National Fire Fighter Near-Miss Reporting System
May-Structural Collapse

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Part 1: Introduction

The built-environments that form our response districts and communities pose unique challenges to the day-to-day responses of U.S. fire departments and in their subsequent operations at structural alarms. With the variety of occupancies and building characteristics present, there are definable degrees of risk potential with recognizable strategic and tactical measures that must be taken. Although each occupancy type presents variables that dictate how a particular incident is handled, most company operations evolve from basic strategic and tactical principles rooted in past performance and operations at similar structures.

Combat fire suppression and rescue is typically considered a primary response priority of fire and emergency service agencies. We plan, prepare, train, outfit and anticipate the call for fire suppression services - that alarm dispatch that communicates a possible or actual report of fire in a structure and occupancy and the need to dispatch, deploy and orchestrate the equipment, resources, manpower and expertise necessary to safely handle the fire and incident.

Combat fire suppression and interior rescue and support operations, incident severity, magnitude and frequency can vary widely in their application and potential as an incident response factor. There is one element that is a constant in deployment, response and operations during combat structural fire operations; and that is the interface and interaction with the structure, the occupancy and its inherent features, hazards, risks and performance characteristics.

Every year, 100 or more firefighters die in the line of duty in the United States - on average, about one every 80 hours. Every six hours, a firefighter is seriously or critically injured on the job. Most of these fatalities and injuries could be prevented if firefighter safety was a primary concern of every fire firefighter, fire department and fire service organization. Recognizing that much can be done to prevent these deaths and injuries, the Firefighter Life Safety Initiatives Program was created to unite the fire service to address the problem, and more importantly, find and apply solutions.

Strong Efforts to Reduce LODDs

Following the goals of the United States Fire Administration to reduce line-of-duty firefighter fatalities by 50 percent by the year 2014, the National Fallen Firefighters Foundation (NFFF), partnering with fire organizations and fire service leaders from around the United States, created pathways and programs by which to prevent line-of duty firefighter deaths and, by extension, serious injuries. These are the Everyone Goes Home Program and the 16 Firefighter Life Safety Initiatives, created from the first National Firefighter Life Safety Summit in 2004, and six subsequent mini summits held between 2004 and 2007.

Sixteen Firefighter Life Safety Initiatives

Recognizing the need to do more to prevent line-of-duty deaths and injuries, the National Fallen Firefighters Foundation has launched a national initiative to bring prevention to the forefront. In March 2004, the Firefighter Life Safety Summit was held in Tampa, Florida to address the need for change within the fire and emergency services. Through this meeting, 16 Life Safety Initiatives were produced to ensure that *Everyone Goes Home®*. The first major action was to sponsor a national gathering of fire and emergency services leaders. Organized by the National Fallen Firefighters Foundation, the held in Tampa, Florida, in March 2004 produced 16 major initiatives that will give the fire service a blueprint for making changes.

The National Fallen Firefighters Foundation (NFFF) has been developing a major role in helping the U.S. Fire Administration meet its stated goal to reduce the number of preventable firefighter fatalities. The Foundation sees fire service adoption of the summit's initiatives as a vital step in meeting this goal.

1. Define and advocate the need for a cultural change within the fire service relating to safety; incorporating leadership
2. Enhance the personal and organizational accountability for health and safety throughout the fire service.
3. **Focus greater attention on the integration of risk management with incident management at all levels, including strategic, tactical, and planning responsibilities.**
4. All firefighters must be empowered to stop unsafe practices.
5. Develop and implement national standards for training, qualifications, and certification (including regular recertification) that are equally applicable to all firefighters based on the duties they are expected to perform.
6. Develop and implement national medical and physical fitness standards that are equally applicable to all firefighters, based on the duties they are expected to perform.
7. Create a national research agenda and data collection system that relates to the initiatives.
8. Utilize available technology wherever it can produce higher levels of health and safety.
9. Thoroughly investigate all firefighter fatalities, injuries, and near misses.
10. Grant programs should support the implementation of safe practices and/or mandate safe practices as an eligibility requirement.
11. National standards for emergency response policies and procedures should be developed and championed.
12. National protocols for response to violent incidents should be developed and championed.
13. Firefighters and their families must have access to counseling and psychological support.
14. Public education must receive more resources and be championed as a critical fire and life safety program.
15. Advocacy must be strengthened for the enforcement of codes and the installation of home fire sprinklers.
16. Safety must be a primary consideration in the design of apparatus and equipment.

Operating inside a burning structure is always inherently dangerous, regardless of any specific building construction practices or materials. Firefighters and incident commanders must constantly evaluate, assess and consider the potential risks and benefits of taking an offensive strategy quickly and carefully before committing personnel to interior operations.

IAFC's 10 Rules of Engagement

The International Association of Fire Chief's (IAFC), in 2001, developed and published its "10 Rules of Engagement for Structural Firefighting" that apply to all fires:

ACCEPTABILITY OF RISK

1. No building or property is worth the life of a firefighter.
2. All interior fire fighting involves an inherent risk.
3. Some risk is acceptable, in a measured and controlled manner.
4. No level of risk is acceptable where there is no potential to save lives or savable property.
5. Firefighters shall not be committed to interior offensive fire fighting operations in abandoned or derelict buildings.

RISK ASSESSMENT

1. All feasible measures shall be taken to limit or avoid risks through risk assessment by a qualified officer.
2. It is the responsibility of the Incident Commander to evaluate the level of risk in every situation.
3. Risk assessment is a continuous process for the entire duration of each incident.
4. If conditions change, and risk increases, change strategy and tactics.
5. No building or property is worth the life of a firefighter.

With any structure, regardless of its construction type, materials, occupancy classification, age or size, strategic and tactical decision-making during combat structural fire operations demands a focused and continuing assessment of building structural integrity, fire behavior and construction performance to ensure the safety and integrity of tactical company missions within the incident action plan. It demands an intimate knowledge of construction techniques, engineering principals and performance measures.

The fire and emergency service profession expends a tremendous amount of time and effort in varying disciple areas to develop, expand or enhance knowledge, skills, abilities, proficiencies and capabilities. Yet when asked, "How much do you really know about building construction, performance and structural integrity?"; the response is typically far less than we would expect or have. The initial or continuing education process on the subject of building construction, principles, sciences or engineering is at best minimal, marginal or non-existent.

But still, we respond daily to structures, occupancies and buildings; placing personnel inside of these envelopes and enclosures, many times under untenable and hazards conditions, and command incident operations or undertake tactical assignments with little due regard to how the building will perform or with the poise, ignorance or audacity that we'll mange to knock the fire down, make the grab and take in the job, as successfully as we have in the past. You know, nothing has adversely affected your organization in the past like a Fire Fighter Line of Duty Death

(LODD) or serious event or you are conditioned to be fatalistic, that it's all part of the job and accept that "tonight could be the night".

