Career Lieutenant and Fire Fighter Killed and Two Fire Fighters Injured by Wall Collapse at a Large Commercial Structure Fire - Pennsylvania

Executive Summary

On April 9, 2012, a 60-year-old male career lieutenant (Victim #1) and a 25-year old male career fire fighter assigned as "Tiller" (Victim #2), both assigned to Ladder 10, died when a wall collapsed during fire-fighting operations at a commercial structure fire. One engine company (Engine 2) was initially dispatched. Upon arrival, Engine 2 radioed that the fire was spreading throughout the structure. The vacant and abandoned warehouse covered more than half a block. This incident would eventually grow to 5 alarms. The fire would extend to an occupied furniture store. Ladder 10 (L10) was dispatched on the 2nd Alarm and assigned to deploy an elevated master stream. The fire originated in Building 1 on Side C and rapidly extended to the other structures within the vicinity. Building 2 located east of the building of origin and situated on Side A sustained the structural and wall collapse that resulted in the fire fighter fatalities and injuries. L10 set-up a ladder pipe operations on Side A of the fire building. The collapse occurred after the lieutenant and three fire fighters from Ladder 10 were sent inside the furniture store to operate a hand line to stop the fire extension. Two fire fighters were trapped by the collapse and were injured. The lieutenant and another fire fighter were buried by the collapse and died as a result.

Ladder 10 is shown operating a ladder pipe on Side "A" of the fire. This photo is prior to the wall collapse that resulted in the fire fighter fatalities and injuries.
(Photo courtesy of the fire department)

Contributing Factors

- *Multi-alarm fire in an vacant/abandoned structure*

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- *Dilapidated building conditions*
- *High winds*
- *Collapse zone maintenance, control and compliance*
- *Fireground communications*
- *Personnel accountability*
- *Training on fireground operations*
- *Situational awareness.*

Key Recommendations

- *Municipalities and local authorities having jurisdiction should develop strategies for the prevention of and the remediation of vacant/abandoned structures and for arson prevention and have programs in place to address abandoned building abatement and demolition.*
- *Fire departments should consider an unsafe building marking system as part of an overall program to address fighting fires in abandoned/vacant/derelict buildings.*
- *Fire departments should ensure that collapse zones are established, marked, maintained and complied with over the length of the fire incident.*
- *Fire departments should ensure critical benchmarks are communicated to the Incident Commander.*
- *Fire departments should ensure an effective personnel accountability system is used to account for all fire fighters and first responders assigned to any incident.*
- *Fire departments should ensure that Incident Safety Officers are adequately trained to recognize hazards such as building collapse and enforce exclusion zones, communicate with division/group supervisors and the Incident Commander.*
- *Fire departments should ensure that fire fighters are trained in situational awareness, personal safety, and accountability.*

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH "Fire Fighter Fatality Investigation and Prevention Program" which examines line-of-duty-deaths or on duty deaths of fire fighters to assist fire departments, fire fighters, the fire service and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with State or Federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department or those interviewed. The NIOSH report's summary of the conditions and

For further information, visit the program Web site at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).

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Introduction

On April 9, 2012, a 60-year-old male career lieutenant (Victim #1) and a 25-year- old male career fire fighter (Victim #2), both members of Ladder 10, died when a wall collapsed during fire-fighting operations at a vacant commercial structure fire (See Photo 1). Two other career fire fighters from Ladder 10 were injured in the collapse. On April 11, 2012, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research, Fire Fighter Fatality Investigation and Prevention Program of the incident. On April 16, 2012, four NIOSH investigators traveled to Pennsylvania to conduct an investigation. The NIOSH investigators met with the Fire Commissioner and senior staff of the fire department, fire marshal's office, the International Association of Fire Fighters local union, the city's Department of License and Inspection (L&I), and the fire communication center (FCC). The investigators reviewed fire department standard operating procedures, training records from the department and the Commonwealth of Pennsylvania, dispatch and tactical channel printouts plus audio radio transmissions. The investigators reviewed Department of License and Inspection records on inspections and citations for the incident structure, including photographs documenting the condition of the structure prior to the incident. During the investigation, witness statements were reviewed and interviews were conducted with the fire fighters and fire officers involved in the incident. The NIOSH investigators inspected and photographed the personal protective clothing (turnout gear) of both victims which was under control of the Fire Marshal's Office.

Photo 1: Location in the furniture store where the four members of Ladder 10 were located after the collapse of the adjacent warehouse.
(*NIOSH Photograph)*

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Fire Department

The fire department involved in this incident has 61 fire stations with 2,200 uniformed members which serve a population of approximately 1,526,006 within an area of about 144 square miles. The department operates 11 battalions in 2 divisions North – Division 2 (Deputy Chief) and South – Division 1 (Deputy Chief). The South Division operates 5 Battalions (1, 3, 4, 7, and 11). The North Division operates 6 Battalions (2, 8, 9, 10, 12, and 13). The fire department currently has 56 engine companies, 27 truck companies, 1 rescue company (heavy rescue company), 2 squad companies (pumpers plus special operations unit), and 3 fire boats (plus one in reserve). The department operates specialty companies for technical rescue, hazardous materials incidents, and aircraft rescue fire-fighting (ARFF).

Eight of the engine companies are designated as *Pipeline* (e.g., Pipeline 61) which means the pumper carries large diameter hose (1500 feet of 5-inch hose). Four of the engine companies are designated as Squirts (e.g., Squirt 55) which have a 50 foot articulating boom. Three of the engine companies are designated as *Deluge* (e.g., Deluge 24) which carry a 4-inch monitor. Two of the engine companies are designated as *Foam* (e.g., Foam 33) which carry Class "B" foam. One engine company operates as a Quint (Quint 69) which is equipped with a 75 foot rear mounted aerial. Two of the ladder companies are 85 foot snorkels (articulating boom with a platform, Snorkel 2 and Snorkel 28). Two of the ladder companies are ladder towers (Ladder Tower 6 and Ladder Tower 22). The remainder of the ladder companies are tractor-drawn aerials.

The staffing on an engine company is an officer and three fire fighters. The staffing on a truck company is an officer and four fire fighters. Each battalion chief is assigned a field incident technician as is each of the two division chiefs (North Division and South Division).

In addition to fire suppression, hazardous materials mitigation, and special operations response, the fire department operates an Emergency Medical Services (EMS) Division which consists of 13 Basic Life Support (BLS) Medic Units, 37 Advanced Life Support (ALS) Medic Units, and support staff including EMS Field Officers. Thirty of the medic units operate on a full-time basis and 20 of the medic units operate on a part-time basis. The fire department operates an aircraft rescue fire-fighting (ARFF) station at the international airport in the southern part of the city in the 7th Battalion.

Department members assigned to the Operations Division work a daily 10/14 shift (0800-1800 and 1800- 0800) with four platoons or shifts (42-hour work week). All fire department apparatus are maintained by the city's fleet maintenance division. Annual testing (e.g., pumps and ladders) as recommended by the National Fire Protection Association (NFPA) Standards, is conducted by qualified vendors.

The department has an Incident Command System SOP OP 19 (2007), in which collapse zone establishment is mentioned as a function of the Safety Officer in Section 4.14. Establishing and enforcing collapse zones is a critical role of the Incident Commander, Division/Group Supervisors, and the Safety Officer.

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Fire Communications Center

The city uses an 800-MHz digital trunk radio system that has 25 radio channels. The city receives approximately 3.5 million telephone calls annually with the fire and EMS communications center fielding approximately 500,000 calls (including 311 calls). The city has a 311 phone system where complaints can be called into Department of License and Inspection (L&I). The 311 phone system is a central complaint non-emergency phone line. The fire department does have a process in which the fire department notifies the Department of License and Inspection by the 311 phone system whenever the fire department identified hazardous structures or code violations.

The number of fire and EMS calls are approximately 300,000–325,000 annually. The city fire department dispatches in two districts, north and south and also has a tactical channel for each district. All fire fighters carry a portable radio equipped with an emergency button that allows a fire fighter to transmit an emergency signal by pushing the button on his/her portable. When this emergency button is activated a signal is sent to the dispatcher and the fire fighter is able to talk with an open microphone for 10 seconds. The dispatch center has 4 dispatchers and 4 call takers on duty for fire and rescue communications 24 hours a day, (two for fire and two for EMS). 911 calls are received first at the police department and then transferred to the fire communications center (with the police call taker staying on the line during the transfer to see if police involvement is necessary). In addition to the 4 dispatchers on duty, the communications department also has 3 quality assurance supervisors, 1 GIS information technology supervisor and a staff supervisor for training. The training program for dispatchers includes a 14-16 week program (8 weeks of classroom) in addition to annual refresher and continuing education. The center's computer aided dispatch system (CAD) has the ability to flag properties. *Note: A flag is an additional information notifier that will provide dispatchers with information such as hazardous materials or other hazards for a given address.* Mobile data terminals (MDTs) are in all chief vehicles and ambulances, engines and ladder companies.

At the time of this incident, the fire department and L&I had a limited, formal process for exchanging information. No formal process was established for getting target hazard properties or flagged property information from L&I or the fire department to the Fire Communications Center for inclusion into the CAD system.

Training and Experience

The Commonwealth of Pennsylvania does not have prerequisite training or education requirements for an individual to become a fire fighter. The department participates with the Pennsylvania State Fire Academy in the Voluntary Participation and Certification Program, which started in 2003 to provide national certification through the National Board on Fire Service Professional Qualifications (ProBoard) and the International Fire Service Accreditation Congress (IFSAC) for department members.

To become a member of the fire department, an individual must apply and successfully compete in a civil service examination for fire fighters. Prospective candidates are selected in rank order from the established civil service list to initiate the process to become a fire fighter. The process includes department interviews, and criminal and background investigations. If selected for conditional

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appointment, a candidate must successfully pass a medical examination that complies with NFPA 1582 *Standard on Comprehensive Occupational Medical Program for Fire Departments*[1]. Selected candidates are appointed as cadets (or recruit fire fighters) in an extensive 20-week academic, practical, and physical training program at the department's fire academy.

At the Academy, recruit fire fighters are trained in fire-fighting operations as well as emergency medical services, for which they must obtain state certification as an emergency medical technician. Upon the successful completion of training, recruit fire fighters are assigned as a probationary fire fighter and receive national certification as a NFPA 1001, *Standard for Fire Fighter Professional Qualifications*[2], *Fire Fighter I* and *Fire Fighter II*, plus Hazardous Material Awareness and Hazardous Materials Operations certification, and as a state certified emergency medical technician/basic (EMT/B). The probationary fire fighter is assigned to the Operations Division on either an engine company or a truck company. As EMT's, firefighters are also assigned as needed to work on Basic Life Support (BLS) medic units. During the probationary period, the probationary fire fighter is tested by the fire academy staff at six months (written and practical examinations) and 12 months (written examination). Recertification for an EMT/B and paramedic (EMT/P) is every 2 years, which requires 18 hours of continuing education for EMT/B and 24 hours for EMT/P.

Members assigned to the Operations Division are required to complete at least one hour of training per shift. Also, fire fighters and fire officers are required to complete 170 hours of training annually. The training must include "Near-Miss Calendar" monthly drills on a particular scenario, which is included in the total training hours. *Note: Due to financial constraints affecting overtime and daily staffing of companies, the fire department has had to detail fire fighters throughout the city to maintain minimum staffing on a prescribed number of engine companies, truck companies, and medic units (i.e.,"rolling brown outs"). This reduces the department's ability to send companies to the department's fire academy for in-service training (e.g.,live fire training).*

Victim 1 (Lieutenant) was appointed to the fire department in 1974 and was promoted to lieutenant in 1983 and had 38 years of experience. The fire department did not have electronic training records prior to 1992, however the department's training chief indicated that the lieutenant likely did take the department's officer development program in 1983. Victim 1's training included:

- Fire academy training at the time of his appointment;
- Fire officer development program at the time of his promotion in 1983.

Other training recorded in Victim 1's training record include, SCBA Safety (1992), Semi-automatic external defibrillator (1992, 1993), AIDs awareness (1995), Emergency Vehicle Operations Course (1996), in-service training (1996), confined space training (1997), trench rescue (1997), first responder/CPR (1997), EMS/hazmat continuing education (1997), basic vehicle rescue (1998), Terrorism (1998), SCBA training (1999), Amtrak training (1999), communicable disease training (2000, 2001), rapid intervention training (2001), 800 radio training (2002), WMD refresher training (2003), 800 MHz digital trunk radio system refresher training (2004), ICS-700, introduction to NIMS training (2005), ICS-100, ICS 200, *Basic ICS* (2005), arson awareness, vehicles (2005), ethics training (2006), PECO training (2006), SCBA CBRN upgrade training (2007), cellar fire operations (2007),

EEOC training (2007), NFIRS [National Fire Incident Reporting System] (2008), Con Ed-2 basic fire ground operations (2009), communications unit training (2009), point source capture systems training (2009, 2010), personal escape harness training (2010).

Victim 2 was appointed to the fire department in 2006. Training recorded in Victim 2's training record includes: Cellar fire operations training (2006); NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, Fire Fighter I & Fire Fighter II certification (2006); IS-700 Introduction to NIMS (2006); ICS 100, *Introduction to ICS*(2006)*;* ICS 200, *Basic ICS* (2006);"Mayday" training (2007); Ethics training (2007); SCBA CBRN upgrade training (2007); driver/pump operator (2007); EEOC training (2008); air bag training (2008); NFIRS training - Modules 1 and 2 (2009); Communications Unit training (2009); point source capture training (2009, 2010); personal escape harness training (2010); and Ladder training (2011).

Equipment and Personnel

In the event of a structure or building fire, the Fire Communications Center (FCC) assigns the appropriate number and type of fire companies to the incident. All incidents are assigned a box number based upon the location of street boxes that were used as a method of transmitting alarms to the Fire Communications Center, as well as a means for the fire department to communicate from an incident with the Fire Communications Center, which was done primarily before the radio system came into existence. All of the street boxes have been removed from service but their locations are maintained within the FCC computer system.

The FCC sends three assignment levels to reported or confirmed structure fires:

- **Tactical Box Alarm Assignment**:
  - 2 Engines
  - 2 Ladders
  - 1 Battalion Chief

The *Tactical Box Alarm Assignment* is assigned to fires in a single-family dwelling

- **Box Alarm Assignment**:
  - 4 Engines
  - 2 Ladders
  - 2 Battalion Chiefs

The *Box Alarm Assignment* is assigned for fires in commercial or industrial buildings, factories, warehouses, educational buildings, or multiple-family dwellings under six stories in height.

- **High-Rise Box Alarm Assignment**:
  - 3 Engines
  - 3 Ladders
  - 2 Battalion Chiefs(1 for Lobby Control)

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- Rescue Company (Rescue 1)
- 1 Medic Unit

The *High-Rise Box Alarm Assignment* is assigned for fires in buildings seven stories or greater in height.

- **All-Hands**
  - Additional ladder company – Rapid Intervention Company (RIC)
  - A squad company
  - Rescue 1
  - Medic Unit

When the 2 engines, 2 ladders, and the Battalion Chief assigned to the *Tactical Box Assignment* are all working at a fire, the *All-Hands Assignment* is requested, bringing an additional Ladder Company to serve as the Rapid Intervention Company (RIC), a Squad Company (either Squad 47 or Squad 72), the Rescue Company, and a Medic Unit.

- **Working Fire Assignments**
  - Deputy Chief (Division 1 or Division 2)

If the fire is severe enough, a *Working Fire Assignment* will be transmitted above the *All-Hands Assignment*, bringing a Deputy Chief to the scene.

If the fire is large and of enough severity, the Incident Commander, either a Battalion or Deputy Chief, will transmit additional alarms, starting with a Signal 2-2-2(2nd Alarm) Assignment going up to nine, to bring more companies and staffing to the scene above the existing *Tactical Box Assignment*, *Box Alarm Assignmen*t, or *High-Rise Box Assignment*, and in addition to the *All-Hands Assignment* and *Working Fire Assignment*.

- **Signal 2-2-2(2nd Alarm) Assignment** (*Additionally*):
  - 5 Engines(1 for Logistics)
  - 2 Ladders
  - 4 Battalion Chiefs

- **Signal 3-3-3(3rd Alarm) Assignment** (*Additionally*):
  - 4 Engines
  - 1 Ladder
  - 1 Battalion Chief

- **Signal 4-4-4(4th Alarm) Assignment** (*Additionally*):
  - 4 Engines
  - 1 Ladder

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- **Signal 5-5-5(5th Alarm)** to **Signal 9-9-9(9th Alarm) Assignments** (*Additionally per Alarm*):
  - 4 Engines per Alarm

When a report of a small fire such as a rubbish or trash fire is received, the FCC will send an "Outside Fire Assignment" and the closest engine company is sent. If a ladder company is available to respond from close by, it will also be added.

- **Outside Fire/Local Alarm**:
  - 1 Engine or 1 Engine and 1 ladder

This incident was dispatched as Box 361 and grew in size to a Signal 5-5-5(5th Alarm) fire. One engine company (Engine 2) was dispatched to a local alarm based upon one telephone call from a transit authority supervisor who reported smoke in the area. Upon arrival, Engine 2 reported a fire in a vacant warehouse. The officer of Engine 2 had the pump operator drive around the entire block (360 degrees) to get an accurate size-up of the incident before contacting the FCC with a complete assessment of the situation.

Per department procedures the following companies were dispatched to the initial report of a structure fire through the 2nd alarm. The response for Box 361 included:

Local Alarm
- Engine 2, dispatched to a local alarm of report of smoke in the area

High-Rise Assignment
- Engine 25: Officer and 3 fire fighters;
- Engine 29: Officer and 3 fire fighters;
- Pipeline 50: Officer and 3 fire fighters;
- Ladder 3: Officer and 4 fire fighters;
- Ladder 16: Officer and 4 fire fighters;
- Ladder 12: Officer and 4 fire fighters;
- Battalion 8: Battalion Chief and Field Incident Technician;
- Battalion 10: Battalion Chief and Field Incident Technician;
- Rescue 1: Officer and 5 fire fighters.

All Hands and Working Fire Dispatch
- Engine 55: Officer and 3 fire fighters;
- Ladder Tower 22: Officer and 4 fire fighters;
- Battalion 3: Battalion Chief and Field Incident Technician;
- Medic 15: 1 EMT and 1 Paramedic;
- Medic 2: 1 EMT and 1 Paramedic;
- Engine 13: Officer and 3 fire fighters;
- AU1: Assistant Fire Marshal;

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- Squad 72: Officer and 3 Fire Fighters;
- Squad 72A: 2 fire fighters;
- Division 2: Deputy Chief and Field Incident Technician.

Signal 2-2-2 (2nd Alarm) Assignment

- Engine 7: Officer and 3 fire fighters;
- Pipeline 28: Officer and 3 fire fighters;
- Engine 45: Officer and 3 fire fighters;
- Engine 27: Officer and 3 fire fighters:
- Pipeline 3: Officer and 3 fire fighters;
- Ladder 10: Officer and 4 fire fighters;
- Ladder 14: Officer and 4 fire fighters;
- Battalion 4: Battalion Chief and Field Incident Technician;
- Battalion 1: Battalion Chief and Field Incident Technician;
- Battalion 2: Battalion Chief and Field Incident Technician;
- Battalion 9: Battalion Chief and Field Incident Technician.

Timeline

This timeline is provided to set out, to the extent possible, the sequence of events according to recorded radio transmissions. Times are approximate and were obtained from review of the dispatch records, witness interviews, and other available information. Times have been rounded to the nearest minute. This timeline is not intended, nor should it be used, as a formal record of events. ***Note:*** *The complete timeline is listed in Appendix 1.*

Incident and Fire ground Conditions	Time	Response & Fire ground Operations
April 9, 2012		
"911 Call received a telephone call which reported smoke in the area;	**0312 hours**	
Engine 2 dispatched to a "Local Alarm" assignment;	**0313 hours**	
	0317 hours	Engine 2 (E2) on scene; E2 reports a 6-story building, (actually 5 stories), 60' x 1 city block; Heavy fire showing on the 1st and 2nd floors; Requested a Box Alarm;
	0318 hours	E2 reported the fire was all the way to the roof; "Strike a 2nd Alarm and prepare for the 3rd Alarm";

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Incident and Fire ground Conditions	Time	Response & Fire ground Operations
FCC dispatched a "High Rise Box" Alarm Assignment for Box 361; E25, E29, P50, L3, L16, L12 (Lobby Control), B8, B10, and Rescue 1;	**0319 hours**	
FCC dispatched an "All Hands" Assignment and a "Working Fire" Assignment for Box 361; E55, LT22, B3, M15, M2, E13, AU1, E55, Squad 72, Squad 72A, and Division 2; **Note:** *The balance of the "High Rise Box" adds the additional resources above the normal "All Hands" Assignment*;	**0322 hours**	
FCC dispatched a "2nd Alarm" Assignment for Box 361; E7 (Logistics Company), P28, E45, E27, P3, L10, L14, B4 (Logistics), B1, B2, B9 (Safety Officer);	**0324 hours**	
"3rd Alarm" Assignment for Box 361 dispatched by FCC: P20, P34, E11, and E44;	**0328 hours**	
FCC dispatched a "4th Alarm" Assignment for Box 36; Units dispatched: E64, P49, E36, E70;	**0341 hours**	
FCC dispatches a "5th Alarm" Assignment for Box 361; E22, Foam 33, E35, and P61;	**0401 hours**	
	0414 hours	Current Assignments: Alpha Division B8, E33, E44, P61; L10, L14; Bravo Division: B3, E2, P20, E29, E64, E70, SQ 72, L3, L16; Charlie Division: B10, P34, LT22; Delta Division: B1, E35, Rescue 1

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Incident and Fire ground Conditions	Time	Response & Fire ground Operations
	0414 hours	**Exposures:** Battalion 4, Pipeline 3, Ladder 2, Ladder 12, Engine 7, Engine 25, Ladder 12, Engine 55, Engine 50, Engine 70, Engine 35, Pipeline 49, Engine 27, Engine 28, Engine 59, Engine 22, Engine 3, Engine 11, and Engine 28;
	0430 hours	Rescue 1 forced entry into furniture showroom from Boston Street (side A). They reported to Division A that they found fire in the furniture showroom. Division A ordered Rescue 1 to stretch 1¾" hose line into furniture showroom to contain the fire; the hose line was the high rise pack off of E44; The Rescue 1 officer established a secondary interior collapse zone (exclusion zone) and told his men to bounce water off the ceiling and not to go into the secondary collapse zone;
	0440 hours	Crews from L10 and Rescue 1 go in and out of the furniture store showroom multiple times to check on possible fire extension due to the collapse of the fire building into the furniture store showroom; (***Note**: L10 crew entered the showroom to relieve Rescue 1 crew. L10 crew re-enters the furniture store showroom every 10 – 15 minutes for approximately the next 60 – 70 minutes*).
	0555 hours	"Safety" (Battalion 9) contacted "Command" and advised that a collapse had occurred in the furniture store showroom; requested a RIC and medic units to this area;
	0556 hours	"Safety" advised "Command" that they have a company, 3–4 fire fighters, trapped in the furniture store showroom; there was debris on them and they need to be extricated; "Command" acknowledged the message;

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Incident and Fire ground Conditions	Time	Response & Fire ground Operations
FCC dispatched E53-29, L5, and Collapse 1 for the collapse at furniture store showroom as the Rescue Group; L8-22 replaced L5;	**0601 hours**	
FCC has Medic15 and Medic 2 to report to the furniture store;	**0601 hours**	
	0602 hours	Bravo Division sent Squad 72 to "Rescue Group"; Rescue Group was: FM1, E53-29, Pipeline 61, L8-22, L12, Squad 47, Squad 72, and Rescue 1;
	0612 hours	L10 "Inside Hook" fire fighter removed from the collapse;
	0622 hours	L10 "Search & Rescue" fire fighter removed from the collapse and transported to trauma center;
	0706 hours	L10 lieutenant removed from the collapse and transported to trauma center;
	0725 hours	L10 "Tillerman" removed from the collapse and transported to trauma center;
Incident terminated.	**1631 Hours**	

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Building Construction and History

The fire building was a vacant 5-story factory mill building, built in the 1872 to 1893 era, which included a basement and a floor area of approximately 80,000 square feet (see Figure 1 and Photo 2), and encompassed the south half of the city block. The mill building consisted of a complex of five attached buildings with various building additions and alterations performed in 1882-1893 and into the early 1900s. This building had a number of additions over the 140-year history. At the time of the fire, the building was vacant with a large number of homeless people known to occupy or frequent the structure. The building was suffering from considerable deterioration and was not secured and was considered abandoned. The building owner had an open zoning permit to build an 81-unit apartment building.

The complex of buildings that encompassed the city block area were developed and constructed over a 140 year period. The north half of the city block was comprised of operating commercial occupancies of various vintage and building type and included a furniture store and warehouse, retail storefronts and a standalone vacant bank building (see Figure 1 and Photo 2).

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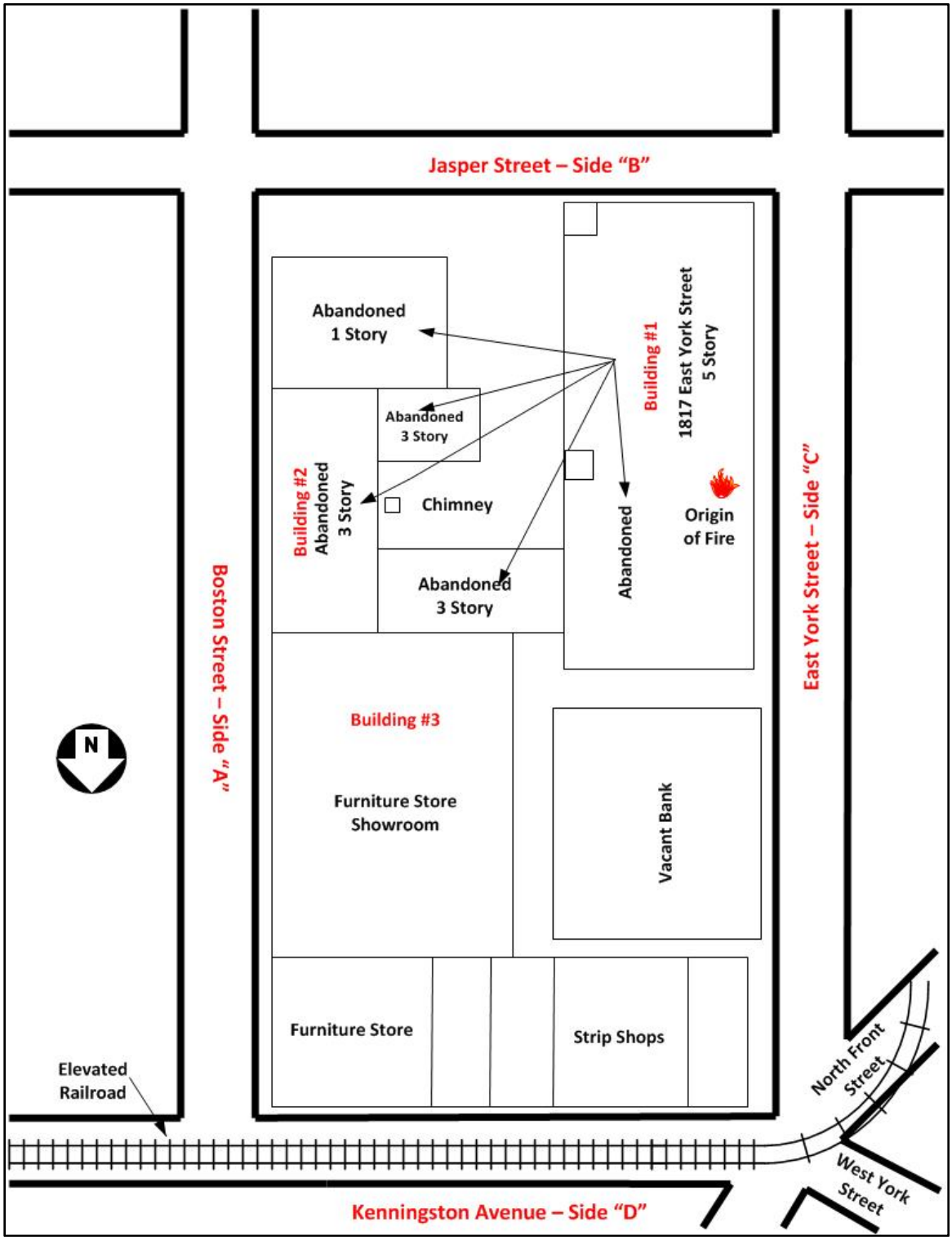

Figure 1. Diagram of the fire building and location where the fire originated.

