# Residential Design
# Loads & Construction

Presentation by:
**Structural Design Solutions, P.C.**
Engineering & Inspection Services

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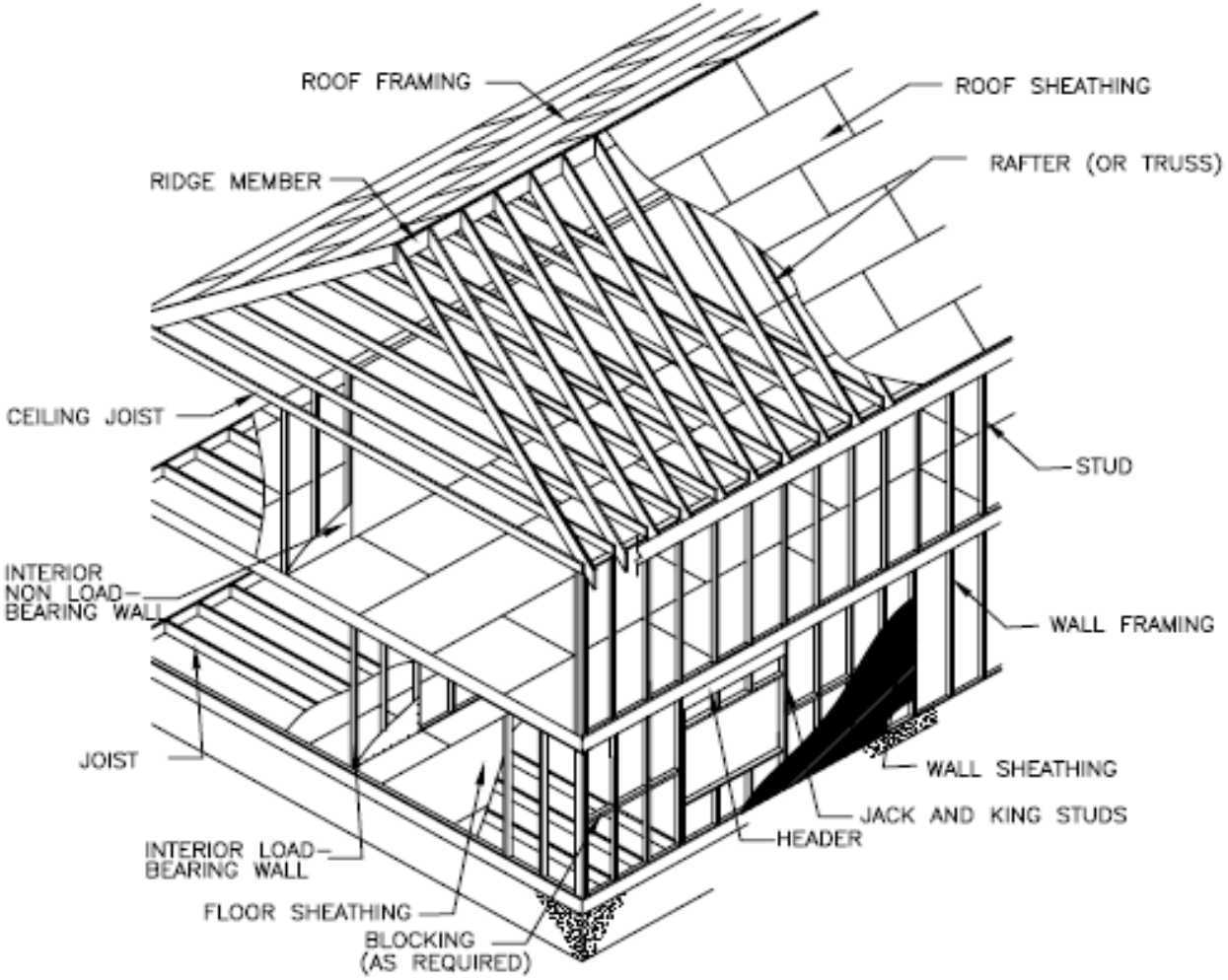
www.structural-design-solutions.com

# Design Criteria

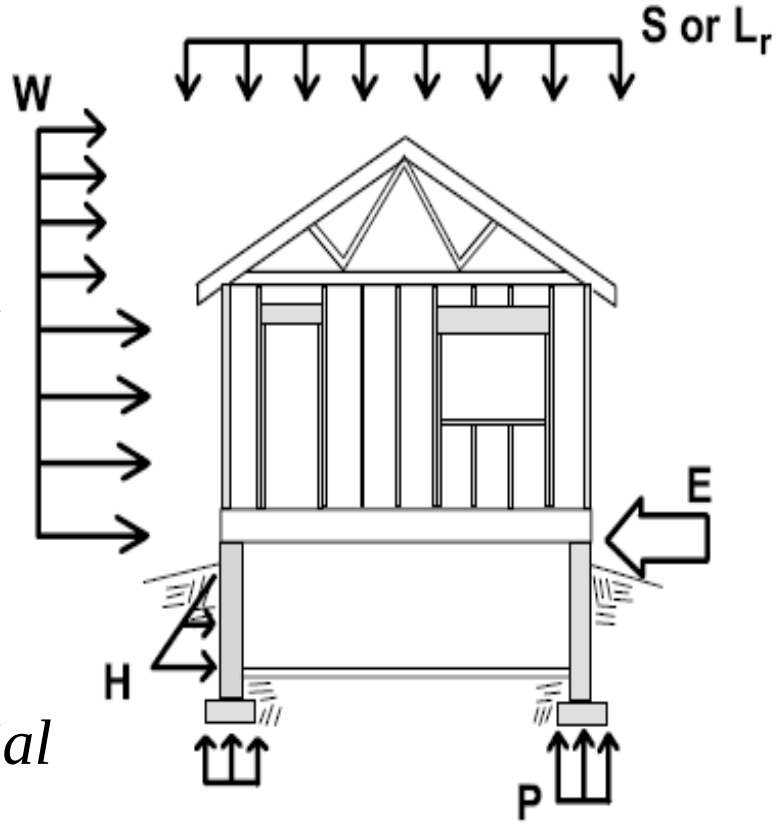
- Structural Safety & Integrity
  - Buildings shall resist all lateral (wind & earthquake) and vertical structural loads thru a continuous load path transmitting them ultimately to the ground
- Structural Serviceability
  - Portions of buildings shall limit vertical deflections & lateral drift (movements)
  - Problems can usually be identified by material fatigue, such as exterior veneer or interior wall cracks or squeaky floors
- Durability
  - Specified materials and construction methods will result in a long-lasting building

# Construction Terms



# Loading Types

- Dead Load
- Live Load
- Cold Weather Load
- Soil Load
- Wind Load
- Earthquake Load
  - *Not required in NC for typical residential home*



