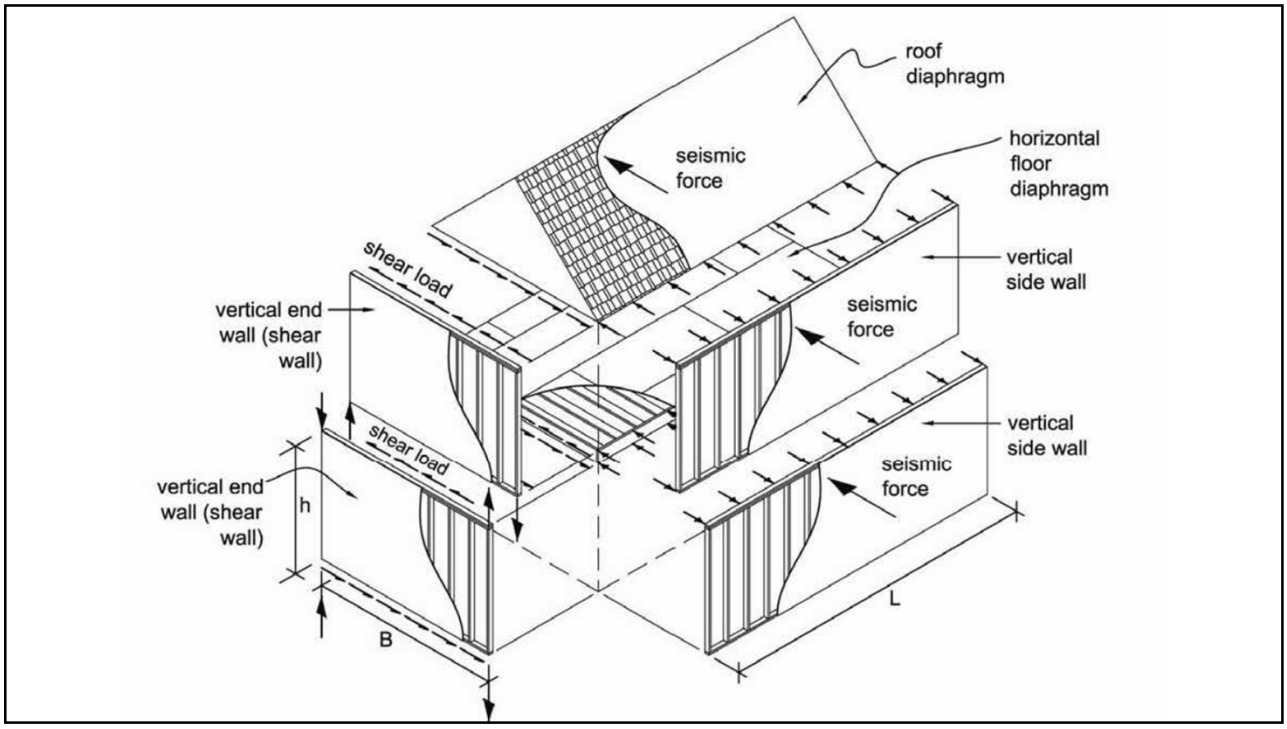
roof diaphragm
seismic force
horizontal floor diaphragm
vertical side wall
shear load
vertical end wall (shear wall)
seismic force
vertical side wall
shear load
vertical end wall (shear wall)
seismic force
h
B
L

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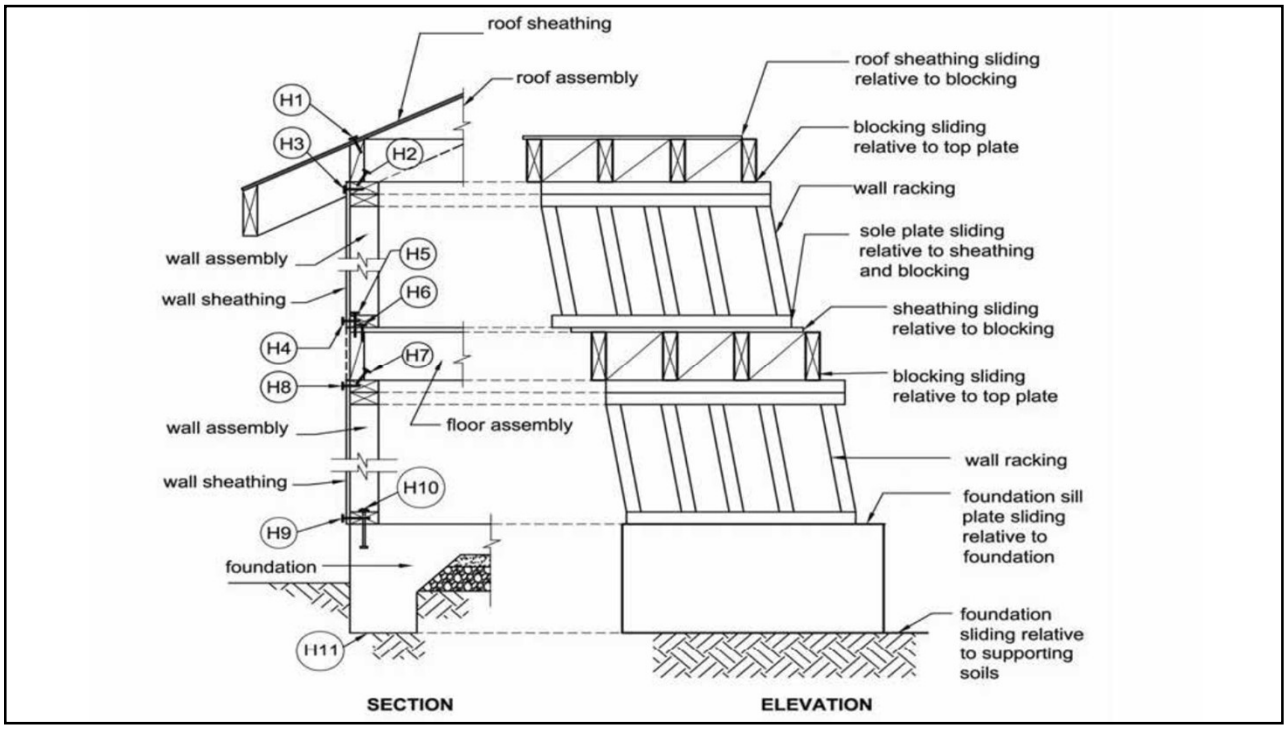

