LESSON 4
BUILDING CONSTRUCTION
SESSION 2

Objectives
- The Student Shall:
  - List 5 fire spread concerns associated with Heavy Timber Construction
  - Identify 2 structural concerns related to Heavy Timber Construction

Objectives
- The Student Shall:
  - Identify 5 types of wood frame construction
  - List 8 fire spread concerns associated with all wood frame structures
  - Identify the inherent structural concerns in each of the 5 types of wood frame construction
Building Construction

**Objectives**

- The Student Shall:
  - Identify and explain the strategic considerations related to fires involving truss construction
  - Give an example of hybrid construction and the potential impact on fire department operations

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Building Construction

**Objectives**

- The Student Shall:
  - Define both vertical and horizontal collapse zones
  - List 3 types of wood frame wall collapse
  - Identify 3 types of masonry wall collapse
  - Identify 4 types of wood floor collapse

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Building Construction

**Heavy Timber Construction**

- NFPA Class IV -- Mill Construction
  - Exterior walls = brick / masonry
  - Interior structural members made of substantial wood
    - Columns at least 8” x 8”
    - Joists at least 6” x 10”
    - 3” side-laid planking floors covered by 1” top plank
    - Combustible roof (Heavy Timber Truss)
Heavy Timber Construction

- Major advantage
  - Structural integrity of members
  - Small surface to mass ratio
  - Harder to ignite
  - More resistant to collapse
- No concealed spaces
  - Stream penetration ability

Includes:
- Textile mills
- Factories
- Churches

Heavy Timber: Fire Spread Concerns

- Structural Fire Load
  - Massive amount of wood
  - Retain integrity
    - Small surface to mass ratio
  - May be soaked by years of process-related materials
    - Oils / Greases / easily ignited fluids
    - Dust
    - Increase ignitability
Building Construction

**Heavy Timber: Fire Spread Concerns**

- **Radiant Heat**
  - Exposure problem
  - Has ignited buildings up to 1000’ away
  - Flying brand problems
  - Beyond capability of most FD’s
- Defensive strategy
  - Establish collapse zones
  - Consider secondary collapse threat
  - Protect exposures

- **Hazardous Processes**
  - Plastics
  - Flammable Liquids & Gases
  - Hot fire production
    - Higher BTU production
  - Heavy floor loads
  - Heavy Roof Loads
    - Earlier collapse

- **Renovations**
  - Condos / Museums / Retail
    - Lightweight construction
    - Drop Ceilings
    - Voids created where concealed spaces did not exist
    - Added weight to structure
    - May overtax old sprinkler system
    - Multi-tenant occupancy
    - Change in fire hazard profile
Heavy Timber: Fire Spread Concerns

- Inadequate Sprinkler System
  - Lack of maintenance
  - Insufficient for hazard
    - Occupancy changes without fire protection upgrade
    - Current fire load greater than that for which system was originally designed

Heavy Timber: Structural Concerns

- Collapse rare in early stages
- Later stage collapse
  - Floor collapse followed by wall collapse
- Exception:
  - Buildings which have had repeated fires
  - Years of rot and neglect
  - Renovation-created structural compromise
  - Fire wall presence may limit damage

Heavy Timber: Structural Concerns

- Steel Spread Plates
  - Tie opposite walls together
    - May be tied into timbers
- Indicators:
  - Decorative stars
  - Circles / squares / diamonds
Heavy Timber: Structural Concerns

- Steel Spreader Plates
  - Unprotected steel rod
  - Symmetrical pattern plates
    - Built into original design of structure
  - Arbitrary pattern plates
  - Placed to support weakened wall
  - Exercise extreme caution
  - May cause change in strategy

Both will be adversely affected by the heat of a fire.

Wood Frame Construction

- NFPA Class V
- All structural elements are wood
  - Entire building combustible
  - Rarely higher than 3 or 4 stories
  - Include
    - Private dwellings
    - Churches
    - Tenements
    - Row houses
    - Mixed-Use Occupancies

Wood Frame Construction

- 5 Types:
  - Braced frame
  - Balloon Frame
  - Platform Frame
  - Truss Construction
  - Wooden I Beam Construction
Wood Frame: Fire Spread Concerns

- **ALL wood frames:**
  - Unenclosed Stairways
    - Path of least resistance for fire and smoke travel to upper floors
    - Trap occupants and FF’s on upper floors
  - Hose placement priority
  - Reason for Vent, enter, search (VES) operations
  - Multiple avenues of approach

Wood Frame: Fire Spread Concerns

- **ALL wood frames:**
  - Combustible Exterior
    - Autoexposure
  - Closely-spaced buildings
  - Radiant Heat
  - Combustible siding
    - Asphalt (Gasoline) siding
    - Must be kept wet