# Dead Loads

- Defined as the Weight of Permanent Portions of a Building
- Typically includes all Construction Materials

# Dead Loads, cont'd

Typical Weights of Horizontal Systems

- Roof Construction
  - Asphalt Shingles ~ 15 psf (pounds per sq. foot)
- Ceiling Construction
  - Gypsum (Sheetrock) finish ~ 10psf
- Floor Construction
  - Carpet or Vinyl ~ 10 psf
  - Hardwood Floor ~ 12 psf
  - Ceramic Tile ~ 15 psf

# Dead Loads, cont'd

Typical Weights of Vertical Systems

- Timber wall, wood sheathing, & gypsum interior finish, with:
  - Vinyl Siding ~ 8 psf
  - Thin Coat Stucco ~ 11 psf
  - Standard Brick Veneer ~ 45 psf
- 8 inch Masonry Wall fully grouted ~ 75 psf
- 8 inch Concrete Wall ~ 96 psf

# Live Loads

- Non-Permanent Weight
- Includes:
  - Occupants
  - Furniture
  - Appliances
  - Storage

**TABLE 4.1**
**LIVE LOADS FOR STRUCTURAL MEMBERS**

| APPLICATION | UNIFORM LOAD (psf or plf) | CONCENTRATED LOAD (lbs) |
|---|---|---|
| Roof | | |
| - Slope ≥ 4:12 | 15 psf | 250 lbs |
| - Slope < 4:12 | 20 psf | 250 lbs |
| Attics | | |
| - without storage[1] | 10 psf | 250 lbs |
| - with storage[2] | 20 psf | 250 lbs |
| Floors | | |
| - Bedroom areas | 30 psf | 300 lbs |
| - Other areas | 40 psf | 300 lbs |
| Garages | 40 psf | 2,000 lbs |
| Decks & Balconies[3] | 60 psf | 300 lbs |
| Stairs | 40 psf | 300 lbs |
| Guardrails & Handrails | 20 plf | 200 lbs |
| Grab bars | n/a | 250 lbs |

# Cold Weather Loads

Snow

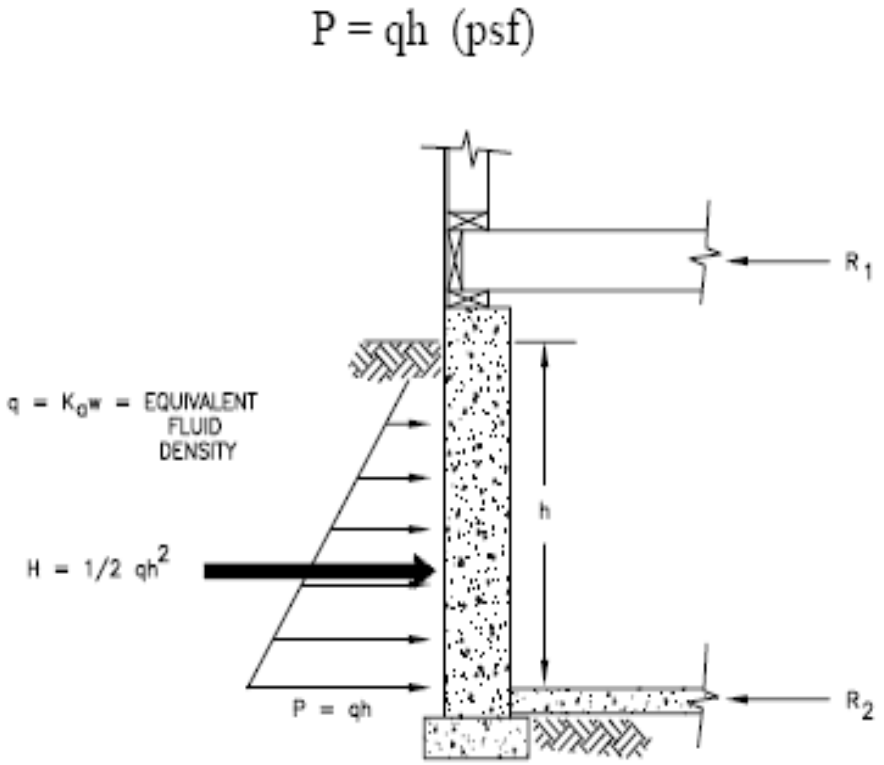
- Typically applied to exposed roofs or decks
- Ground snow load commonly ~ 10 psf
- Usually roof live load governs unless snow drifts are considered

Frost Heave

- Condition where soil under footing freezes and exerts upward movement on the foundation
- Bottom of Footings must be below frost depth to avoid this issue, commonly 12 inches in the Charlotte and Surrounding areas – refer to IBC for exact values

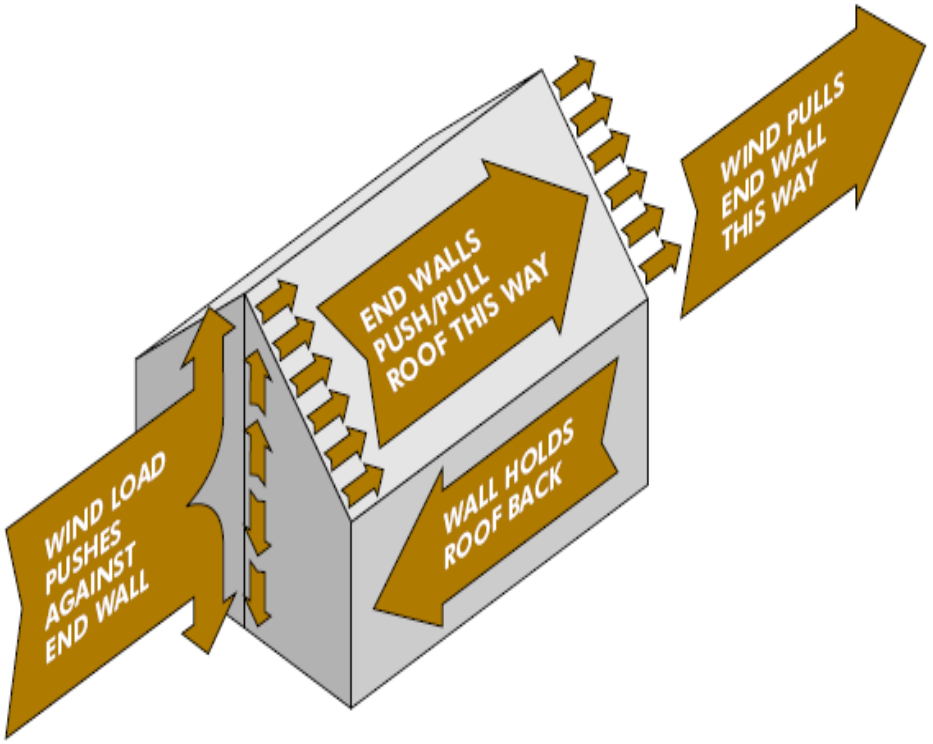
# Soil Load

- Soil Backfill exerts pressure on walls
- Based on height of wall and restraint
- Typical Wall Force per ft
  - Basement
    - $18h^2$ (lb/ft of wall)
  - Retaining
    - $30h^2$ (lb/ft of wall)