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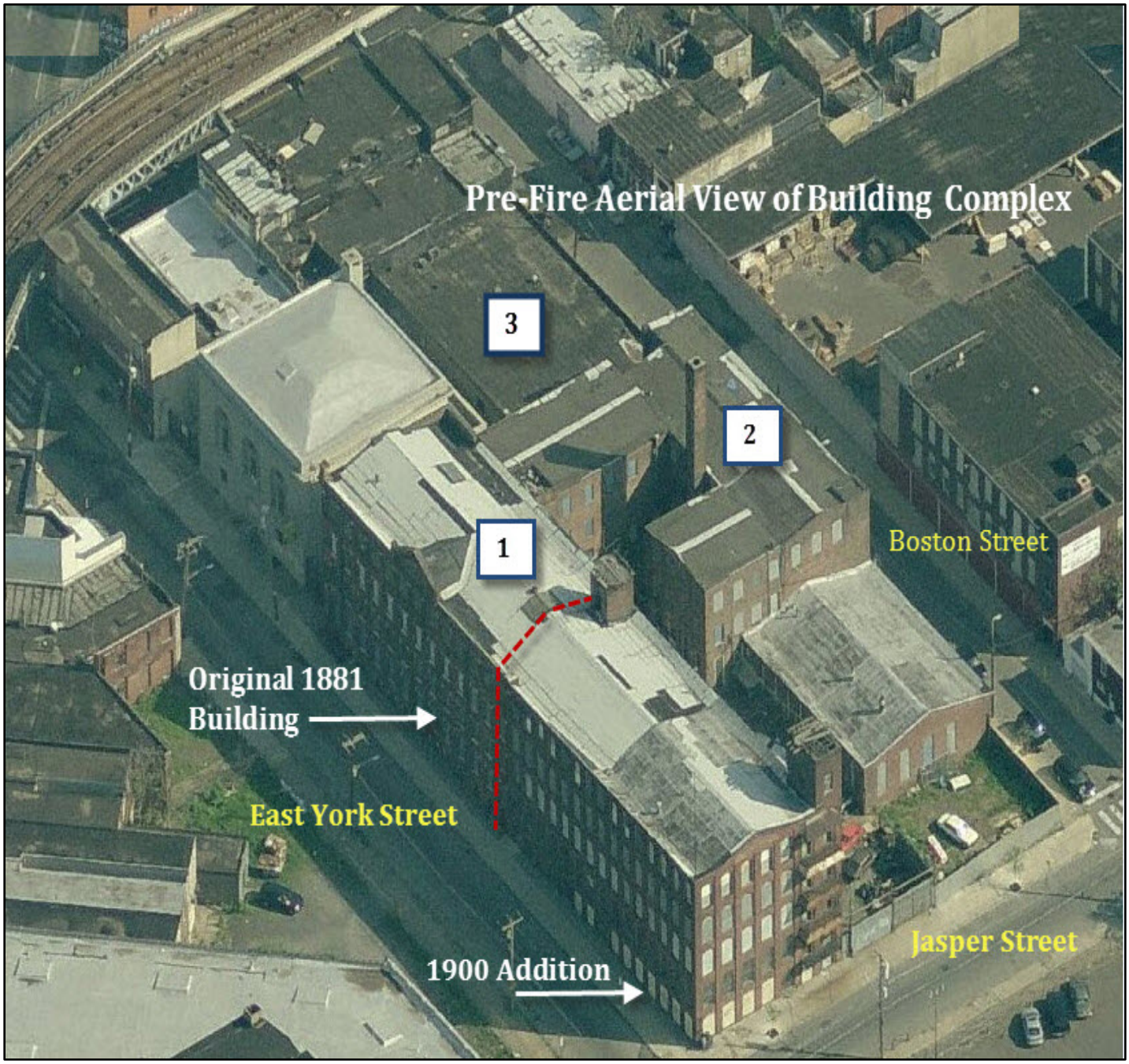

Photo 2. Pre-fire aerial view of building complex showing the building of origin (1), and the building that collapsed (2) onto the roof of the furniture store showroom (3).
(Bing.com Maps/ analysis diagram courtesy of Buildingsonfire.com.)

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The various buildings were erected of Mill Construction and Semi-Mill Construction (similar to Type IV Heavy Timber), Heavy Timber (Type IV construction) and common Brick and Joist construction (Type III construction),[3] all with common characteristics and features found in Heritage Construction [4,5] (see Figures 2, and 3).

Reading the Building & Predictive Indicators of Collapse

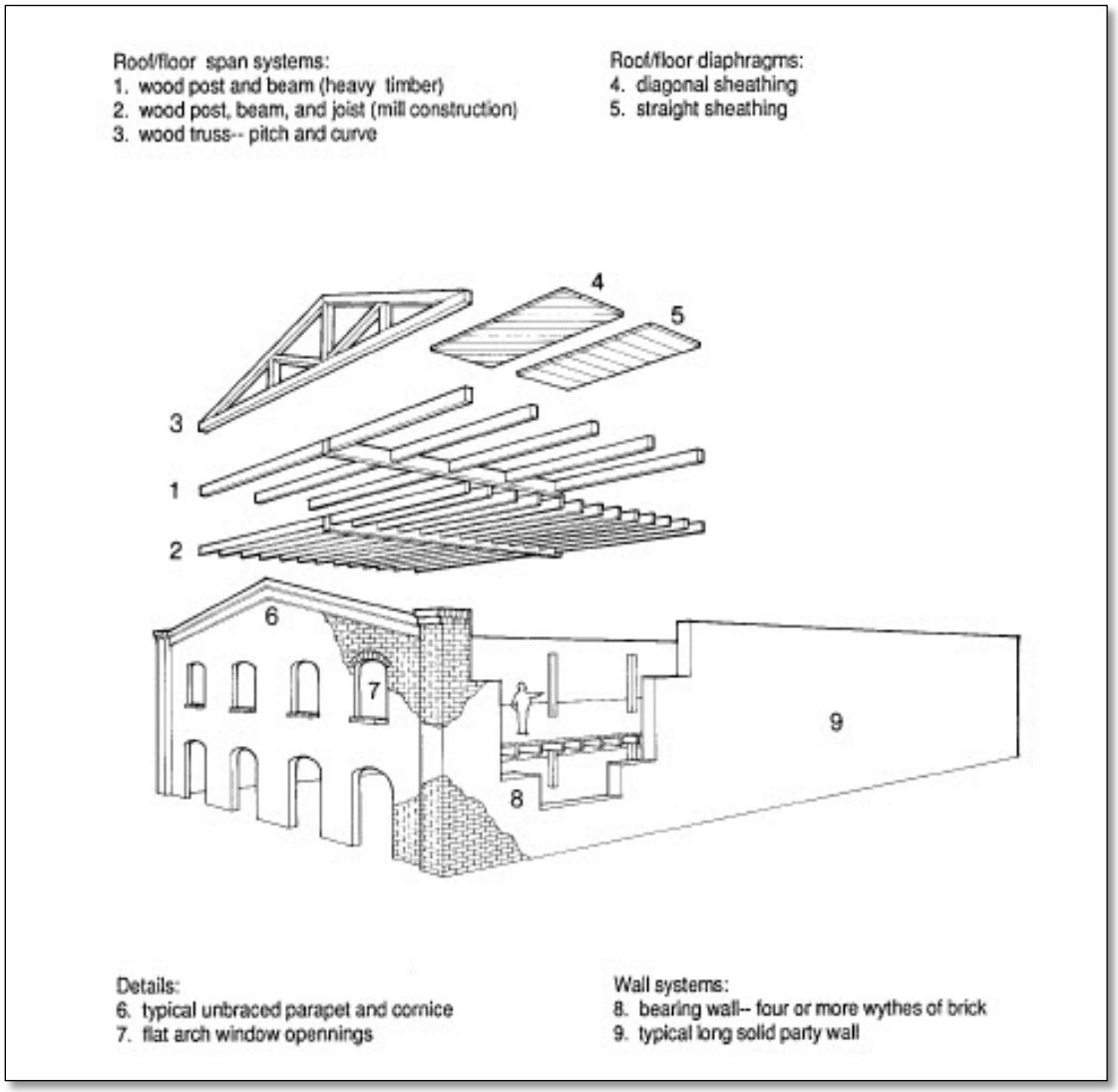

Figure 2. Common mill and heavy timber construction details
(Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook. Second Edition 2002.)

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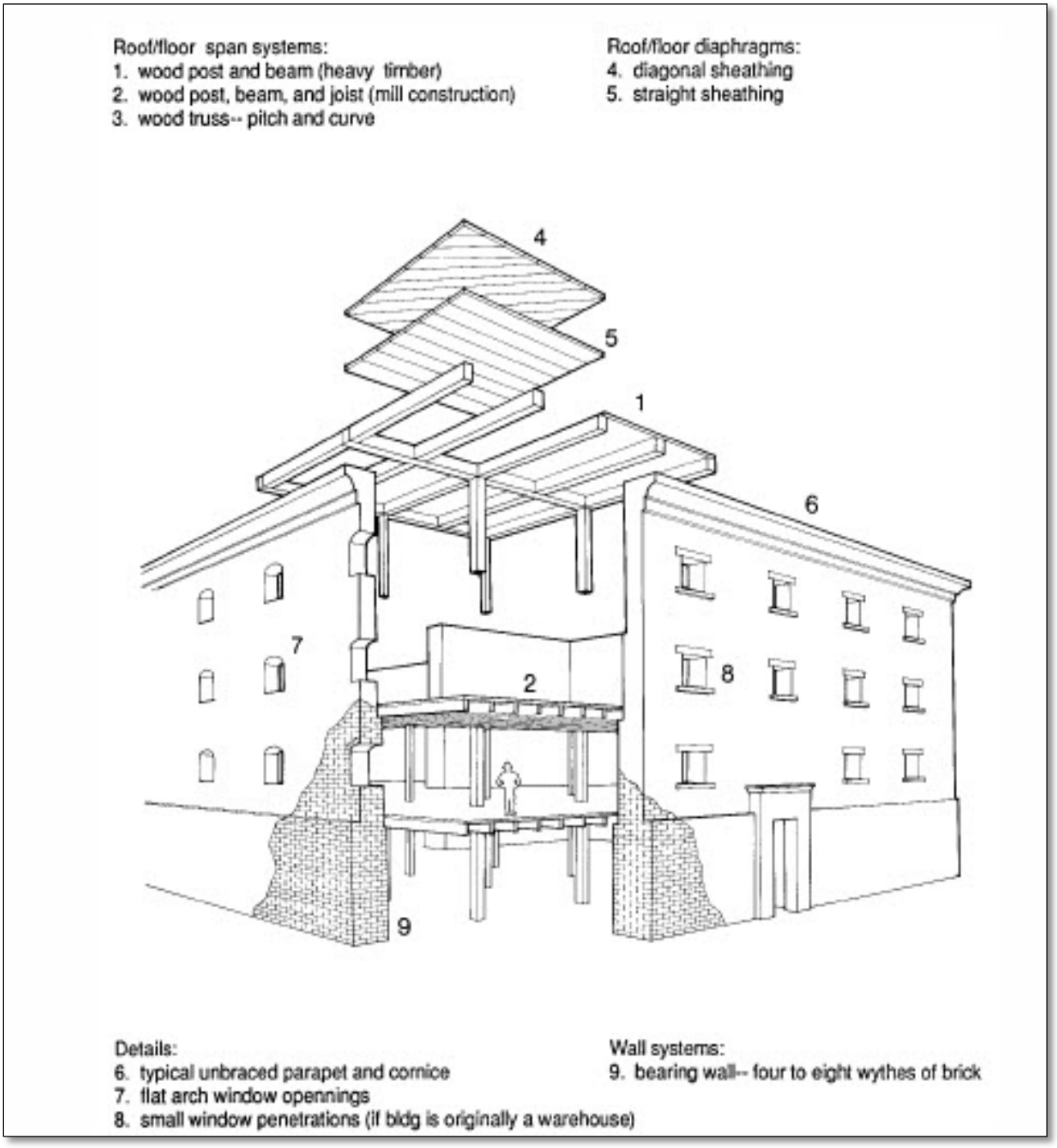

Figure 3. Common mill and heavy timber construction details
(Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook. Second Edition 2002.)

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Building 1 (Hosiery Building)
- **Constructed:** circa 1881
- **Occupancy:** Industrial Manufacturing—Factory & Office
- **Construction System:** Mill Construction
  - Girders: 12 x 12 inch, pocketed/fire-cut & restrained
  - Columns: 12 x 12 inch, square with cast iron caps
  - Bays: 13 at 8 feet on center
  - Floor: 3-inch wood plank with 1-inch top boards (4 inches total)
    - nonflooding protective floors
    - basement: cement floor
- **Size:** 5 stories, including a basement
  - Height: curb line to cornice, approximately 58 feet
- **Floor Area:** 105 feet x 50 feet (5,250 square feet per floor)
  - Total Floor Area: 26,250 square feet, est.
  - Open Floor Plan
- **Perimeter Walls:** Brick Masonry Wall Construction
  - Floor Heights: basement, 11 feet; 1st through 4th floors, 12 feet each
  - Wall Thickness: basement through 3rd floor, 22-inch multiwythe wall (*Note: A wythe is a continuous vertical section of masonry one brick unit in thickness.*); 3rd floor to roof cornice, 18-inch multiwythe wall
  - Pilaster Wall Construction: between window openings
  - Thinner masonry wall wythe construction between pilasters (*Note: A pilaster is a projecting column built into or applied to the face of a wall.*)
  - Large Window Treatments: represented 30% of wall area
  - Decorative Brick Cornice and Roof Edge
- **Roof:** Heavy Timber Rafters with Wood Deck and covering
- **Protective Systems**: Sprinkler System/Fire Separation/ Fire Doors /Enclosed stair towers were not operational (out of service) for any of the structures.

Building 1, *Addition:* Circa 1900–1910 est.
- **Historical Research Documents identify a significant building addition that was erected and added to the primary building (Building #1) that expanded the building foot print to the south of the original ca1881 building**. All features similar to original structure.
- **Occupancy:** Industrial Manufacturing—Factory & Office
- **Construction System:** Semi-Mill Construction
  - Girders and Beams: 12-inch x 12-inch
- **Size:** five stories, including a basement
  - Height: curb line to cornice approximately 58 feet
- **Floor Area:** 104 feet x 50 feet (5,200 square feet per floor)
  - Total Floor Area: 26,000 square feet est.
  - Open Floor Plan with some compartmentation (alterations)
- **Bays:** 18 at 8 feet on center

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TOTAL Building Area: (1881 and 1919)
Floor Area: 209 feet x 50 feet
Total Bays: 28 at 8 feet on center
Total Building Floor Area: 52,250 square feet, est.

Building 2
Constructed: circa 1872
First original building erected on the property and the oldest of the structures in the complex
Note: This building collapsed during this incident, resulting in the firefighter fatalities.
Occupancy: Industrial Manufacturing—Factory
Construction System: Mill Construction
Girders: 12-inch x 12-inch at 18 feet on center, pocketed/fire-cut & restrained
Columns: 12-inch x 12-inch square with cast iron caps at 18 feet x 7 feet 6 inch on center grid line
Bays: 12 at 7 feet, 6 inches on center
Floor: 5/4-inch wood plank [1-1/4-inch total]
Nonflooding protective floors
Basement: cement
Size: 3 stories, including a basement
Height: curb line to cornice, approximately 46 feet
Floor Area: 90 feet x 36 feet (3,240 square feet per floor)
Total Floor Area: 12,960 square feet
Open Floor Plan
Perimeter Walls: Brick Masonry Wall Construction
Floor Heights: basement through second floor and fourth floor, 10 feet, 6 inches each; 3rd floor, 11 feet
Wall Thickness: basement to first floor, 18-inch multiwythe wall; 1st floor to roof cornice, 13-inch multiwythe wall
Pilaster Wall Construction between window openings
Thinner masonry wall wythe construction between pilasters
Large Window Treatments: represented 30% of wall area
Decorative Brick Cornice and Roof Edge
Roof: Heavy Timber Rafters with Wood Deck and covering

Protective Systems: Sprinkler System/Fire Separation/Fire Doors/Enclosed Stair Towers (Protective systems were not maintained or in service at the time of the fire.)

NIOSH investigators met with representatives from the city's Department of License & Inspection (L&I) to obtain information on complaints received by L&I and any action taken. L&I has 109 inspectors (60 construction and 49 abatement) who serve the entire city. Complaints on properties (including complaints from the fire department) come into L&I through a 311 phone system—a central complaint, non-emergency phone line. According to interviews with NIOSH, L&I received a total of nine complaints for the fire building's address from October 31, 2011 through April 9, 2012. On

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November 8, 2011 a notice of violation was issued for dangerous fire escapes. On February 1, 2012 the building was categorized as abandoned by the Department of License and Inspection. The last inspection by the Department of License and Inspection on the building was February 14, 2012 and no violations were recorded but a follow-up inspection was requested. No "911" calls were received for any criminal activity (e.g., trespassing, breaking and entering) for the fire building's address. At some point prior to the fire, city officials identified approximately 65 people living in the building.

L&I estimated 20,000 vacant, abandoned, and hazardous structures—commercial and residential—were within the city limits. L&I estimated that 70% of the code violations in the city are brought into compliance after the first citation. The procedure for L&I enforcement is after three notices and no action, legal action is taken against the building owner. Tax delinquency is the main route that the city has to take possession of a property.

This area of the city was the predominant location for textile mills, factories, and manufacturing complexes from the 1870s–1930s, and numerous structures of similar design, construction, and condition can be found within close proximity. Large-scale, multiple-alarm incidents have historically confronted the fire department in this area.

The fire originated in Building 1 on Side C and rapidly extended to the other structures within the vicinity of the south block. Building 2, located east of the building of origin and situated on Side A, sustained the structural and wall collapse that resulted in the fire-fighter fatalities and injuries.

Building 1 was adjoined along the north property line to an adjacent three-story building (6,048 square feet), which further adjoined Building 2.

Building separation between the three structures consisted of masonry brick walls with limited wall openings and protective sliding fire-rated doors on each common floor level. Based on the building's material conditions and degree of deterioration, the operability of these fire doors and the integrity of the masonry wall partitions were doubtful.

The southernmost section of Building 2 along Side A had a four-story, L-shaped extension running perpendicular to Building 1 to the west. Building 1 and Building 2 were physically separated by a semi-enclosed yard area a distance of 65 feet at the farthest and 30 feet at the nearest points.

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Fire-Fighter Risk Profile

The most current occupancy status prior to the fire found the buildings to be vacant, abandoned, and unsecured. They were in various stages of decay and deterioration prior to the fire and represented hazards defined by the building's inherent construction systems and features, past occupancy use, stages of occupancy use based on the building's life span, and material conditions resulting from the effects of age, exposure, deterioration, and wear.

There were consistent reports of unauthorized access to the unsecured premises by various individuals including the homeless. These reports suggest that interior features and conditions could have been compromised over the past 15 to 20 years as the building lay dormant and vacant.

The siting and location of the building complex in relationship to surrounding commercial, retail, and residential occupancies and transportation systems presented numerous challenges in the event of a fire (see Figure 1 and Photo 2).

Both existing Building 1 and Building 2 had sprinkler systems present, however they were not operable at the time of the fire. Both buildings contained integrated passive and active fire and safety protective systems that included a sprinkler system, fire doors, separations, and fire resilient and resistant materials. The standardization of structural components and assembly systems worked collectively to provide and maintain building integrity and system performance. Material mass, distance, and resiliency of these systems are integral to performance in these building types.

As the fire originated and developed, several factors provided ready travel paths for flame and heat propagation and for fire extension: the lack of operable and functioning sprinklers, possible unsecured or inoperative interior fire doors, and introduction of unchecked vertical and horizontal travel paths, open penetrations, and chases; and building deterioration. The inherent building materials in the form of the heavy-timber structural components provided sufficient fuel to allow fire growth in both intensity and magnitude, allowing for rapid extension.

All members should be trained to recognize subtle or readily apparent collapse indicators and be able to read the building and comprehend collapse considerations for primary and secondary collapse conditions. Understanding the mechanism of a building collapse and the causal factors that contribute to the structural collapse provides the Incident Commander, Incident Safety Officer, division/group supervisors, company officers, and fire fighters with the skill sets to anticipate and proactively manage the fire ground versus responding adversely and in a reactionary manner.

The risk assessment of a building during fire-fighting operations must be continuous with building intelligence and reconnaissance communicated on degrading conditions, fire extension and compromise, building integrity considerations, the effects of fire spread and suppression on the interior compartment(s), and the structural system and building envelope. The "Fire Risk Matrix" listed below can be used to conduct the continuous risk assessment during fire-fighting operations in which the potential for structural collapse exists.

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The Occupancy Risk Profile for Building 1 on "Side Charlie" and Building 2 on "Side "Alpha" can be assessed and categorized based on the follow *Buildings-on- Fire Risk Matrix* (see Figure 4).[5]

Levels	Severity of Risk
Catastrophic	May result in personnel death, grave personnel injury, large-scale destruction, and perilous conditions
Critical	May cause severe personnel injury, possible death; major property loss or significant degraded conditions
Marginal	May cause or result in personnel injury, prominent property loss or degraded and compromised conditions
Normal	Hazards and conditions are consistent with generally accepted Fire Service work practices and operational parameters for adequately resourced and trained companies. Operations may cause or result in some personnel injury, corresponding property loss or damage conditions consistent with firefighting principle & practices
Negligible	Conditions have minimal threat to the safety and wellbeing of companies operating under generally accepted Fire Service work practices and parameters

Figure 4. Buildings-on-fire Risk Assessment Matrix for Fire Fighters.
(Courtesy of Buildingsonfire.com and the Command Institute, additional information can be accessed at http://buildingsonfire.com/buildings-on-fire-risk-assessment-matrix ***)***

Building Risk and Severity Considerations

- Building construction system and type
- Building size and volume
- Building age and vintage
- Physical condition, deterioration, and decay
- Degree of compartmentation: connectivity of floors, compartments, and spaces
- Exposure to environmental elements
- Inherent structural compromise and collapse potential—internal
- Structural collapse characteristics of unreinforced masonry (URM)
- Operability of fixed suppression or protections systems—level of defense
- Fire loading and potential for significant heat release rates/effects on fire suppression
- Building security, accessibility, and controls
- Neighborhood or communal threat
- Special circumstances affecting community heritage
- Identifiable and measurable safety parameters
- Adequacy of fire flow rates based on postulated fire growth
- Probability of civilian life hazard and risk threat
- Probability of fire department life hazard and risk threat

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- Identified severity of risk level and acceptability of risk to organization

Masonry Perimeter Walls

The complex of structures all shared vernacular architectural features in the use of masonry materials and construction for their perimeter enclosure walls that were common during the late 19th and early 20th centuries (see Figure 5). Utilizing masonry brick, the perimeter walls were constructed of unreinforced masonry that rose to a height of approximately 58 feet for Building 1 and 46 feet for Building 2.

Unreinforced masonry (URM) walls, when they are not veneers, are typically several wythes thick. (A wythe is a term denoting the width of one brick.) Therefore, header bricks will be apparent in the exposed surface. Headers are bricks laid with the butt end on the exterior face, and function to tie wythes of bricks together.

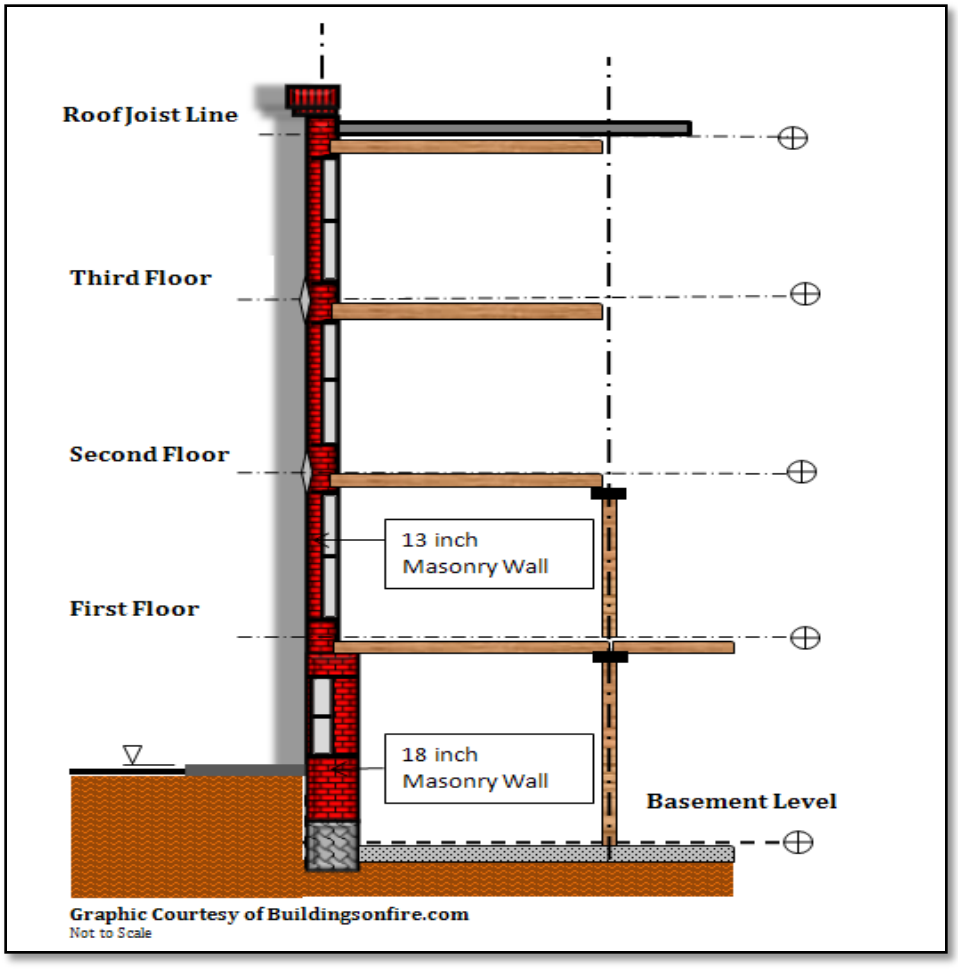

Figure 5. Masonry brick perimeter wall construction
(Graphic courtesy of Buildingsonfire.com.)