Wood Frame: Fire Spread Concerns

- **ALL wood frames:**
  - Combustible Roof
    - Flying brands
      - May require Brand Control Group on leeward side of fire
    - Dangerous working platform
      - Platform
      - Aerial Ladder
      - Roof Ladder
Wood Frame: Fire Spread Concerns

- ALL contiguous wood frames:
  - Attached cockloft potential
  - Attached cellars potential
    - Must be investigated early
  - Combustible shafts
    - Totally enclosed
    - Partially enclosed

Wood Frame: Structural Concerns

- ALL wood frames:
  - Structural additions create eccentric load and increase chance for wall collapse
    - Eccentric loads create bending tendency on supporting member
  - Fire escapes
    - Lack of maintenance
    - Destruction of supporting wall
    - Overload

- Veneer wall coverings
  - Misleading size-up (Check sides & rear)
  - Create eccentric load
  - Single thickness of masonry
    - Decorative brick, stucco, or stone
Wood Frame: Structural Concerns

- **ALL wood frames:**
  - Veneer wall coverings
  - Dependent on wall for stability
  - Attached by unprotected metal "ties"
    - Fire spread in space between veneer and supporting wall destroy ties
    - Collapse hazard

Braced Frame

- **Usually at least 100 years old**
- **Walls are Non-bearing**
  - Structural weight on vertical posts and horizontal girts
    - Wood beams 4" x 4" or 6" x 6"
  - Mortise and tenon connection
    - Proper joint connection is critical to stability

Braced Frame: Fire Spread Concerns

- **Old, dried out wood**
  - Reduced ignition temperature
- **Fire attack on mortise and tenon joints create structural instability**
- **Buildings usually closely-spaced**
Building Construction

**Braced Frame: Structural Concerns**

- Failure point is usually mortise and tenon joint
  - Point of connection
  - Least amount of wood
- Wood dimension of lower floors same as upper floors
  - No compensation for added weight above
  - Greatest structural weight on ground floor

- Fail without warning
  - Inward-outward collapse
- Heavy fire on lower floor will cause overloaded structural supports to crack and fail at 1st floor/2nd floor connection
  - Lower floor falls outward
  - Upper floor(s) fall inward
  - May lean-over if unattached

**Balloon Frame**

- All studs continuous for full height of building
- No inherent fire stopping between floors
- Stacked windows are reason for suspicion
Balloon Frame: Fire Spread Concerns

- Rapid fire extension from floor to floor via open exterior wall studs
  - Expect basement fire to spread to attic
  - Open floor joist channels promote horizontal spread under floor
  - Personnel-intensive
  - Smoky due to lack of oxygen in voids
  - Extensive and creative pre-control overhaul
  - Place lines in anticipation of fire spread

Balloon Frame: Structural Concerns

- Smaller vertical members (2” x 4”) holding up larger horizontal members (floors / roof) [3’ x 10”]
  - Non-bearing walls often fail in 90° collapse
  - Floors may be left intact and intensify radiant heat problem
  - Bearing wall failure usually causes complete failure
  - Roof and/or floor failure may cause wall failure and vice-versa

Platform Frame:

- All studs are one story in height
- Floors provide some inherent fire stopping
  - Designed to confine fire to one floor
- Usually limited to 3 floors
  - Each floor is a separate platform built on top of the one below
Platform Frame: Fire Spread Concerns

- Utility pokethroughs negate the integrity of the platform design
  - Plumbing
  - Electrical
  - HVAC ductwork
  - Soffits

Platform Frame: Structural Concerns

- Fail in similar ways to balloon frame
  - Bearing wall destruction
    - Walls with windows fail more readily
    - Floors will fail from the height of the bearing wall failure
    - Floors may burn through and cause localized collapse

TRUSS CONSTRUCTION

- As strong as its weakest link
- Failure of any part of the truss is likely to collapse entire truss
- Once truss is involved in fire:
  - Withdrawal and roll call
  - Establish collapse zones
  - Switch to defensive strategy
  
  EARLY ID = KEY TO SAFETY
TRUSS CONSTRUCTION

Assess fire conditions
  - Pre-flashover: Contents fire
    - Usually no structural compromise
    - Marginal interior operation
    - Recon / monitor roof, floor spaces, cockloft
  - Post-flashover; structure involved
    - Expect collapse
    - Roof ventilation:
      - Conduct from aerial device

TRUSS CONSTRUCTION
Lightweight Wood Truss

MAY FAIL IN AS LITTLE AS 5 MINS.
  - 5 minutes of fire exposure, not 5 minutes after FD arrival
  - NO WARNING!!!
    - 2" x 4" wood members
    - Parallel Chord – floor and flat roof
    - Peaked – roof
      - Condos / Townhouses
      - Newer housing developments
      - Renovations