Our world has evolved and changed. There are a variety of technological and sociological demands that create a continuing element of change in the built environment and our infrastructure. These changes influence the way we do business in the street, interface up close and personal with the buildings in your community and equate to the risks and hazards you and personnel will be confronted with. According to the U.S. Fire Administration's Annual Firefighter Fatalities Report, the most hazardous duty for firefighters in 2006, as in most years, was working on the scene of a fire incident. Thirty-six firefighters died while engaging in activities at the scene of a fire in 2006:

- Two Alabama firefighters were killed when they were crushed by a collapsing wall at the scene of a commercial structure fire in February, 2006.
- Two New York City firefighters were killed when they were caught in the collapse of a building during a fire fight in August, 2006.

In addition to the multiple firefighter fatality incidents described above, 11 firefighters suffered fatal traumatic injuries at structure fires in 2006:

- A New Jersey volunteer firefighter died of smoke inhalation at a fire in his home. After discovering the fire, the firefighter evacuated others and fought the fire as other firefighters responded.
- A Mississippi inmate volunteer firefighter became disoriented in a residential structure fire.
- A New Jersey volunteer firefighter died during a rescue attempt in a residential structure fire. The firefighter had located a civilian fire victim and was crawling toward the exit when a floor collapse claimed both lives.
- A Colorado career fire officer became disoriented or trapped in a residential structure fire. He died seven days later.
- An Indiana volunteer firefighter died after falling into the basement of a residential structure fire when fire-weakened flooring gave way.
- A Wisconsin firefighter fell through the fire-weakened floor of a residential structure and was trapped in the basement.
- A New Jersey firefighter was trapped by rapid fire progress in an apartment fire.
- A Maryland firefighter was trapped within a residential structure as he and other firefighters attempted to exit the building due to rapid fire development.
- An Indiana firefighter became disoriented in a large residence and died of smoke inhalation and burns.
- A Georgia firefighter became disoriented during a fire in an abandoned residence. He suffered fatal burns and died six days after the fire.
- A Texas firefighter was killed as he fought a structural fire in a commercial building. A collapse occurred and buried the firefighter under debris.

Two firefighters died in 2006 when fire-weakened floors gave way and dropped the firefighters into the basement of the structure. Both of these incidents involved the failure of engineered lumber products under fire conditions.

FEMA Director and former United States Fire Administration (USFA) Administrator, R. David Paulison provides firefighters with a simple, yet significant message. Chief Paulison states: "What we're trying to do is change the culture of the fire service. It's no longer acceptable to put your life on the line for a piece of property. Yes, we're going to save lives and we're going to put our lives on the line if we have to save somebody else. But stop and think what you're doing before you go into a burning building." The United States Fire Administration National Fire Data Center reports that "for a ten year period, 1997-2006, 23.5% of on-duty firefighter fatalities occurred at the scene of structure fires."

With any structure, regardless of its construction type, materials, occupancy classification, age or size, the majority of incidents requiring actual operation time occur when the structure is in use or vacant. Buildings in the United States can be classified within five fundamental construction types: Fire-Resistive, Non-Combustible, Ordinary (exterior protected), Heavy Timber and Wood Framed.

These are represented in various forms and sub-classifications within the National Fire Protection Association (NFPA) 220 Standard on Types of Building Construction, as well as within each of the Model Codes Standardization Council (MCSC) Recommended Types of Construction, and the three Model Building Codes, UBC, BNBC and SBC.

Part 2: Construction Types

Types of Building Construction based on the *combustibility and the fire resistance rating of a building's structural elements.*

- Fire walls, nonbearing exterior walls, nonbearing interior partitions, fire barrier walls, shaft enclosures, and openings in walls, partitions, floors, and roofs are not related to the types of building construction and are regulated by other standards and codes, where appropriate.

Key NFPA 220 Definitions

- **Fire Resistance Rating.** The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of NFPA 251.
- **Flame Spread Index.** A number obtained according to ASTM E 84 or UL 723.
- **Limited-Combustible Material.** Refers to a building construction material not complying with the definition of noncombustible that, in the form in which it is used, has a potential heat value not exceeding 8141 kJ/kg (3500 Btu/lb), where tested in accordance with NFPA 259 and includes either (1) materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of 3.2 mm (in.) that has a flame spread index not greater than 50, or (2) materials, in the form and thickness used having neither a flame spread index greater than 25 nor evidence of continued progressive combustion, and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread index greater than 25 nor evidence of continued progressive combustion, when tested in accordance with UL 723 or ASTM E 84.

- **Noncombustible Material.** A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Materials that are reported as passing ASTM E 136 are considered noncombustible materials.

There are five basic classifications of building construction;

Type I Fire Resistive

Type I fire-resistive construction is a type in which structural elements are of an approved noncombustible or limited combustible material with sufficient fire-resistive rating to withstand the effects of fire and prevent its spread from story to story. Concrete-encased steel, monolithic-poured cement, and steel with spray-on fire protection coatings are typical of Type I, Generally, the fire-resistive rating must be three to four hours depending on the specific structural element. Fire-resistive construction is used for high-rises, large sporting arenas, and other buildings where a high volume of people are expected to occupy the building.

Most Type I buildings are typically large, multistoried structures with multiple exit points. Fires are difficult to fight due to the large size of the building and the subsequent high fire load. Type I buildings rely on protective systems to rapidly detect and extinguish fires. If these systems do not contain the fire, a difficult firefight will be required. Fire can spread from floor to floor on high-rises as windows break and the next floor windows fail, allowing the fire to jump. Fire can also make vertical runs through utility and elevator shafts. Regardless, firefighters are relying on the fire-resistive methods to protect the structure from collapsing.

- These buildings can be recognized by having a skeletal frame work including either poured concrete or heavy steel I beam construction with fire protective coatings.
- These buildings will generally have localized collapse and possible spalling of the concrete and have a potential for beam sagging prior to the total collapse.
- Generally the load will be supported and the load will be in place.
- There have been cases of areas totally consumed by fire that did not produce threat of building or area collapse.
- Care must be taken in these buildings that are under construction where the fire involves formwork or unprotected steal I beams.

Collapse Hazards

- There are two basic types of fire-resistive construction: reinforced concrete buildings and structural steel buildings.
- Both are designed to resist fire which burns out an entire floor without spreading flames to other floors or collapsing the structure.
- However, during serious fires a collapse danger does exist with both types of construction. In reinforced concrete buildings, heated concrete ceilings collapse on top of firefighters; in steel skeleton buildings, heated concrete floors buckle upward.
- Both of these structural failures are caused by spalling, the rapid expansion of heated moisture inside the concrete.
- Small amounts of moisture, normally trapped inside concrete, expand when heated by fire and create an internal pressure within the concrete. This pressure can cause heavy sections of concrete to crack away from a ceiling and collapse down onto fire operations or on top of a firefighter.

- This type of collapse occurs in a building without a suspended ceiling, where the concrete ceiling above the fire is directly exposed to flames below.
- In steel skeleton construction, the under side of each floor is not concrete; each floor consists of light-gauge corrugated steel sheet which supports several inches of concrete floor above it.
- Heat from a fire reaching the under-side of the corrugated steel is conducted through the concrete floor directly above.
- The moisture in the concrete above the steel is heated, and the internal pressure develops in the concrete above.
- Consequently, the expanding concrete buckles upward suddenly 6 to 12 inches.