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Brick header courses (bricks laid perpendicular across the wythes), typically occur every six or seven courses as was found in the construction of these buildings. Sometimes, URM infill walls will not have header bricks, and the wythes of brick are held together only by mortar. The construction of these buildings incorporated brick laid in a soft sand-lime mortar, common for this vintage of construction, which is highly susceptible to deterioration due to age, weathering and exposure to the elements.

These buildings incorporated common empirical design principles, which is a procedure of proportioning and sizing URM elements based on known historical performance for a given application.

Building 2's masonry walls were constructed of an 18-inch wythe wall from the basement to the first floor level, bearing upon a stone rubble foundation with a cement floor. From the first floor level rising to the roof cornice, the wall consisted of a 13-inch wythe brick wall construction. The building's mill construction structural system was integrated into the bearing and non-load-bearing walls within the interior (see Figure 5).

Building 2 incorporated URM construction with large 40-inch x 84-inch windows with 10-inch x 12-inch lights. This provided an approximate 23 square feet of glazing area per window treatment. Placed uniformly within the primary wall facing, the windows were inset within a 13-inch wythe brick infill area that spanned 5 feet between vertical masonry pilasters). A segmental brick arch and lintel spanned across each window opening and provided the structural support for the window opening and the brick wall above (see Figure 6).

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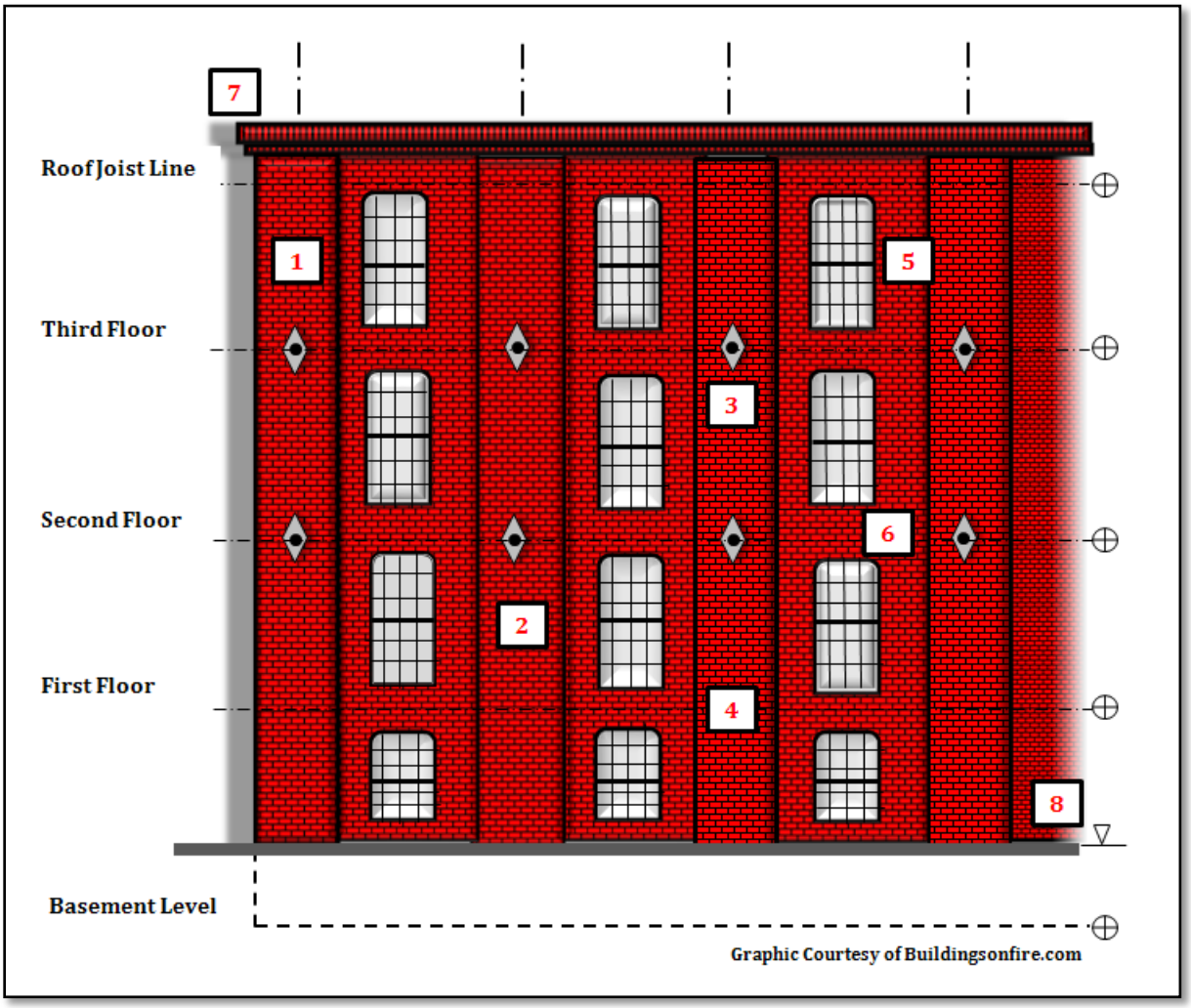

Figure 6. Masonry Brick Perimeter Wall Construction Floor Detail.
(Graphic Courtesy of Buildingsonfire.com.)

Exemplifying Features of Building 2 noted in Figure 6.

Note 1: Figure 6 shows the URM wall construction consisting of common brick units, several wythes thick laid in a sand-lime mortar with a common (a.k.a American) bond pattern of brick work. The east and west masonry wall faces of Building 2 contained a masonry wall surface area of 3800 square feet (est.) representing 70% of the solid area of these perimeter walls.

Note 2: Masonry Pilaster (2 feet wide) constructed to align with the building's interior structural framing system forms the building's bay areas and rises vertically along the exterior face from the curb line to the roof cornice. Has increased wythes (18 inches) for stiffening due to structural load capacity and support requirements (See Figure 7 and Photo 3).

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Note 3: Spreader plates and strap anchors are diamond-shaped plates located uniformly at each bay along the 2nd- and 3rd-floor lines, aligning with the building's interior structural framing system and connecting the heavy timber floor girder to the masonry wall. (See Figures 6 and 7).

Note 4: The existing face of Building 2, exhibited evidence of out-of- plane wall orientation with extensive deterioration or absence of mortar joints between brick courses, suggesting a relatively unstable or weakened perimeter wall. Efflorescence is evident in various views of the building face as were missing and loose bricks and brick courses (See Photo 3).

Note 5: Window treatments consist of 40-inch x 84-inch windows with 10-inch x 12-inch lights with a segmental brick arch and lintel above. Windows were installed in 13-inch wythe infill wall areas between pilasters, resulting in 23 square feet (est.) of glazing area per window treatment. The window treatments of the wall facing provided 1,000 square feet (est.) of surface area, representing 30% open area of the perimeter wall.

Note 6: As a result of using masonry pilasters for stiffening and structural integrity, the wall section between the pilasters need only be thick enough to span horizontally, thus allowing for less material and cost in construction. This has collapse considerations during fireground operations.

Note 7: Roof cornice was a decorative brick treatment on the street face, common to most buildings constructed in this era. Materials and construction features are highly susceptible to deterioration due to age, weathering and exposure, movement and loss of alignment, thus compromising structural integrity, and becoming a collapse hazard.

Note 8: URM perimeter walls incorporated large spans of window treatments, pilaster construction and infill brick at the spandrel areas. (*Note: A spandrel is the space between two arches or between and arch and a rectangle enclosure, see Photo 3*). These areas are susceptible to curtain-fall wall-collapse conditions versus monolithic segmental wall failures and collapse, resulting in collapse debris piles within the vertical wall plane proximal to the base at the sidewalk/curb location of the building.

The material condition of the overall wall as viewed from street level areas suggests that building performance and overall integrity in both fire and non-fire incident conditions could have a high-risk factor for stability loss, compromise, and collapse. Disconnected downspouts on Side A depicted evidence of further wall, bond and joint deterioration along the pilaster face and infill spandrel areas.

The loss of bonding integrity of mortar joints and deficient brick facing suggests a heightened degree of awareness would be prudent during subsequent fire department operations. Efflorescence (white discoloration of the brick) is evidenced in various views of the building face as were missing and loose brick courses. Efflorescence is a fine, white, powdery deposit of water-soluble salts left on the surface of masonry as the water evaporates (See Photo 3).

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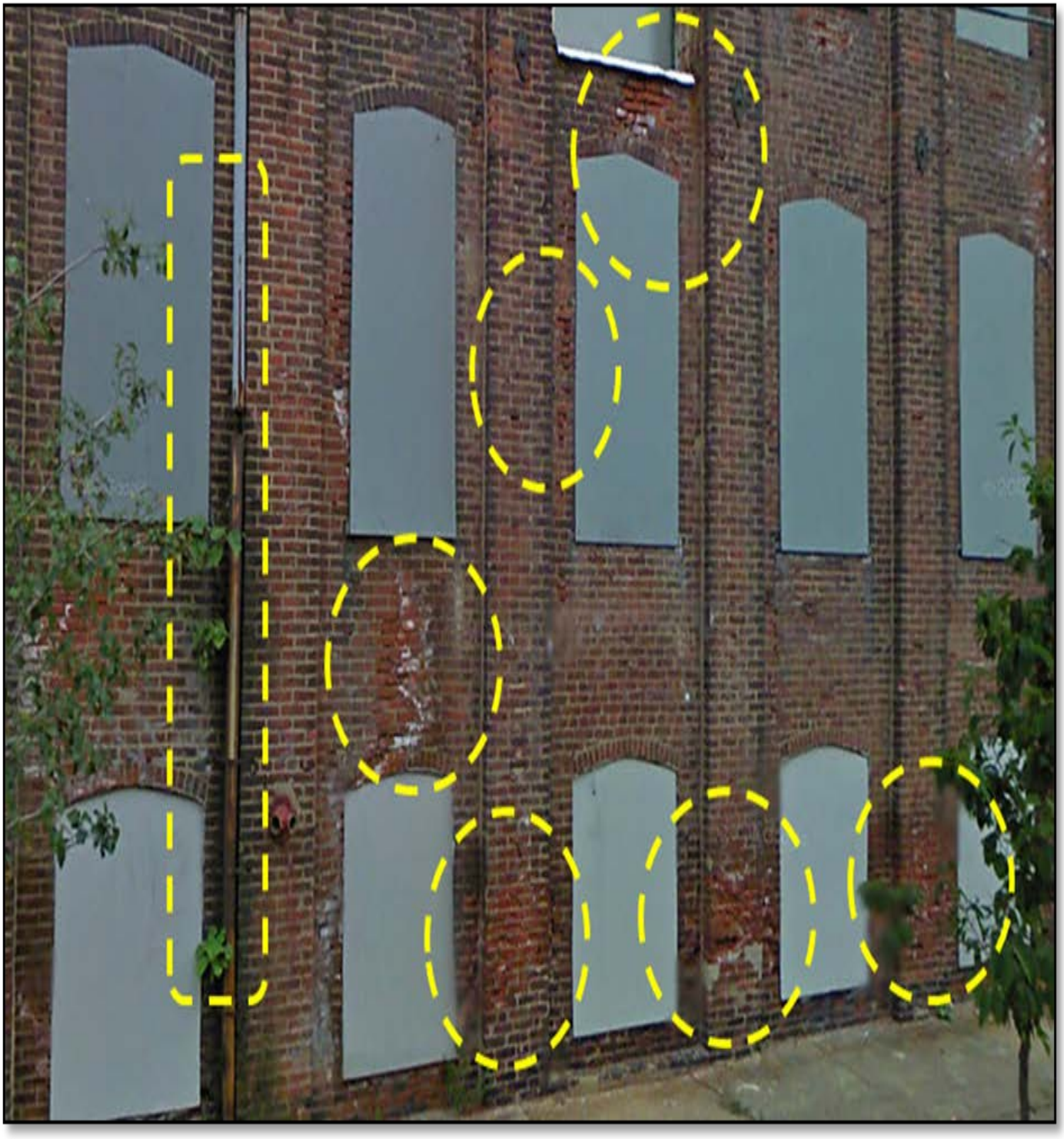

Photo 3. Building 2 Masonry Perimeter Wall Deficiencies – Side "Alpha".
(Photo Google Street Maps/ analysis diagram courtesy of Buildingsonfire.com.)

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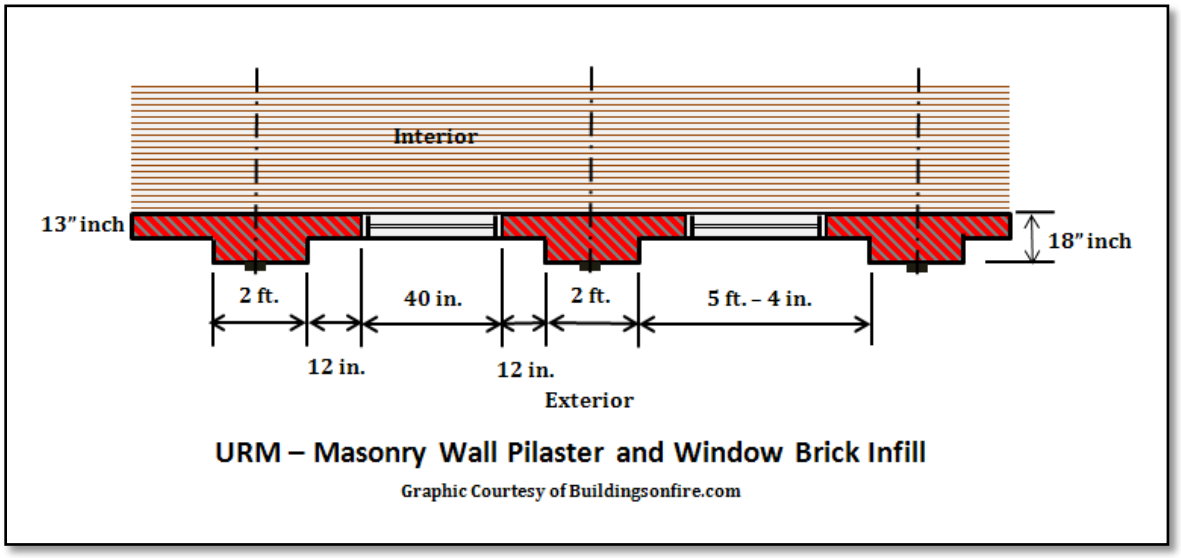

Figure 7. URM-Masonry Wall Pilaster and Infill Plan
(Graphic courtesy of Buildingsonfire.com.)

The east and west face of Building 2 incorporated masonry vertical pilasters that formed 12 bays across the width of the building (See Figure 7). The pilasters provided wall stability to the building face with an increased wall thickness for the bearing and attachment points of the heavy timber wood girders that comprised the structural floor system of the building. Metal diamond spreader plates were evident on the Side Alpha of Building 2 facing Boston Street and were installed at the 2nd- and 3rd-floor levels.

As a result of using masonry pilasters features for stiffening and structural integrity, the wall sections between the pilasters need only be thick enough to span horizontally, thus allowing for less material and cost in construction. This creates a slender brick infill panel versus a predominate monolithic wall with thicker wythes and number of brick course. This directly affects the type of potential wall collapse that can be projected and assessed.

Wrought iron strap anchors were installed at the center line of the masonry pilasters at the floor line and were attached to the upper section of the wood floor girder on the interior side and fastened to the exterior wall face at the alternate end that was threaded. The diamond spreader plate was firmly attached to the masonry wall face with a nut. This connection to the heavy timber wood girder provided a positive connection point to establish the structural diaphragm assembly between the outer masonry perimeter walls and the building's internal structural and floor system.

The heavy timber wood girder had an angle cut to its end, commonly referred to as a fire cut (See Figure 8). This design feature allowed the wood girder to fail and fall free from the masonry wall in the event of a fire and collapse without causing collateral damage to the masonry wall, increasing the

likelihood that the perimeter wall would maintain its structural integrity and lessen the potential for injury to fire-fighters operating in the street areas.

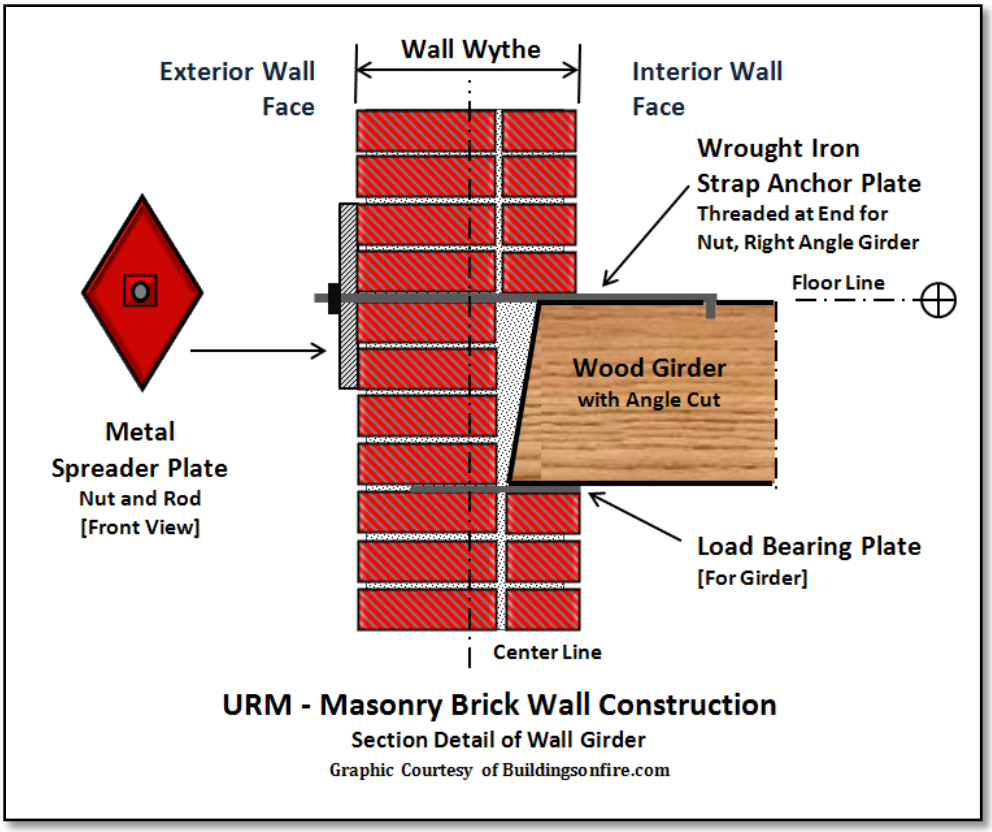

Figure 8. URM- Masonry Brick Wall Construction and Girder Detail
(Graphic courtesy of Buildingsonfire.com.)

Based on potential severity and urgency factors seen in the buildings, a fire of any great magnitude should require pre-fire planning to identify predictable incident events and occurrences as well as planning for likely collapse zones.

The Identified Severity of Risk Level (See Figure 4) for predicted incident conditions suggests a level of **Critical;** which - May cause severe personnel injury, possible death; major property loss or significant degraded conditions. In other words: the probability for a multiple alarm fire occurring in this building or complex creating limiting conditions of operations, high resource demands, operational severity, urgency and escalating incident growth issues were highly probable and could be expected. Therefore, precautions and instituted plans could have been identified, formulated and implemented prior to the initiating incident that may have contributed towards increased operational and incident management efficiencies, operational effectiveness, control and amplified managed risks.

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Building Collapse Indicators and Factors

Inherent building characteristics, predictability of performance under fireground conditions, occupancy risk profile and physical conditions as previously described, collectively provide crucial performance indicators that when recognized and managed suggest a need for a higher degree of operational safety.

It was documented early in the evolving incident at 03:30 hours as first arriving companies were performing size-up and initial tactical assignments, the fire rapidly extended and communicated through Building 1 on "Side Charlie". During this early period, an extensive collapse of a multi-story section or expanse of the perimeter wall occurred that intensified the fire severity. Decisive strategy and effective incident management prompted the Incident Commander to fight this fire defensively.

Collapse zones and management areas were established, but may not have been adjusted, maintained, controlled and complied with through all phases of operations during the incident. Subsequently, as fire extension and communication rapidly traveled from Building 1 to the other adjoining buildings located on the premise, Building 2 located on "Side Alpha " became involved in fire resulting in fire suppression, management and operations being conducted from various geographical locations designed by the "Sides Alpha thru Delta" demarcations.

As fire consumed and deteriorated the interior structural support systems that formed the integral floor/wall structural system, a catastrophic collapse of the "Side Alpha" perimeter wall occurred along the street causing a curtain-fall collapse of masonry materials along the sidewalk and into the adjoining street.

Research of the affected buildings using Google Earth Street View Images conducted prior to the incident provided a glimpse of building conditions and building collapse indicators.

A review of Photo 4, Building 2 "Side Alpha", *Wall Collapse Indicators of north perimeter of Building 2,* illustrated prominent building features that were present on the North Perimeter Wall pre-fire incident. These features provided an indication of the buildings predictability and susceptibility to adverse conditions if exposed to fire or continued environmental duress (see Photo 4).

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Photo 4. Wall collapse indicators of north perimeter of Building #2, Side A exposure.
(Photo Google Street Maps/ analysis diagram courtesy of Buildingsonfire.com.)

Building 2 North Wall Collapse Precursors (See Photo 4, 5 and 6)

Note 1: Prominent masonry wall cracks and compromise can be seen running diagonally and laterally on the brick face up to the cornice. This area appears to have a large steel C-channel acting as a spreader plate fastened in a vertical orientation providing structural stability to a weakened or compromised perimeter wall area. The proximity of the C-channel spreader plate and the corresponding cracks and fissures make this corner highly prone to further compromise and collapse.

Note 2 & 3: These areas appear to also have two additional large steel C-channel acting as a spreader plate fastened in a vertical orientation providing structural stability to a weakened or compromised perimeter wall area. Spreader plate at the

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#2 location is smaller in length whereas plate #3 spans a length between the 2nd and 3rd stories. The corresponding vertical distance of this C-channel spreader plate makes this perimeter wall area highly prone to compromise and collapse.

Note 4: An existing unsupported brick chimney is attached to the face of the north perimeter. This chimney spans a vertical distance of 16 feet to the building roof edge, and is located approximately 8 feet from the roof of the furniture store showroom building (Side D Exposure). This appears to be a remnant from the previous residential building located adjacent to Building 2. This chimney is a prominent collapse hazard that is unsupported and highly vulnerable to a wide range of initiating events that could lead to a collapse (also see photos 5 and 6).

Note 5: The wall area located directly under the chimney and spanning the width of the north perimeter wall (18 feet), consisting of approximately 150 square feet of brick face, exhibits signs of deterioration, compromise, and weathering. Evidence is present of mortar erosion, joint deterioration, loss of course bonding, and efflorescence. Further deterioration was likely caused by concentrated water erosion caused by the open chimney flue pathway from the upper roofline to the wall area below. This wall deterioration affects perimeter wall integrity and resiliency from the effects of fire, flame, heat, and environmental duress, resulting in an inherently unstable and susceptible wall that is prone to collapse or compromise **(also see photos 5, 6 and 7)**.

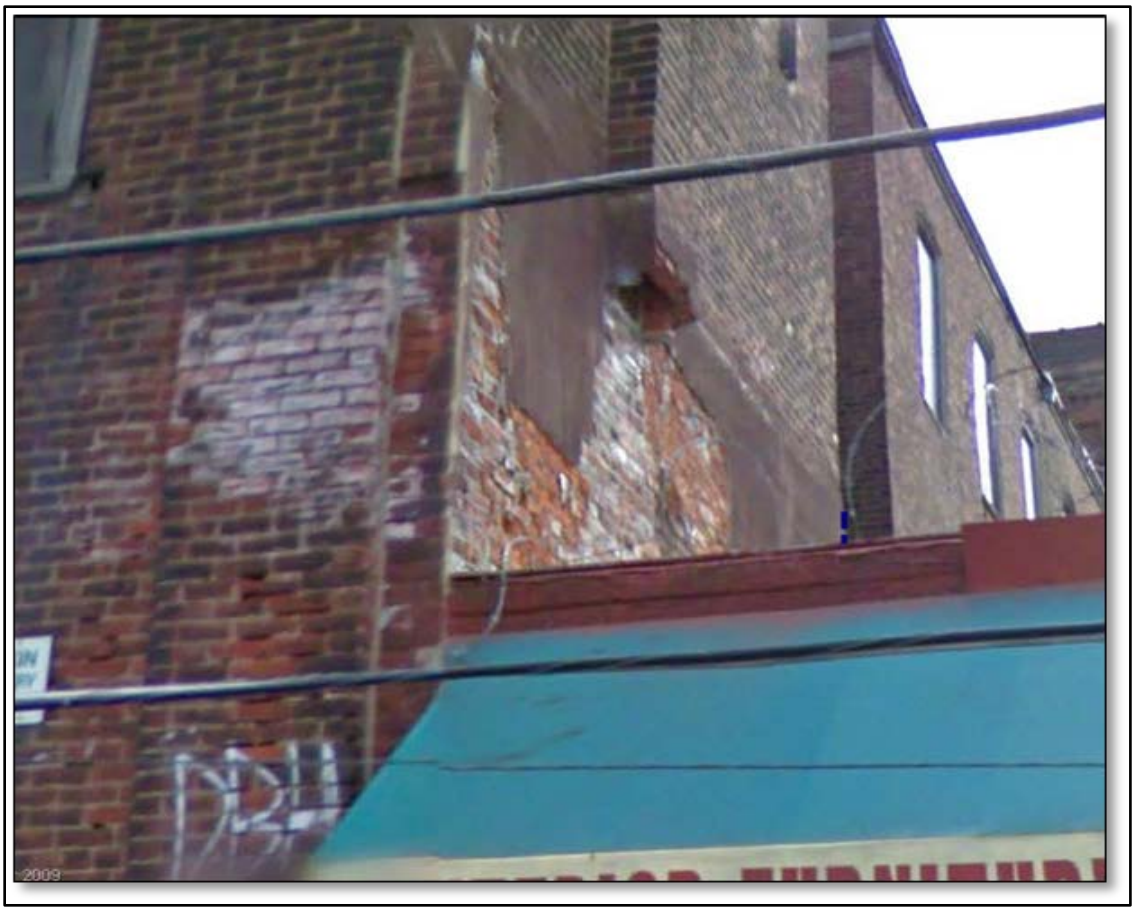

Photo 5. Pre-fire detail of north perimeter of Building #2, Side A exposure.
(Photo Google Street Maps/ analysis diagram courtesy of Buildingsonfire.com.)