TRUSS CONSTRUCTION
Lightweight Wood Truss

Concerns: Connection methods:
  - Unprotected steel: Prone to failure
    - Sheet metal surface fastener
    - "Gusset plate" or "Gang Nail"
      - Penetrates only ¼ - ½" into the wood
      - Pulls free and curls up when exposed to heat
      - Rough handling at site or during transportation weakens prior to installation
      - May be insufficiently fastened
      - Moisture caused corrosion
      - Impact load failure
TRUSS CONSTRUCTION
Lightweight Wood Truss

- Concerns:
  - Minimal dimension of wood
    - 2' x 4' may be 1-1/2' x 3' or less
  - Failure to compartmentalize
    - Open attic
    - Sheetrock only reaches ceiling
    - Poke throughs
  - Open construction of truss
    - Each piece simultaneously exposed
    - Horizontal and vertical spread
    - All trusses in area exposed at once

TRUSS CONSTRUCTION
Composite Lightweight Truss

- Wood top and bottom chords
- Steel web members
  - Wood mortised out to fit stamped steel into top and bottom chord
  - Pin connector
  - Wood mass compromised at mortise
  - Steel conducts heat into mortise
  - Early failure as in other lightweight trusses

TRUSS CONSTRUCTION
Bowstring Truss

- Deadliest type of roof
- Humpback Roof Design
  - May be hidden by parapet
  - 4 bearing walls
- Open truss area collects heat from fire below
- Spaced as much as 20' on center
  - One truss failure = 40’ wide opening
  - Retreat perpendicular to trusses
**TRUSS CONSTRUCTION**

**Bowstring Truss**

- Truss ends supported by side walls
- Front and rear walls support sloping hip rafters extending from front and rear truss sections
- Collapse without warning
  - Roof collapse causes inward-outward collapse of end walls
  - Transfers roof load to sloping hip rafters in end walls

**Strategic Considerations**

- Early identification is the key to safe operations
- Recon of truss area critical
  - Use man-made openings
  - Operate from aerial device
  - No fire in truss
  - Reinforce marginal interior operation
  - Continue to monitor truss area
  - Fire involves truss
    - Withdraw personnel
    - Pursue defensive strategy

- Reports from Roof critical to strategic decision
- Beware of conflicting roof / interior reports
  - Interior reports minimal heat and smoke condition
  - Roof reports heavy fire
- WITHDRAW IMMEDIATELY!!!
Building Construction

Wooden I-Beams

- Used in floors and roof construction
- 2” x 4” top and bottom chord
- Plywood or chipboard web
  - Adhesive material adds to fire load
  - Provides some lateral fire-stopping
- 5 minute collapse potential
- No warning

Building Construction

Hybrid Construction

- Makes use of more than one construction type
  - Walls & partitions are unprotected metal stud (Class 2)
  - Floors supported by steel truss
  - Plywood floors
  - Roof is wood, usually truss (Class 5)
- Very little fire resistance
  - Prone to early & progressive collapse
  - Preplan is crucial

Building Construction

Hybrid Construction

- Can be created by renovations or alterations
  - Heavy timber may be renovated to include lightweight materials
  - Extensive use of new technology / building methods
  - Meets structural codes, but so do trusses (Any questions?)
Collapse Considerations

- Types of Wall Collapse
  - Wood frame:
    - 90° angle
    - Full height of wall
    - Inward-outward
    - Usually braced frame
    - No warning – MOST DEADLY
    - Lean-over
    - Corner buildings

- Masonry Wall Collapse
  - 90° angle
  - Wall separates at top
  - Inward-outward
  - Bowstring truss
  - Curtain fall
  - Veneer
  - Heavy Timber

- Types of Floor Collapse
  - Tent Floor
  - Pancake Collapse
  - V Shape
  - Lean To
    - Supported
    - Unsupported
**Collapse Considerations**

- **Collapse Safety**
  - Any collapse threat should cause an immediate reevaluation of the current strategy
  - Pre-established evacuation signal
    - Radio emergency transmission
    - Apparatus air horn / siren

- **Strong Command presence**
  - Command and control
  - Roll Calls
  - Establishment of Collapse Zones
    - Vertical = at least height of facing wall
    - Horizontal = Entire width of weakened wall
  - Consider secondary collapse
    - May cause expansion of zones

**Summary**

- **Heavy Timber Construction**
- **Wood Frame Construction**
  - Braced Frame
  - Balloon Frame
  - Platform Frame
  - Lightweight Truss
  - Wooden I-Beam
- **Bowstring Truss Construction**
Summary

- Hybrid Construction
- Collapse Zones
  - Vertical
  - Horizontal
- Masonry Wall Collapse
- Wood Frame Wall Collapse
- Wood Floor Collapse

Conclusion

- Be a student of building construction
- Preplan buildings
- Utilize an information recall system
  - Palest ink is better than the sharpest memory

Next Lesson

- Lesson 5: Engine Company Operations
- Reading Assignment:
  - Fireground Strategies
  - Ch. 2