Building Construction Review and size up

Source: Fire Officer's Handbook of Tactics, Third Ed., John Norman

Size up

- What should we consider when sizing up a building?
  - Construction
  - Occupancy
  - Time

- Officers, Incident Commanders, Safety Officers need to continually conduct size up, not just upon arrival, but as incident continues.

- As officer is inside while team is working, officer must know how to predict building collapse

Deaths per 100,000 fires (‘96-2000)

- Vacant Buildings:
  - 18.1 percent of deaths
  - What were we risking our lives for?
- Stores:
  - 12.9 percent of firefighter deaths
- Public Assembly:
  - 12.9 percent of firefighter deaths
- Residential:
  - 3.7 percent of firefighter deaths
  - At least we were risking our lives for someone, possibly.

Occupancy defines risk

- Why do we risk our lives when there is no occupancy but a high risk of injury or death?

- Factories and warehouses:
  - have large, open floor areas, which may present us with fires that are beyond ability of hand line to control.
  - High danger of truss construction with fires spreading across ceilings which are often unprotected

Risks of occupancy

- Retail areas:
  - Smaller, but more difficult to advance hand lines.
  - Heavy fire load
  - Hazardous materials a strong possibility
    - True Value, Rite Aid, Hallowick

- Residential:
  - All types of hazards, but usually designed to be lived in, and has layouts we typically understand

Time: Time of day, Time of Year

- Time of day should give us idea of the occupancy / life hazards.
- Schools at 2pm vs. Schools at 12am
- Church on Sunday at 12, or Dec. 25th at 12am
- Residential:
  - 5am, 2 cars in driveway
  - 2pm, no cars, no lights
- Holiday time: gifts? Extra stock in stores?
- Manpower shortages?
  - Hunting season? Summer nights?

Time

- How long has the fire been burning?
  - What is effect of time on structural stability?
  - How far has fire spread?
  - Can anyone survive in the building?

- How long until other resources arrive at our location?
  - Water, trucks, manpower, additional engines, RIT team, etc

- How long until the building flashes?

Burn Time: Residences

- No fire venting through windows:

  = fire has not been at flashover stage for more than a minute or two

  - (assuming it did not start in a void space)
- Fire that has vented out of one or two windows:

  = usually confined to one room and has not been at flashover for anywhere from 1 – 5 minutes.
- Other non-vented windows on each side of the ones that are showing fire, good sign! Shorter burn time.
- The more windows showing fire, the longer the burn time.
- Fire on two floors:

  = prolonged burning or an accelerant to spread fire rapidly. Both are dangerous!

Look for signs of advanced fire

- Fire burning through a wooden wall (not merely on the surface)
  - Collapse may be imminent, since wooden walls support roof joints and floor
  - Many firefighters injured by collapsing staircases from fire below
- If there is no outward indication of these situations, use a standard interior attack.
- If initial attack makes good progress, keep fighting
- If initial attack does not make progress, pull out!
- Continue to evaluate the progress of the fire as the attack continues.

Report signs of progress

- Incident Commander needs to have reports from all interior crews:
  - Are all crews knocking down fire?
  - Is one crew succeeding, but other crew getting overwhelmed?
    - If so, pull out!
  - What are the timers saying on our efforts?

Building Construction

- Construction has many implications on fire spread and firefighting.
  - Degree of compartmentation of a building can promote or thwart spread of fire
  - Large, open floor spaces provide an opportunity for fire to spread readily through exposed area
  - Older buildings are constructed of wood – the structure creates a heavy fire load
  - Newer metal buildings add nothing to fire load.
    - Exception is metal deck roof fire: Fire under roof, heats the tar on the roof. When exposed to fire, drips fireballs on people.

Building Construction

- Hidden voids:
  - Fire travels through the voids.
  - Voids are responsible for destruction by fire of more buildings than any other construction related fire.
  - Cocklofts, pipe chases, and channel-rail voids provide concealed highways.

