Residential Design
Loads & Construction

Presentation by:
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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 ~ 10 psf

• 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

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>UNIFORM LOAD (psf or plf)</th>
<th>CONCENTRATED LOAD (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Slope ≥ 4:12</td>
<td>15 psf</td>
<td>250 lbs</td>
</tr>
<tr>
<td>- Slope &lt; 4:12</td>
<td>20 psf</td>
<td>250 lbs</td>
</tr>
<tr>
<td>Attics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- without storage¹</td>
<td>10 psf</td>
<td>250 lbs</td>
</tr>
<tr>
<td>- with storage²</td>
<td>20 psf</td>
<td>250 lbs</td>
</tr>
<tr>
<td>Floors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Bedroom areas</td>
<td>30 psf</td>
<td>300 lbs</td>
</tr>
<tr>
<td>- Other areas</td>
<td>40 psf</td>
<td>300 lbs</td>
</tr>
<tr>
<td>Garages</td>
<td>40 psf</td>
<td>2,000 lbs</td>
</tr>
<tr>
<td>Decks &amp; Balconies³</td>
<td>60 psf</td>
<td>300 lbs</td>
</tr>
<tr>
<td>Stairs</td>
<td>40 psf</td>
<td>300 lbs</td>
</tr>
<tr>
<td>Guardrails &amp; Handrails</td>
<td>20 plf</td>
<td>200 lbs</td>
</tr>
<tr>
<td>Grab bars</td>
<td>n/a</td>
<td>250 lbs</td>
</tr>
</tbody>
</table>
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

LATERAL LOAD ANALYSIS MUST BE CONDUCTED ALONG BOTH AXES OF STRUCTURE

First design:

and then design:
Wind Force Resisting System, cont’d

• Prevents Sliding

• Prevents Overturning

BASE SHEAR

OVERTURNING
Diaphragms Types

- Blocked Diaphragm
- Unblocked Diaphragm

Accommodating Ridge Vents with Blocked Diaphragms:
- Edge nail spacing
- Blocked
- Unblocked
- Half of edge nail spacing

(Not to scale)
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
Typical Framing Details
Vertical Load Path

**Diagram Description:**
- **Roof Load**
- **Second Floor Load**
- **First Floor Load**
- **Soil-Bearing Reaction**
  - Roof + 2 Walls + 2 Floors + Foundation Wall Load

**Load Path:**
- Roof Load
  - Wall Load
  - Second Floor Load
  - First Floor Load

**Reactions:**
- **R1**, **R2**, **R3**, **R4**

**Structural System:**
- Double Top Plate
- Header
- Joist Stud
- King Stud
- Window Sill

**Equilibrium:**
- Equilibrium (Wind Uplift = Total Dead Load)
  - Uplift > Gravity
  - Uplift < Gravity

**Note:** Equilibrium point varies depending on magnitude of wind uplift load and dead load.

**Caution:** Depending on magnitude of uplift force at various points in the load path, metal connectors may be required, particularly in hurricane-prone coastal regions.

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Lateral Load Path

NOTE: IF STIFFNESS OR LOAD IS NONSYMMETRICAL, BUILDING
ROTATION OCCURS (Δ₁ ≠ Δ₂) AND LOADS ARE DISTRIBUTED
BY TORSION (Δ₃ ≠ 0) AS WELL AS BY DIRECT SHEAR IN
THE DIRECTION OF THE LATERAL FORCE. THIS CONDITION VARIES
BUT IS A REALITY FOR MOST DESIGNS. Δ₁ 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
Floor & Wall Systems
Floor Beam Types

- Standard Dimensional Lumber Joist
- Built-Up Member (Dimension Lumber)
- Hot-Rolled Steel Beam (W-Shape)
- Parallel Chord Wood Truss
- Glued Laminated Lumber (GLULAM)
- Built-Up Cold Formed Steel
- Wood I-Joist
- Laminated Veneer Lumber (LVL)
- Parallel Chord Wood Truss
- Steel Bar Joist
- Parallel Strand Lumber
- Plywood Box Beam
- Cold-Formed Steel Joists
- Plywood Web I-Beams (Or Wood I-Joist Per Figure 5.3)
Roof System

Typical Framing
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