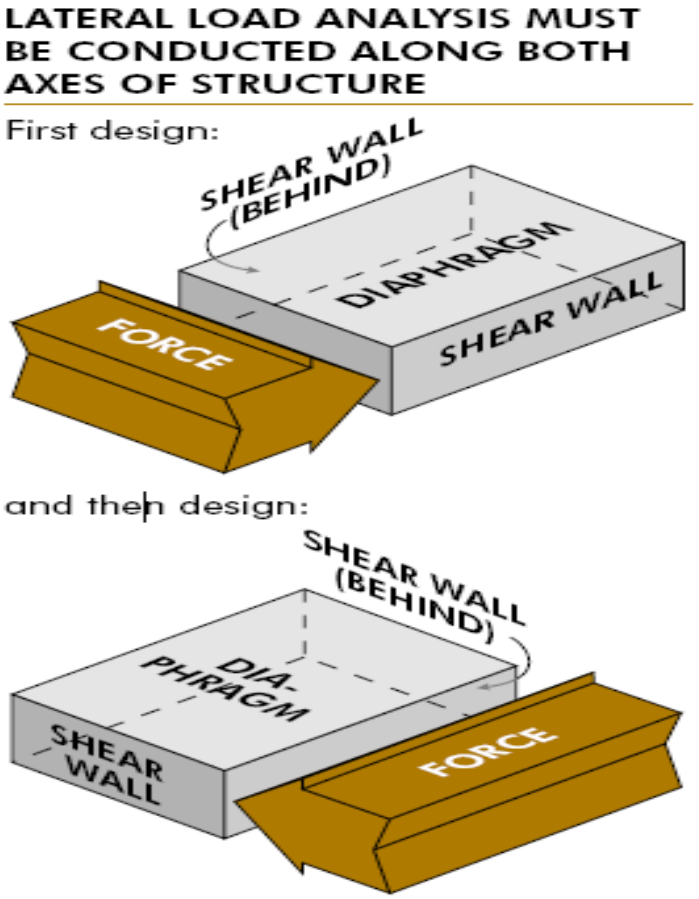
# Wind Loads

- Based on 90 mph wind speed
- Roughly 20 psf
- Based on ASCE 7-05



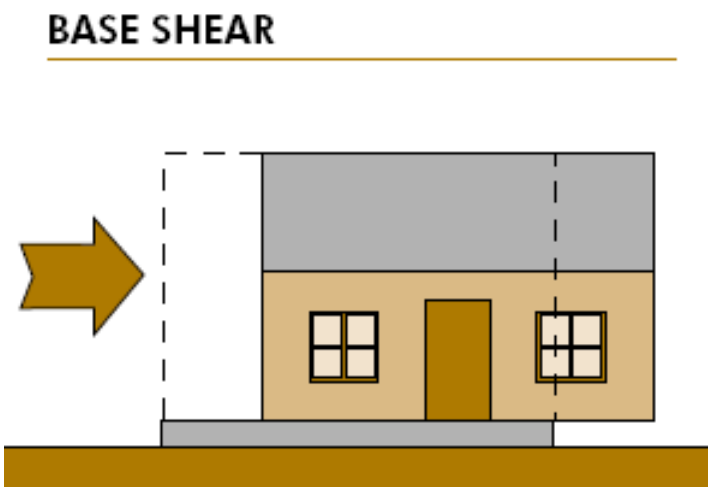
# Wind Force Resisting System

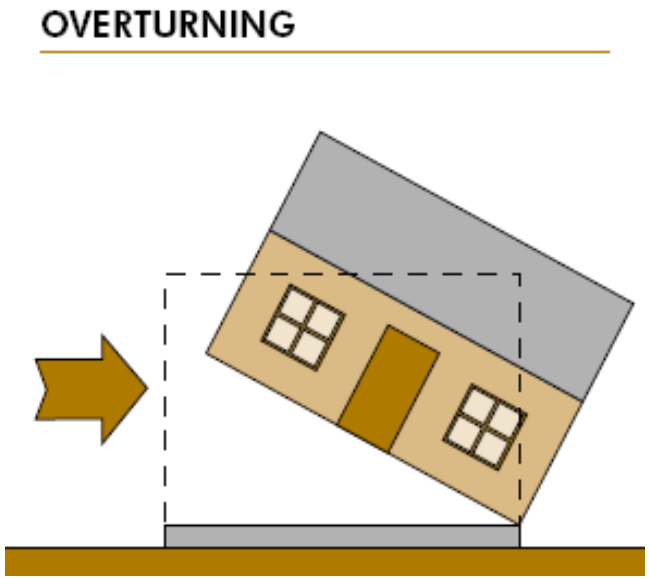
- Portions of structure that keeps building from failure under wind loading
- Diaphragms include Floors & Roofs
- Shear Walls include Timber & Masonry Walls
  - Not all Walls are Shear Walls
- Load Path
  - Wind Hits Wall → Enters Diaphragm → Shear Walls Resist Movement → Foundations Hold Shear Walls