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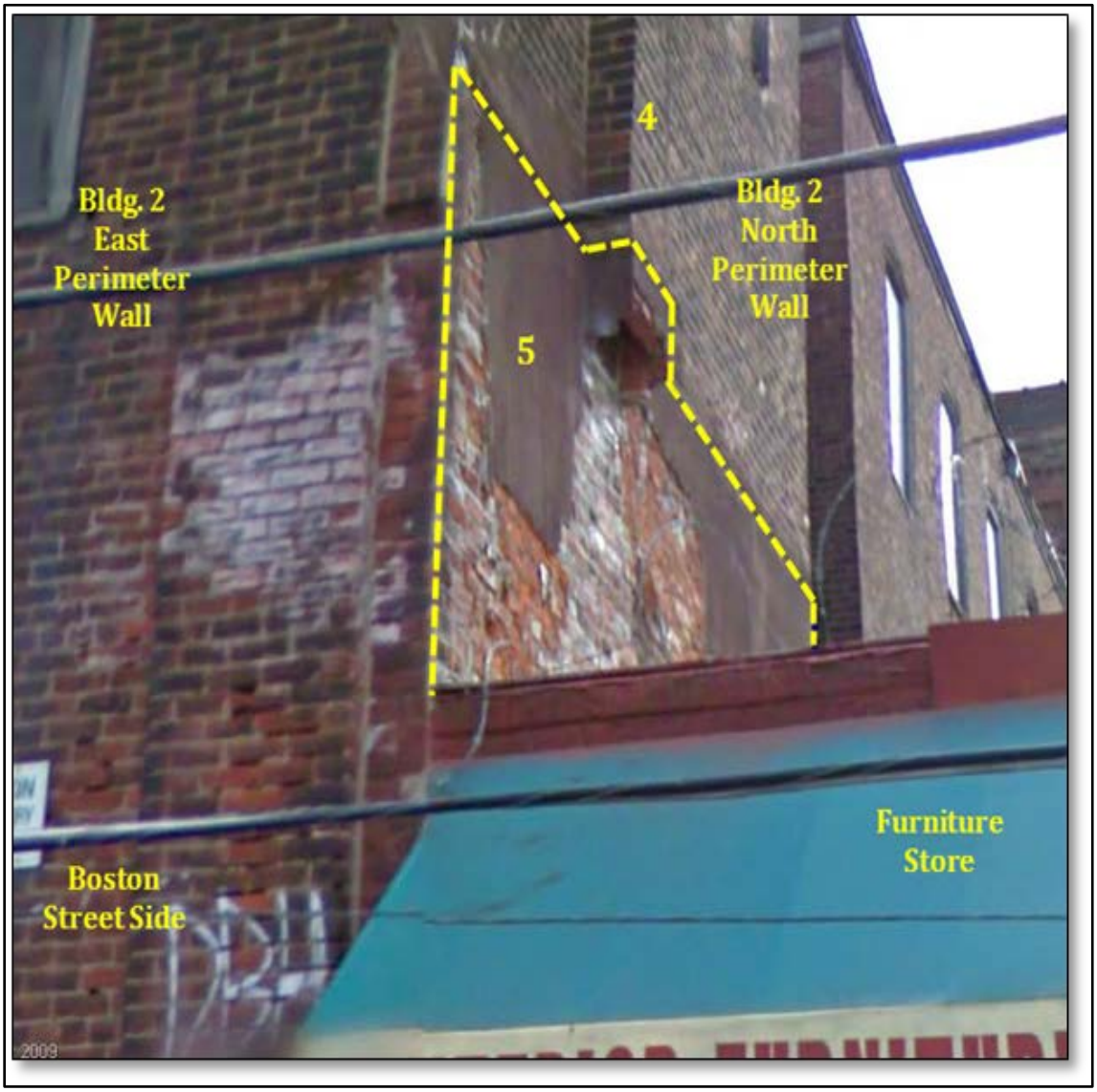

Photo 6. Collapse indicators detail of north perimeter of Building #2, Side A exposure.
(The numbers 4 and 5 above refer to the notes for Photo 4 on page 33).
(Photo Google Street Maps/ analysis diagram, courtesy of Buildingsonfire.com.)

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Photo 7. Alpha Side –Wall Collapse Zones
See Notes Below
(Photo Google Street Maps/ analysis diagram courtesy of Buildingsonfire.com.)

Note 1. Given a 1.5 x building height rule of thumb for collapse zone, the minimum, collapse zone (CZ) for the perimeter wall (PW) would be approximately 69 feet.

Notes 2 and 3. The Building edge at sidewalk level to face of the building across the street was approximately 40 feet.

Note 4. North wall that collapsed into the furniture store showroom.

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Photo 8. Side A wall collapse area of Building 2, see notes below.
(Photo Google Street Maps/ analysis diagram courtesy of Buildingsonfire.com.)

Note 1. Unreinforced Masonry wall construction (URM) masonry brick face along Boston Street. 3.5 story curb to cornice height approximately 46 feet. Given a 1.5 x building height rule of thumb for collapse zone, the minimum, collapse zone (CZ) for the perimeter wall (PW) would be approximately 69 feet. The Building edge at sidewalk level to face of the building across the street was approximately 40 feet. The outline depicts the degree of wall that collapsed or was compromised. The URM east and west masonry wall faces of Building 2 contained a masonry wall surface area of 3800 square feet (est.) representing 70% of the solid area of these perimeter walls.

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Note 2. The subsequent collapse of the URM façade and cornice of Building 2 resulted in a curtain –fall collapse into the immediate sidewalk area at the base of the building resulting in a sizable collapse rubble pile (**refer to Figure 9 and Photo 9**). Collapse Zone considerations and their management for these types of collapse along perimeter operational areas on the fireground are imperative.

Note 3. Evident Building 2, collapse precursor features on the north URM face (Refer to details and narrative related to Photos 5 and 6). Building 2, Boston street view north perimeter wall collapse indicators, illustrated prominent building features that were present on the north perimeter wall pre-fire incident. These features provided an indication of the buildings predictability and susceptibility to adverse conditions if exposed to fire or continued environmental duress.

Note 4. Prominent masonry wall cracks and compromise can be seen running diagonally and laterally on the brick face up to the cornice. This area appears to have a large steel C-channel acting as a spreader plate fastened in a vertical orientation providing structural stability to a weakened or compromised perimeter wall area. The proximity of the C-channel spreader plate and the corresponding cracks and fissures make this corner highly prone to further compromise and collapse.

Note 5. Furniture Store Exposure Building in which the north URM wall subsequently collapsed onto the companies operating inside resulting in the firefighter injuries and both firefighter LODDs.

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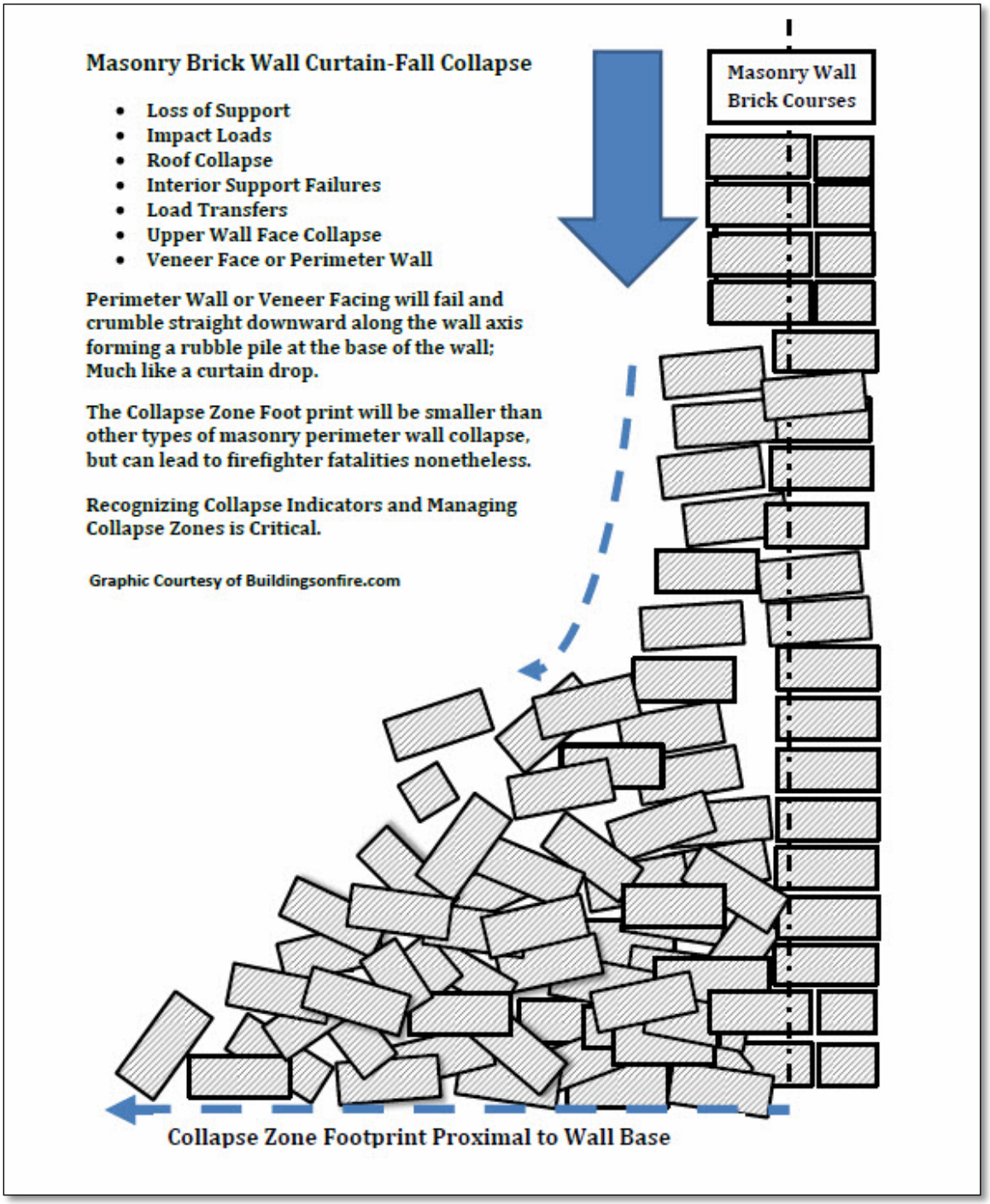

Figure 9. Masonry brick curtain-fall collapse.
(Graphic courtesy of Buildingsonfire.com.)

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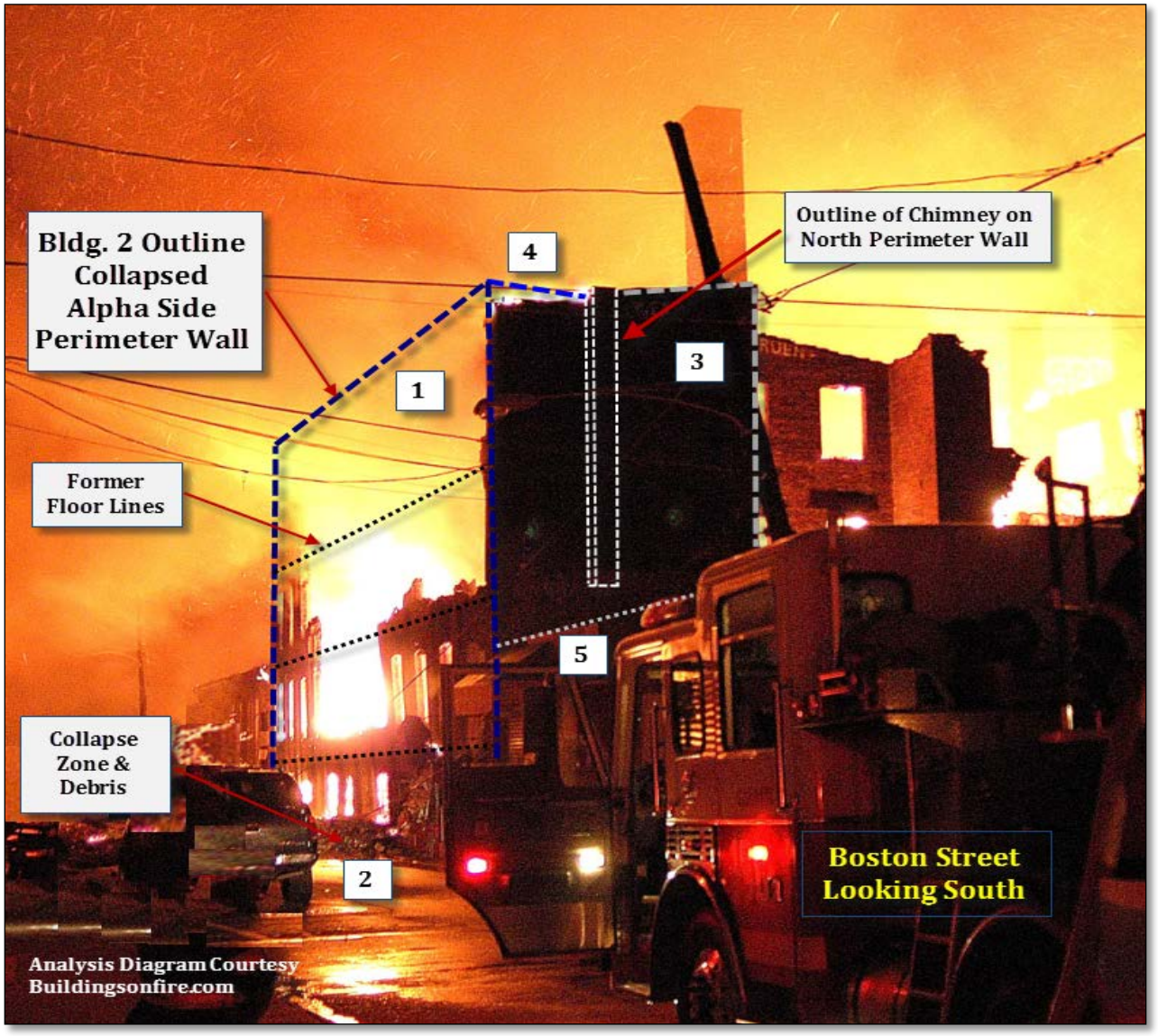

Photo 9. Collapse Assessment of Building 2, Alpha Side.
(*Photo courtesy of the fire department/ analysis diagram courtesy of Buildingsonfire.com.)*

Note 1. Building 2, Alpha Side outline of the perimeter wall showing former floor lines.

Note 2. Debris in collapse zone.

Note 3. Outline of unsupported chimney on north perimeter wall.

Note 4. Approximate original roof line of Building 2 north wall.

Note 5. Furniture Store showroom roof line.

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Weather

The weather (high wind conditions) was a contributing factor in this incident. At approximately 0254 hours, the weather in the immediate area was reported to be 49 degrees Fahrenheit, with a dew point of 31 degrees Fahrenheit, and the relative humidity was 50%. Wind conditions were up to 12 miles per hour from the west with a maximum wind speed of 31 mph and maximum wind gusts of 39 mph. The sky was partly cloudy and there was no precipitation in the past 24 hours.[6]

Investigation

On April 9, 2012, a supervisor for the regional transportation service notified the Fire Communication Center (FCC) at 0312 hours that he noticed smoke in the vicinity (see Figure 1). At 0313 hours, the FCC dispatched Engine 2 (E2) for a report of smoke in the area. This incident would eventually encompass one city block (approximately 400 feet by 200 feet) and involved a number of abandoned and vacant structures intermixed with working businesses. Several of the businesses along the Delta side had occupied apartments above the operating businesses.

At 0315 hours, Engine 2 responded and at 0317 hours arrived on scene. The officer of Engine 2 reported he needed a "Box" (Box Alarm Assignment). The officer advised he had a 6-story building which was 60 feet by 1 city block with heavy fire showing from the 1st and 2nd floors and would be initially operating with 2 engines and 2 ladders in service. At 0318 hours, the officer of Engine 2 radioed FCC reporting the fire was showing all the way to the roof. He ordered "strike out a 2nd Alarm and prepare for a 3rd Alarm."

At 0319 hours, FCC dispatched a *High Rise Box Alarm* Assignment for Box 361: E25, E29, P50, L3, L16, L12 (Lobby Control) , Battalion 8, Battalion 10, and Rescue 1. An "All Hands" and "Working Fire" were transmitted by the FCC two minutes later (0321 hours) dispatching E55, LT22, B3, Medic 15, Medic 2, E13, AU1, Squad 72, Squad 72A, and Division 2.

At 0324 hours, FCC transmitted the 2nd Alarm for Box 361: E7 (Logistics Company), Pipeline 28, E45, Pipeline 3, L10, L14, B4, LO, B1, B2, B9, and Safety Officer. Battalion 8 arrived on scene at 0326 hours and assumed "Command". The incident was divided into geographical divisions (see Figure 1). Battalion 8 was the initial Incident Commander (IC) and then assigned to Alpha Division, once the incident went to an "All Hands" event. Division 2 then assumed command of the incident.

The strategy and the Incident Action Plan (IAP) for this incident were defensive operations to prevent the fire from spreading beyond the block of origin.

At 0326 hours, Charlie Division (B10) contacted "Command" and requested a 3rd Alarm plus the power company to respond due to power lines down and transformers on fire due to the radiant heat. FCC dispatched the 3rd Alarm for Box 361 at 0328. The assignment was: Pipeline 20, Pipeline 34, Engine 11, and Engine 44. (Note: *Due to the request for resources for the exposure fires, FCC did not dispatch a ladder and battalion chief on the 3rd Alarm*).

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At 0330 hours, Charlie Division advised "Command" that an exterior structural collapse had occurred. The collapse zone in Charlie Division was the length of the street. At 0331 hours, "Command" advised Charlie Division that he had the 2nd Alarm companies going along Side "A". "Command" asked Charlie Division if there are any instructions for the 3rd Alarm companies. Charlie Division informed "Command" that master streams needed to be set up on the corners of the structure due to the exterior collapse of the structure (see Photo 10).

Photo 10. Charlie Division during the peak of the fire, viewed from the B-C corner.
(*Photo courtesy of fire department.*)

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At 0332 hours, Battalion 3 arrived on the scene and informed "Command" that he was the "MIRA Chief" and would take the Division facing north. "Command" assigned Battalion 3 to Delta Division. Delta Division requested that all 3rd Alarm companies respond to Side "D". Battalion 3 called "Command" at 0332 hours to confirm that he was Delta Division.

Companies from the 2nd Alarm and 3rd Alarm arrived on the scene and were placed in Bravo Division and Charlie Division. At 0338 hours, Delta Division raised FCC to request a Ladder, Squirt, or Tower Ladder for Side "D". Delta Division had a water supply set up and wanted to put an elevated stream in service at the corner. FCC advised Delta Division to standby.

At 0340 hours, the Chief's Aide for Battalion 8 contacted FCC and stated "on the orders of Deputy 2, strike out the 4th Alarm." At 0341 hours, FCC dispatched Engine 64, Pipeline 49, Engine 36, and Engine 70 to Box 361 on the 4th Alarm. (Note: *Due to the request for resources for the exposure fires, FCC did not dispatch a ladder company on the 4th Alarm*). Per Battalion 8 Chief's Aide, all companies were ordered to stage nearby.

At 0344 hours, Battalion 4 (initially dispatched as Logistics Section Chief, but re-assigned to manage the exposure fires) informed "Command" that there were multiple houses in the immediate area that are on fire due to fire embers. Engine 7 and Engine 3 were assigned to go in-service and had started to extinguish these fires. At 0345 hours, "Command" attempted to contact Bravo Division. "Operations" contacted "Command" and advised him that Battalion 1 was looking for a Division. Was there anyone assigned to Bravo Division? "Command" wanted to put Battalion 1 in Bravo Division and advised everyone to standby. "Command" raised Battalion 3, who stated he was Delta Division but was located at the B/C corner. At 0346, "Command" advised the following assignments for all Battalion Chiefs on the fire ground: "The fire ground is being divided geographically as follows: Boston Street – Alpha Division; Jasper Street – Bravo Division; and York Street – Charlie Division. B8 is the Supervisor of Alpha Division; B3 is the Supervisor of Bravo Division; and B10 is the Supervisor of Charlie Division. The companies are assigned as follows (see Figure 10):

- Alpha Division: B8, E33, E44, L10, L14;
- Bravo Division: B3, E2, P20, E29, SQ72, L3, L16;
- Charlie Division: B10, P34, LT22, Rescue 1"

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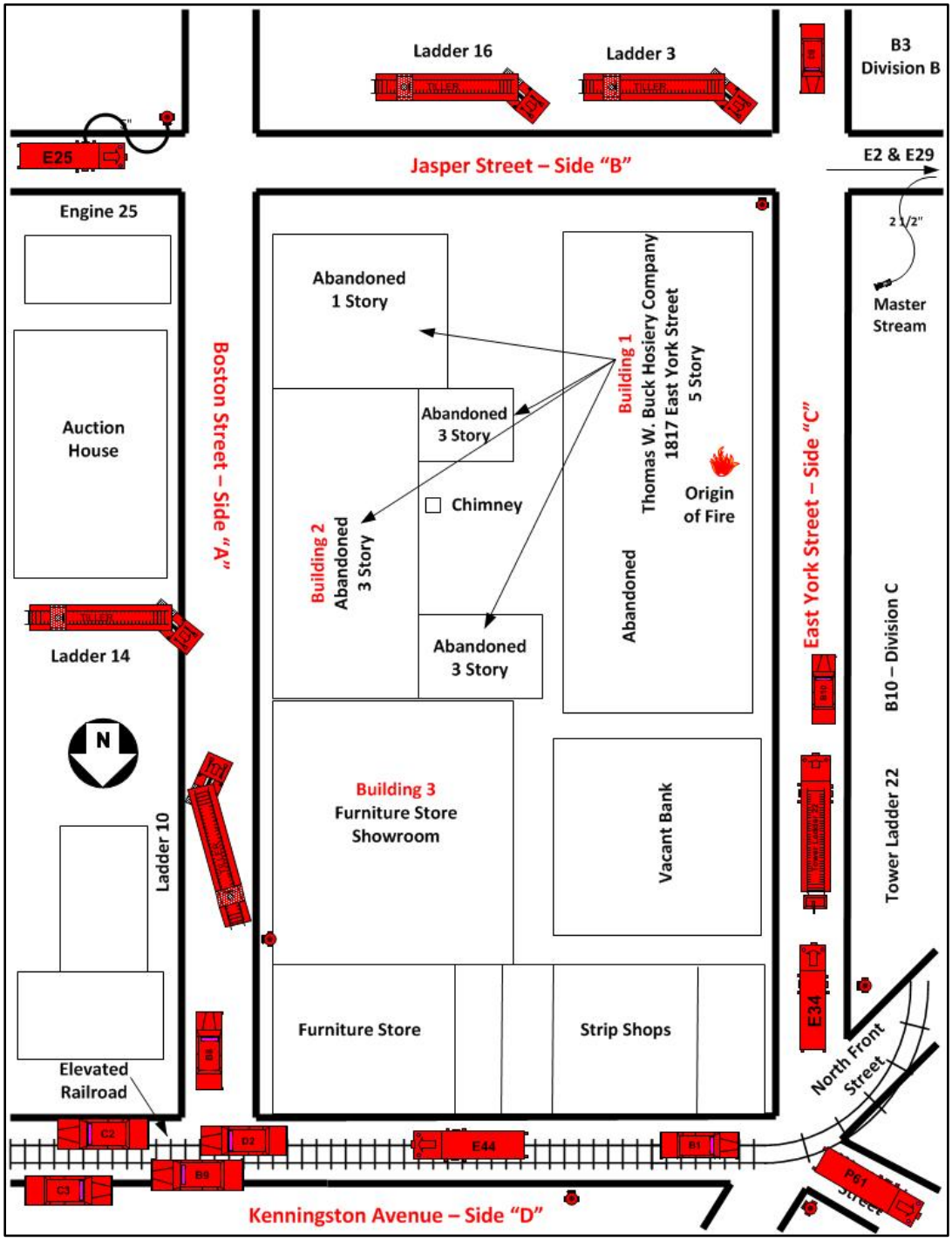

Figure 10. View of the fire building with apparatus placement. Note: the train tracks are elevated and apparatus are actually parked underneath the elevated tracks.

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Shortly after, Battalion 1 was assigned to Delta Division which was the main street on the north side of the block.

At 0349 hours and 0357 hours, *Tactical Box Alarm* assignments were dispatched for structure fires due to the fire brands/embers from the fire at Box 361. Battalion 4 (B4), who was assigned as the Logistics Section Chief on the 2nd Alarm, was reassigned to manage the exposure fires. Battalion 4 was assigned the following companies:

- Engine 7, Engine 25, Ladder 12, Engine 55, Engine 50, Engine 70, Engine 35, Pipeline 49, Engine 27, Engine 28, Engine 59, Engine 22, Engine 3, Engine 11, and Engine 28;

At 0400 hours "Command" requested a 5th Alarm for Box 361. At 0401hours, FCC dispatched Engine 22, Foam 33, Engine 35, and Pipeline 61 to Box 361 on the 5th Alarm. At 0406 hours, Car 3 (Deputy Fire Commissioner) arrived on scene and assumed "Command". Division 2 was assigned as "Operations". At 0404 hours, the following companies were assigned:

- Alpha Division: B8, E33, E44, Pipeline 61, L10, L14;
- Bravo Division: B3, E2, P20, E29, Engine 64, E70, SQ72, L3, L16;
- Charlie Division: B10, P34, LT22, Rescue 1;
- Delta Division: B1, P3, E7, L2, L12

Ladder 10 and Rescue 1 Activities

Engine 7 and Ladder 10 (tractor drawn aerial) were dispatched on the 2nd Alarm to Box 361. As L10 approached from the south and east, the apparatus was hit with fire brands. L10 stopped, then approached the burning structure, driving north along Side Charlie, turned east and drove in front of Side Delta. The driver/operator positioned L10 on Side Alpha and nosed the apparatus as far down the street as possible and parked next to the furniture store showroom. L10 was ordered to get their ladder pipe in operation. E44 was ordered to supply L10, using the hydrant located to the north. Due to poor water pressure, Pipeline 61 dropped a manifold on Side Alpha and supplied L10. At the time, L10 was flowing water on the roof line of the Auction House (Exposure Alpha). The crew of L10 put a 16-foot ground ladder up to the roof of the furniture store showroom. E44 connected a 2½-inch hoseline to Pipeline 61's manifold and put a portable ground monitor in operation on the roof of the furniture store showroom. There was a partial wall collapse into the corner of the office in the rear of the furniture store showroom (the Side B-C corner of the furniture store). The partial wall collapse knocked a hole in the roof and started a fire in the furniture showroom (see Photos 11, 12 and Figure 11).