Type II Non-Combustible

Type II noncombustible construction is a type in which structural elements do not qualify for Type I construction and are of an approved noncombustible or limited combustible material with sufficient fire resistive rating to withstand the effects of fire and prevent its spread from story to story. More often than not, Type II buildings are steel, Modern warehouses, small arenas, and newer churches and schools are built as noncombustible. Because the steel is not required to have significant fire-resistive coatings, Type II buildings are susceptible to steel deformation and resulting collapse. Fire spread in Type II buildings is influenced by the contents. While the structure itself will not burn, rapid collapse is possible from the content BTU release stressing the steel.

Suburban strip malls with concrete block load bearing walls and steel roof structures can be classified as Type II. Fires can spread from store to store through wall openings and shared ceiling and roof support spaces. The roof structure is often of lightweight steel that fails rapidly.

More often than not, the fire-resistive device used to protect the roof structure is a dropped-in ceiling. Missing ceiling tiles, damaged drywall, and utility penetrations can render the steel unprotected. These buildings may have combustible attachments such as facades and signs as well as significant content fire loading.

Collapse Hazards

- There are three basic types of non-combustible buildings: The metal-frame structure covered by metal exterior walls, the metal-frame structure enclosed by concrete block, non-bearing exterior walls; the concrete block bearing walls supporting a metal roof structure.
- On all three types, the steel roof support system may be either one of the following: a system of solid steel girders and beams, lightweight open web bar joist, or a combination of both.
- The collapse danger to a firefighter from a non-combustible building is roof cave-in from the unprotected steel open-web bar joist.
- The main disadvantage of the open-web bar joists is its susceptibility to damage by a fire in the combustible contents inside the building.
- Tests have shown that unprotected lightweight open-web bar joist can fail when exposed to fire for five to ten minutes.
- This possibility makes it extremely dangerous for a firefighter to operate on a roof supported by steel open-web bar joists which are being heated by flames.
- The open-web bar joist is the main structural hazard of non-combustible construction.

Type III Ordinary (Exterior protected)
This type of construction is commonly referred to as ordinary construction or brick and joist construction and is a highly predominate and common construction type. Ordinary construction consists of masonry exterior load-bearing walls that are of non combustible construction. Interior framing, floors, and roofs are made of wood or other combustible materials, whose bulk is less than that needed to qualify as heavy-timber construction.

If the floor and roof construction and their supports have a one-hour fire resistance rating and all openings through the floors (stairwells) are enclosed with partitions having a one-hour fire resistance rating, then the construction is classified as "protected ordinary construction Examples are older apartment buildings, typical late 19th and early 20th century construction, also known as "Main Street U.S.A".

- This type construction would include brick and wood joist buildings not of the size required for heavy timber.
- These structures are more prone to burn through than collapse even under normal floor loads.
- Floor and roof sheathing tend to burn through before structural failure occurs.
- In this type of structure, firefighters tend to be under the collapse rather to be on the collapsing surface.
- Another danger may be unusually high dead loads such as roof mounted HVAC units or high concentration of stock found such as found in supply houses.
- Early collapse is possible in these localized areas with little or no warning.
- Incident command should be notified of these types of loads during the firefighting.
- Personnel should be kept out of the area until stability can be confirmed.
- Other common terms applied to Type III or ordinary constructions are "Main Street USA," and a "Taxpayer." The term "Taxpayer" evolved from "Main Street USA," where a building owner would operate a retail store on the first floor and live in an apartment on the second floor. It was said that the property taxes for the building were paid for by the store's income, and the shop owner lived above the store tax free.
- Buildings of ordinary construction generally are built no taller than six to eight stories due to the thickness of the supporting walls required to support the floor loads above the ground.
- The tallest building of ordinary construction is located in Chicago, Illinois, and is 15 stories high.
- Most ordinary-construction buildings on are only two or four stories high.
- Exterior walls of Type III ordinary construction generally are constructed of brick.
- A true brick wall is two or more courses of brick thick. If a solid brick wall is being built, it is customary to lay five to six layers of brick lengthwise (stretcher rows) in the wall and then lay one at a 90-degree angle (header row) to the courses of brick below.
- This serves to tie the wall together as a solid unit. The bricks laid lengthwise are called "stretchers" and the rows laid at a 90-degree angle, where only the end of the brick is seen, are called "headers." Some walls have been constructed with the headers laid in a pattern in every course or every other course.
- A true brick wall has two or more wythe, while a fascia or decorative wall will have only one wythe of brick. In reading a building, the fact that there are both headers and stretchers could be one indication that it is a solid brick wall.

- Another material commonly used for exterior wall construction is concrete block. The block is the load-bearing wall and carries the loads above.
- Some older buildings used a clay terra cotta block in place of today's modern concrete block as the load-bearing wall. Terra cotta is a material similar to brick, which is fired in a kiln to harden the material.
- The terra cotta block wall was brittle and subject to being broken when struck with heavy objects. The exterior wall was faced with one layer of brick similar to the technique used for block walls.
- One danger of veneered walls placed adjacent to block walls is that it is possible, through various building connections that gases from a fire, such as carbon monoxide, could accumulate in the small cavity between the two walls.
- Wall thickness of a Type III building typically will range from 6 to 30 inches thick, depending upon the load it must carry. Remember that every ounce of weight from the roof load through the first floor of the building must be carried and transmitted to the foundation of the building.
- Bearing walls carry the load of the structure, which is transferred to the wall from the floor joists and roof rafters.
- Failure of a load-bearing wall can result in catastrophic structural collapse. It is critical that all emergency scene personnel be able to identify the load-bearing walls and understand the dangers associated with wall failure.
- Bearing walls are typically the longest walls of the structure.
- This may be the front (street side) or, most often, the sides of the building.
- The longest walls typically are used to support the load, since this requires the shortest span for the floor joists and roof rafters inside the building.
- Walls may have a heavy load that may push in a lateral manner instead of directly downward on the wall, and tend to tip the wall outward. This often happens when loads are applied directly against the walls, or when large open areas lack adequate materials to tie the two walls together.
- To counteract the push against the walls a masonry pier can be built into the block wall, a buttress (brace larger at the bottom than at the top) can be installed, or tie cables and rods can be installed, which is the most common method.
- The concern for the steel tie rods and cables is that they are subject to relaxation or elongation when heated, thus allowing the walls to move.
- The rods and cables are connected with turnbuckles that can be adjusted to compensate for the load applied above
- Type III buildings typically will have two load-bearing walls (long walls) and two curtain walls (short walls). The load of the building is placed on the load-bearing walls, which must be transferred to the ground.
- Buildings of ordinary construction often are renovated, with new void spaces created. These include horizontal voids created by dropped ceilings and vertical voids through new utility chases.
- The cockloft area is particularly vulnerable to rapid fire extension due to the heavy fire load in a confined and open space.
- It is extremely important for fire officers, Incident Commanders (IC's), and Safety Officers to read a building's construction carefully before developing their strategic goals or implementing their tactical objectives.
- The age and renovation cycles of these structures make them prone to structural collapse and rapid fire spread and instability.