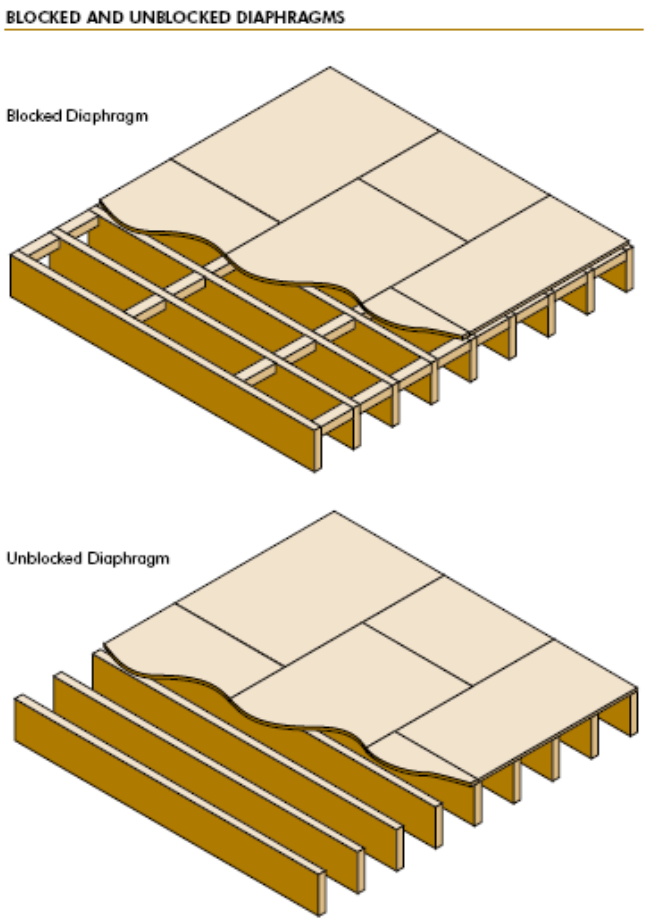
# Wind Force Resisting System, cont'd

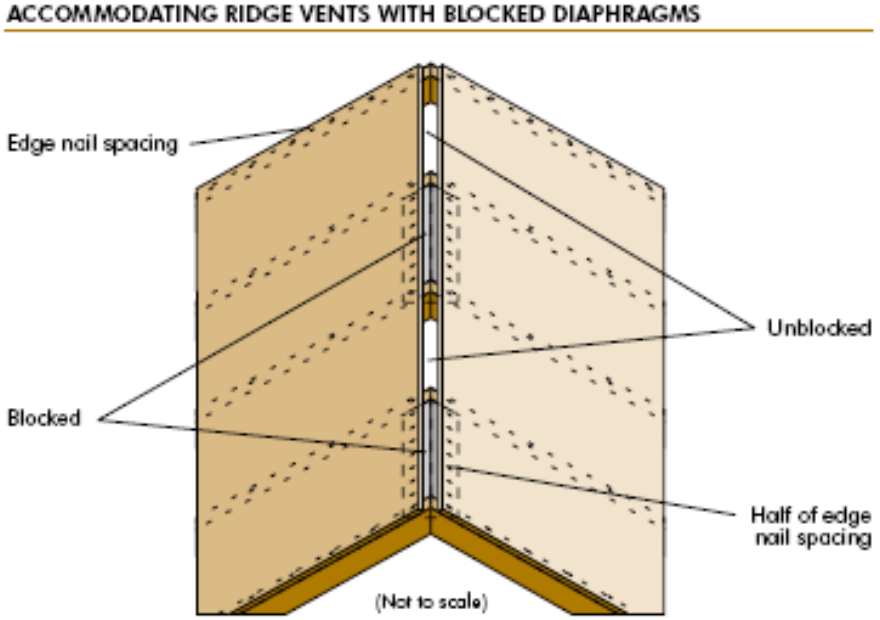
- Prevents Sliding
- Prevents Overturning



# Diaphragms Types

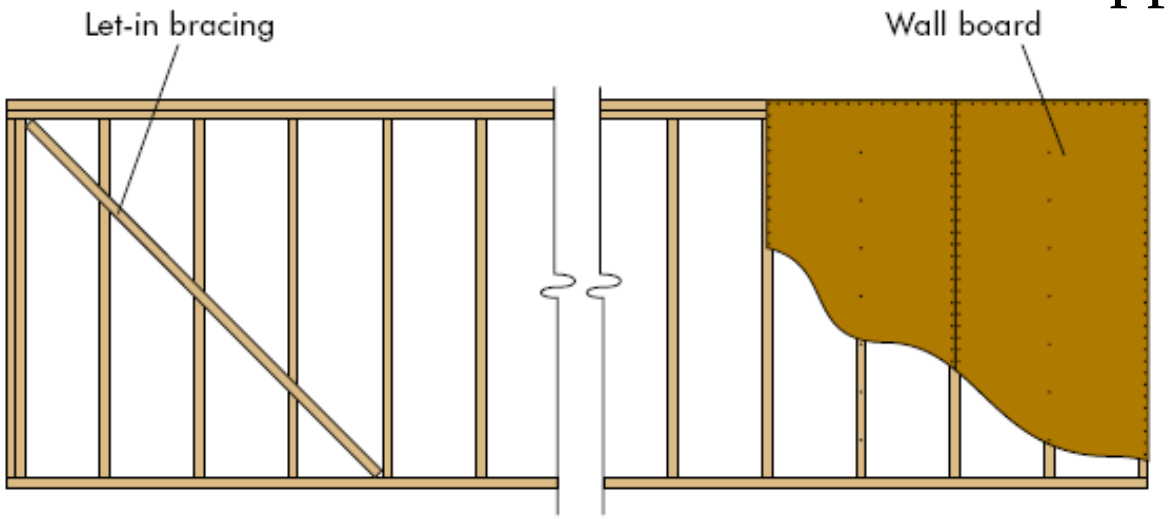


# Timber Shear Walls

Prescriptive

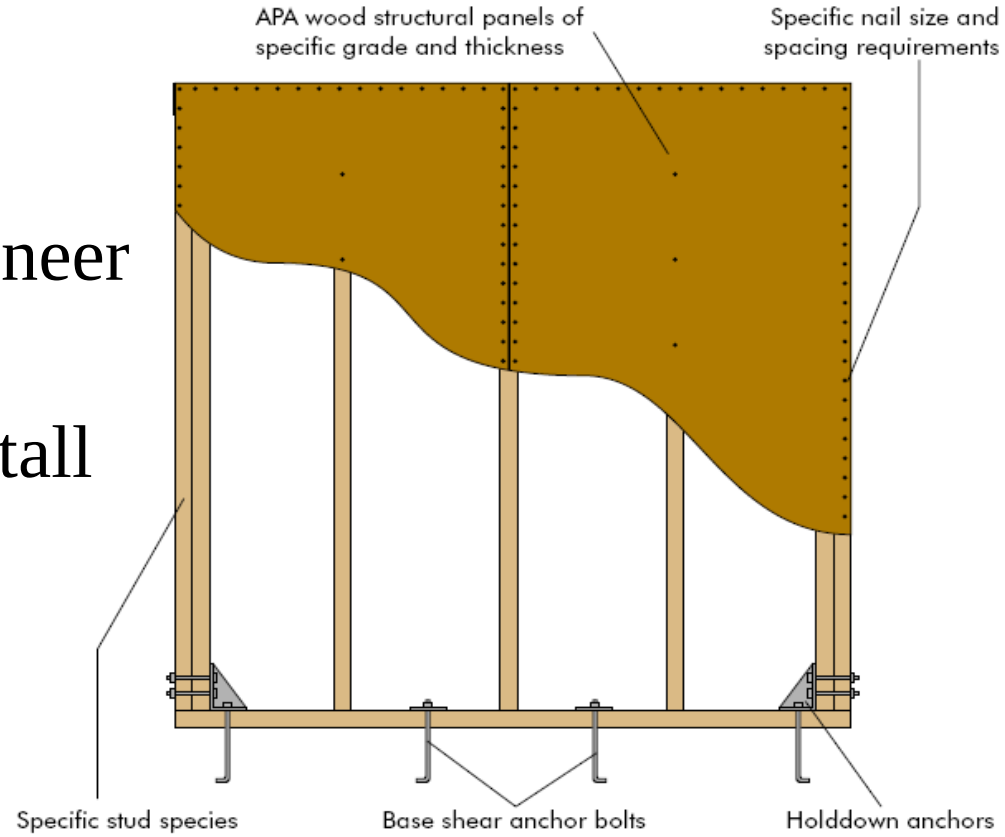
- Most Common
- Cost Effective
- Does Not Require Engineering Analysis
- Limited in Applications