The first assignment for Rescue 1 was to report to the bank on Charlie Division and force the doors in the rear of the bank (See Photo 11). Rescue 1 also cut down a gate between the bank and the furniture store. Several members witnessed the initial collapse of the fire building into the furniture store. Rescue 1 took a ground ladder off TL22 to check on possible extension into the bank building. There was no fire extension in the bank. B8 (Alpha Division) told Rescue 1 to check the furniture showroom for fire extension. Rescue 1 was ordered to get a hose line off of E44. Rescue 1 took three lengths of 1¾-inch hose and a gated wye and hooked into a 3-inch supply line. The hoseline was stretched into the furniture store showroom (see Figure 11). There was fire rolling across the ceiling. A fire fighter from Rescue 1 knocked down the fire and there was minimal smoke. Rescue 1 continued knocking

down the fire. The Rescue 1 officer noted that the partial collapse on the furniture store roof created a secondary collapse zone (interior) and ordered his men to not go in that collapse zone and to bounce the water off the ceiling. Rescue 1 was then ordered to check fire extension in an auction house (Exposure A), which was across the street on Side Alpha from the furniture store showroom. Rescue 1 left the furniture store showroom and left two members in the furniture showroom. They were later relieved by members of L10.

Rescue 1 was reassigned to another duty and left two members on the hoseline. L10 was ordered to relieve the remaining Rescue 1 members and check for fire extension. A fire fighter from Rescue 1 told the crew from L10 that the Rescue 1 lieutenant had told them to continue to extinguish the fire but stay away from the collapse area near the partition wall.

Career Lieutenant and Fire Fighter Killed and Two Fire Fighters Injured by Wall Collapse at a Large Commercial Structure Fire—Pennsylvania

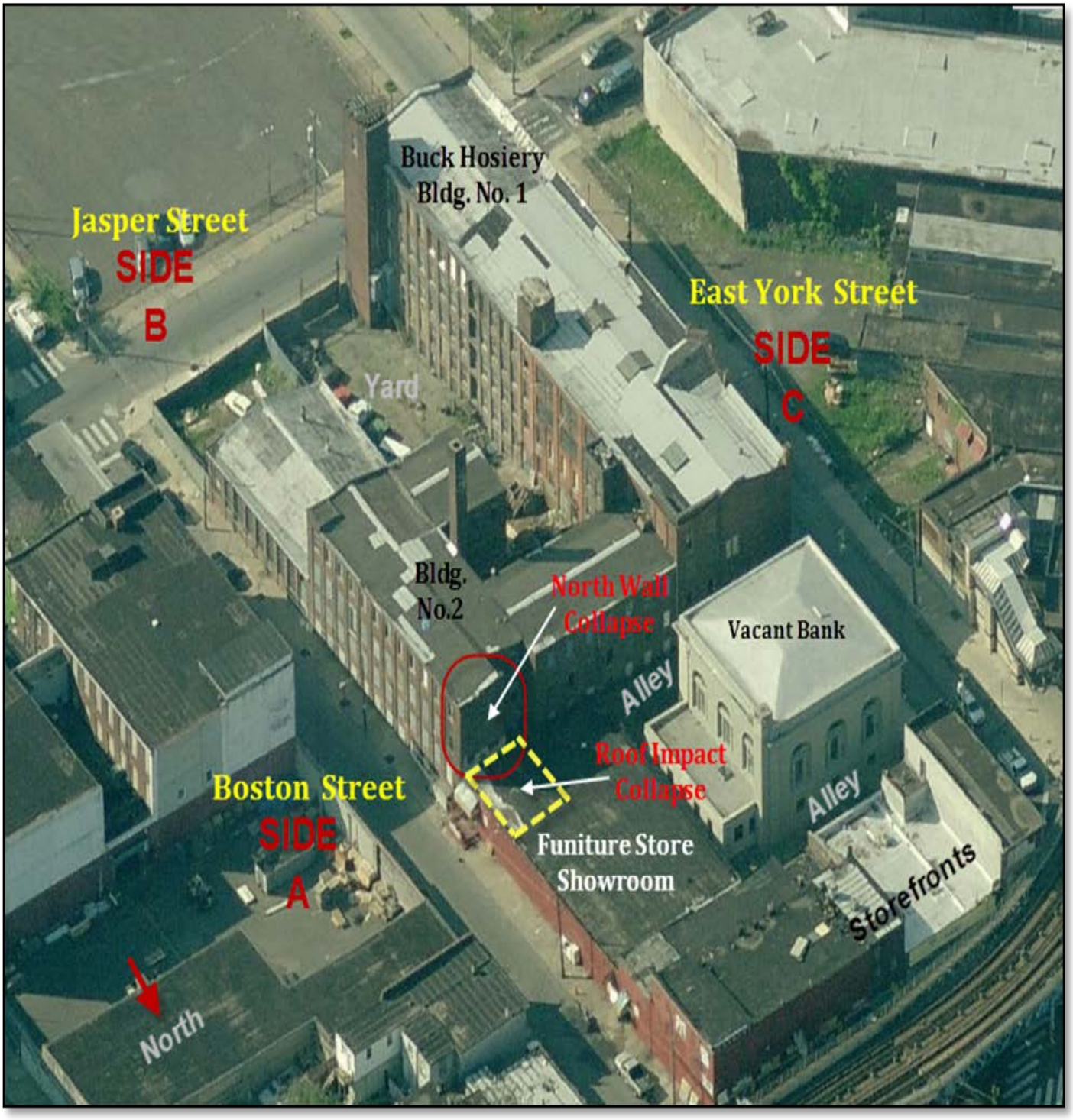

Photo 11. Aerial View of building complex, exposure and north wall collapse.
(Photo Bing.com Maps Image/ analysis diagram courtesy of Buildingsonfire.com)

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Photo 12. Roof of the furniture showroom showing damage from a partial wall collapse that started the original fire inside the furniture showroom. (*Photo courtesy of fire department.*)

Career Lieutenant and Fire Fighter Killed and Two Fire Fighters Injured by Wall Collapse at a Large Commercial Structure Fire—Pennsylvania

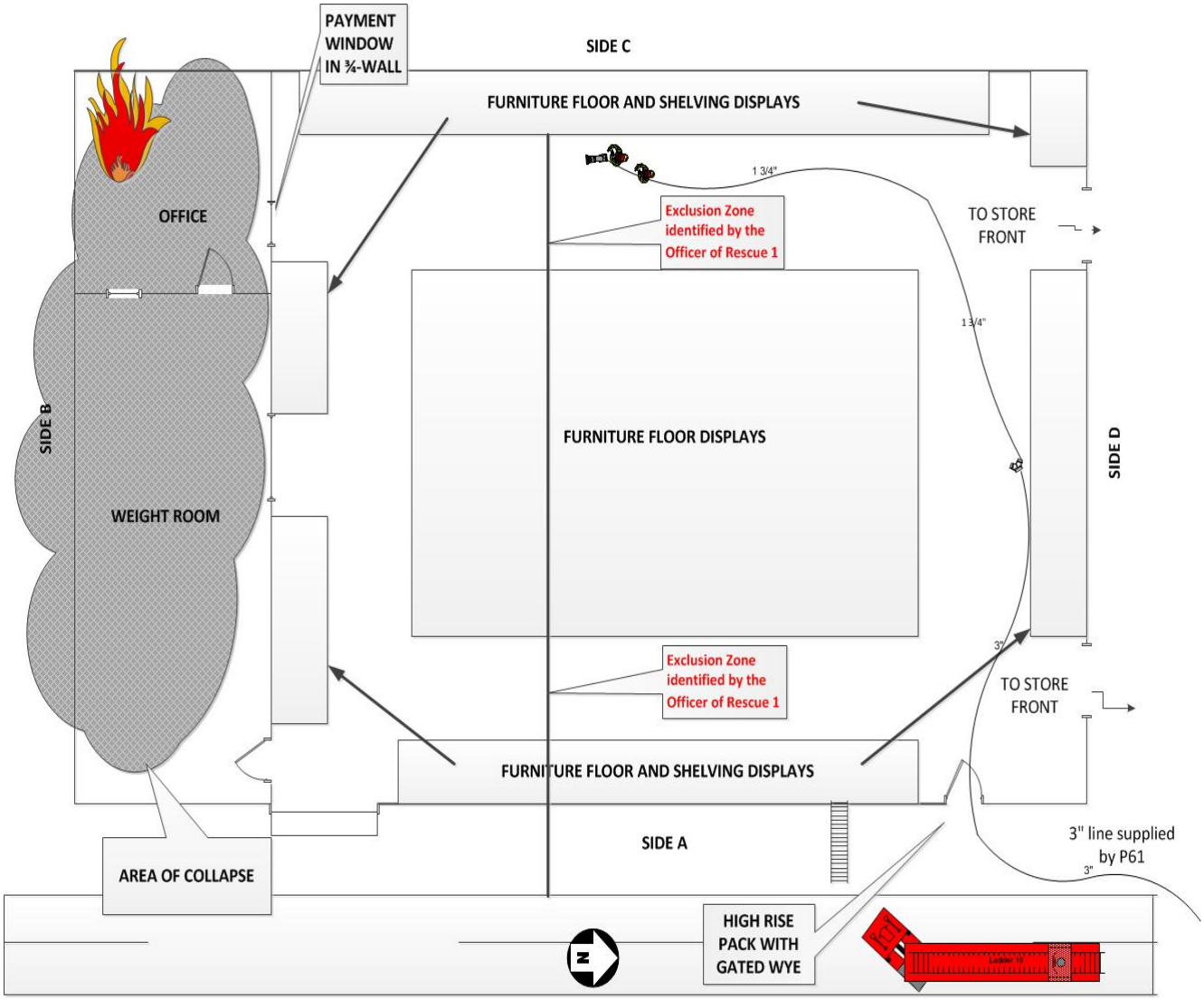

Figure 11. Original position of interior hand line by Rescue 1 in the furniture store showroom.

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A fire fighter (assigned as "Inside Hook" on L10) brought a portable light and power cord off of L10 into the furniture store showroom. The fire fighter could see smoke around the roll-up door on Side Alpha of the showroom from the inside. The fire fighter asked the driver/operator of L10 to knock down the fire with the ladder pipe. The fire fighter went inside to check conditions and then came back outside. Smoke conditions started to increase inside the showroom. The ladder pipe from L10 knocked down the fire and the fire went out, but the smoke conditions worsened. Shortly afterwards Division 2 (Operations), came in and pulled everyone out of the building since the fire was knocked down. The driver/operator of Rescue 1 knew about the wall of the fire building and the potential for collapse, and communicated to L10 that his officer had told them to stay away from the collapse area near the partition wall. Also, "Delta Division" (Battalion 1) instructed the L10 crew to check the conditions inside the furniture store showroom every 10 minutes. The L10 crew went in and out of the building (furniture store showroom) about six times.

Since the fire in the furniture showroom continued to flare up, the fire fighter (assigned as "Inside Hook" on L10) started to reposition the hoseline inside the furniture store showroom and spoke with BC9 (Safety) while they were repositioning the hose. BC9 (Safety) reported that he spoke with the crew as they were moving the hoseline to another part of the showroom (BC9 left the showroom and walked around the scene for 40-45 minutes and returned to Side Alpha just before the collapse). The hoseline was shut down, broken in half and the nozzle recoupled, and the hoseline was moved against the Side A wall inside the furniture store showroom. The lieutenant from L10 told the fire fighter from L10 not to go beyond the broken rafters in the furniture store employee weight room (not the initial interior collapse zone established by the Rescue 1 lieutenant, see Figures 11 and 12).

The collapse occurred while L10 crew members were operating the hand line in the rear of the showroom, knocking down the fire and trying to prevent extension. The fire fighter from L10 (assigned as "Inside Hook") was operating the hoseline into the office and weight room area ("Side Alpha" wall was approximately 20 feet behind the "Search and Rescue" fire fighter (see Figure 12) of the furniture store showroom. The lieutenant from L10 and the two fire fighters assigned to "Search and Rescue" and "Tillerman" from L10 joined the "Inside Hook" fire fighter on the hose line just before the collapse occurred. The lieutenant and the "Tillerman" were about six feet behind the "Search and Rescue" fire fighter. The "Inside Hook" fire fighter was operating the nozzle about four or five feet diagonally in front of the "Search and Rescue" fighter. The "Search and Rescue" fire fighter had a hook and was pulling the ceiling and was struck from behind by the debris from the collapse. This fire fighter was buried up to his waist by bricks. The lieutenant and the tillerman were completely buried by the bricks. The driver/operator of L10 knew that the lieutenant and the three fire fighters were inside. Safety (B9) called for a RIC (Ladder Company) and stated "there is debris on top of members".

Career Lieutenant and Fire Fighter Killed and Two Fire Fighters Injured by Wall Collapse at a Large Commercial Structure Fire—Pennsylvania

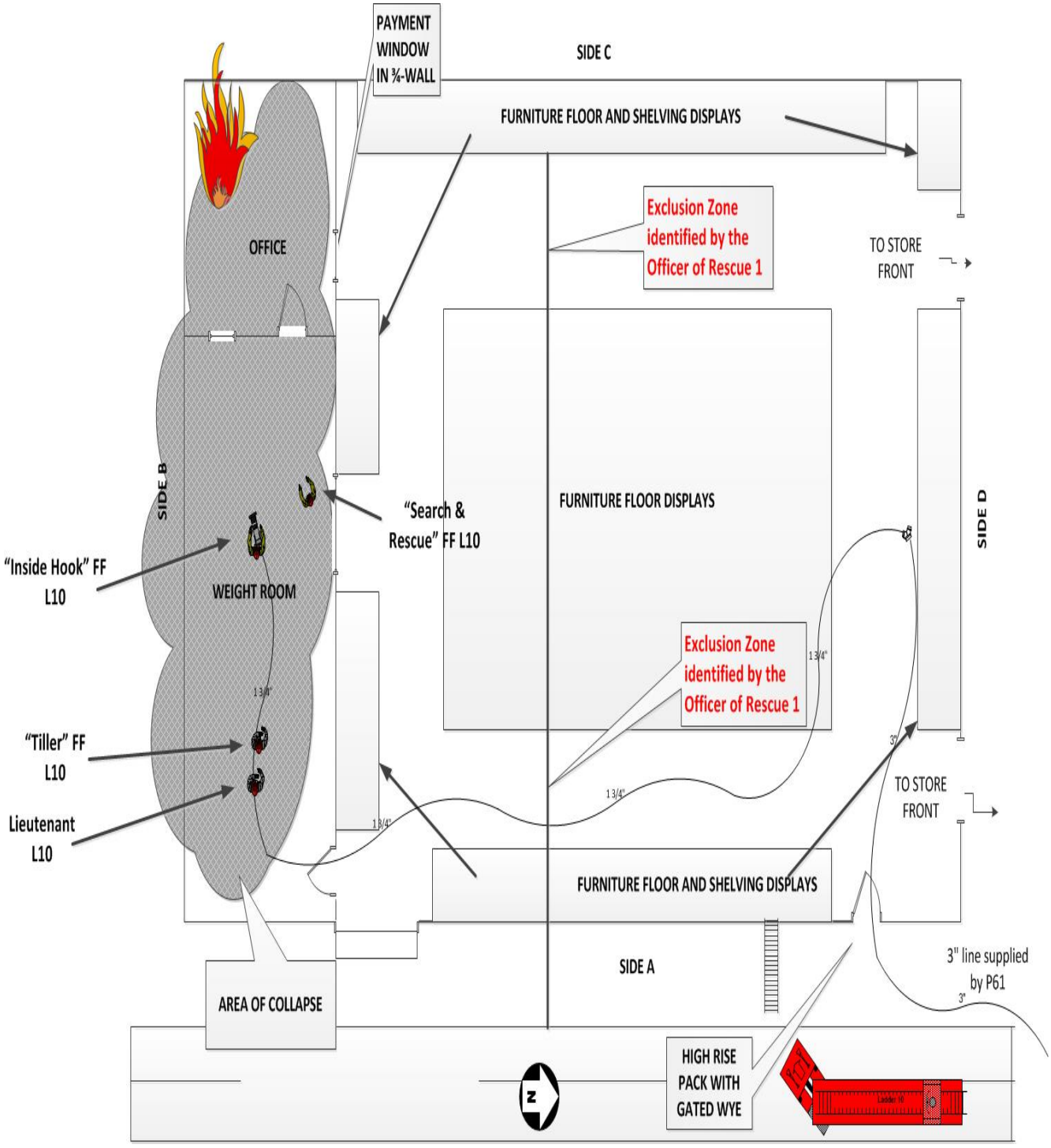

Figure 12. Handline repositioned by Ladder 10 to better access the fire in the rear office of the furniture store showroom.

Career Lieutenant and Fire Fighter Killed and Two Fire Fighters Injured by Wall Collapse at a Large Commercial Structure Fire—Pennsylvania

The Collapse

The collapse occurred in the furniture store showroom in an area behind a partition wall that separated the showroom from an office and weight room to the rear wall (see Photo 13 and Figure 12 and Figure 13). A portion of the fire building collapsed onto the roof of the furniture store. The L10 lieutenant and tillerman were covered by approximately 5 feet of brick. The "Search and Rescue" fire fighter from L10 was buried up to his waist by bricks. The "Inside Hook" fire fighter from L10 was knocked forward and down initially by the collapse. He got up and was knocked down again. The "Inside Hook" fire fighter went to help the "Search and Rescue" fire fighter and attempted to free him. At 0556 hours, the Incident Safety Officer (Battalion 9) reported a collapse of the fire building into the furniture store showroom. Also, there was an emergency radio activation from L10's "Search and Rescue" fire fighter's portable radio.

Rescue 1 was the first company in the structure attempting to rescue the members of L10. The "Inside Hook" fire fighter was able to climb over a partition wall and was helped by Safety (B9), a captain from the Fire Training Center who was an assistant Incident Safety Officer, and B8 (Alpha Division). Fire Marshal 1 and "Command" (Car 3) walked into the furniture store showroom and walked south towards the back of the building (towards the fire building). They followed the 1¾-inch hose line, which disappeared into a pile of bricks.

Fire Marshal 1 was assigned as Rescue Group Supervisor. Command started a PAR on the fire ground (North Tac 1) radio channel. The debris pile extended the entire width of the building so the rescue operation started from two sides. Squad 72 arrived on scene and was assigned to the rescue operation. *Note: Squad 72 and Squad 47 are two-piece companies that are assigned a pumper and a special operations response vehicle under the direction of an officer and four fire fighters.* The captain from Squad 72 ordered Squad 72 to shore the roof area. At the time, there was very little smoke but some fire around the rear of the furniture store showroom. Another 1¾ inch hoseline was brought in to knock down the fire.

The "Inside Hook" fire fighter was removed from the structure at 0612 hours. The "Search and Rescue" fire fighter was removed at 0622 hours. At 0622, the Rescue Group Supervisor requested another squad company (Squad 47) to assist with the shoring operation. Fire fighters found a void space in the collapse area. With the assistance of a search camera plus hearing a portable radio in the void space, one of the members of Rescue 1 got into the void space and found the lieutenant.

At 0706, the L10 lieutenant was removed from the structure. At 0725 hours, the "Tillerman" was removed from the structure. Both the lieutenant and the fire-fighter ("Tillerman") were transported to the local trauma center where they were pronounced deceased.

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Photo 13. Post collapse photo of furniture showroom roof showing the two holes made by the two different wall collapses. (*Photo courtesy of fire department.*)

Career Lieutenant and Fire Fighter Killed and Two Fire Fighters Injured by Wall Collapse at a Large Commercial Structure Fire—Pennsylvania

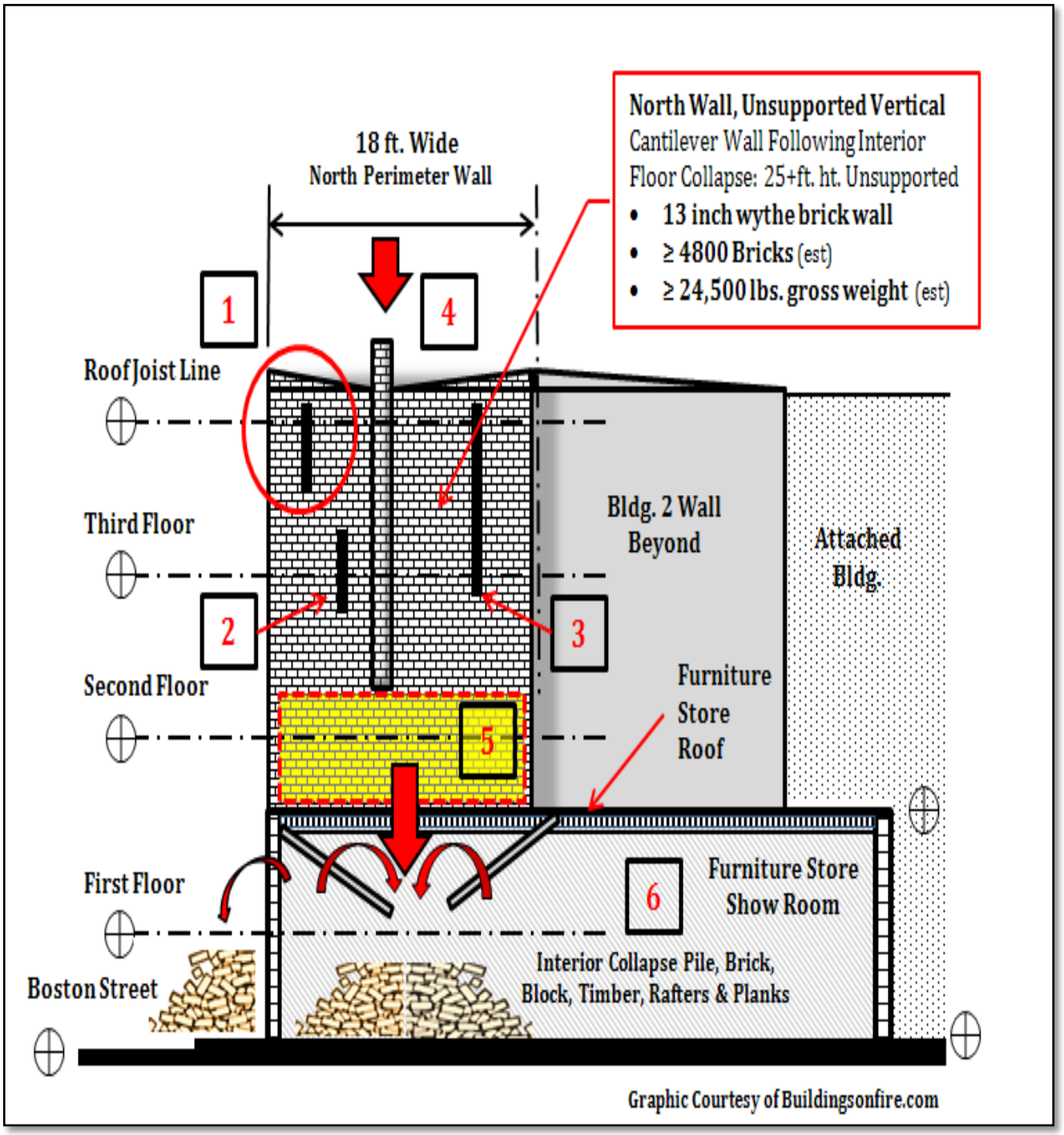

Figure 13. North wall of Building 2 collapse and furniture store sectional view. (*Note: for explanation of notes 1-5, refer to page 37. Graphic analysis diagram courtesy of Buildingsonfire.com.)*

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Fire Behavior and Extension

The fire started in the area of the original Hosiery structure fronting on Side Charlie (Figure 1) and quickly spread throughout the entire factory and warehouse complex. Fire embers were subjecting the surrounding structures to fire spread, and six occupied residential structures and one commercial building caught fire and had to be extinguished by additional fire department units. The area was subjected to winds of 31 miles per hour, and wind speeds were likely affected by the large volume of fire. Officers interviewed reported the high winds made getting water on the fire difficult. Approximately 300 homes in the area were also left without power after power lines in the area were affected by the fire.

Contributing Factors

Occupational injuries and fatalities are often the result of one or more contributing factors or key events in a larger sequence of events that ultimately result in the injury or fatality. NIOSH investigators identified the following items as key contributing factors in this incident that led to the fatalities:

- Multi-alarm fire in a vacant/abandoned structure
- Dilapidated building conditions
- High winds
- Collapse zone maintenance, control, and compliance
- Fireground communications
- Personnel accountability
- Training on fireground operations
- Situational awareness.

Cause of Death

According to the office of the medical examiner, Victim 1 and Victim 2 died from mechanical asphyxia and blunt trauma.

Recommendations

Recommendation #1: Municipalities and local authorities having jurisdiction should develop strategies for the prevention of and the remediation of vacant/abandoned structures and for arson prevention and have programs in place to address abandoned building abatement and demolition.

Discussion: The best way to prevent vacant building fires is to prevent vacant buildings.[7] According to the NFPA, fires in vacant buildings have become a matter of increasing concern as the economy has weakened. The NFPA released a detailed report on vacant building fires that is available at http://www.nfpa.org/press-room/news-releases/2009/nfpa-releases-new-report-on-vacant-building-fires.[7]

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The National Vacant Properties Campaign describes a number of strategies to address the problem of vacant properties and provides examples of how these strategies have been used.[8] Strategies include the following:

- Vacant property registration ordinances that provide contact information and may generate fees to cover municipal cost associated with these properties.
- Land banks for property seized for nonpayment of taxes.
- Rental and point-of-sale inspection ordinances that ensure the property has been maintained when the occupants change.
- Rehabilitation programs for owner-occupied housing and home repair programs.
- Homeownership and landlord training programs.
- Foreclosure prevention.
- Information systems capturing data about individual properties and neighborhoods that allow developing problems to be identified, tracked, and addressed.
- Code enforcement that is typically complaint-driven but may be institutionalized.
- Vacant property coordinators who interact with owners and municipal departments, emphasizing compliance more than enforcement.
- Property maintenance codes related to occupied housing that reduce the likelihood a property will fall into serious disrepair and abandonment.
- Nuisance abatement authority that allows municipalities to address threats to the general public, typically through administrative hearings rather than courts.
- Receivership (legal action that places property in dispute under the control of an independent person).