Collapse Hazards

- The structural hazard of an ordinary constructed building is the parapet wall, the portion of the masonry wall that extends above the roof line.
- The collapse danger of the parapet wall is one of the reasons why the area directly in front of a fire building is so dangerous, and why firefighters are urged either to move inside the doorway or away from the front of the building altogether.
- There are several design features relating to ordinary construction which warrant close observation. These include efflorescence, parging, and spreaders. Efflorescence results when large amounts of soluble salts are used in mortar and excessive water penetrates the masonry.
- Efflorescence appears as a white powdery substance on the wall and indicates weakened mortar.
- Parging is the plastering over of a masonry wall with concrete. It is frequently a cosmetic fix for an unattractive, deteriorated wall.
- A wall out of alignment is always a sign of danger. Spreaders are intended to spread the load among one or more structural members and are frequently used to support a wall in trouble.
- They are often indicated on the outside of a wall by a circle, star, channel, or other device; arranged in a pattern they usually serve a decorative purpose. When placed at random, these spreaders provide additional strength to the wall.

Type IV Heavy Timber

Heavy Timber (Type IV) Construction is characterized by masonry walls, heavy-timber columns and beams, and heavy plank floors. Although not immune to fire, the large mass of the wooden members slows the rate of combustion. Heavy timber construction can be used where the smallest dimension of the members exceeds 5.5 in. (14 cm). When timbers are this large, they are charred but not consumed in a fire and are generally considered akin to a fire-resistant type of construction. Buildings are those of heavy timber construction. These buildings have at least 12” x 12” wood beams with non combustible walls commonly brick or block construction.

- Heavy-Timber or NFPA Type IV buildings will have four bearing exterior walls made from noncombustible materials. Exterior walls typically are thicker at the lower levels, which are meant to carry the accumulated loads from the floors above. Walls (both exterior and interior) will have sockets built into them to accept floor joists or beams from the floor support system.
- Interior load-bearing walls will be of noncombustible materials similar to the exterior walls and play a critical role both in fire separation and in supporting the heavy loads found in this type of building.
- Heavy timber construction is known to be extremely stable under fire conditions due to the size of the load bearing members with large columns and roof support trusses.
- In fire conditions that grow to a point of potential collapse created by fire conditions inside the building, the fire would be so intense that firefighters would be driven out by the heat.
- Care must be taken in any structure with previous fires in the structure. The cumulative damage may cause a large collapse.
- Collapse on an upper floor may cause lower floors to also collapse to the excess loading in these buildings

- Incident commanders must be aware of the collapse zone which is equal to one and one half times the height of the wall. As with all collapse zones personnel and apparatus need to be kept out of the collapse zone.
- Floors may have unprotected openings for stairwells, freight elevators, or conveyor devices, which will allow fire extension to the floors above.
- The positive aspect of these buildings is that they are built for strength, with heavy-timber supports for the floor and roof structure, providing a strong and stable building in the early stages of a fire.
- Heavy-timber buildings also have been called "mill construction," since this was the typical original occupancy for this type of construction. The thick, noncombustible exterior and interior walls were made from multiple courses of brick, which provided a strong base to carry heavy loads from machinery and manufactured goods.
- The floor and roof supports were constructed from large, solid or, in later years laminated timbers covered with thick planks. This building type was very popular as the Industrial Revolution developed, and often these heavy-timber buildings were constructed next to sources of water power.
- Today many of the heavy timber or mill buildings have been converted to other purposes, such as retail sales stores, multiple-family dwelling units, or office spaces.
- Most of these buildings were protected by sprinkler systems. One advantage of this method of construction was that very little of the structure was enclosed to create voids.
- Exterior wall construction had to be noncombustible, commonly brick, block, or stone. Walls at the lower levels were typically thicker than those at the top level. This stepped wall system allowed for greater load carrying capacity at the lower levels, and the loads were accumulated from the upper floors and transmitted to the building's foundation.
- Typically, the walls were 24 to 36 inches thick at ground level. Wall sockets would be placed in both the interior and exterior walls to accommodate the floor support timbers. Common walls between buildings and floor supports seldom were used in heavy-timber construction.
- Generally each building had a separation to reduce the potential of fire spreading from one building to another.
- Unlike ordinary construction, which typically had two bearing walls and two curtain walls, the heavy-timber building would have four bearing walls, and no curtain walls. Lintels or arches to transfer loads over openings were made from materials of substantial strength.
- Occasionally, additional bracing or support cables were added to the exterior walls to provide additional strength to keep the walls from pushing outward.

Collapse Hazards

- Falling masonry walls which crash to the ground and spray bouncing chunks of bricks and mortar along the street or pavement are the structural hazards of heavy timber buildings.
- This type of construction does not collapse during the early stages of a fire when interior firefighting is taking place. However, after several hours, its floors will collapse and the free-standing walls will fall into the street and on to the roofs of lower buildings nearby.
- Consequently, withdrawing to protect exposures is the strategy used at a fire involving heavy timber construction when the initial attack fails.

Type V Wood Frame

Buildings include wood frame buildings with standard dimensional lumber like 2"x 4" up to and including 2" x 12" lumber.

- This type of construction will tends to burn through sheathing prior to collapse, but would not apply to wood frame construction using light weight truss and wood floor I beam construction.
- Buildings with lightweight wood truss floor and/or roof assemblies (collapse in 5-10 minutes).
- Expect any house and most multi-family residential structures built after about 1970 to have some form of lightweight construction. If not sure, open the ceiling just inside the door as you enter and in a multi-story house open it again when you reach the top floor

Collapse Hazards

- The structural hazard of a wood frame building is the combustible bearing wall constructed of 2x4 inch wood studs.
- A wood frame building is a bearing wall structure. The two side walls are usually bearing (that is, supporting a load other than their own weight); the front and rear walls are usually non-bearing.
- The structural supports of the side bearing walls are only 2x4 inches in size and roof joists also 2x10 inches.
- Firefighters should know that wood-frame buildings use smaller structural members to support larger structural members, and the weak link in this design is smaller structural supports, the 2x4 inch bearing walls.
- Failure of a bearing wall will trigger simultaneous failure of the floors and roof.

Part 3: Inherent Construction & Occupancy Considerations

Regardless of construction classification, each building type and occupancy can be affected adversely by flame and heat impingement due to fires, weather and environmental conditions, improper or inadequate construction techniques and methods as well as substandard or inappropriate construction materials and system assemblies. Again, the question begs to be asked, "What do you know about building construction?"

There are varying degrees of perception versus reality related to response and operational demands, technological advancements, impacts from standards and regulations, shifting cultural values, society's sophistication, expectations, emergency services proficiencies and expertise, internal and external forces, increasing response and operational risks and our organization's perception versus reality. There are challenges and demands within the structures and occupancies we operate within, in which uncertainty and risks are always present.

These risks must be managed by cue-based indicators with experience and knowledge, with the clear understanding that errors and omissions may be very unforgiving and can lead to serious injuries, deaths and property loss. The dynamics of firefighting and interaction within a structure during combat structural fire engagement has a correlating dependency between command and company officers; between risk management, building construction and firefighter survival; relationship on incident mitigation and the recognition primed decision making (RPDM) or naturalistic decision-making process.