# Timber Shear Walls, cont'd

Engineered

- Stronger
- Designed by Engineer
- Requires Specific Knowledge to Install



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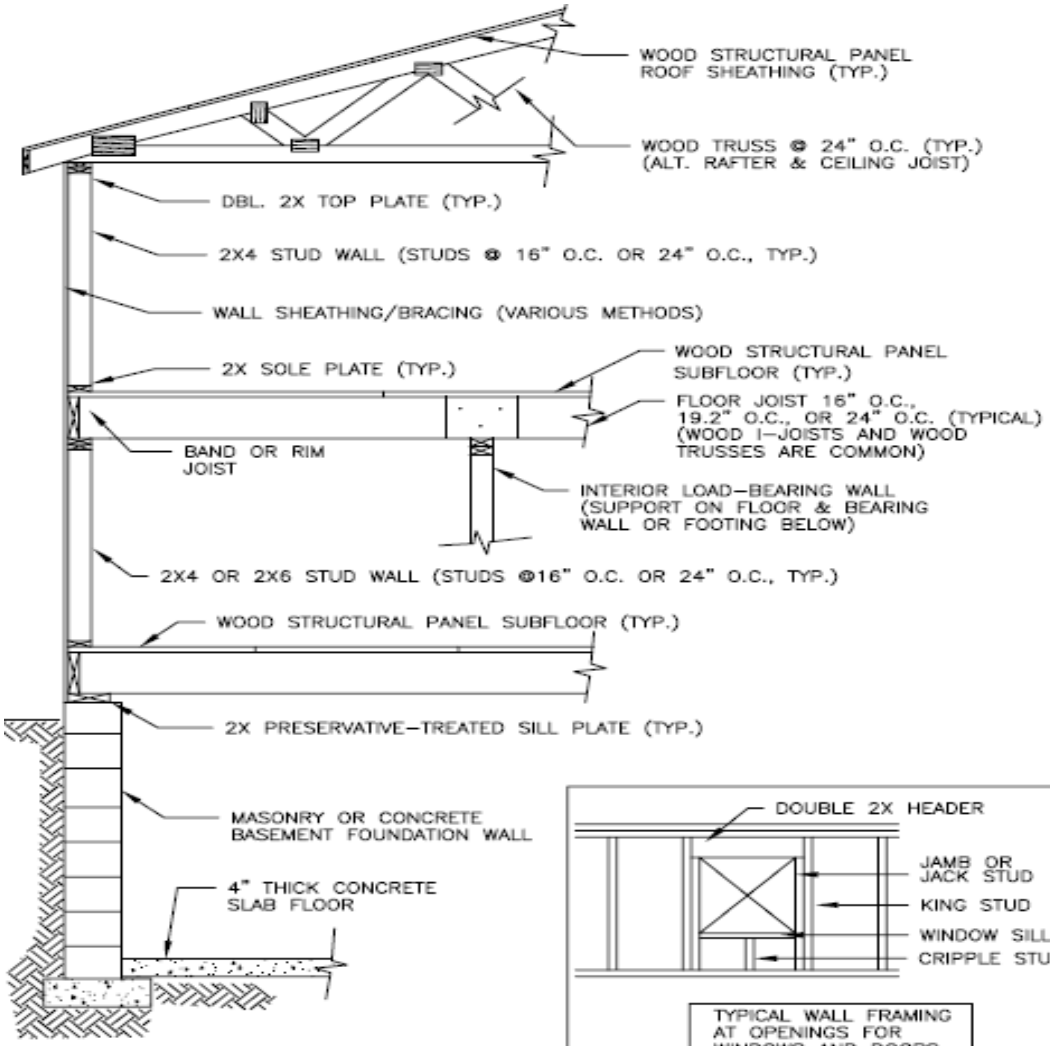
# Typical Framing Details



