WOOD CONNECTIONS

- **Building code provisions:**
  - How loads must be determined
  - What stresses are allowed in structural members
  - Formulas for designing members of various materials

LOADING

- **Ch 16 of IBC** details how loads must be calculated
  - Requires construction method be based on a rational analysis in accordance with well-established principles of mechanics and provide a path for all loads and forces from their point of origin to the load resisting elements
- Analysis must include distribution of:
  - Horizontal shear
  - Horizontal torsional moments: torsion due to eccentricity between center of application of a lateral force and the center of rigidity of the force-resisting system
  - Stability against overturning
  - Anchorage: resists the uplift and sliding forces on a structure
- When building design is based on allowable stress or working stress design, each component must be designed to resist most critical effect resulting from the combination of loads listed
- Basic load combinations per **IBC Sec 1605.2.1**

**Live Loads**

- **Required floor live loads:** given in **IBC Table 1607.1**
- **IBC** allows for the live load to be reduced in most cases
  - May not be reduced for any public assembly occupancy with live loads less than or equal to 100psf
  - May not be reduced for any member supporting one floor oof a parking garage
  - With a live load exceeding 100psf
- Reduced live load is determined using \[ L = L_o \times (0.25 + 15/K_{L_{LAT}}) \]
- **Additional code provisions:**
  - Provisions must be made for designing floors to accommodate concentrated loads as shown I
  - If these loads acting on any space 2 1/2ft square on an otherwise unloaded floor would result in stresses greater than caused by the uniform load then the floor must be designed accordingly
  - Where uniform live floor and roof loads are involved the design may be limited to full dead load on all spans in combination with full live loads on adjacent spans and on alternate spans.
    - Important where structural continuity of adjacent spans is involved
    - Code requires investigation of loading conditions that would cause maximum shear and bending moments along continuous members
  - Live loads for each floor or portion thereof in commercial or industrial buildings must be conspicuously posted
  - Interior walls permanent partitions and temporary partitions over 6’ high must be designed to resist all loads on them but in no case less than a force of 5psf applied perpendicular to the wall

**Dead Loads**

- Vertical load due to the weight of all permanent structural and nonstructural components of a building
- Code does not specifically state required dead loads but designers must use standard unit weights for various building materials
- **However:** specific provisions
  - Floors in office buildings where partition locations are subject to change must be designed to support a uniformly distributed live load equal to 20psf
  - Access floor system may be designed to support an additional 10psf of uniformly distributed dead load over all other loads
**Lateral Loads**

- **Wind loads calculations dependent on:**
  - The height of the structure above the ground
  - Exposure of the structure
  - A wind stagnation pressure at a standard height of 33ft above the ground
  - Portion of the structure under consideration
  - Factor related to the importance of the building during an emergency (fire station)

- **Buildings over 400' tall must be designed in accordance with national standards**
  - Wind tunnel testing

- For earthquake loads code requires that stresses be calculated as the effect of a force applied horizontally at each floor or roof level above the base

**ALLOWABLE STRESSES**

**Wood**

- **National Design Specification for Wood Construction** give allowable unit stresses in structural lumber and glue laminated timber
  - Allowable stresses for extreme fiber in bending
  - Tension parallel to the grain
  - Horizontal shear
  - Compression perpendicular and parallel to the grain

- Stresses given are for normal loading and must be adjusted according to various conditions

- **Repetitive use:** factor C, equals 1.15 is used when several beam members such as joists or rafters are used together. In order to use...
  - Members cannot be over 4"t
  - Cannot be spaced more than 24" oc
  - Must be joined by traverse load distributing elements such as bridging or decking
  - Must be at least three members in a group

- **Duration of load:** amount of stress a wood member can withstand is dependent on time of load producing the stress
  - **Normal duration of load:** allowable design loads are based on this and assumed to be 10 years
  - Duration of loads shorter than this the allowable stress may be increased according to the following
    - 15% for two months duration (snow)
    - 25% for seven days duration as for roof loads
    - 60% for wind or earthquake loads
    - 100% for impact loads
  - If a member is fully stressed to the maximum allowable stress for more than 10 years under conditions of maximum design load, the allowable stress cannot exceed 90% of those listed in the tables

- **Fire-retardant treatment – NDS-2001 National Design Specifications for Wood Construction:** states that the effect of retardant chemicals on strength must be considered