Can the command and company officer truly make a difference in the outcome during structural fire combat? If they can make a difference - what tools are required to succeed? What are the relationships to?; Knowledge, Experience, Technical skills, Proficiency , Core values, Depth and degree of separation, Maturity and stability, Cue-based mastery, Learning curves, Variables of liabilities, Community-based risks There are basic sets of parameters that can provide all operating personnel at structural fire operations with effective tools to increase operational effectiveness, safety and enhance incident stability and lead the forward progress towards event mitigation. This includes the effective integration of BECOME SAFE™ (Naum, 2004) concepts;

- **B**uilding,
- **E**valuation,
- **C**onstruction/occupancy,
- **O**perational hazards,
- **M**anage time and elements,
- **E**ngagement,
- **S**ituational awareness,
- **A**ssessment and analysis-fluid,
- **F**ire behavior and effects,
- **E**valuate and execute

The best defense firefighters have against building collapse is to understand the principles of building construction and the effects that fire has on a building; then apply this information on the fireground. Sometimes collapse indicators are evident in the initial size-up, but more often they are discovered by members operating in and around the fire building.

Every officer and firefighter must continuously size-up the building for collapse indicators (no matter how small) and then report the information to Command. Most often it is the compilation of a number of small collapse indicators, often from different parts of the building, which provides the IC with the information necessary to predict an impending collapse, safely evacuate firefighters from a building, and switch to a Defensive Operation.

What may seem minor and inconsequential to you may be an important part of the IC's collapse risk-benefit analysis. Report any and all safety concerns to the IC. Let the IC decide if it is important or not. As an IC if you feel you are not getting enough information from those operating on the scene, you must ask for it.

Remember they are working in a hectic, noise, dark and hazardous environment. It's easy to become distracted and forget to give Command an updated situation report. We can't prevent fire buildings from collapsing, but we can prevent firefighters from being killed and injured by collapses by recognizing and reporting the following collapse indicators.

Hotel Vendome Fire & Collapse. Boston, MA 1972

- At 2:35 PM on Saturday, June 17, 1972, Box 1571 was received at Boston Fire Alarm. It would be the first of four alarms required to extinguish a raging fire at the former Hotel Vendome on Commonwealth Avenue at Dartmouth Street. It took nearly three hours to stop the blaze. Apparatus at the scene included 16 fire engines, 5 ladders, 2 aerial towers and 1 heavy rescue. All apparatus had full crews.
- Once the fire was out, the BFD commenced a routine overhaul operation. Then, at 5:28 PM, without warning, the southeast section of the building collapsed.
- More than any other event in the three hundred year history of the Boston Fire Department, the Vendome tragedy exemplifies the risk intrinsic to the firefighting profession and the accompanying courage required in the performance of duty. Nine firefighters were killed on that day, eight more injured; eight women widowed, twenty-five children lost their fathers.
- The popularity of the hotel led to the fateful decision, around 1890, to carve a new ballroom out of several rooms on the first floor.
- To create the larger space, the main load-bearing wall that ran across the first floor of the building was removed, which left only a single cast iron column to support the weight of the four floors above.
- Nobody could have possibly imagined the sequence of events that would doom the building and nine of the men whose job it was to save it from a fire 80 years later.

Black Sunday 01.23.2005 FDNY. Rapid fire progression, smoke conditions and other primary indicators, illegal renovations and unexpected floor plan layouts, operational challenges;

- As a major snow storm swept through the New York area on January 23, 2005, firefighters were called to an apartment fire at 236 East 178 Street in the Morris Heights neighborhood of the Bronx about 8:00 am.
- First arriving units encountered fire on the third floor of a four story multiple dwelling.
- As units went about their assignments, crews continued to search for extension. Crews reported a loss of water pressure as they searched the fire floor in the building which had undergone several illegal renovations.
- The victims and injured fire fighters were searching for any potentially trapped occupants on the floor above the fire. The fire started in a third floor apartment and quickly extended to the fourth floor. Fire fighters had been on the scene less than 30 minutes when they became trapped by advancing fire and were forced to exit through the fourth floor windows. The six fire fighters were transported to metropolitan hospitals where the two victims were later pronounced dead.
- Conditions changed rapidly, fast moving flames forced the firefighters to jump to the ground some forty feet below.
- Four FDNY firefighters received life changing injuries, while an FDNY Lieutenant and Firefighter were killed in the line of duty.

NIOSH- Preventing Injuries & Deaths of Fire Fighters Due to Structural Collapse recommendations;

1. Ensure that the incident commander conducts an initial size-up and risk assessment of the incident scene before beginning interior fire fighting.

2. Ensure that the incident commander always maintains accountability for all personnel at a fire scene both by location and function.

3. Establish Rapid Intervention Crews (RICs) often called rapid intervention teams and make sure they are positioned to respond immediately to emergencies.

4. Ensure that at least four fire fighters are on the scene before beginning interior fire fighting at a structural fire (two fire fighters inside the structure and two outside).

5. Equip fire fighters who enter hazardous areas (such as burning or suspected unsafe structures) to maintain two-way communications with the incident commander.

6. Ensure that standard operating procedures and equipment are adequate and sufficient to support radio traffic at multiple-responder fire scenes.

7. Provide all fire fighters with personal alert safety system (PASS) devices and make sure that they wear and activate them when they are involved in fire fighting, rescue, or other hazardous duties.

8. Conduct Pre-fire planning and inspections that cover all building materials and components of a structure.

9. Transmit an audible tone or alert immediately when conditions become unsafe for fire fighters.

10. Establish a Collapse Zone around buildings with parapet walls.

Structural Collapse Fire Tests: Single Story, Ordinary Construction Warehouse NISTIR 6959

Two fire tests were conducted in a warehouse located in Phoenix, Arizona to develop data for evaluation of a methodology for predicting structural collapse.
In addition, the volume fraction of carbon monoxide was measured at selected locations during each test. Stacks of wood pallets were used as the primary fuel source and were ignited using paper and an electric match.
Some combustible debris and the building structural elements provided the remainder of the fuel load. Peak temperatures obtained at different elevations ranged from approximately 300 °C (570 °F) to 800 °C (1470 °F). Peak carbon monoxide volume fraction reached 4 % in the first test and 5 % during the second test.