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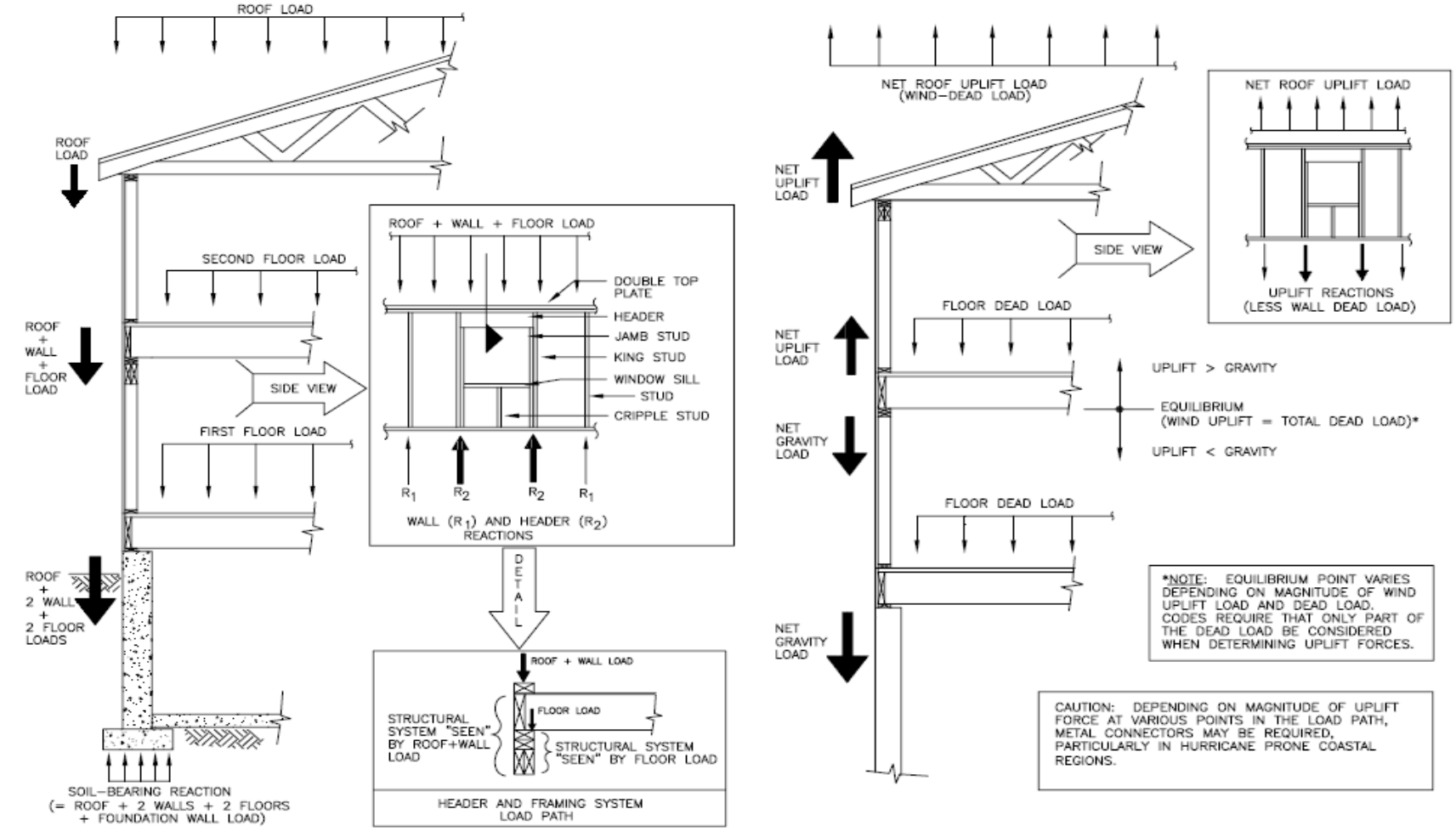
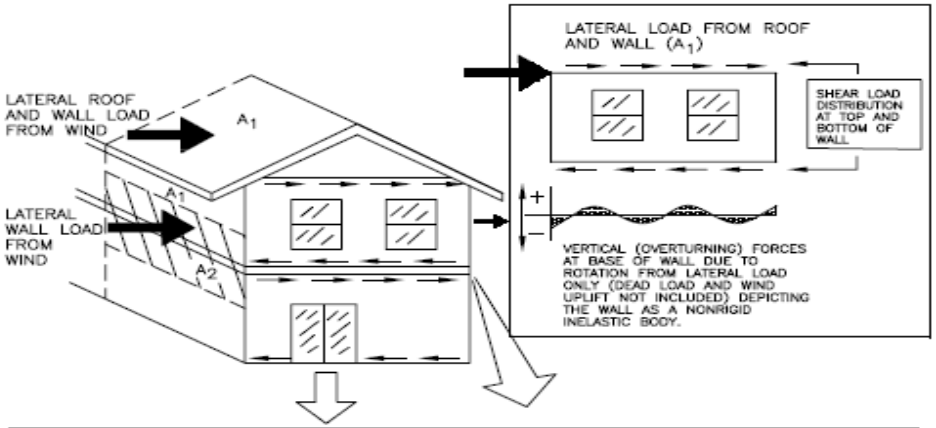
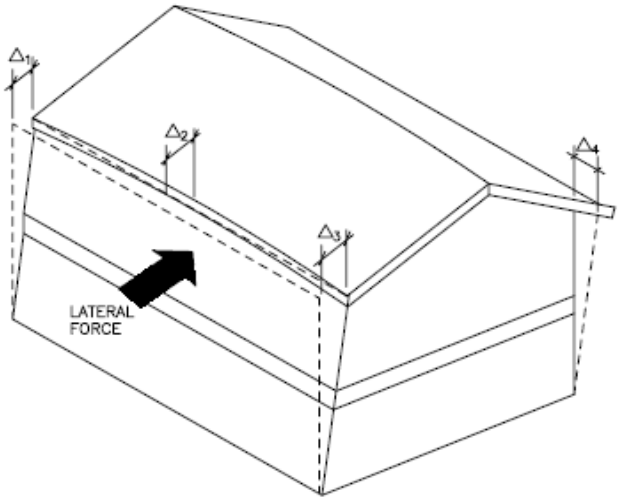
# Vertical Load Path



# Lateral Load Path



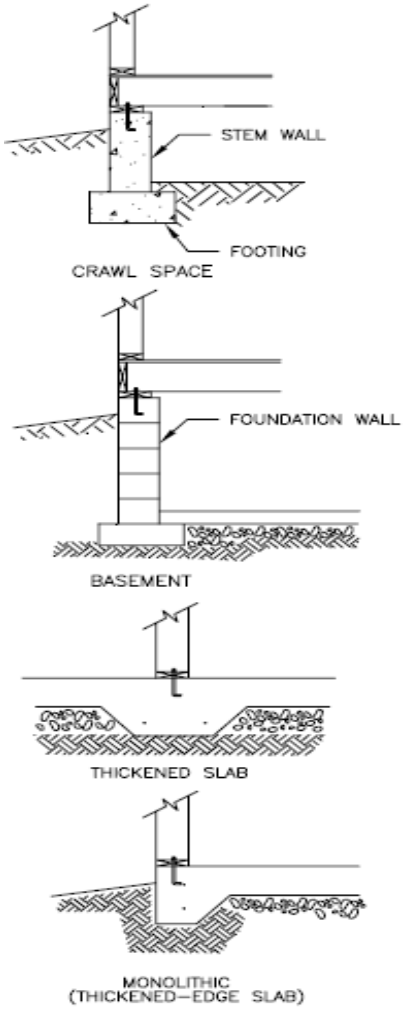

NOTE: IF STIFFNESS OR LOAD IS NONSYMMETRICAL, BUILDING ROTATION OCCURS ($\Delta_1 \neq \Delta_3$) AND LOADS ARE DISTRIBUTED BY TORSION ($\Delta_4 \neq 0$) AS WELL AS BY DIRECT SHEAR IN THE DIRECTION OF THE LATERAL FORCE. THIS CONDITION VARIES BUT IS A REALITY FOR MOST DESIGNS. $\Delta_2$ IS THE BENDING DEFORMATION OF THE HORIZONTAL DIAPHRAGM (I.E., ROOF).