- **Size factor adjustment:** Design values for bending, tension and compression parallel to the grain for visually graded dimension lumber 2” to 4” thick must be multiplied by size factors given at the beginning of Tables 4A, 4B and 4E of NDS-91 of the national Design Specifications for Wood Construction
  - When the depth of a rectangular sawn bending member 5” or thicker exceeds 12” bending design values $F_b$ must be multiplied by a size factor determined by the formula:
    \[ C_r = \left( \frac{12}{d} \right)^{1/9} \]
  - There is also a slenderness factor adjustment for unsupported beams
Steel

- Allowable stresses for structural steel are expressed as a fraction of the yield stress of the steel and vary with type of stress the member is under (shear, compression, bending and tension) and with unsupported lengths and geometry of the section.
  - More common code requirements for allowable stress are as follows:
    - For tension on the gross area
      \[ F_t = 0.6F_y \]
    - For tension on the net effect area
      \[ F_t = 0.5F_u \]
    - For shear on gross sections
      \[ F_v = 0.40F_y \]
    - At beam end connections were the top flange is coped and similar conditions where failure might occur along a plane thru the fasteners allowable shear stress is
      \[ F_v = 0.30F_y \]
    - For bending where the beam is laterally supported and the section meets the requirements of a compact section and is loaded in the plane of the minor axis
      \[ F_b = 0.66F_y \]
    - For bending where the beam is not a compact section but where it is supported laterally
      \[ F_b = 0.60F_y \]

- Allowable stresses for bolts, rivets and threaded parts are based on the type of load place on them and are given as values in kips per square inch based on the ASTM designation of the fastener or as a fraction of the minimum tensile strength of the type of fastener.
- Allowable stresses for welds are based on the yield strength of the base metal or on the nominal tensile strength of the weld metal.
  - Allowable stress is then multiplied by the area of the weld.

Concrete

- IBC Ch. 19 makes reference to Building Code Requirements for Reinforced Concrete, ACI 318 published by the ACI.
- Concrete construction is based on the specified compressive strength \( f'_c \) expressed in pounds per square inch.
- Samples for strength tests are taken for each class of concrete placed:
  - Must be taken not less than once per day
  - Not less than once for each 150yd\(^3\)
  - Not less than once for each 5000ft\(^2\) of surface area of slab or wall
- Average of all sets of three consecutive strength test must equal or exceed \( f'_c \) and no individual test can be less than 500psi below the \( f'_c \) value.
CONSTRUCTION REQUIREMENTS

Wood
- Bottom of wood joists must be at least 18” above exposed ground and bottom of wood girders must be at least 12” above ground unless they are treated or made of a species with a natural resistance to decay
- End of wood girders entering masonry or concrete walls must be provided with a 1/2” air space on top, sides and end unless the wood is of natural resistance to decay or treated
- Foundation plates and sills must be treated or made of foundation redwood
- Under floor areas such as crawl spaces must be ventilated with openings having a net area of not less than 1ft² for each 150ft² of under floor area and the must be place to provide cross ventilation
- Wood used for construction of permanent structures located nearer than 6” to earth must be treated or wood of natural resistance to decay
- All wood used as structural members must be protected from exposure to the weather and water with approved protection
- Fire stops are required in walls at the ceiling and floor levels and at 10’ intervals both vertical and horizontal
- Fire stops are required at interconnections between concealed vertical and horizontal spaces such as soffits and dropped ceilings
- Fire stops are required in concealed spaces in stairway construction and in vertical openings between floors and the roof that could afford a passage for fire

Steel
- Roof systems w/o sufficient slope for drainage be investigated to ensure stability under ponding conditions
- Horizontal framing members be designed for deflection criteria and ponding requirements
- Trusses longer than 80’ be cambered for the dead load deflection

Concrete
- Construction loads cannot be supported nor any shoring removed until concrete has sufficient strength to safely support its weight and loads placed on it
  - However: some formwork can be removed if the structure in combination with remaining formwork can support loads
- There are limitations on amount and placement of conduits and other pipes embedded in concrete so as to not decrease the load resisting area.
  - Aluminum conduits cannot be embedded unless effectively coated to cover to prevent aluminum-concrete reaction or electrolytic action between steel and aluminum
  - Pipes carrying fluids or gasses must be pressure tested prior to placement of concrete
- The size and bending of reinforcement are clearly spelled out to ensure that a sufficient bond is developed between the concrete and steel and that all reinforcement acts together
- Minimum concrete cover over reinforcing is specified