On its web site, Interfire provides a draft ordinance (http://www.interfire.org/res_file/ord.asp) to address blighted structures and vacant lots based on the Anti-Blight Law of Bridgeport, Connecticut, and the vacant lot ordinance of Aberdeen, Texas, and procedures to secure buildings developed by the Department of Housing and Urban Development and the Federal Emergency Management Agency.[8] InterFire has several other items from various sources relating to vacant buildings www.interfire.org/features/vacantbuildings.asp, including materials developed by the International Association of Arson Investigators and the U.S. Fire Administration.[8]

In this incident, the fire building was a vacant 5-story factory mill building. Built in 1882, it had a floor area of approximately 80,000 square feet and a number of additions over the 140-year history. At the

time of the fire, the building was vacant with a large number of homeless people known to occupy or frequent the structure. The building was suffering from considerable deterioration (see Photos 3, 4, and 5) and was not secured and considered abandoned. The building owner had an open zoning permit to build an 81-unit apartment building on the site.

The area where the collapse occurred was originally townhouse-style, single-family residences. The original roof line of the residential structure is visible in Photos 5, 6, and 7, along with an unsupported chimney on the wall that collapsed in this incident. There was considerable evidence of building deterioration in the area and a building marking system could have alerted fire fighters to areas of structural instability that would be prone to collapse. Some of these areas of concern are seen in Photos 3 and 4.

Recommendation #2: Fire departments should consider a marking system for unsafe buildings as part of an overall program to address fighting fires in abandoned/vacant/derelict buildings.

Discussion: Abandoned buildings can and do pose numerous hazards to fire fighters as well as the general public.[9,10,11] Philadelphia Deputy Fire Chief James Smith (retired) described two basic types of vacant buildings. The first type is awaiting resale and is basically the same as any other building. The second type has been vacant for a longer period of time and has been stripped of items that could be sold, such as piping and cabinetry. This type of building could not be used for legitimate occupancy without extensive renovation and may be abandoned by the owner. These properties are particularly dangerous to fire fighters.[12]

Hazards should be identified and warning placards affixed to entrance doorways or other openings to warn fire fighters of the potential dangers. Such hazards can be structural as the result of building deterioration or damage from previous fires. Gutted interiors also increase the amount of exposed burnable materials and contain open pathways for rapid flame spread. Structural hazards can occur when building owners or salvage workers remove components of the building such as supporting walls, doors, railings, windows, electric wiring, utility pipes, etc. Abandoned materials such as wood, paper, and flammable or hazardous substances, as well as collapse hazards, constitute additional dangers fire fighters may encounter. Collapse hazards can include chimney tops; parapet walls; slate and tile roof shingles; metal and wood fire escapes; heating, ventilation, and air conditioning (HVAC) units; or other mechanical equipment such as solar electrical collectors and cells, advertising signs, and entrance canopies.

Prior to implementing operations, the Incident Commander must perform a risk assessment considering life safety and the safety of fire fighters. At large and/or advanced fires in vacant or abandoned buildings, exterior operations should be the primary tactical consideration. The Incident Commander may vary from the current strategy and the incident action plan should a life hazard or extreme exposure protection issues arise.

A warning placard should be 18 inches x 18 inches and marked with 2-inch-wide lines on lime yellow, reflective background. The reflective sign indicates to fire fighters that hazards exist inside the building. Fire departments should consult with fire prevention, code enforcement, and/or building

departments to consider requiring an exterior placard or markings on abandoned and vacant structures to inform fire fighters of the structure's status and identify potential hazards.[13,14] Figure 14 illustrates symbols used on warning placards developed and used by the New York City Fire Department (FDNY).[11] Fire departments should develop additional policies that specifically cover the hazards encountered with these structures, such as training in size-up, building construction features present in typical buildings and construction methodologies characteristic of this era, safety considerations, tactics and strategy, and risk-versus-gain profiles.[5, 8]

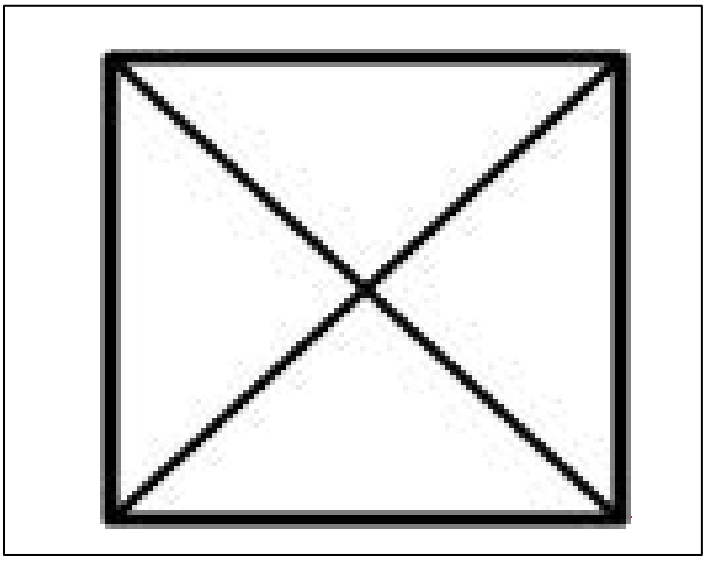

Figure 14.

Warning placard used by FDNY to identify hazards in vacant buildings. This 18-inch by 18-inch Square box with 2-inch wide lines is only a small portion of the FDNY Vacant Building Fires Procedures. Departments should consider building marking as part of their overall strategy for fighting fires in Vacant Buildings.

Fire departments should work with city and local authorities to develop and implement a strategy to identify, mark, secure, and where possible, demolish unsafe structures within their jurisdictions. The IAAI / USFA Abandoned Building Project, conducted by the International Association of Arson Investigators and the US Fire Administration, is one example of a program that can be utilized to aid and assist fire-fighter safety and health by identifying, marking, and removing unsafe structures.[9] The Abandoned Building Project Toolbox can be found at http://www.interfire.org/features/AbandonedBuildingProjectToolBox.asp.

The toolbox contains the Abandoned Building Project Report, *Managing Vacant and Abandoned Properties in Your Community*, and other reference materials. This report includes recommendations

on how fire departments can work with governmental authorities to reduce the public safety hazard created by unsafe and abandoned buildings. A number of locations across the country have developed laws and regulations that address the public safety hazards created by vacant and abandoned buildings. Examples are the Commonwealth of Massachusetts Abandoned or Dangerous Building Regulations 780 CMR and 527 CMR[15] and the City of Cincinnati Vacated Building Maintenance License.[16] The NFPA 1 Fire Code, Annex Q Fire Fighter Safety Building Marking System, makes direct reference to the potential resolution to identifying hazardous structures and contents through building marking programs.[17]

In this incident, there was considerable evidence of building deterioration, and a building marking system could have alerted fire fighters to areas of structural instability that would be prone to collapse. Some of these areas of concern are seen in Photos 3 and 4. Since this incident the fire marshal's office has established a new procedure to work directly with the Department of License and Inspection to communicate information regarding hazardous structures. Fire department company officers can send an email to the fire marshal's office with details of any hazardous building with the address and code violation and the fire marshal's office will communicate this information to the Department of License and Inspection. At the time of the fire, there was no formal process for the Department of License and Inspection to mark dangerous and abandoned buildings and there was no process for the Department of License and Inspection to notify the fire department when hazardous buildings were identified. The fire department did have a process in which the fire department notified the Department of License and Inspection by calling the 311 phone line whenever the fire department identified hazardous structures.

Recommendation #3: Fire departments should ensure that collapse zones are established, marked, maintained, and complied with throughout long- duration incidents.

Discussion: Fire fighters are at significant risk for injury or death due to structural collapse during fire-fighting operations. The United States Fire Administration and the National Fire Protection Association (NFPA) report that 984 fire fighters died between 2000 and 2010. Structural collapse caused 134 of these fire fighter line-of-duty deaths (13.7%). Structural collapse often results in multiple fire fighter injuries and fatalities. While structural collapse is a significant cause of injury and death to fire fighters, the potential for a structural collapse is one of the most difficult circumstances to predict.

During initial size-up and ongoing fire-fighting operations, the Incident Commander must consider numerous variables to determine the structural integrity of a burning structure. A collapse zone is defined as the area around a structure that would contain debris if the building were to collapse. This is generally 1½ times the height of the structure. A collapse zone, when established, should be identified by colored tape, signage cones, flashing beacons, fences, or other appropriate means. "No Entry" should be enforced by the Incident Commander, Incident Safety Officer, division/group supervisors, and company officers. When it is not possible or practical to mark a collapse zone, the Incident Commander should identify the collapse zone area to all fire ground personnel via radio or other communication methods. [18] The collapse zone can be enforced by personnel positioned at entry points. No personnel or apparatus should be allowed to operate in the collapse zone except to

cautiously place unmanned master stream devices and then immediately withdraw once they are in operation.[19]

Understanding the influence that building design and construction have on structural collapse has a direct correlation to safe fire-fighting operations and fire fighter survivability. In virtually every case, structural collapse results from damage to the structural system of the building caused by the fire or by fire-fighting operations. The longer a fire burns in a building, the more likely the building will collapse. Older buildings that have been exposed to weather and that have been poorly maintained are more likely to collapse than newer, well-maintained buildings. The walls of buildings—especially curtain walls, false fronts, marquees, and parapet walls—and heavy signs can all come crashing down. Although fire fighters have no choice but to pass through the collapse zone (area extending horizontally from the base of the wall to 1½ times the height of the wall) when entering or leaving the building, they should spend as little time there as possible.[19] Chief Christopher Naum, SFPE (Command Institute) notes, *"The potential for structural collapse in a building on fire can be predicated by a building's inherent susceptibility to a variety of factors that include fire dynamics and behavior, fire exposure and extension, environmental impact, fire suppression activities and age, deterioration and occupancy use factors. The predictability of a building's performance and risk to structural collapse, compromise or failure must be foremost in the development and execution of incident action plans (IAP) with collapse precursors or indicators identified, monitored and managed by Incident Commanders, supervisors and operating companies."*

Based upon continuous risk assessments being conducted, coupled with pre-incident planning information, a collapse zone should be established if factors indicate the potential for a building collapse. Fire departments should not rely solely on the amount of time a fire has been burning as a collapse indicator. An external load—such as a parapet wall, steeple, overhanging porch roof, awning, sign, or large electrical service connections—may cause a structural collapse. The following factors should all be considered:

- fuel loads
- fire behavior and building ventilation characteristics
- fire duration, size and location
- pre-existing structural damage/deterioration
- renovation/modifications to structure
- presence of wall anchor plates or stars
- height and age of the building
- types of doors and windows
- engineered load systems/lightweight truss construction
- roof design and covering
- fire protection features such as sprinkler systems, standpipe systems, automatic fire alarm system.[18]

Establishing a collapse zone is critical when structural stability is the reason for a defensive fire attack. Construction features combined with fire factors indicate the most probable type of structural failure.[20]

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Given the fact that the Incident Commander is always working with incomplete and imperfect information, it is difficult to accurately predict the type of collapse and resultant collapse zone. The only safe collapse zone is one that is equal to the height of the building plus an allowance for scattering debris. A good rule of thumb for setting a collapse zone for most buildings is to establish an area 1½ times the height of the fire building. This sometimes presents a dilemma when the safe zone is beyond the street width, meaning that effective defensive positions are within the collapse zone. A risk-versus-benefit analysis is essential. The crucial question that any Incident Commander must ask is, "What could I potentially save in relation to the risk being taken?" Obviously, no building is worth a fire fighter's life, therefore, imminent risk to a fire fighter's life to save a building is unacceptable.[20] When a defensive operation represents a reasonable risk, positions at the corners of the buildings are normally safer than those on the flat side of a wall. Consideration should also be given to using unstaffed ground monitors to reduce the risk of placing personnel in exposed positions. When total collapse is imminent, collapse zones represent exclusion zones that no one is permitted to enter regardless of the level of protective clothing.[20]

Exclusion zones can also exist or extend into buildings, especially when roof structures are suspect. In addition, exclusion zones would include other areas containing imminent hazards such as falling glass, areas containing atmospheres within or near the flammable range, and any other area that the Incident Commander or Incident Safety Officer deems too hazardous to enter. Collapse and exclusion zones are not the only safety considerations regarding access. The concept of limiting access to the fire scene is defined in a variety of ways. The safe area around the fire building(s) is normally staffed by police who keep unauthorized personnel out of the inner zones. Incident conditions must be considered when determining the dimensions of the fire perimeter. A good rule of thumb for approximating a fire perimeter is 2 blocks beyond the fire building in all directions.[20] Inside of a fire perimeter there can be a number of zones much like a hazardous materials incident scene. A cold zone would be an area where personal protective equipment is not required and is usually where the command post is established and other functions such as rehabilitation and medical treatment areas. The hot zone would be an operating area considered safe only when wearing appropriate levels of personal protective equipment. The Incident Commander and the safety officer have a responsibility to establish and enforce the hot zone.

Everyone has a responsibility to abide by the decisions made for the established collapse zones. If the fire is not contained and an exterior (defensive) attack becomes necessary, the hot zone is moved far enough away from the structure to place the fire fighters outside the collapse zone. The collapse zone then becomes an exclusion zone. In large or extended fire-fighting events, these zones must be continually adjusted as necessary and all personnel at the scene must be made aware of the locations of the exclusion or collapse zones. **For incidents in which the transfer of Command occurs multiple times, the incident is of long duration, or the incident scene covers a large geographical area, the collapse zones need to be continuously re-enforced.[18] It is important for division supervisors to not only adjust and enforce collapse or exclusion zones with their own personnel, but to also communicate changes with the Incident Commander.**

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In this incident, the Incident Commander and other officers stated during NIOSH interviews that a defensive strategy was established from the beginning of fire suppression operations; multiple divisions were assigned due to the large geographical area of the fire; and that collapse zones were established early into the event. The initial "911" call for the incident was received at 0312 hours. Engine 2 arrived on scene at 0315 hours, and reported a 6-story building 60 feet by one city block, with heavy fire showing on the 1st and 2nd floors and requested a Box Alarm. At 0318, Engine 2 requested a 2nd Alarm, and advised FCC to prepare for a 3rd Alarm. At 0330 hours, "Delta" Division advised command that there was an exterior collapse of the structure and then advised that the collapse zone was now the length of the street. Additional alarms were requested throughout the next few hours eventually stopping after a 5th Alarm had been struck.

There were a number of serious exposure fires including residential structure fires that additional companies were dispatched to during this time that were caused by flying embers from the main body of fire. The fire was reported under control at 0521 hours by command. The collapse that killed the two members of Ladder 10 occurred at 0555 hours and was reported to command by the Incident Safety Officer that a collapse had occurred in the furniture store showroom (a radio emergency button activation was also initiated by the L10 "Search and Rescue" fire fighter plus an open radio was recorded at 0555 hours). This collapse occurred 2 hours and 40 minutes after Engine 2 arrived on the scene. During this time many assignments had taken place and many more companies arrived and were put to work in these different operations. Collapse zone needs would have changed during this period, and, in fact, the radio transmission from Delta division at 0330 shows that adjustments were being made to a collapse zone. The marking, maintenance and communication of the collapse zones over the period of the long duration very large fire was critical due to changing needs, hazards, conditions and the possibility of different companies and personnel operating over the long period of time. The Rescue 1 officer recognized the need for an interior collapse or exclusion zone to keep his crew a safe distance away from the initial collapse area. The interior collapse zone was not marked, but established based on Rescue 1's hoseline position. This information was reportedly communicated to the L10 crew. Marking the collapse or exclusion zone with a physical barrier and notifying the command post and safety officer(s) of its location, helps to ensure that fire fighters do not operate in areas of potential building collapse.

Chief officers advised the L10 crew to go in and check for fire extension periodically and at a certain point the L10 crew repositioned the hoseline to get a better angle of attack on the fire. This action to advance the hoseline resulted in the L10 crew moving into the interior collapse zone.

The department has an SOP for incident command (OP 19-[2007]). Collapse zone establishment is mentioned as a function of the Incident Safety Officer in section 4.14 of OP 19 (2007) and also as a responsibility of the Incident Safety Officer in OP 40, 4.12. The SOP states the Incident Safety Officer responsibilities in collapse zones as, "*Monitor and evaluate visible smoke and fire conditions and advise the Incident Commander of the potential for flashover, backdraft, collapse or fire extension. The Incident Safety Officer will establish a collapse/safety zone and determine the safest paths for personnel to operate.*"

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Establishing collapse zones is a critical role of the Incident Commander and equally important is identifying, marking, and communicating them as well as maintenance of the collapse zones. Collapse zone marking is also mentioned in a supplement to the department training manual in the safety section of the supplement on size-up. The department training manual states: *During an exterior fire attack, three (3) zones should be established. These zones will provide the Incident Commander an adequate level of safety and accountability, for all participants at the incident.* ***Zone 1*** *is the immediate collapse zone indicated with banner tape and/or rope. Once this zone is established, everyone should remain outside of this area.* ***Zone 2*** *is designated for operating forces.* ***Zone 3*** *is designated for police, media, spectators, etc.*

Recommendation #4: Ensure the Incident Commander communicates the strategy and incident action plan to all members assigned to an incident.

Discussion: When establishing command at any incident, one of the most important responsibilities of the Incident Commander is to create an appropriate Incident Action Plan (IAP). Based upon the initial size-up, the Incident Commander has to absorb and process a lot of information in a very short period of time and develop an initial IAP that is based upon the department's standard operating procedure/guideline, encompasses effective strategy and tactics, and incorporate the incident priorities (life safety, incident stabilization, and property conservation).[21]

In order for resources assigned to an incident to work together effectively and in a coordinated effort, the resources must all work from the same plan. Each resource must know what the incident objectives are and what their individual roles are in achieving those objectives. The development and management of the overall strategy (situation evaluation, operational risk management plan, and evaluation and decision-making process) become the basis for the Incident Action Plan (tactics). *Note: For most Type V and Type IV incidents, these incidents most often will not have a formal (written) Incident Action Plan due to the short duration of the incident. In this case, the tactics serve as the Incident Action Plan.* The basic order of development is: **strategy** first and **Incident Action Plan**, second. Connecting the strategic, tactical, and task levels so they all operate within the same basic plan is a major goal of the incident management system.

Changes in tactics or communication regarding incident hazards should be communicated to all incident personnel. The first wall collapsed on Charlie division at 0330 hrs. This collapse would have been a warning of the imminent threat for collapse of other walls of Buildings #1, #2, and #3, and that other collapses in these older style buildings and surrounding exposure buildings constructed with unreinforced masonry construction could occur. This should have been communicated to all members working at the incident. NFPA 1500 and NFPA1561 state that "Emergency Traffic" shall be used to communicate this type of information to members at the incident. It states, "To ensure that clear text is used for an emergency condition at an incident, the Emergency Service Organization shall have an SOP that uses the radio term emergency traffic as a designator to clear radio traffic. The communication system shall provide a standard method to give priority to the transmission of emergency message and notification of imminent hazards over that of routine communications to all levels of the incident command structure. This procedure shall have direction on cancelling the emergency traffic transmission at the conclusion of the broadcast." [22,23]

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In this incident, though command was transferred several times, command maintained a defensive strategy establishing collapse zones on all sides of the structure. When the initial collapse occurred into the furniture store showroom a hoseline was taken into the area of the collapse. This deviated from the strategy, or the strategy to include and extend the collapse zone into exposed structures wasn't communicated to the Incident Commander. Building 2 was three stories higher than Building 3 (furniture store) and the potential would have been apparent that Building 2 could collapse and fall onto the roof of Building 3.

The fact that companies were operating on the interior of the furniture store may not have been communicated to Command. L10 crew was assigned to relieve Rescue 1 and told to check on fire extension periodically. The L10 crew members repositioned the hoseline to get a better angle of attack on the fire, and this repositioning of the hoseline put them deeper into an area identified by the Rescue 1 officer as an interior collapse zone. The collapse occurred in the intersecting areas of Alpha Division and Delta Division. Command must ensure that every division/group supervisor is clear on the strategy and the incident action plan. Additionally, this information must be communicated to the Incident Safety Officer. Once the Incident Commander had developed a strategy and the incident action plan (tactics), which for this incident were very good, this information must be communicated via the radio to all members assigned to the incident. Everyone must know the strategy that is being implemented and understand their role.

Recommendation #5: Ensure critical benchmarks are communicated to the Incident Commander.

Discussion: The size-up of interior conditions is just as important as exterior size-up. The Incident Commander monitors exterior conditions while company officers monitor the interior conditions, communicating to the Incident Commander as soon as possible. Knowing the location and the size of the fire inside the building lays the foundation for all subsequent operations. Interior conditions could change the Incident Commander's initial strategy.[24] Also, when operating inside the structure, company officers should communicate to the Incident Commander or division supervisor when making initial entry, while searching and clearing areas, during fire attack, and when exiting the structure.

Proper size-up and risk-versus-gain analysis require that the Incident Commander gather a number of key pieces of information and be kept informed of the constantly changing conditions on the fire ground. The Incident Commander must develop and utilize a system that captures pertinent incident information to allow continuous situational evaluation, effective decision making, and development of an incident management structure. Decisions can be no better than the information on which they are based. The Incident Commander must use an evaluation system that considers and accounts for changing fire ground conditions in order to stay ahead of the fire. If this is not done, the incident action plan will be out of sequence with the phase of the fire, and the Incident Commander will be constantly surprised by changing conditions.[24,25,26]

Interior size-up is just as important as exterior size-up. Since the Incident Commander is located at the command post (outside), the interior conditions should be communicated by interior crews as soon as possible to the Incident Commander. Interior conditions could change the Incident Commander's

strategy. Interior crews can aid the Incident Commander in this process by providing reports of the interior conditions as soon as they enter the fire building and by providing regular updates, especially when benchmarks are met (e.g., "primary search complete is all clear" and "the fire has been knocked down").

Retired Fire Chief Alan Brunacini states that critical fire ground factors, including interior and exterior conditions, are among the many items that the Incident Commander must consider when evaluating tactical situations. These items provide a checklist of the major issues involved in size-up, decision making, initiation of operations, and review and revision. The Incident Commander deals with these critical factors through a systematic management process that creates a rapid overall evaluation, sorts out the critical factors in priority order, and then seeks out more information about each factor. The Incident Commander must train and prepare (through practice) to engage in conscious information management. Incident factors and their possible consequences offer the basis for a standard incident management approach. A standard approach is the launching pad for effective incident decision making and successful operational performance. The Incident Commander must develop the habit of using the critical factors in their order of importance as the basis for the specific assignments that make up the incident action plan. The Incident Commander must create a standard information system and use effective techniques to stay informed at the incident. The Incident Commander can never assume the action-oriented responders engaged in operational activities will stop what they are doing so they can feed the Incident Commander with a continuous supply of objective information. It is the Incident Commander's responsibility to do whatever is required to stay effectively informed.[26]

In this incident, when the initial collapse occurred into the furniture store showroom and a hoseline was taken into the area of the collapse, this operation should have been communicated to "Command". When the crew of Ladder 10 and the member of Rescue 1 stayed inside the furniture store showroom, this also needed to be communicated to "Command." "Command" could have been contacted to advise that a collapse had occurred and started a small fire in the back of the furniture showroom and companies were still operating on the interior of the furniture store. "Command" could have also been informed of conditions in the structure, amount of fire, length of operation in the furniture store showroom, any safety issues such as an interior collapse or exclusion zone needs, supervision, and personnel accountability.

Recommendation #6: Emergency fireground conditions or operations must be communicated to all fire fighters to ensure they receive and follow these orders.

Discussion: The emergency fireground conditions can include but are not limited to the following: Mayday, a change in the strategic mode of operation, missing or injured fire fighters, deteriorating or extremely hazardous structural conditions, weather changes that will intensify the situation or endanger lives, or dramatic changes in smoke conditions. All of these situations require prompt and coordinated actions to avert an operational adversity. Effective communications is the key to assuring that appropriate action occur or are implemented quickly. NFPA 1561 *Standard on Emergency Services Incident Management System*, states in Paragraph 6.3.4, "Emergency traffic shall be declared by the Incident Commander, a division/group supervisor, or any member who is in trouble, subjected to an emergency condition, or aware of such a condition."[23]

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The emergency notification system should provide a means to rapidly notify or warn all persons who might be in danger if an imminent hazard is identified or if a change in strategy is made. An emergency message format with a distinctive alert tone and definitive instruction should be used to make such notifications. [23]

All responders operating at an incident should maintain situational awareness and conduct continuous risk assessment throughout the incident. Any unsafe or changing condition should be communicated to the Incident Commander, as well as the division/group supervisor, and any members working or operating in the affected area.

This process only works as well as the members that operate the system. When conditions or actions occur that can adversely impact the safety of fire fighters or responders operating at an emergency incident, it is imperative this information is communicated to the Incident Commander. In turn, this information can be broadcast to all fire fighters, especially to those operating in the affected area or in an area affected by changing conditions.

At this incident, numerous officers recognized the potential for collapse while operating in the furniture store showroom. Members continued to operate in this area, which was never communicated to the Incident Commander. Numerous officers were also aware of the operations in the furniture store showroom, but this was never communicated to the Incident Commander.

Recommendation #7: Ensure an effective personnel accountability system is used to account for all fire fighters and first responders assigned to any incident.

Discussion: Personnel accountability on a fire ground means identifying and tracking all personnel working at the incident. A fire department should develop its own system and standardize it for all incidents. Accountability on the fire ground can be maintained by several methods: a passport system, a system using individual tags assigned to each fire fighter, a riding list provided by the company officer, a SCBA tag system, or an incident command board.[10,19,22,23] Some personal alert safety system (PASS) devices incorporated into SCBA have the ability to communicate automatically with a command /control module at the incident command post, establishing an automatic accountability system. NFPA 1500 (Chapter 8, Section 8.4) and NFPA 1561 (Chapter 4, Section 4.5) contain guidelines for the development of an accountability system for fire ground and other emergency operations.[22,23]

As the incident escalates, additional staffing and resources will be needed, adding to the burden of tracking personnel accountability. At this point a tactical worksheet should be established with an assigned accountability officer or chief's aide. In large incidents, this can also be used at the division level, with resources being assigned and tracked at the division level.

An important aspect of a personnel accountability system is the personnel accountability report (PAR). A PAR is an organized on-scene roll call in which each supervisor reports the status of their crew when requested by the Incident Commander.[22] The use of a personnel accountability system is recommended by NFPA 1500 *Standard on Fire Department Occupational Safety and Health* Program

[22] and NFPA 1561 *Standard on Emergency Services Incident Management System.*[23] A functional personnel accountability system requires the following:

- development of a departmental SOP
- training all personnel
- strict enforcement during emergency incidents

The control of the personnel accountability system should be assigned to an individual responsible for maintaining the location and status of all assigned resources (resource status) at an incident. This is a separate role from the duties of the Incident Commander. The Incident Commander is responsible for overall command and control of the incident. Due to the importance of responder safety, this function would be assigned to a personnel accountability officer or resource status officer. This function can be staffed by the chief's aide, staff assistant, field incident technician, chief officer, or other responder familiar with the department's accountability system.[23]

There are many different methods and tools for accounting of resources. Some examples are as follows:

- command boards,
- tactical worksheets,
- apparatus riding lists,
- electronic bar-coding systems,
- accountability tags or keys (e.g. PASSPORT System).[23]

Different methods and tools for resource tracking and accountability can be used in conjunction with one another to facilitate the tracking of responders by both location and function. The components of the personnel accountability system should be modular and expand with the size and complexity of the incident. [23]

As the incident escalates, additional staffing and resources may be needed, adding to the burden of tracking personnel. The tactical worksheet or incident command board should be established early with an assigned accountability officer or aide. As the incident escalates and additional fire companies respond, a chief's aide or accountability officer assists the Incident Commander with accounting for all firefighting companies at the fire, at the staging area, and at the rehabilitation area. With an accountability system in place, the Incident Commander may readily identify the location and time of all fire fighters on the fire ground. A properly initiated and enforced personnel accountability system that is consistently integrated into fire ground command and control enhances fire fighter safety and survival by helping to ensure a more timely and successful identification.