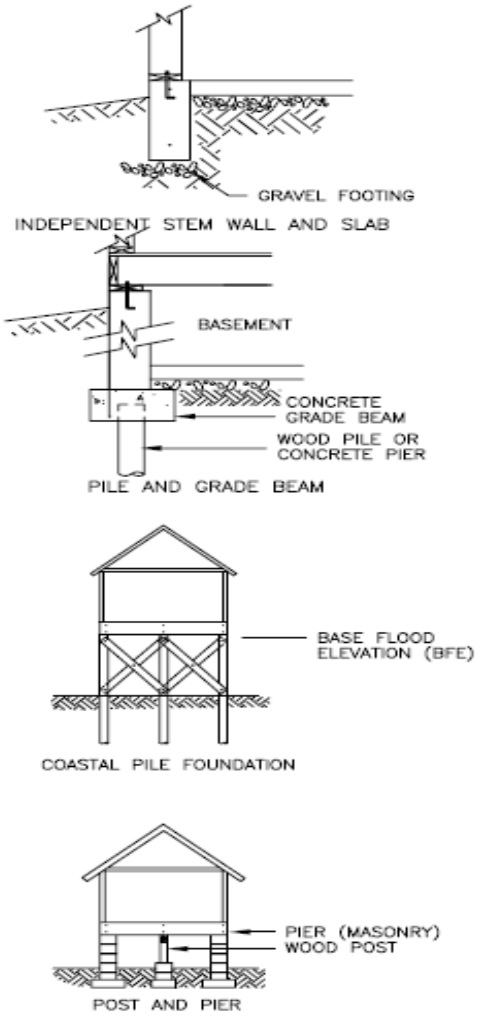
→ = LATERAL SHEAR (RACKING) LOAD FROM WIND PRESSURE ON WINDWARD AND LEEWARD (NOT SHOWN) TRIBUTARY AREAS. THE TRIBUTARY SURFACE PRESSURE LOADS ARE TRANSFERRED TO THE WALLS THROUGH THE FLOOR AND ROOF BY DIAPHRAGM ACTION.

NOTE: WHILE LATERAL LOADS ARE SIMILARLY TRANSFERRED TO WALLS BY DIAPHRAGM ACTION, SEISMIC FORCES ORIGINATE FROM THE TRIBUTARY MASS OF THE BUILDING (I.E., PLAN AREA), NOT THE EXTERIOR SURFACE AREA AS IS SHOWN FOR WIND.

# Foundations

- Vary depending on local conditions
- Most Common are the crawl space, basement, & monolithic
- Foundation must resist vertical and horizontal loads



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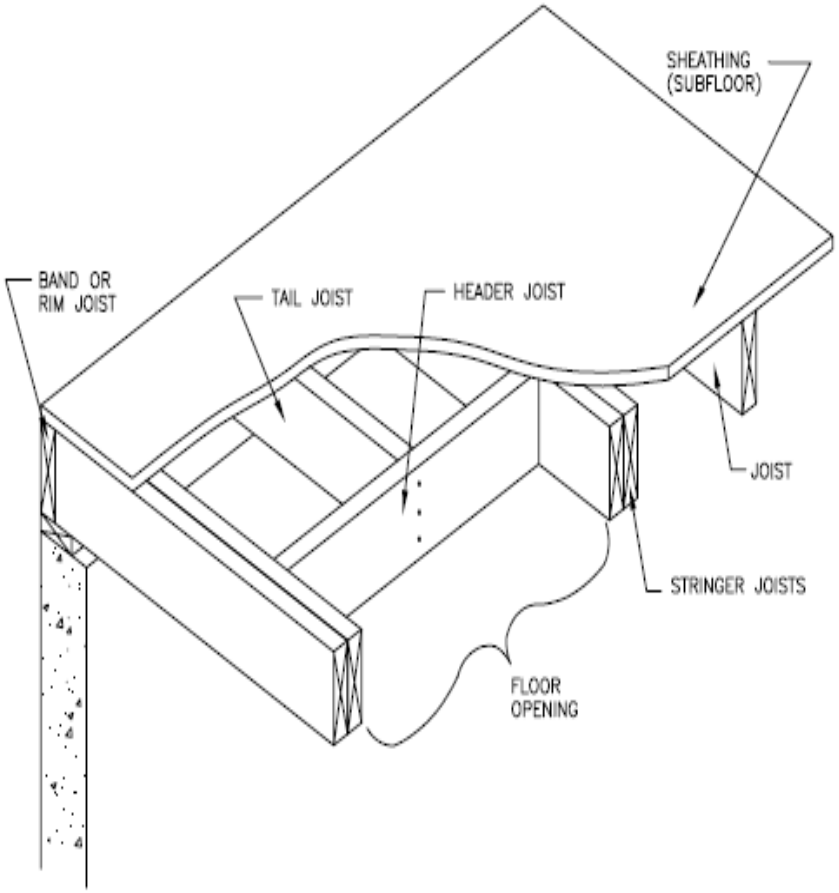
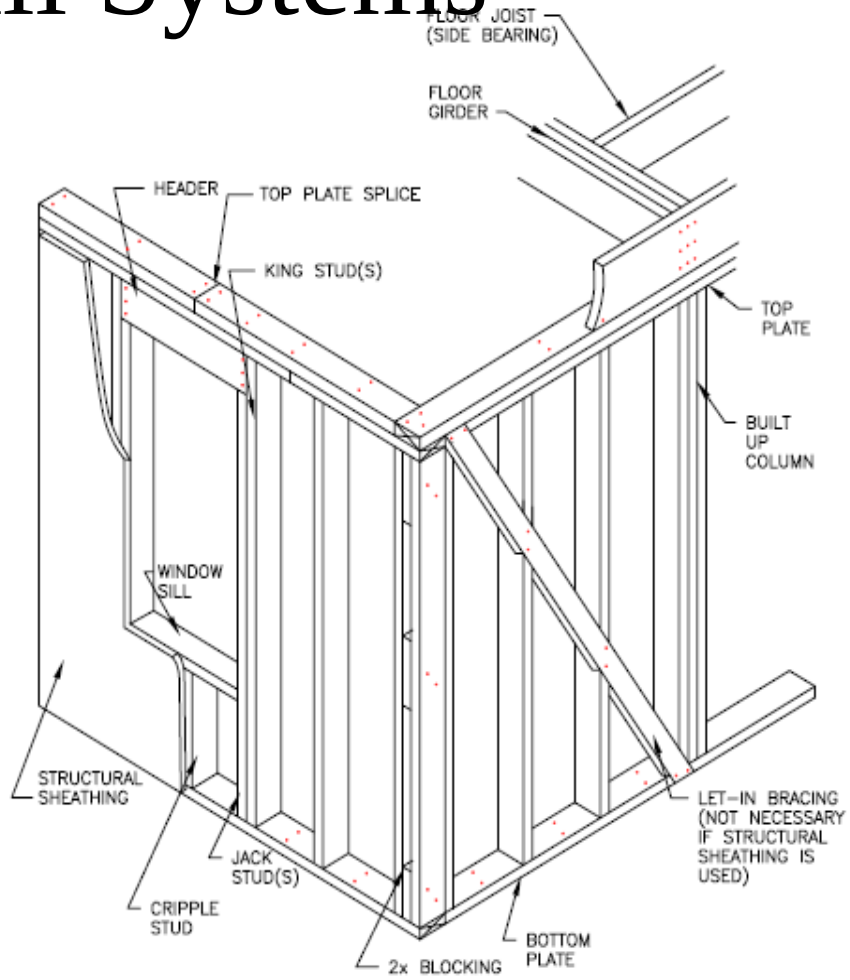
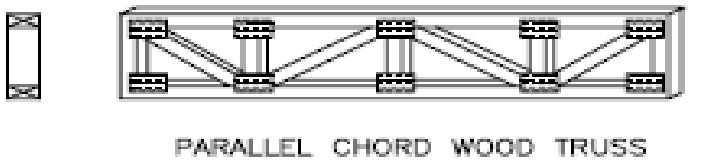
# Floor & Wall Systems