The roof of the front half of the structure burned through approximately 18 min after ignition of the fire for the first test. The roof of the back half of the structure burned through about 15 min after the start of the second test.
www.fire.nist.gov/bfrlpubs/fire03/PDF/f03093.pdf

Recommended Readings and Additional Studies;
College Courses; Research your local community college systems and look into taking a FESHE approved course on Building Construction Principles or Fire Dynamics & Behavior

On-line Training opportunities are available;
- USFA; www.NFAonline.com
- Open Fire Academy International www.openfireacademy.org
- Multimedia Educational Resource Learning Online Training Merlot www.merlot.org

Suggested Case Studies;
- Wooster Street Collapse, FDNY, (1958)
- Wonder Drug Store, (aka 23rd Street Collapse) FDNY (1966)
- Hotel Vendome Fire & Collapse, Boston (1972)
- Walbaum's Fire, FDNY, NY (1978)
- Lynn, MA Conflagration (1981)
- Warehouse Explosion, Buffalo, NY (1983)
- Detroit, MI Warehouse Fire (1987)
- Hackensack Fire & Collapse, NJ (1988)
- West 31st Collapse, NYC (1988)
- Warehouse Fire, Seattle (1989)
- Mary Pang Fire, Seattle (1995)
- Worcester Cold Storage Fire, MA (1999)
- Hardware Store Fire, (aka Father's Day Fire) (2001)
- Mercantile Fire, Coos Bay, OR (2003)
- 236 East 178 Street, Bronx, FDNY (aka Black Sunday) (2005)
- Brooklyn Warehouses 10 Alarm Fire, NYC (2007)

Research & Reports;
- National Firefighter Near Miss Reporting System Reports & Case Studies; www.firefighternearmiss.com
- USFA Technical Report Series; www.usfa.dhs.gov/statistics/reports/
- NFPA Investigative Reports; www.nfpa.org
- NFFF Everyone Goes Home Program; www.everyonegoeshome.com
- NIOSH Firefighter Fatality Investigation and Prevention Program; www.cdc.gov/niosh/fire/
- Buildings on Fire Web Portal; www.buildingsonfire.com
- National Institute of Science & Technology-NIST; www.fire.nist.gov/bfrlpubs/

Collapse Safety Indicator Check List
A quick operational safety list for collapse considerations was developed and published in the 2008 Near Miss Reporting presentations by Battalion Chief G.O Lyons (Ret.) Arlington County Fire Department (VA). It's worth repeating this insightful list again, since it contains timely truths related to collapse safety considerations.

The Lyon's Safety List

General collapse safety considerations for firefighters and fire officers.
Buildings that have been renovated may have any or all of the following:

- Structural components have been removed or altered.
- Drop ceilings under the original ceiling (sometimes more than one false ceiling)
- Mixed construction, lightweight trusses, and wood I-beams are commonly used for renovations and additions to older buildings and often made to look like the original structure.
- Vacant and poorly maintained buildings increase collapse potential.
- "Rain-roof" renovations that cover the original roof with a lightweight roof assembly may hide fire or hamper ventilation of the roof.
- Non-combustible construction buildings with parallel cord metal truss roof assemblies. These assemblies can begin to fail when heated to as little as 600 degrees Fahrenheit.
- Older buildings that have changed occupancy often house heavy material or equipment that the floors and roof were not designed for contain highly flammable materials without sprinkler protection have had interior walls removed or openings not shown on the original building plans
- have multiple drop ceilings
- Commercial building with large wide open undivided floor space and wide roof spans may have heavy fire loads. This is true in warehouse type occupancies.
- Warehouses and commercial "big box stores" with metal high-rack storage systems may have heavy fire loads, no fire sprinklers in the racks, or poorly secured racks.
- Building with bow-string truss roof assemblies.
- Buildings with parapet walls extending above the roof.

Size Up Considerations
Applicable to all construction or occupancies.

- Buildings with fire on more than one floor present a special danger.
- Buildings that are under construction, renovation or demolition may have
- Less structural stability due to fresh concrete, bearing walls removed, or
- renovations to other structural components.
- Heavier fire loads due to construction materials stored in the building.
- Buildings that are exposed to heavy fire conditions longer than 20 minutes may be too dangerous for an interior attack. Consider defensive operations from the start with large caliber hose lines.
- Generally a fire that is called in by neighbors and or a passerby may be assumed to be in the advanced stages of fire development and may be too dangerous for an interior attack. A focused risk assessment is highly advised.

- Basement fires; as these fires force personnel to make entry through intense smoke and heat. Ventilation is difficult at best. Egress is limited, often one way in or out.
- Buildings that have experienced a previous fire without adequate repair.
- Buildings with large canopies or signs attached to the façade as they may fail before the building collapses.

Exterior Safety Indicators

- Walls leaning or out of plumb.
- Bulges in the walls, especially at the floor and roof levels.
- Frame buildings with brick veneer – look at the windows for an indicator of brick veneer versus masonry walls. (Windows in brick veneer walls are usually almost flush with the wall while in masonry walls they are recessed 4-6 inches.)
- Moving cracks in the masonry walls - most masonry buildings have some cracks so look for cracks that get wider or longer or that have smoke or water pushing from them.
- Distorted window and door openings that are out of square
- A portion of the building has already collapsed (loose bricks, part of the parapet wall, etc.)
- Damage to the building from heavy streams (especially tower ladder streams)

Interior Operational Indicators

- Intense fire that is not affected by interior attack lines.
- Multiple drop or false ceilings.
- Fire located in floor or roof truss assemblies.
- Creaking, cracking, or any unexplained or unusual noise.
- Heavy equipment stored over a basement, on an upper floor or roof.
- Water pooling on a floor or flat roof may indicate that it is sagging.
- Clean flooring material showing at the baseboards indicates the walls and floor are pulling apart.
- Doors that won't close in their frame, or are difficult to open due to warped frame work.
- Sagging ceiling or the collapse of a ceiling.
- Plaster sliding or pulling off of the lath in older construction and buckling or cracking sheet rock in new construction.
- Water accumulation from heavy streams.

Part 4: Case Study 08-0099

The near-miss case study that follows involves an deep seated fire within a complex of buildings built in the late 1800's and resulted in a partial structural collapse, rapid fire development and the need for a firefighter to rapidly evacuate an interior area by bailing through a window.

Event Description

The incident involved a row of interconnected warehouses, built in the late 1800's. One structure was totally involved and the adjacent warehouse was almost totally involved. The firewall between the second and third warehouse impeded the fire's progress. During later operations, a ladder truck parked within the collapse zone of the second warehouse was covered in a collapse.

Three firefighters barely escaped injury. Companies conducted tertiary inspections of the third warehouse to check for fire extension, smoke conditions, and general conditions in the third warehouse. Personnel were told they could "drop that gear," (airpack and tools).

Two personnel had on their bunker gear and helmets but no hoods, masks, airpacks, or gloves. Proceeding to the second floor, no fire extension was evident, interior shop fans were operating to evacuate smoke in the building. Proceeding to the third floor to conclude operations and break down a fire hose that had been brought up through a third floor window, a firefighter saw fire had sprung up in the Charlie/Delta corner of the floor and was growing very rapidly and in a few moments had grown out of all proportion and now covered almost half the warehouse wall on the Charlie side. Heat conditions were the worst he had experienced in 10 years of inner-city firefighting. The ensuing fire required the firefighter to immediate bailout through the window of the building.

Lessons Learned

Lessons and suggested learning's from this incident;

1. Command must understand the characteristics and expected performance of buildings of Type III (Ordinary) and Type IV (Heavy Timber) construction.
2. Command and Company Officers must understand the inherent structural collapse potential for these construction types and consider appropriate collapse and safety zones during initial and sustained operations.
3. Command should always be conservative in their strategic assessment construction features such as fire walls and fire separations.
4. When transitioning from offensive to defensive to offensive operations, conduct a through risk assessment of building integrity and safety considerations before assigning crews back into interior areas of a compromised structure.
5. Provide adequate precautionary protection handlines during all operational tasks in the event of unexpected fire flare-up or extension.
6. Ensure all crews are operating with full protective PPE equipment during all phases of operations, until such time the incident is fully mitigated.
7. Ensure personal RIT/FAST equipment is available for personnel operating within large area structures for rapid egress and emergency escape.

