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

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

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)

Building Construction

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

Building Construction

Heavy Timber Construction

- Includes:
  - Textile mills
  - Factories
  - Churches

Building Construction

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

Building Construction

Heavy Timber: Fire Spread Concerns

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

Building Construction

Heavy Timber: Fire Spread Concerns

- 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 life hazard profile

Building Construction

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

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Building Construction

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

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Building Construction

Heavy Timber: Structural Concerns

- Steel Spreader Plates
  - Tie opposite walls together
    - May be tied into timbers
  - Indicators:
    - Decorative stars
    - Circles / squares / diamonds

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Building Construction

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

Building Construction

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

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Building Construction

Wood Frame Construction

- 5 Types:
  - Braced frame
  - Balloon Frame
  - Platform Frame
  - Truss Construction
  - Wooden I Beam Construction

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Building 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

Building Construction

Wood Frame: Fire Spread Concerns

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

Building Construction

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

Building Construction

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

Building Construction

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

Building Construction

Wood Frame: Structural Concerns

- ALL wood frames:
  - Veneer wall coverings
    - Misleading size-up (Check sides & rear)
    - Create eccentric load
    - Single thickness of masonry
      - Decorative brick, stucco, or stone

Building Construction

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

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Building Construction

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

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Building Construction

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

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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

Building Construction

Braced Frame: Structural Concerns

- 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

Building Construction

Balloon Frame

- All studs continuous for full height of building
- No inherent fire stopping between floors
- Stacked windows are reason for suspicion

Building Construction

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

Building Construction

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

Building Construction

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

Building Construction

Platform Frame: Fire Spread Concerns

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

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Building Construction

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

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Building Construction

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

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Building Construction

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

Building Construction

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

Building Construction

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

Building Construction

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
      - Pokethroughs
  - Open construction of truss
    - Each piece simultaneously exposed
    - Horizontal and vertical spread
    - All trusses in area exposed at once

Building Construction

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

Building Construction

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

Building Construction

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

Building Construction

TRUSS CONSTRUCTION
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

Building Construction

TRUSS CONSTRUCTION
Strategic Considerations

- 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?)

Building Construction

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

Building Construction

Collapse Considerations

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

Building Construction

Collapse Considerations

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

Building Construction

Collapse Considerations

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

Building Construction

Collapse Considerations

- Collapse Safety
  - 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

Building Construction

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