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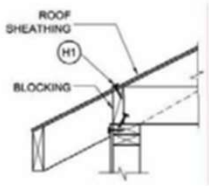
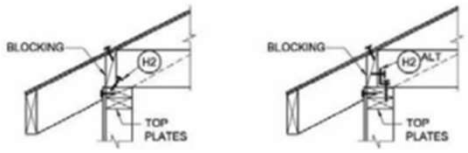
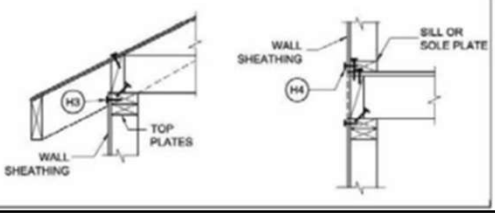
Table 2-1 Load Path Connections for Horizontal Sliding

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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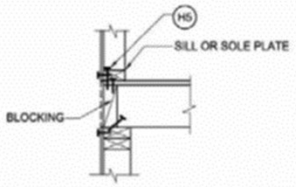
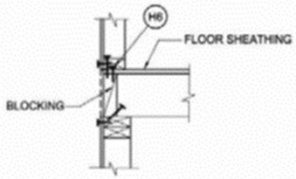
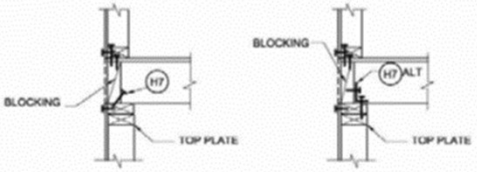
Item	Minimum Fastening per *IRC* Table R602.3(1) and Discussion	Illustration
H5	**At Braced Wall Panels** Three 16d box (0.135"x3 1/2") or three 16d sinker (0.148x3 1/4") face nails each 16 inches on center (space evenly). **Between Braced Wall Panels** One 16d box (0.135"x3 1/2") or one 16d sinker (0.148x3 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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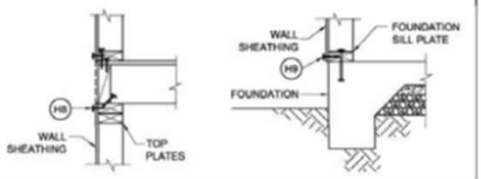
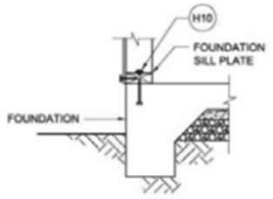
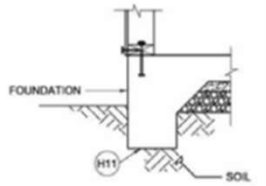
Item	Minimum Fastening (*IRC* Table R602.3(1) U.O.N.) & Discussion	Illustration
H8 & H9	**Sheathing[a] Nailing[b]** 5/16" to ½" 6d common @ 6" 19/32" to 1" 8d common @ 6" 1 1/8" to 1 1/4" 10d common @ 6" • Provides wall racking resistance. • Six-inch nail spacing applies to sheathing edges. Twelve-inch 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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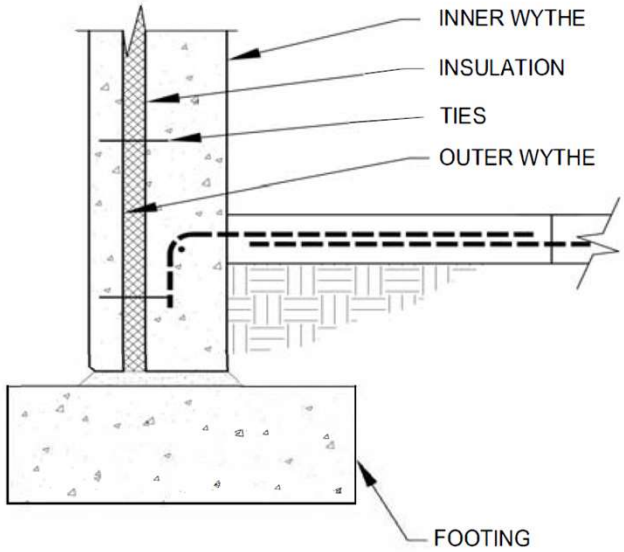

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Structural Risk Category

- 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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