Comments

Fires involving Type III (Ordinary) and Type IV (Heavy Timber) construction features are prone to rapid unexpected fire progression and are highly susceptible to structural collapse. Its imperative personnel are knowledgeable of collapse indicators and take precautionary measures to reduce the risk to personnel during fireground operations.

Recognizing collapse indicators and the signs of rapid fire progression, smoke conditions and other primary indicators can provide insights for improved command management and risk reduction to personnel and equipment. Emergency operations in Type III and Type IV occupancies required a heighten awareness of building features, avenues for fire travel and a need to utilize full PPE at all times.

Discussion Points

Incident commanders and company officers should have an understanding of the various types of building construction and the unique characteristics each type has on structural stability and the effects fire and heat on the building's structural assembly system or features.

1. All personnel regardless of the stage of fire operations must utilize full PPE ,
2. maintain a high regard for situational awareness and continuously monitor fire behavior, fire travel and changing conditions
3. Recognize collapse indicators
4. Understand Building performance characteristics under fire conditions
5. Type III and Type IV structures require special safety considerations due to building age, deterioration, modifications or renovations over the years.
6. Maintain exterior and interior collapse zones for personnel and apparatus
7. Always maintain secondary escape routes when operating within interior areas

Discussion Questions

After reviewing this case study consider the following as they apply to you, your crew and your Department.

1. Does your department conduct frequent periodic classes and course of instruction on building construction, fire behavior?
2. Does your Department have a training program focusing on identifying structural collapse indicators?
3. Do your Department officers and commanders understand the inherent structural stability and safety factors for occupancies and structures of Type III and Type IV construction?
4. Does your Department conduct periodic pre-fire planning of large complexes or structures?
5. Does your Department conduct periodic table-top sessions and exercises based upon your pre-fire planning?
6. Does your department have an evacuation procedure SOP/SOG and are your personnel trained and aware of the procedure? Does the procedure have multiple methods to alert personnel of a building evacuation or need for emergent bail-out and egress?
7. Does you Rapid Intervention Team take proactive tactical measures to support unexpected "Mayday" situation (i.e. - putting up ladders, opening secondary means of egress, etc.) while performing team activities?
8. Does your Department assign a Safety Officer(s) to all operations?
9. How do you address the potential need for more than one Safety Officer in complex or high risk situations?
10. How important is the relationship of situational awareness, building/ occupancy performance and PPE?
11. During perceived low risk task assignments, how does the diminished use of PPE affect personnel safety when unexpected conditions or situations occur?
12. What did you take away from this near miss event? What types of changes can you suggest be made in your organization to prevent a similar incident from occurring?

Part 5: Crew Resource Management Discussion Points

- **Communication** – Interruptions in communications flow will result in messages and orders being misinterpreted, not properly convened, completely missed or not carrier out.
    - Changing or unexpected conditions must be communicated to the incident commander in a timely fashion.
    - All crews should be equipped with a portable radio
    - Stand by staging of rapid intervention team personnel, closer to operational areas should be considered when operating in large area structures and occupancies.

- **Situational Awareness** – All crews must maintain a heightened sense of situational awareness during ALL PHASES of operations
    - Fire crews must be aware of building construction, fire progression, and the inherent dangers present before entering buildings.
    - Fire crews must be aware of collapse zones and when operating within them, utilize the highest degree of situ awareness.
    - Fire crews on the outside who become aware of dangerous conditions inside the hot zone must enter only with direction from the incident commander.
    - Crews must maintain Accountability during all operational phases.
    - Crews should anticipate unexpected conditions and plan accordingly.
    - Crews must maintain a high degree of diligence at all times during control fire phases of operations.
    - The Incident Commander must adhere to strong principles of risk assessment and implement this during transitioning phases of operations.
    - Crews must maintain a high degree of awareness in large area structures and occupancies

- **Decision Making (Risk-Benefit Analysis)** – depends on four factors: information, experience, knowledge, and urgency
    - Consideration must be given before entering any building whose structural integrity may have been compromised due to heavy fire involvement or during the use of masterstreams. This is especially important when there no occupant or life safety benefit.
    - Performing periodic risk benefits analysis and altering operational strategies at transitional points provides for increased safety focus and corresponding tactical assignments.
    - When reentering structures, be cognizant of changing structural integrity, compromise and unexpected fire extension. Utilize conservative recon and limited access, implementing effective communication reports and cautious operations.
    - Never diminish the levels of personal protective equipment (PPE) to be used during ALL phases of operations.
    - Large scale operations with multiple operational periods require consistent actions plans and periodic risk-benefit analysis to validate operational safety and effectiveness.
    - Incident Commanders must the implications when utilizing operable building HVAC systems to support fire operations and the affects of system(s) use on fire behavior, travel and crew safety.

    - The use of Safety Officer(s) provides reconnaissance and mission critical information to support command management and decision-making.

- **Teamwork** – to accomplish a common goal, a group must work together, cooperate, and have a leader and followers
    - Maintain crew integrity at all times
    - Crews assigned to breaking down equipment and pick up, must work in close unison and monitor surrounding building conditions for unexpected situations.
    - Incident Command must implement and assign adequate levels of supervisory oversight for operating crews in order to provide focus on safety and precautionary observations.

- **Task Allocation** – knowing the strengths and weakness of team members, assigning tasks accordingly, and dividing labor so no team members are overworked
    - Crews were tasked were assignments not utilizing full protective clothing ensembles (PPE) not considering unexpected environmental changes.
    - Companies were assigned operational tasks within a collapse zone, not recognizing the hazards and unforeseen safety issues based upon unrecognized collapse indictors.
    - Crews assigned to interior inspections, reconnaissance, mop up operations and take-up assignments should be provided with supervisory oversight.
    - Assigning a Safety Officer and support personnel provides the Incident Commander with additional insights into operational conditions and factors to be considered.

- **Debrief** – analysis of team and individual actions in a productive manner to reinforce good practices, correct bad practices to avoid mistakes in the future, and share experience. This is often called a post incident analysis.
    - Every incident presents an opportunity to learn. A post incident analysis should be conducted after every "working" incident, especially those involving near-miss situations.
    - Have crews complete recollection documents to aid and support the formal post incident analysis process later.
    - Provide for an informal debriefing (critique) after returning to quarters and a more formal critique and post incident analysis at a later date.
    - The post incident analysis should be conducted in a timely period of time after the event, to make use of retained recollections and corresponding actions.
    - Information realized through the formal critique and post incident analysis is critical in educating fire officers and firefighters, reinforcing effective and efficient work practices, and identifying gaps and areas for improvement requiring change management within the areas of procedures, strategies, or tactics.
    - Lessons learned and shared from post incident analysis and near-misses may prevent history repeating events from occurring.