This department had a procedure for accountability that details the use of 2-inch x 5-inch paper hydrant/roll call sheets. The driver has one copy and the officer keeps one copy. The paper sheets have the names of the fire fighters assigned to that company in alphabetical order.

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There has been much technological advancement in accountability systems. There are currently available PASS systems that have the capacity to act as a standard PASS device but also transmit a signal to the command console when the fire fighter has gone into alarm. Additionally, the Incident Commander can signal any and all fire fighters through their PASS device when there is a need to evacuate a structure.

In this incident, in order to maintain an effective span of control, the Incident Commander divided the incident into four divisions plus exposures. A division supervisor was placed in charge of each division with the company officers reporting to their respective division supervisor. The area where the collapse occurred (furniture showroom) was located at an intersection of division responsibilities (Divisions Alpha and Delta). When the companies went into the furniture store showroom, the company officer of Rescue 1 communicated with a division officer that a hoseline was being deployed into the structure. "Command" should have been notified that companies were operating inside this exposure. This is essential from a strategy and tactics standpoint, and also from a personnel accountability standpoint.

Note: *Battalion 8's field incident technician remained with command and operated as the communications officer for command throughout the incident. NIOSH investigators noted the outstanding performance of this communications officer while reviewing radio transmissions and during interviews.*

Recommendation #8: Fire departments should ensure the Incident Safety Officers are adequately trained to recognize the potential for building collapse and enforce exclusion zones. Information regarding collapse zones must be communicated to division/group supervisors and the Incident Commander.

Deputy Chief John Sullivan of Worcester, MA Fire Department states, "The Incident Safety Officer's (ISO) role is challenging and dynamic. We often task our Incident Safety Officer with more responsibilities than any other human could possibly accomplish on the fire ground. The Incident Safety Officer should focus primarily on perimeter scene safety and is instrumental in assisting the IC with establishing collapse zone parameters and making certain that any personnel and equipment are properly positioned." [27] The Incident Safety Officer serves as a key figure in fire ground operations (not tactics), by gathering a broad overall perspective of the fire ground and acting as the eyes and ears for the Incident Commander. While the Incident Commander can be over-tasked with strategic objectives and may not be able to give full attention to every safety detail, the Incident Safety Officer can assist the Incident Commander as well as other command level officers.[27] Fire departments should ensure that the Incident Safety Officers are trained in how to assist the Incident Commander and other officers in fire ground operations (not tactics) and how the role they serve merges with the overall strategic plan of the Incident Commander. A fire department Incident Safety Officer should have training beyond company level officers with increased focus on safety issues such as the following:

- Fire department Incident Safety Officer training
- Fire department health and safety officer training (acute and chronic threats to fire-fighter health)
- Fire ground risk assessment

- Risk management
- Accountability
- Fire ground hazards and hazard recognition, evaluation, mitigation and elimination
- Building construction and collapse
- Fire behavior
- Fire ground tactics and strategy
- Personal protective equipment use, capabilities and needs (SCBA and personal protective gear)
- Fire fighter rehabilitation

Chapter 6 of NFPA 1521 *Standard for Fire Department Safety Officer* defines the role of the Incident Safety Officer at various emergency incidents and identifies the necessary duties and responsibilities. Duties of the Incident Safety Officer include recon of the fire ground and reporting pertinent information back to the Incident Commander; ensuring the department's accountability system is in place and operational; monitoring radio transmissions and identifying barriers to effective communications; and ensuring established safety zones, collapse zones, hot zones, and other designated hazard areas are communicated to all members on scene.[28] Larger fire departments may assign one or more full-time staff officers as safety officers who respond to working fires. In smaller departments, every officer should be prepared to function as the Incident Safety Officer when assigned by the Incident Commander. The presence of the Incident Safety Officer does not diminish the responsibility of individual fire fighters and fire officers for their own safety and the safety of others. The Incident Safety Officer adds a higher level of attention and expertise to help the fire fighters and fire officers. The Incident Safety Officer must have particular expertise in analyzing safety hazards and must know the particular uses and limitations of protective equipment.[29]

Fire departments should recognize the importance of an Incident Safety Officer who can function effectively on the fireground based upon the necessary knowledge, skills, abilities, and experience. **Experience is an extremely valuable resource.** While a fire department may use an appointed officer as Incident Safety Officer, the appointed Incident Safety Officers may not be as quick to recognize a hazardous situation or operation and cause an unintentional delay in the engagement to correct. This can be overcome by increased training of all individuals who may be appointed as the Incident Safety Officer, ensuring they have clear understanding of responsibilities and expectations.

Fire departments should establish a training and education program for Incident Safety Officers. This ensures that officers, who could be appointed on-scene as the Incident Safety Officer have the necessary knowledge, skills, and abilities to effectively function in this position. On large incidents such as this incident, departments should consider assistant Incident Safety Officers. Chief Christopher Naum, SFPE (Command Institute) notes, *"Understanding a building's design and structural anatomy, occupational risks, construction methods and materials and vulnerabilities under fireground conditions has a direct correlation to safe fire-fighting operations and fire-fighter survivability."*

In this incident, the department did have a pre-designated Incident Safety Officer, but the Incident Safety Officer role on this incident was filled by a responding operational battalion chief. Additional

assistant Incident Safety Officers were appointed but they lacked specific Incident Safety Officer training.

Recommendation #9: Fire departments should ensure that fire fighters are trained in situational awareness, personal safety, and accountability.

All fire fighters operating at an incident should maintain situational awareness and conduct a continuous risk assessment throughout the incident, reporting unsafe or changing conditions to the Incident Commander. For incidents in which the transfer of "Command" occurs multiple times, the incident is of long duration, or the incident scene covers a large geographical area, the collapse zones need to be continuously enforced.[18] Fire fighters need to understand the importance of situational awareness and personal safety on the fire ground. The fire ground dangers and hazards can and do change as the incident becomes larger and the event duration increases. The structural conditions of the fire building(s) can change significantly and endanger areas of the fire ground that were not present earlier in the event.

Essentials of Fire Fighting and Fire Department Operations[19] defines situational awareness as an awareness of the immediate surroundings. On the fire ground, every fire fighter should be trained to be constantly alert for changing and unsafe conditions. Even though a safety officer may have been designated for the incident, all personnel are obligated to remain alert to their immediate surroundings. They must maintain their situational awareness and be alert for unsafe conditions. This applies not only to the conditions found within a burning structure, but to the exterior fire ground as well.[19] In virtually every case, structural collapse results from damage to the structural system of the building caused by the fire or by fire-fighting operations. The longer a fire burns in a building, the more likely that the building will collapse. Older buildings that have been exposed to weather and that have been poorly maintained are more likely to collapse than newer, well-maintained buildings. The walls of buildings—especially curtain walls, false fronts, marquees, and parapet walls—and heavy signs can all come crashing down. Although fire fighters have no choice but to pass through the collapse zone (area extending horizontally from the base of the wall to one and one-half times the height of the wall) when entering or leaving the building, they should spend as little time there as possible.[19]

One of the most critical aspects of coordination between crews is maintaining situational awareness. The opposite of situational awareness is tunnel vision where the fire fighters become so focused on fire-fighting or other operational assignments that they fail to sense changes in their environment. Fire fighters can maintain their situational awareness by looking up, down, and around themselves as well as listening for new or unusual sounds and feeling vibrations or movement. Fire fighters and officers should communicate any changes in their environment to other members as well as to the Incident Commander.

The International Association of Fire Chiefs, Safety, Health and Survival section developed the "Rules of Engagement for Structural Fire Fighting." The rules of engagement have been developed to assist both the fire fighter and the Incident Commander (as well as command team officers) in risk assessment and "Go or No-Go" decisions. The fire ground creates a significant risk to fire fighters and

it is the responsibility of the Incident Commander and command organization officers to minimize fire fighter exposure to unsafe conditions and stop unsafe practices.[30]

The rules of engagement can assist the Incident Commander, company officers, and fire fighters (who are at the highest level of risk) in assessing their situational awareness. One principle applied in the rules of engagement is that fire fighters and the company officers are the members most at risk for injury or death and will be the first to identify unsafe conditions and practices. The rules integrate the fire-fighter into the risk assessment decision making process. These members should be the ultimate decision makers as to whether it's safe to proceed with assigned objectives. Where it is not safe to proceed, the rules allow a process for that decision to be made while still maintaining command unity and discipline.

Rules of Engagement for Fire-Fighter Survival:

- Size-up your tactical area of operation. (Pause for a moment, look over the area of operation, evaluate individual risk exposure, and determine a safe approach to completing your tactical objectives.)
- Determine the occupant survival profile. (Consider occupant survival as part of your individual risk assessment and action plan.)
- Do not risk your life for lives or property that cannot be saved. (Do not risk your life when fire conditions prevent occupant survival and when significant or total destruction of the building is inevitable.)
- Extend limited risk to protect savable property. (When trying to save a building, limit risk exposure to a reasonable, cautious, and conservative level.)
- Extend vigilant and measured risk to protect and rescue savable lives. (During high-risk primary search-and-rescue operations where lives can be saved, manage search-and-rescue operations in a calculated, controlled, and safe manner while remaining alert to changing conditions.)
- Go in together, stay together, and come out together, when two or more fire fighters operate as a team.
- Maintain continuous awareness of your air supply, situation, location, and fire conditions. (Maintain situational awareness by knowing where you are in the building and what is happening around you and elsewhere that can affect risk and safety.)
- Constantly monitor fire ground communications for critical radio reports.
- Report unsafe conditions or practices that can harm you. Stop, evaluate, decide. (Officers should prevent exposure to unsafe conditions or practices by allowing any member to raise an alert about a safety concern without penalty and by mandating supervisors address safety questions to ensure safe operations.)
- Abandon your position and retreat before deteriorating conditions can harm you. (Be aware and exit early to a safe area when you are exposed to deteriorating conditions, unacceptable risk, and a life-threatening situation.)
- Declare a Mayday as soon as you think you are in danger. (Officers should ensure fire fighters are comfortable with declaring a Mayday as soon as they think they are in trouble.)[30]

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The Incident Commander's rules of engagement for fire-fighter safety:

- Rapidly conduct or obtain a 360-degree situational size-up of the incident. (As part of the risk assessment plan and action development plan, determine the safest approach to tactical operations before fire fighters are placed at substantial risk.)
- Determine the occupant survival profile. (Consider fire conditions in relation to the occupant survival of a rescue event before committing to a high-risk search and rescue.)
- Conduct an initial risk assessment and implement a safe action plan. (Before fire fighters are placed in high-risk positions on the fire ground, develop a safe action plan by conducting a size-up, assessing the survival profile, and completing a risk assessment.)
- Consider a defensive strategy when you do not have the resources to safely support and protect fire fighters. (Do not commit fire fighters to high-risk tactical objectives that cannot be accomplished safely due to inadequate resources on the scene.)
- Do not risk fire-fighter lives for lives or property that cannot be saved. Seriously consider a defensive strategy. (Do not commit fire fighters to high-risk fire-fighting operations that may harm them when fire conditions prevent occupant survival or when significant or total destruction of the building is inevitable.)
- Extend limited risk to protect savable property. (Limit risk exposure to a reasonable, cautious, and conservative level when trying to save a building that is believed, following a thorough size-up, to be savable.)
- Extend vigilant and measured risk to protect and rescue savable lives. (During high-risk search-and-rescue operations where lives can be saved, manage search-and-rescue and supporting fire-fighting operations in a highly calculated, controlled, and cautious manner while remaining alert to changing conditions.)
- Maintain frequent two-way communications and keep interior crews informed of changing conditions. (Request frequent progress reports and continually inform all interior crews of changing fire conditions observed from the exterior that may affect crew safety.)
- Obtain frequent progress reports and revise the action plan. (Obtain frequent progress reports to continually assess fire conditions and any risk to fire fighters and to regularly adjust and revise the action plan to maintain safe operations.)
- Ensure accountability of every fire fighter, their location, and status. (Maintain a constant and accurate accountability of the locations and status of all fire fighters within a small geographic area of accuracy within the hazard zone and be aware of who is presently in or out of the building.)
- Seriously consider a defensive strategy, if after completion of the primary search, little or no progress toward fire control has been achieved.
- Always have a rapid intervention team in place at all working fires.
- Always have fire-fighter rehab services in place at all working fires. (Ensure all fire fighters who endured strenuous physical activities at a working fire are rehabilitated and medically evaluated for continued duty and before being released from the scene.)[30]

Chief Christopher Naum, SFPE (Command Institute) notes, "*In most situations involving a structure fire, the probability of and anticipation for structural collapse or compromise are inevitably*

minimized, overlooked or at times disregarded until the catastrophic conditions present themselves with little to no time to react accordingly. The loss of situational awareness coupled with distracted attention to subtle or obvious pre-collapse building indicators and gaps in building and construction system knowledge combine to elevate operational risks to personnel on the fireground at structure fires."

In this incident, the fire had burned and extended for many hours before the collapse that killed the two fire fighters. Many partial collapses had occurred during the event and the danger areas changed. Some areas that were in the collapse zone were no longer a threat from collapsing building materials and other areas became dangerous areas from evolving collapse hazards. The victims had entered an exposure building to check on the possible extension of fire into that structure. A hoseline had already been extended into the structure by members of a rescue company and an interior collapse or exclusion zone had been established. This interior collapse or exclusion zone should have had a physical barrier and the command post and safety officer should have been notified. Later in the incident, members of Ladder 10 repositioned the interior hoseline to better apply water on the fire in the back of the furniture warehouse and the re-positioning of the line put them within the interior collapse/danger zone. The fire fighters from Ladder 10 were inside the furniture showroom and could no longer see the 40 foot brick wall of the abandoned factory/warehouse that eventually collapsed into the furniture showroom. Sensory deprivation (inability to see the wall) could have allowed the crew's situational awareness to be over-ridden by the need to get a better attack angle on the fire inside of the warehouse.

Incident Commanders, division/group supervisors, safety officers, company officers, and fire fighters need to understand how these danger areas can change and how they can take personal action such as being aware of un-noticed hazards and communicating those concerns and actions to the appropriate levels in the command structure. Fire fighters and officers operating at an incident should maintain situational awareness and conduct a continuous risk assessment throughout the incident, reporting unsafe or changing conditions to the Incident Commander.

Recommendation #10: Fire departments should ensure that all members engaged in emergency operations receive annual in-service training on fire ground operations.

Discussion: Fire departments should ensure that all fire fighters and line officers receive fundamental and annual refresher training according to NFPA 1001[2] and NFPA 1021.[31] Initial and continual training provide an opportunity to ensure that all fire fighters and line officers are proficient in their knowledge and skills in recognizing and mitigating hazards. Training on structural fire-fighting should include, but not be limited to, departmental standard operating procedures, fire fighter safety, building construction, and fire ground tactics. NFPA 1500, Chapter 5,[22] requires that the fire department provide an annual skills check to verify minimum professional qualifications of its members.[22]

NFPA 1001 *Standard for Fire Fighter Professional Qualifications* was established to facilitate the development of nationally applicable performance standards for uniformed fire service personnel.[2] NFPA 1021 *Standard for Fire Officer Professional Qualifications* was developed in the same way to determine that an individual possesses the skills and knowledge to perform as a fire officer.[31] The intent of both of these standards is to develop clear and concise job performance requirements (JPRs)

that can be used to determine that an individual, when measured to the standard, possesses the skills and knowledge to perform as a fire fighter or a fire officer, and that these JPRs can be used by any fire department in the country. Training is an ongoing process. Whether held daily, weekly, or monthly, training allows members to maintain proficiency at their present levels, meet certification requirements, learn new procedures, and keep up with emerging technology.[31, 32] Many departments may find themselves with difficult mandatory training such as EMS and other special needs training that may impact the ability of the department to provide annual in-service training on fire-fighting skills. Although the decrease in fires and fire deaths is a testament to the progress that the fire service has made, fire departments still need hands-on, practical skills training to learn and maintain proper fire-fighting procedures. Most importantly, fire-fighter safety and survival can be continually reinforced through annual in-service training.

Fire departments should develop and implement a written training program that ensures members are trained and competencies are maintained in order to effectively, efficiently and safely execute all responsibilities.[33] This is consistent with the organizational statement that establishes the existence of the fire department, the services the fire department is authorized and expected to perform, and the organizational structure.

The primary goal of all training, education and professional development programs is the reduction of occupational injuries, illnesses, and fatalities. As members progress through various job duties and responsibilities, the department should ensure the introduction of necessary knowledge, skills, and abilities to members who are new in their job titles as well as ongoing development of existing skills.[22] These programs should include, but not limited to, the following:

- Community risk reduction (fire prevention, public education, investigations, etc.)
- Health and safety
- Fire suppression
- Emergency medical services
- Human resources (e.g. leadership, supervision, inter-personal dynamics, equal employment opportunity)
- Incident management system
- Hazardous materials
- Technical rescue
- Information systems and computer technology
- Position specific development (e.g. fire fighter, company officer, chief officer, telecommunicator, investigator, inspector, driver/operator).[22]

Training for fire ground operations and emergency incidents should be conducted annually. This training should include, but not be limited to, department standard operating procedures, search and rescue, hoseline operations, ground and aerial ladders, ventilation, fire attack, fire-fighter safety, building construction, fire behavior, incident management, proper use of personal protective equipment and SCBA, personnel accountability, incident scene rehabilitation, and fire ground strategy and tactics.

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It is essential that all members (especially those engaged in emergency operations) receive this training on an annual basis. In-service training is an excellent method for evaluating the proficiency of members to ensure they have the necessary knowledge, skills, and abilities to perform the tasks assigned during fire ground operations. This process allows a selected number of companies to receive both classroom and practical training. An example would be to have a first-alarm assignment of companies placed out of service for a period of time (e.g., 8 hours) to ensure for the necessary amount of time to complete the tasks.

NFPA 1500 *Standard on Fire Department Occupational Safety and Health*, Chapter 5, *Training, Education and Professional Development*, states in paragraph 5.1.9, "As a duty function, members shall be responsible to maintain proficiency in their skills and knowledge and to avail themselves of the professional development provided to members through department training and education programs."[22] Additionally, training programs for all members engaged in emergency operations shall include procedures for the safe exit and accountability of members during rapid evacuation, equipment failure, or other dangerous situation and events. In-service training should extend to incident management and the personnel accountability system used by the fire department. Accurate long-term record keeping of all personnel training is an important part of the training program.

Recommendation #11: Fire departments should ensure that fire fighters use all personal protective equipment appropriate for the assigned task while participating in fire-fighting and overhaul operations.

Discussion: Carbon Monoxide (CO) exposure from smoke is cumulative and can affect a fire fighters cognitive and motor skill. NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*, Chapter 7, contains general recommendations for fire-fighter protective clothing and protective equipment.[22] Chapter 7.1.1 specifies that "the fire department shall provide each member with protective clothing and protective equipment that is designed to provide protection from the hazards to which the member is likely to be exposed and is suitable for the tasks that the member is expected to perform." Chapter 7.1.2 states, "protective clothing and protective equipment shall be used whenever the member is exposed or potentially exposed to the hazards for which it is provided." Chapter 7.2.1 states, "members who engage in or are exposed to the hazards of structural fire-fighting shall be provided with and shall use a protective ensemble that shall meet the applicable requirements of NFPA 1971 *Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*." [34] Chapter 7.9.7 states, "when engaged in any operation where they could encounter atmospheres that are immediately-dangerous-to-life-or-health (IDLH) **or potentially IDLH**, or where the atmosphere is unknown, the fire department shall provide and require all members to use SCBA that has been certified as being compliant with NFPA 1981 *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire and Emergency Services*."[35] Additionally, the OSHA Respirator Standard (29 CFR 1910.134) requires that all employees engaged in interior structural fire-fighting use self-contained breathing apparatus.[10, 36]

In this incident, several fire fighters reported to NIOSH investigators that they entered the furniture showroom without SCBA. The smoke conditions were described as light, but in the back of the showroom a fire had started after a partial collapse breached a portion of the roof. The fire fighters

from Rescue 1 had stretched a hand line into the showroom and were applying water from a distance considered to be an interior safe zone. Ladder 10 crew relieved Rescue 1 and repositioned the hoseline to get a better attack position on the small fire in the office area of the showroom. A large section of the fire building wall then collapsed through the roof trapping the victims from Ladder 10. The fire fighters from Ladder 10 were not wearing SCBA and therefore didn't have PASS devices that could have activated and sounded their location. Fire fighters should wear SCBA and PASS whenever they are in IDLH or potentially IDLH environments. One of the advantages of having the SCBAs and PASS devices available is the ability to use the PASS device independently of the SCBA. If the fire fighters had been wearing their SCBA (even if they were not on air) and activated their PASS devices so they would be in the on position, the PASS devices would have activated in the alarm mode (from lack of motion) after the collapse and rescue crews may have been able to find their location more quickly. There are new electronic tracking technologies that monitor a fire fighter's PASS device currently available on the market that send a signal to the command post when a fire fighter's PASS device is activated. Some of these devices allow the command officer to order an evacuation signal to all or some of the fire fighters on the fire ground. Some of the new technologies are manufacture specific and others are stand alone.

Rescue crews were able to locate the trapped members by "bonking" the victims' portable radios in an effort to locate them. Bonking the radios is a term that describes members pushing the transmitting button on portable radios and obtaining feedback from other radios close by.

The department does have an SOP on SCBA use and the responsibilities of fire fighters and officers regarding SCBA use in hazardous atmospheres. The SOP does provide guidance for SCBA use in exterior operations (such as multi-alarm fires). A portion of that SOP is described below:

4.6 EXTERIOR OPERATIONS

4.6.1 On all exterior operations where a hazardous atmosphere exists (e.g., automobile, dumpster, hazmat incidents, railroad ties, or multi-alarm fires), SCBA with PASS device will be worn by all members entering the hazardous atmosphere and/or exposed by position, location or activity to the by-products of complete or incomplete combustion. Keep in mind that products of combustion from ALL FIRES, whatever their size, are harmful to health when inhaled, and are accumulative over time. Automobile fires, for example, give off some of the most health-damaging products of combustion.

4.6.2 Listed below are the only exceptions to wearing SCBA with PASS device, provided that personnel are not operating in a hazardous environment or atmosphere inclusive of:

a. Members engaged in master stream operations; e.g., setting up appliances, stretching hoselines, operating pumps, platforms, or Squirts.

b. When directed by the Incident Commander or operations officer.

c. When functioning as the Logistics Officer or company outside the perimeter of the hazardous environment.

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d. When assigned within the Emergency Medical Service (EMS) branch or group with the exception of the forward first-aid station.

Recommendation #12: Ensure adequate rehabilitation in accordance with NFPA 1584 Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises.[37]

Discussion: NFPA 1584, *Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises*[37] establishes the minimum criteria for developing and implementing a rehabilitation process for fire department members at incident scene operations and training exercises operating within an incident management system. The physical and mental condition of personnel should be monitored to ensure their health does not deteriorate to the point it affects the safety of each fire fighter or endangers the safety and integrity of the operation. An Incident Commander should consider the circumstances of each incident and make suitable provisions for rest and rehabilitation for personnel. This process shall include medical evaluation and treatment, food and fluid replenishment, and relief from extreme climatic conditions.

Effective emergency incident rehabilitation is an important element of fire-fighter health and safety. Quoting Gregory Cade, former U.S. Fire Administrator, "Emergency responder rehabilitation is designed to ensure that the physical and mental well-being of members operating at the scene of an emergency do not deteriorate to the point where it effects their safety. It can prevent serious and life-threatening conditions such as heat stroke and heart attacks from occurring." The International Association of Fire Chiefs (IAFC), Safety, Health and Survival section developed the Rules of Engagement for Structural Fire Fighting. One of the rules for an Incident Commander is to always have fire-fighter rehab services in place at all working fires (ensures all fire fighters who endured strenuous physical activities at a working fire are rehabilitated and medically evaluated for continued duty and before being released from the scene).[30] NFPA 1584[37] states an Incident Commander should establish rehabilitation operations when emergency operations pose a safety or health risk to fire fighters and other responders. Criteria for implementation of incident scene rehabilitation are described in NFPA 1584[37] Chapter 6. Rehabilitation operations should be provided in accordance with fire department SOPs, NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*,[22] and NFPA 1561 *Standard on Emergency Services Incident Management System*.[23]

Rehabilitation efforts shall include the following:

1. Relief from climatic conditions
2. Rest and recovery
3. Active and/or passive cooling or warming as needed for incident type and climate conditions
4. Rehydration (fluid replacement)
5. Calorie and electrolyte replacement as appropriate for longer duration incidents
6. Medical monitoring
7. Member accountability
8. Release from rehab[37]

Fire ground rehab is the term often used for the care given to fire fighters and other responders while

performing their duties at an emergency scene. The Incident Commander shall consider the circumstances of each incident for the rest and rehabilitation for all personnel operating at the scene. Fire ground rehab includes medical evaluation, treatment and monitoring, food and fluid replenishment, mental rest, and relief from extreme climatic conditions.[32,38,39] When the size of the operation or geographic barriers limit member's access to the rehabilitation area, the Incident Commander shall establish more than one rehabilitation area. The site shall be a sufficient distance from the effects of the operation where members can safely remove their personal protective equipment and can be afforded physical and mental rest.[37]

Site designations could include but not be limited to the following:

- A nearby garage, building lobby, or other structure
- Several floors below a fire in a high-rise building
- A school or municipal bus
- The cabs of fire apparatus or any other enclosed area of emergency vehicles at the scene
- Inflatable tents
- An open area in which a rehab area can be created using tarps, fans, etc.[38]

Several considerations for rehabilitation sites are as follows:

- Should be in a location that will provide physical rest by allowing the body to recuperate from the demands and hazards of the emergency or training evolution.
- Should be far enough away from the scene that personnel may safely remove their turnout gear and SCBA and be afforded mental rest from the stress and pressure of the emergency or training evolution. (Provisions should be available to have SCBA cylinders refilled.)
- Should provide suitable protection from the prevailing environmental conditions. During hot weather it should be in a cool, shaded area and during cold weather it should be in a warm, dry area.
- Should enable personnel to be free of exhaust fumes and noise from apparatus, vehicles, or equipment, including those involved in the rehabilitation group operations.
- Should be large enough to accommodate multiple crews based on the size of the incident.
- Should be easily accessible by EMS units.
- Should allow prompt re-entry back into the emergency operation upon complete recuperation.
- Crews assigned to rehab will be instructed to turn portable radios off and/or have portable batteries recharged or exchanged.[38]

The rehab group supervisor shall secure all necessary resources required to adequately staff and supply the rehabilitation area. The supplies should include the items listed below.