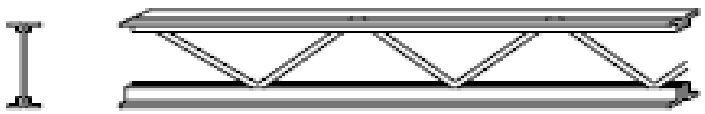
# Floor Beam Types

STANDARD DIMENSIONAL LUMBER JOIST



PARALLEL CHORD WOOD TRUSS

WOOD I–JOIST



STEEL BAR JOIST

COLD–FORMED STEEL JOISTS

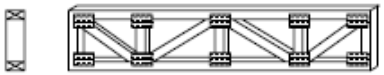
BUILT–UP MEMBER (DIMENSION LUMBER)

HOT–ROLLED STEEL BEAM (W–SHAPE)

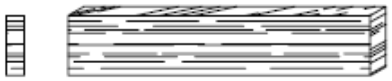
GLUED LAMINATED LUMBER (GLULAM)

BUILT–UP COLD FORMED STEEL

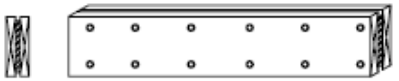
LAMINATED VENEER LUMBER (LVL)



PARALLEL CHORD WOOD TRUSS

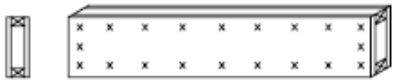


PARALLEL STRAND LUMBER



FLITCH PLATE

PLYWOOD WEB I–BEAMS (OR WOOD I–JOIST PER FIGURE 5.3)



PLYWOOD BOX BEAM

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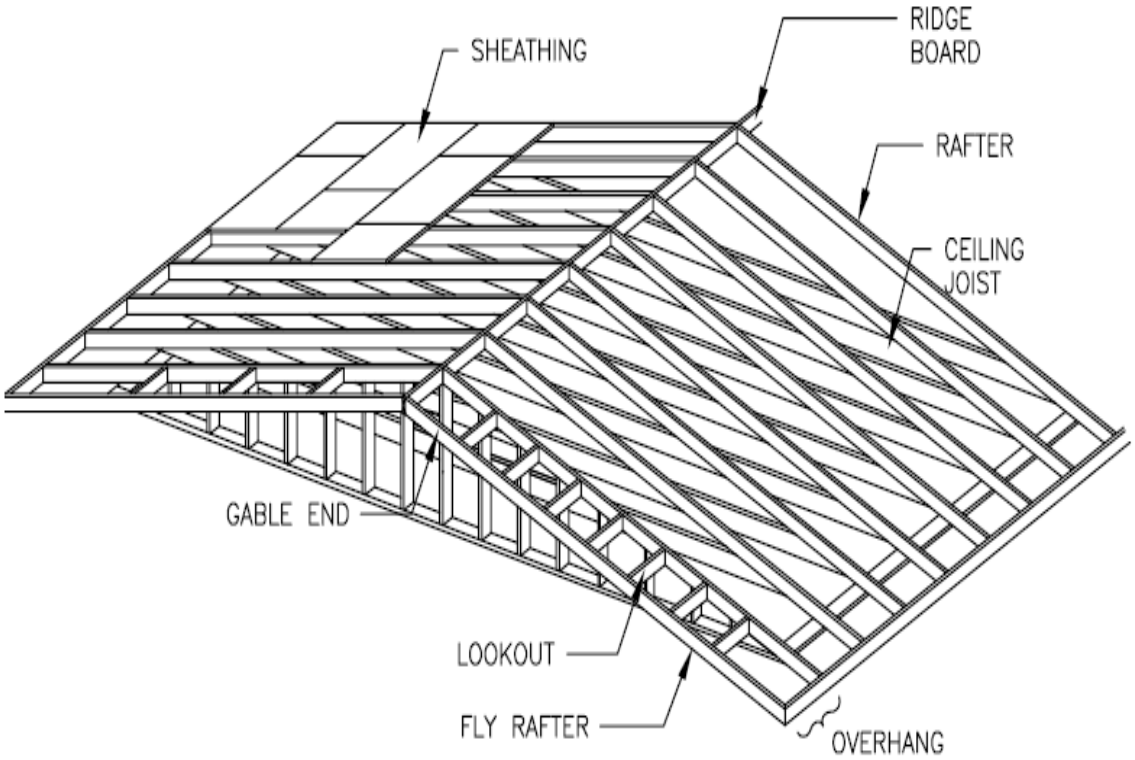
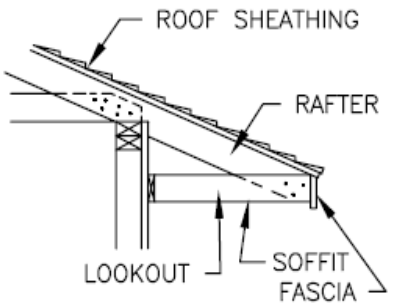
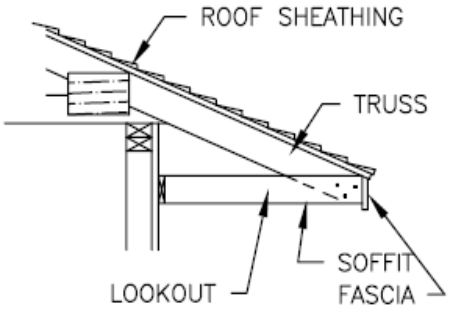
# Roof System

## Typical Framing




EAVE OVERHANG (RAFTER)




EAVE OVERHANG (TRUSS)

# Residential Design Conclusions

- This presentation was intended for a simple overview of the loading and design of residential homes
- When structural elements are in question, please contact a registered professional engineer to determine its integrity and safety
- Please refer to our other presentations for additional information located at: *www.structural-design-solutions.com*