May

Report Number: 08-0000099
Report Date: 02/20/2008 15:50

Synopsis
Warehouse fire challenges Firefighters

Demographics
Department type: Paid Municipal
Job or rank: Fire Fighter
Department shift: 24 hours on - 24 hours off
Age: 43 - 51
Years of fire service experience: 7 - 10
Region: FEMA Region IV
Service Area: Suburban

Event Information
Event type: Fire emergency event: structure fire, vehicle fire, wildland fire, etc.
Event date and time: 02/07/2007 06:00

What were the contributing factors?

- Fatigue
- Decision Making
- Situational Awareness
- Procedure
- Staffing

What do you believe is the loss potential?

- Property damage
- Life threatening injury
- Other

Event Description

On the morning of February 7, 2007 at 0130 hours [business and department name deleted] was reported as being on fire. Our company was investigating a residential smell of smoke on the west end of town when we responded to the second alarm. When we arrived, there were several engines, two ladder trucks and a quint in operation putting water on the fire via towers and monitors.

I was the firefighter on [unit number deleted] and saw the entire end of town was filled with burning debris and glowing ash. The warehouse, which was actually a row of connected warehouses, was built in the late 1800's. It was totally involved and the warehouse immediately to the north was almost totally involved. The firewall between the second and third warehouse had impeded the fire's progress.

I was initially assigned to operate the master stream from [unit number deleted] with another firefighter. This comprised the majority of my tasks with the exception of deployment and positioning of monitor streams for the next several hours. During that time, a ladder truck parked within the collapse zone of the second warehouse was covered in a collapse. Three firefighters barely escaped injury. Just before dawn, I was assigned to a company of 4 other firefighters (two other firefighters plus myself and two captains) to conduct a tertiary inspection.

Two other companies had conducted similar inspections in the past couple of hours to check for fire extension, smoke conditions, and general conditions in the third warehouse. As we began to make our way toward the stairwell, I was advised by several department members that I could "drop that gear," meaning my airpack and tools. I did not do this because it has been my practice for the past 10 years and 2 departments to keep my PPE on.

Two of the personnel had on their bunker gear and helmets but no hoods, masks, airpacks, or gloves. We were appalled to find that the employees in this warehouse, which was functioning as a woodworking and furniture refinishing shop, were not only present but working as if nothing was going on. We proceeded to the second floor.
No fire extension was indicated and interior shop fans were turned on at the order of Incident Commander to evacuate what smoke there was in the building. We then proceeded to the third floor to conclude operations and break down a fire hose that had been brought up through a third floor window via a haul line.

Two firefighters remained outside the fire door in the stairwell and the two captains were at the fire hose window on the Alpha side of the building. I began breaking down the hose to carry the nozzle end back down the stairwell with us and the captains began lowering the remaining hose via the line. As I turned to begin gathering the hose, I saw that fire had sprung up in the Charlie/Delta corner of the floor and was growing very rapidly. I grabbed the coupling end of the hose and ran it back toward the Alpha windows telling the captains to reconnect the hose and have the line charged immediately that we had fire in the C/D corner and that we needed additional resources to that floor ASAP.

I then turned and saw that the fire had grown out of all proportion and now covered almost half the warehouse wall on the Charlie side. I dropped to a knee, masked, hooded, gloved up, and went on air. By the time I was ready to make my way to the nozzle, which was laying near the fire door entrance to the stairwell, smoke had banked down to waist level (just over my head while on my hands and knees). I made my way toward the stairwell as quickly as I could and found that the huge fire door had closed on the hose which was now charged. I turned and followed the hose back to the window and could not see the fire captains anywhere.

I decided that they could possibly have tried to make their way back along the hose to the stairwell. Knowing that they did not have proper PPE in the rapidly deteriorating conditions, I knew I had to conduct a search as quickly as possible contingent on the possibility that they had gone down somewhere on the way to the closed fire door. I followed the hose back to the door and by now the smoke had banked entirely to the floor and visibility was zero. Heat conditions were the worst I had experienced in 10 years of inner-city firefighting.

I had been in some bad fires many times before but nothing like this. Nothing! Federal and state arson investigators later said the temps at that time were in excess of 1200 degrees. I began crawling in a Z pattern, referencing the hoseline at the center of each sweep to keep my bearings. There was a ton of furniture and trash all over the place and almost all of it on fire from the sound of things. A stack of what felt like headboards collapsed on me followed by some other things. I was pretty much pinned and my right glove came off.

Somehow I found it almost immediately and got it back on. I could feel my skin sloughing off as I did so. By then, I knew that I would probably not be able to find the two other men and the heat was such that I thought I was pretty much going to die. I tried a few times to get enough breath to stop breathing for a second and finally I did. I heard pumpers whining and knew that I was on the Alpha side where the windows were.

I managed to back out of the collapsed furniture and started making my way through the clutter and found a window. I broke it out and looked down. My mask was melted and blackened and I could only see through a thin ring of unburnt plastic at the edge of where the regulator mounts onto the mask. I looked to my right and saw the hose about three windows down and knew I could fast-rope down that hose if I could get to it. I pulled back in and crawled along through some more furniture and made the window. I slung one leg out and wrapped myself around the hose like I was coming out of a Blackhawk helicopter and started to slide down.

Because of the burns to my right hand and arm, I could not hold onto the hose properly and almost as soon as I started to descend I lost my grip and fell about 45 to 50 feet to the sidewalk. I tried to execute a PLF (parachute landing fall) and succeeded for the most part but broke my back at T12-L1 from the pack shelf on my air pack. I received a concussion from my helmeted head bouncing off the pavement. A bunch of my brothers dragged me away. Glass and other crap were falling from the windows blowing out above us.

They cut my gear away, boarded me and got me into an ambulance where they transported me to our level 1 trauma center. I asked about the other firefighters who were up there with me and was told to not worry about them. I thought the only reason they would say that was because they were dead. It turned out that the guys in the stairwell made it down that way and the two captains had gone down the fire hose as I later did. That was a relief.

The warehouse ended up burning to the ground. Fireground operations (to include overhaul) concluded 48 hours later. Nine months to the day I was back on the job (light duty). I now perform administrative duties. This fire was most likely due to arson. The incident is still under investigation.

Note: The brackets [ ] in this report denote identifying information being removed by the reviewer.

Lessons Learned

Actions we as a department could take in a similar situation would be to:

1. Ensure that ALL personnel have on ALL of their gear at ALL times. Period!!
2. Secondary means of egress.
3. Watch the collapse zones.
4. All citizens kept off premises.
5. RIT or RIC personnel deployed to their designated area(s) and standing by.
6. Relief personnel designated and deployed as needed.
7. Delegation of duties by the Incident Commander.
8. Staffing increase from 3 personnel per unit to 4 personnel per unit and 5 personnel for Special Ops (Rescue & HAZMAT).

9. Development and implementation of Mayday procedures specific to warehouse and other large building fires.
10. Development and implementation of a constructive After Action Review process for all incident personnel.
11. Development and implementation of a Critical Incident Stress Debriefing program.
12. Self rescue training and equipment (either improvised or manufactured).