Building Construction

- Ability to resist collapse when threatened by fire.
  - Buildings are composites of materials joined together in a way designed to resist the pull of gravity.
  - Fire attacks these materials, breaks their hold on each other, causes them to fail.
  - Some materials are resistive to failure. Some materials help the failure along.

Types of Construction

- Type 1 Fire Resistive
- Type 2 Non-Combustible
- Type 3 Ordinary Construction
- Type 4 Heavy Timber
- Type 5 Wood Frame

Type 1: Fire Resistive

- Walls, partitions, columns, floors and roofs are non-combustible.
- Elements are designed to withstand effects of fire for a "limited time" and to prevent its spread.
- Poured or pre-cast concrete, steel framed buildings with an applied fire proofing
- For steel framed construction, must have fireproofing to protect the steel

Type 1

- Fire resistance of up to 4 hours
- Usually a skeletal framework, either of poured concrete or steel I-beams.
- Collapse is usually localized. Concrete on ceiling spalls or several of the I-beams sag.
- The load being supported generally remains in place.
- Buildings under construction, being poured in place, are supported by wood frames. These could collapse and drop the entire walls.

Type 2: Non-Combustible

- Walls, partitions, columns, floors and roofs are noncombustible.
- They provide less fire resistance. They do not withstand effects of fire and they do not prevent its spread
- “Non-combustible” refers to fuel contributed by the structural components, not to its resistance to spread the fire.
- Usually exposed metal floor and roof systems and metal or masonry walls.
- Any sizable fire in the contents of the building will rapidly destroy the structural integrity of the unprotected steel.
- These are least stable and most likely to collapse when exposed to fire. Metal deck on exposed steel-bar joists are a huge danger.

Type 2

- Most dangerous type of building, and most susceptible to collapse when exposed to fire!
- Why?
  - Large quantities of unprotected steel are used in its construction.
  - Steel's behavior under fire conditions creates a lot of problems.
  - A 100' long I beam heated uniformly to 1,000 degrees will expand 9 ½ inches lengthwise.
    - Results in walls being pushed down
  - At 1,500 degrees, steel loses strength, twisting, sagging, dropping its load.
  - After cooling, will contract in length while retaining its distorted shape.
  - The ends of the beams, once the steel shrinks, might no longer rest on its supports.

Type 3: Ordinary Construction

- Masonry or other non-combustible walls with a 2 hour fire-resistance rating.
- Floors, roofs and interior partitions made of wood.
- Wood is smaller than heavy timber.
- Easier to ignite and offers less resistance to burn-through or collapse.
- Most brick buildings are made this way.
- Residential, commercial & manufacturing buildings can be type 3.
- Think of an Ordinary Construction as an “Oven”. All solid brick outside with wood inside.

Type 3

- These buildings are more prone to burn-through than collapse, especially under normal floor –load limits.
- The floor or roof sheathing above burns though long before the floor joists fail.
- Firefighters are not likely to be working on the falling surface, but more likely working below of the danger, unaware of the overhead conditions.
- Hung ceilings or smoke or fire can obscure danger.
- Ex: Plumbing supply warehouse – high floor loads are the main danger.
- Dangers are not easily discovered before failure.

Type 4: Heavy Timber

- Exterior walls are masonry or other non-combustible material with at least a 2 hour fire-resistive rating.
- Interior columns, beams, and girders are of heavy timber (minimum 8 x 8), and floors and roofs are of heavy planks (3 x 6 minimum).
- Very heavy fire load, but provide a lot of fire resistance
- Sheer bulk of wood make them difficult to ignite.
- Lack of hidden voids makes firefighting less complex than in regular buildings.
- Once ignited, requires substantial amount of water to cool large surfaces. If not extinguished quickly, will produce very hot fire.

Type 4

- Very stable buildings due to size of their load bearing members
  - Usually 12 x 12 wooden columns and brick walls

- More common danger is a building which had already had a fire previously, weakening the building already.

Type 5: Wood frame

- Walls, floors and roofs that are made wholly or in part of wood or other combustible material.
- Wood frame buildings actually pose less of a collapse hazard than non-combustible buildings.