- Fluids: water, activity beverage, oral electrolyte solutions, and ice
- Food: soup, broth, or stew in hot/cold cups
- Medical devices: blood pressure cuffs, stethoscopes, oxygen administration devices, cardiac monitors, intravenous solutions, and thermometers

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- Other: awnings, fans, tarps, smoke ejectors, heaters, dry clothing, extra equipment, floodlights, blankets and towels, traffic cones, and fire line tape (to identify the entrance and exit of the rehabilitation area)
- Hygiene facilities for long-term operations[38]

During this incident, the fire fighters performed informal rehab at their individual locations. Fire fighters reported during interviews that they were fatigued after many hours of fire-fighting operations. While fire ground rehabilitation was not a direct factor in the deaths of the two fire fighters, fire ground rehab is an important part of a fire department's occupational safety and health program. There were varied reports of the smoke levels inside of the furniture showroom from very light to light smoke conditions. If fire fighters are continuously exposed to smoke conditions and performing strenuous tasks for hours at a time, fire ground rehab should be formalized to ensure members are evaluated for continued duty.[38,39]

Recommendation #13: Ensure information on pre-incident planning and vacant/abandoned buildings are available to the fire department and are available to the Incident Commander. Consider technologies that allow target hazard information to be available on mobile data terminals (MDTs) in fire apparatus and command vehicles.

Discussion: Pre-incident planning is the process of gathering and recording information that could be critical for public safety personnel making life-saving decisions at an incident such as a fire, terrorist attack, or natural disaster. Pre-incident plans generally include information that will be used by decision makers at a fire or other incident.

Pre-fire planning is essential, no matter the size of a fire department. Even the smallest towns contain buildings or sites that require pre-incident plans, especially schools, hospitals, nursing homes, medical clinics, hazardous materials manufacturer or shipper, transportation agency (e.g., a railroad), or any other businesses that is deemed by the fire department to be a high-risk occupancy or target hazard. A detailed pre-fire plan shows a building's floor plan, doors and other access points, hydrant locations, roof construction, sprinkler and fire department connection, alarm panel location, stairwells, utility shut-offs, ingress and egress, occupant contact information, and other pertinent information. Also, a pre-incident plan identifies deviations from normal operations and can be complex and formal or simply a notation about a particular problem, such as the presence of flammable liquids, explosive hazards, lack of hydrants, modifications to structural building components, or structural damage from a previous fire.

NFPA 1620 *Standard for Pre-incident Planning* serves as the foundation for this process. The purpose of NFPA 1620 is to develop pre-incident plans to assist responding personnel in effectively managing emergencies for the protection of occupants, responding personnel, property, and the environment.[40]

Many emergency response agencies use mobile data terminals (MDTs) in fire apparatus and command vehicles. With the advancements in technology information that is stored in an agency's computer-aided dispatch (CAD) system, information on pre-incident planning and target hazard occupancy can be provided to responding units for a defined occupancy. This information can be a valuable tool for

the first responders, especially when the jurisdiction has many target hazard occupancies. Also, this information assists the Incident Commander in developing a strategy and incident action plan for an occupancy that has been pre-planned and/or is a target hazard.

Companies and command officers may be coming from different locations and may not be familiar with a specific occupancy. In some cases the jurisdiction's building department may have information that the fire department does not have. Information such as the number and type of code violations and whether the building has been abandoned or undergoing extensive renovation can provide valuable assistance to fire fighters and officers responding to a target hazard. On the street side, an occupancy may appear to be just for sale awaiting a new tenant, but a further investigation might reveal that the building has suffered severe structural damage and dilapidated conditions and could in fact be abandoned.[10]

In this incident, the fire department responded to a structure that had been abandoned for many years. The building was not marked with any type of sign or warning information that identified the potential hazards. The first arriving officer knew the building and hazards, correctly sized up the building and potential fire spread, committed to a defensive attack, and called for additional assistance. Businesses located on the same block were occupied (not abandoned) and presented exposure hazards.

In October 2011, the city's Department of License and Inspection (L&I) received five complaints that the structure was deteriorated, and in November 2011 they received more complaints on dangerous fire escapes. L&I issued a notice of violation on the property on November 8, 2011. In January and February of 2012, L&I received more complaints on the property and on February 1 the building was categorized as abandoned. On February 8, 2012, another call on the property was received and the inspector issued another notice of violation citing building code violations. A total of nine complaints on the property were reported to NIOSH investigators by L&I for this address. There was no formal process for the L&I to mark dangerous and abandoned buildings and there was no process for the L&I to notify the fire department when hazardous buildings were identified.

The fire department did have a process in which the fire department notified the L&I by a 311 phone system whenever the fire department identified hazardous structures or code violations. Communication between the building and fire departments on hazardous properties is critical to the fire department when they may be called upon to respond to the occupancy in an emergency. With technologies such as MDTs and CAD systems, information can be placed into the address file of hazardous occupancies and be part of the automatic dispatch system. These systems exist to improve communication and make important occupancy detail available to emergency responders.

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Recommendation #14: Fire departments should consider a predesignated Incident Safety Officer.

Discussion: A predesignated Incident Safety Officer can monitor the incident action plan, conditions, activities, and operations to determine whether they fall within the criteria as defined by the fire department's risk management plan.

NFPA 1561 *Standard on Emergency Services Incident Management System* states in Paragraph 5.3.1 that "The Incident Commander shall have overall authority for management of the incident."[23] NFPA 1561 Paragraph 5.3.2 states, "The Incident Commander shall ensure that adequate safety measures are in place."[23] With the advent of the incident command system, the goal is to ensure that the Incident Commander is responsible for the safety and welfare of all members and other first responders that were on-scene at an incident.

Based upon the size and complexity (e.g., abandoned factory) of an incident, the Incident Commander must delegate responsibilities that include safety. The incident command system can be expanded to include functions necessary to effectively command and control an incident. Though the Incident Commander is still responsible for the safety and welfare of all members and first responders on-scene, this responsibility is delegated to the Incident Safety Officer.[22] A predesignated Incident Safety Officer, independent of the Incident Commander, responds automatically to incidents as defined by the fire department. Upon arrival at the incident, the safety officer should meet with the Incident Commander to confirm the Incident Safety Officer assignment and be integrated into the personnel accountability system. Upon confirmation, the Incident Safety Officer should obtain the following information:

- Overall situation status and resource status
- Strategy and incident action plan
- Known hazards and concerns plus the establishment of control zones
- Status or rapid intervention crews
- Establishment of the rehabilitation group
- Confirmation of established radio communication channels (command channel, tactical channels)

Once the information is obtained, the Incident Safety Officer should don the personal protective equipment appropriate for the potential hazards that he/she will be exposed to. **Also, the Incident Safety Officer should be identified by a vest or helmet**. The Incident Safety Officer should perform a reconnaissance of the incident and began initiating functions of this position.

Based upon the size and complexity of the incident, the Incident Safety Officer may request the appointment of assistant Incident Safety Officers.

Types of incidents that might require expansion of the safety officer role include the following:

- Incidents covering a large geographical area (e.g., high-rise structure) that include numerous branches, divisions, or groups.

- Incidents where significant acute or chronic responder health concerns require coordination and input to the planning section (responsible for accounting for the organizational structure, availability of resources, deployment of resources, and the situation status reports).
- Incidents requiring interface with local, state, federal, or other health and safety representatives.
- Multiagency incidents where Unified Command is established.
- Incidents where Area Command is established.[28]

Assistant Incident Safety Officers assigned to branches, divisions, or groups can be addressed according to their area of responsibility. For example, an assistant Incident Safety Officer assigned to "Division Alpha" can be addressed as "Division Alpha Assistant Incident Safety Officer." The assistant Incident Safety Officers assigned to branches, divisions, or groups report to and follow direction from the Incident Safety Officer in the command staff, but the assistant Incident Safety Officer works with the supervisory person in the assigned branch, division, or group to assure safety conditions are being met. [23,41,42,43]

NFPA 1521 *Standard for Fire Department Safety Officer* defines the role of the Incident Safety Officer (ISO) at an incident scene and identifies duties such as recon of the fire ground and reporting pertinent information back to the Incident Commander; ensuring the department's accountability system is in place and operational; monitoring radio transmissions and identifying barriers to effective communications; and ensuring established safety zones, collapse zones, hot zones, and other designated hazard areas are communicated to all members on scene.[28]

Larger fire departments should consider one or more full-time dedicated Incident Safety Officers who are on duty and can routinely respond to working fires (e.g., full-time shift safety officers). In smaller departments, every officer should be prepared to function as the Incident Safety Officer when assigned by the Incident Commander. The presence of an Incident Safety Officer does not diminish the responsibility of individual fire fighters and fire officers for their own safety and the safety of others. The dedicated Incident Safety Officer adds a higher level of training, attention, and expertise to help the Incident Commander, division commanders, as well as the fire fighters and fire officers. The Incident Safety Officer must have particular expertise in analyzing safety hazards and must know the particular uses and limitations of protective equipment. [44,45,46]

Experience is an extremely valuable resource. The Incident Safety Officer must understand the effects of fires on materials and construction types.[43] One of the important functions of an Incident Safety Officer is to offer judgment about the collapse potential of buildings during incidents. To do this, Incident Safety Officers must front-load their building construction knowledge so that they can "read" the building and predict collapse potential. This ability comes from a long-term commitment to reading and studying information on building construction. Knowledge of building construction starts with an understanding of the loads, forces, and materials found in the structural makeup of buildings. The Incident Safety Officer can provide a fire department with a higher level of expertise to perform the necessary incident scene functions and assist the Incident Commander with fire ground safety.

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Some Incident Commanders believe that any fire officer should be able to fill the fire department Incident Safety Officer function at any time under any circumstance, and therefore believe their agency really does not need a predesignated Incident Safety Officer. Just as Incident Commanders have various levels of knowledge and expertise, so do other fire officers. Likewise, the requirements necessary to be a fire officer may change from department to department, a problem if mutual aid situations arise. Additionally, the emphasis placed on safety may vary from one Incident Commander to another.[47]

Chief Stephen Raynis (Chief of Safety with the New York City Fire Department) notes: *"If a fire officer is not usually assigned as an ISO, it is very difficult to remove ones' self from the thought process of being a tactical officer and concentrate on safety concerns only."*

Recommendation #15: Research organizations and manufacturers should consider new technologies for enhanced accountability and fire ground command tools.

Discussion: Manufacturers, equipment designers and researchers should conduct research into refining existing and developing technology to track the movement of fire-fighters inside structures. Fire-fighter fatalities often are the result of fire-fighters becoming lost or disoriented on the fire ground. The use of systems for locating lost or disoriented fire fighters could be instrumental in reducing the number of fire-fighter deaths on the fire ground. The National Institute for Standards and Technology (NIST) has been evaluating the feasibility of real-time fire fighter tracking and locator systems.[48,49] Research into refining existing systems and developing new technologies for tracking the movement of fire fighters on the fire ground should continue.[32]

Many emergency response agencies use mobile data terminals in fire apparatus and command vehicles. With the advancements in technology information that is stored in an agency's computer-aided dispatch (CAD) system, information on pre-incident planning and target hazard occupancy can be provided to responding units for a defined occupancy. This information can be a valuable tool for the first responders, especially when the jurisdiction has many target hazard occupancies. Also, this information assists the Incident Commander in developing a strategy and incident action plan for an occupancy that has been pre-planned and/or is a target hazard. Another important resource that the CAD system can provide to fire fighters and other first responders is the ability to view an image (photo) of the structure. This can be done using a mapping program (e.g., Google Earth) that gives the fire officer a current view, including a street view, of the building.

Recommendation #16: Fire departments should comply with the National Incident Management System for interoperability and compatibility during emergency operations.

Discussion: The National Incident Management System provides for interoperability and compatibility among agencies on a local, tribal, state, and/or federal basis. The National Incident Management System includes a core set of concepts, principles, and terminology. Homeland Security Presidential Directive 5 identifies this core set as the Incident Command System. The Incident Command System includes multiagency coordination systems; training; identification and management of resources

(which includes resource typing: a system for classifying resources); qualification and certification; and the collection, tracking, and reporting of incident information and incident resources.[50]

As an example of proper terminology, a *division* is the organizational level having responsibility for operations within a defined geographic area. A *group* is an organizational level responsible for a specified functional assignment at an incident. The use of *divisions/groups* within the Incident Command System provides a standard process to divide the incident scene into smaller subordinate management units or areas. [23]Complex emergency situations often exceed the capability of one officer to effectively manage the entire operation. Based upon current federal guidelines, departments and agencies currently using the term *sector* are encouraged to change terminology to become compliant with the National Incident Management System for incident management and daily operations by using the terms *division* for reference to organizational components based on geographic area and *group* for organizational components based on functions.

Moreover, fire departments operate with other local agencies such as law enforcement, emergency medical services, public works, highway department, and emergency management. Also, state and federal agencies may be involved with emergency incidents that occur in a fire department's jurisdiction. The use of proper terminology is essential for a successful outcome of the incident and the safety of all responders.

In this incident, the fire department used the terminology for divisions and groups as "sectors". The fire department utilized the terminology "Alpha Sector", "Bravo Sector", etc. Since this incident occurred the fire department has changed to "division" and "group" to become compliant with the National Incident Management System (NIMS) and NFPA 1561, *Standard on Emergency Services Incident Management System*.[23] With this change in terminology, this report uses the terminology "division" and "group".

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Investigator Information

This incident was investigated by Stephen Miles, Murrey Loflin, Jay Tarley, and Safety Engineer Timothy R. Merinar, with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Surveillance and Field Investigations Branch, Division of Safety Research, located in Morgantown, WV. An expert technical review was provided by Chief Christopher J. Naum, SFPE (Command Institute). Chief Naum provided information on building construction, historical data and structural collapse hazards. An expert technical review was also provided by Robert D. Neamy, Deputy Chief (Retired), Los Angeles Fire Department, and Steve Raynis, Chief of Safety, Fire Department of New York (FDNY). A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division. This report was co-authored by Steve Miles and Murrey Loflin. Some text provided by expert reviewers was incorporated into the final report.

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Appendix 1

Expanded Timeline

This timeline is provided to set out, to the extent possible, the sequence of events according to recorded radio transmissions. Times are approximate and were obtained from review of the dispatch records, witness interviews, and other available information. Times have been rounded to the nearest minute. NIOSH investigators have attempted to include all radio transmissions. This timeline is not intended, nor should it be used, as a formal record of events.

Incident and Fire ground Conditions	Time	Response & Fire ground Operations
April 9, 2012		
"911 Call received a telephone call which reported smoke in the area;	**0312 hours**	
Engine 2 dispatched to a "Local Alarm" assignment;	**0313 hours**	
	0315 hours	Engine 2 responded;
	0317 hours	Engine 2 (E2) on scene; E2 reported a 6-story building, (actually 5 stories), 60' x 1 city block; Heavy fire showing on the 1st and 2nd floors; Requested a Box Alarm;
	0318 hours	E2 reported the fire was all the way to the roof; "Strike a 2nd Alarm and prepare for the 3rd Alarm";
FCC dispatched a "High Rise Box" Alarm Assignment for Box 361; E25, E29, P50, L3, L16, L12 (Lobby Control), B8, B10, and Rescue 1;	**0319 hours**	
	0321 hours	Battalion 10 responded;

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Incident and Fire ground Conditions	Time	Response & Fire ground Operations
FCC dispatched an "All Hands" Assignment and a "Working Fire" Assignment for Box 361; E55, LT22, B3, M15, M2, E13, AU1, E55, Squad 72, Squad 72A, and Division 2; **Note:** *The balance of the "High Rise Box" adds the additional resources above the normal "All Hands" Assignment*;	**0322 hours**	
FCC dispatched a "2nd Alarm" Assignment for Box 361; E7 (Logistics Company), P28, E45, E27, P3, L10, L14, B4 (Logistics), B1, B2, B9 (Safety Officer);	**0324 hours**	
	0326 hours	Battalion 8 assumed "Command";
	0326 hours	Battalion 10 (B10) reported on scene; "Command" advised that the street in front of "Command" will be designated as Alpha Division (Boston Street) and the next street over (York Street) will be designated as Charlie Division; B10 assigned as Division supervisor for Charlie Division; B10 advised "Command" to strike a 3rd Alarm; Also requested the power company due to transformers and power lines burning due to radiant heat;
"Command" contacted FCC and requested a 3rd Alarm;	**0327 hours**	
"3rd Alarm" Assignment for Box 361 dispatched: P20, P34, E11, and E44;	**0328 hours**	

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Incident and Fire ground Conditions	Time	Response & Fire ground Operations
	0330 hours	Charlie Division advised "Command" that there has already been an exterior collapse of the structure; He advised that the collapse zone is now the length of the street on Side "C" from Division B to Delta Division including the width of the street and sidewalks; Charlie Division needed LT22 in service and to be supplied by an engine company;
	0331 hours	Charlie Division advised "Command" that master streams need to be set up on the corners of the structure because the exterior was coming down. Charlie Division had Rescue 1 check a vacant bank building for fire extension;
FCC "South Fire" dispatcher radioed B8 Chief's Aide and requested the size and dimensions of the structure as well as occupancy type.	**0331 hours**	
	0332 hours	Battalion 3 on scene; Assigned as "Delta Division" by "Command"; "Delta Division" requests that 3rd Alarm companies report to him; (*Note: This designation is changed to Bravo Division at 0346 hours because the location of Command was changed to Boston Street from East York Street*); Medic 2 on scene at Jasper @ York Streets;
FCC "South Fire" dispatcher issued "Command's" orders for 3rd Alarm companies to report to "Delta Division";	**0333 hours**	Rescue 1 tried to gain access into the vacant bank building; Charlie Division advised that the fire is contained to the building of origin; there has been a collapse on the southwest corner of the building; (the corner of East York Street and Jasper Street); Medic 15 on scene at Arizona @ Emerald Streets;

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Incident and Fire ground Conditions	Time	Response & Fire ground Operations
	0334 hours	B8 Chief's Aide reported that they have a 4-story (actually 5-story building – Building #1) building – 300' x 500' and a 2-story building (actually 3 stories – Building #2) with heavy fire on all floors of the 4-story building; with heavy fire on all floors of the 4 story building;
	0335 hours	B8 Chief's Aide stated that police officers had reported small fires in residential areas east of this incident due to the high winds and fire brands;
	0337 hours	Charlie Division requested an engine company to supply LT22; Charlie Division advised that he needed the first due engine (E7, which as reassigned from its assignment as Logistics) on the 2nd Alarm to report to him to supply LT22;
	0340 hours	B8 Chief's Aide stated that Division 2 is on scene; Division 2 had assumed "Command"; B8 Chief's Aide to FCC: On the orders of Division 2, strike out a "4th Alarm" Assignment; 4th Alarm companies are assigned to a staging area by B8 Chief's Aide. B8 assigned as "Operations";
FCC dispatched a "4th Alarm" Assignment for Box 36; Units dispatched: E64, P49, E36, E70;	**0341 hours**	
	0341 hours	Battalion 4 (re-assigned from Logistics to Exposures) managed incidents east of the fire due to flying embers; dealt with rubbish fires, trash fires, tree fires, and structure fires; Assigned E27, E7, and P3;
	0343 hours	Pipeline 34 on scene; directed by Operations to supply Ladder 10;

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Incident and Fire ground Conditions	Time	Response & Fire ground Operations
FCC contacts B8 Chief's Aide stated there are multiple reports of fires on streets east of the fireground;	**0345 hours**	"Battalion 1 contacts "Command" about an assignment as a division supervisor; "Command" advised that Battalion 1 be assigned in "Bravo Division"; "Battalion 3 contacts "Command" who stated he is operating as "Bravo Division"; B3 stated there have been multiple collapses in "Bravo Division"; Battalion 9 (Incident Safety Officer) arrived on scene; Battalion 2 operated as an Assistant Incident Safety Officer;
	0346 hours	"Command" made an announcement to all Battalion Chiefs on the fireground; "Alpha Division" was B8; Bravo Division was B3; Charlie Division was B10; Alpha Division: B8, E33, E44, L10, L14; Bravo Division: B3, E2, P20, E29, SQ 72, L3, L16; Charlie Division: B10, P34, LT22, Rescue 1; Delta Division; B1;
FCC notified Car 3 to respond;	**0347 hours**	Car 3 (Technical Services Deputy Commissioner) responded on Box 361;
	0349 hours	Bravo Division stated he had two exposures in his division; These exposures are on the southeast corner of East York Street near the corner of Jasper Street across the street from the fire building: The exposures were a 2-story building that was 40'x 60'and a 5-story building that was 60' x 150'; both buildings were vacant; the 5-story building was being protected from radiant heat;

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Incident and Fire ground Conditions	Time	Response & Fire ground Operations
"Tactical Box Alarm" assignment for Box 7531 for dwelling fire: E63-55; E22-7, L5-3, and L29-12; fire was due to embers from the fire at Box 361. (*Note: the first number is the covering company's actual designation; the second number indicates the engine company or ladder company which they are covering);*	**0349 hours**	
	0351 hours	Bravo Division asked "Command" for a squirt, tower ladder, or snorkel; needed this equipment to cover the exposure;
	0352 hours	Charlie Division contacted "Command" to inform him that P34 is being used to supply LT22; requested two more engine companies with master stream devices;
"Tactical Box Alarm" Assignment for Box 572: E53-29, E12- 13, L8-22, and L2 for a dwelling fire; the fire was due to fire brands from the fire at Box 361;	**0357 hours**	
	0358 hours:	"Command" sent E64 and E70 to Bravo Division; Bravo Division advised to have these companies to lay a line coming in and setup master stream devices in the vacant yard.
	0359 hours	Bravo Division repeated the message to "Operations"; E64 and E70 acknowledge;
	0400 hours	"Command" requests a 5th Alarm for Box 361;
FCC dispatches a "5th Alarm" Assignment for Box 361; E22, Foam 33, E35, and P61;	**0401 hours**	
	0406 hours	Car 3 on scene; Car 3 assumed "Command" for Box 361; Division 2 assigned as "Operations";

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Incident and Fire ground Conditions	Time	Response & Fire ground Operations
	0414 hours	Current Assignments: Operations: Division 2 Alpha Division B8, E33, E44, P61; L10, L14; Bravo Division: B3, E2, P20, E29, E64, E70, SQ 72, L3, L16; Charlie Division: B10, P34, LT22; Delta Division: B1, E35, Rescue 1
	0414 hours	**Exposures:** Battalion 4, Pipeline 3, Ladder 2, Ladder 12, Engine 7, Engine 25, Ladder 12, Engine 55, Engine 50, Engine 70, Engine 35, Pipeline 49, Engine 27, Engine 28, Engine 59, Engine 22, Engine 3, Engine 11, and Engine 28;
FCC notified Car 2 to respond;	**0421 hours**	Car 2 (Deputy Commissioner - Operations) responded to Box 361;
	0430 hours	Rescue 1forced entry into furniture showroom from Boston Street (side A). They reported to Division A that they found fire in the furniture showroom. Division A ordered Rescue 1 to stretch 1¾" hose line into furniture showroom to contain the fire; the hose line was the high rise pack off of E44; The Rescue 1 officer established a secondary interior collapse zone (exclusion zone) and told his men to bounce water off the ceiling and not to go into the secondary collapse zone;
	0436 hours	Car 2 on scene;

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Incident and Fire ground Conditions	Time	Response & Fire ground Operations
	0440 hours	Crews from L10 and Rescue 1 go in and out of the furniture store showroom multiple times to check on possible fire extension due to the collapse of the fire building into the furniture store showroom ; (***Note**:L10 crew entered the showroom to relieve Rescue 1crew, crews enter the furniture store showroom every 10 – 15 minutes for approximately the next 60 – 70 minutes*)
B8 Aide advises FCC that per the orders of Car 3 place this fire "under control";	**0521 hours**	
Announcement on South Tac 1 for all companies to monitor their apparatus fuel level;	**0526 hours**	
	0539 hours	Smoke was reported in the furniture store which faces Kenningston Street; Delta Division (B1), E35, and Rescue 1 ordered to open up the store fronts on Delta Division and into the structure ;
Animal Control requested for a dog found in the furniture store on the 2nd Floor;	**0553 hours**	
	0554 hours	Delta Division contacted "Operations"; Advised the smoke on the 2nd and 3rd floors of the furniture store is trapped smoke;
	0555 hours	"Operations" contacted "Command" ; reported that the smoke in the furniture store was nothing but trapped smoke;
	0555 hours	"Safety" (Battalion 9) contacted "Command" and advised that a collapse had occurred in the furniture store showroom; requested a RIC and medic units to this area;
	0555 hours	Emergency Button activation from L10 – "Search & Rescue"; open radio "mic" with a fire fighter calling "get me out";

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Incident and Fire ground Conditions	Time	Response & Fire ground Operations
South Fire Dispatcher notified B8 Chief's Aide about the Emergency Button activation from L10 – Search & Rescue;	**0556 hours**	
	0556 hours	"Safety" advised "Command" that they have a company, 3 – 4 fire fighters, trapped in the furniture store showroom; there was debris on them and they need to be extricated; "Command" acknowledged the message;
	0558 hours	Alpha Division contacted "Command" and stated there was a collapse inside the rear of the furniture store showroom; requested additional staffing for RIC; "Command" acknowledges;
"Alpha Division" contacts FCC and requested the collapse unit and an additional RIC (ladder company); their assignment was to report to the rear of the furniture store showroom on Boston Street;	**0559 hours**	
	0559 hours	"Operations" notified Alpha Division about deployment of personnel into the 1-story section of the furniture store; Assigned Fire Marshal (FM) 1 as the "Rescue Group" supervisor;
FCC dispatched E53-29, L5, and Collapse 1 for the collapse at furniture store showroom as the Rescue Group; L8-22 replaced L5;	**0601 hours**	
FCC has Medic 15 and Medic 2 to report to the furniture store;	**0601 hours**	
	0602 hours	Bravo Division sent Squad 72 to "Rescue Group"; Rescue Group was: FM1, E53-29, Pipeline 61, L8-22, L12, Squad 47, Squad 72, and Rescue 1;

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Incident and Fire ground Conditions	Time	Response & Fire ground Operations
	0612 hours	L10 "Inside Hook" fire fighter removed from the collapse;
	0622 hours	L10 "Search & Rescue" fire fighter removed from the collapse and transported to trauma center;
	0706 hours	L10 lieutenant removed from the collapse and transported to trauma center;
	0725 hours	L10 "Tiller" removed from the collapse and transported to trauma center;
Incident terminated;	**1631 Hours**	

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