Type 5

- This is "4th" safest type of building, safer than Type 2.
- Standard wood frame home, with dimensional lumber, is more likely to burn through, chasing personnel out, before it collapses. The warning is more pronounced. Thus, safer as collapsed is predictable.
  - Type 2 does not give warning before collapse.
- However, lightweight truss construction presents much greater danger.

Causes of Collapse

- Structural weakness due to faults in design, shoddy workmanship, and illegal or improper renovations.

- Fire damage to wood structural members
  - Wooden structural elements burn through at a rate of about 1 inch for every 45 minutes of open burning time.
  - If fire can attack two sides of a joist, the standard 1 ½ inch wide 2x8 jist will burn completely through in less than 45 minutes, and lost load carrying ability long before that.

Causes of collapse

- Heating of unprotected steel.
  - Lightweight steel-bar joists lose strength in as little as 5-10 minutes of fire exposure.
  - Steel sags prior to total failure, so it may provide warning to firefighters working on a steel deck, but not visible to firefighters under the deck.
- Cooling of highly heated cast-iron columns or facades.
  - Cast iron is older construction material.
  - Very brittle.
  - Unsuitable for use as beams, but was used as columns a lot in past.

Causes of collapse

- Explosions of fuels, explosives or from backdraft
  - Explosions can exert a lot of force on a brick wall and cause collapse easily.
  - Prevent backdraft: vent at top prior to entering

- Overloading floor and expansion of absorbent materials
  - Newspapers, bales of materials (cotton, rags, etc) can absorb water and create extreme weight, causing collapse failure. Also swelling of items can push walls and knock columns out of plumb.

Causes of collapse

- Overloading of the floors and roof
  - Accumulating snow is good example.
  - Run off from fire streams, and weight of the water
  - 1,000 gpm master stream adds approximately 8,500 lbs to building every minute!
  - 1 ft deep over an area 20 x 20 ft wide represents nearly 25,000 pounds added to the load
- Cutting or removing structural members during overhaul
  - Avoid removing any structural components unless they are not supporting weight other than their own.

Causes of collapse

- Vibration and impact load
  - Sudden shocks and impacts can cause loss of supports of loads.
  - Shaky structures may not be able to withstand the shock

Collapse indicators

- Occupancy by problem businesses
  - Heavy loads, such as with printing shops, appliance dealerships, plumbing stores
- Construction
  - Discussed previously
- Overloaded floors
  - Make sure to observe the floor loading to see if it presents a risk of collapse to the floor below
    - Heavy equipment, water loads

Collapse indicators

- Heavy fire burning more than 20 minutes
- No appreciable runoff
  - Water is collecting somewhere! Weight is dangerous.
- Cracks or bulges in walls
  - Collapse may be imminent when these appear, unless they have been there for years.
  - Look for expanding cracks
  - Once discovered, this is cause for immediate evacuation if extensive

Collapse indicators

- Water or smoke seeping through a solid wall
  - This indicates a buildup of pressure on the interior as well as a weakness in the wall construction
  - Leads to failures

- Roof pulling away from wall
  - Evidenced by relatively clean wood on the ends of beams that were set into the wall or by gaps in the roofing material at the wall joint

Collapse indicators

- Roof sagging or feeling spongy
  - This is the last warning sign before collapse
  - Evacuate immediately
  - Consider determining the cause of the sagging
- Any obvious movement of floors, walls or roofs
  - Might be too late once these signs are noticed
- Noises
  - Creaking or groaning sounds are heard in wood buildings as movement occurs
  - Cracking timbers may also be audtible

Collapse indicators

- Plaster siding off the walls or plaster dust hanging in the air
  - When shifting occurs on the wall, the plaster may be wiggled off in fairly large chunks.
  - If plaster dust is obvious in an area that has otherwise been untouched, suspect that subtle movement of structure is taking place.
  - Windows may also be cracked or doors may be swinging by itself.
    - More likely in class 4 buildings.