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NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A summary of a NIOSH fire fighter fatality investigation

November 6, 2007

Revised March 14, 2008

Floor Collapse at Commercial Structure Fire Claims the Lives of One Career Lieutenant and One Career Fire Fighter - New York

SUMMARY

On August 27, 2006, a 43-year-old male career Lieutenant (victim #1) and a 25-year-old male fire fighter (victim #2) died after the floor they were operating on collapsed at a commercial structure fire. At approximately 1230 hours, crews were dispatched to a fire. The victims' engine was dispatched at 1236 hours as an additional unit alarm and arrived on the scene at approximately 1240 hours. At approximately 1251 hours, victim #1, victim #2 and fire fighter #1 advanced a 2 ½-inch hand line through the front of the structure and down an aisle toward the rear of the store. The fire was located in the rear interior of the structure (discount store) that sold a variety of numerous small household commodity items. Approximately three minutes later, the structural members supporting the floor directly below the victims failed. The V-shaped collapse of the floor caused victim #1 and victim #2 to fall into the basement and shelving stocked with merchandise to fall in on top of them. Multiple MAYDAYs were transmitted and the fire fighter assist and search team (FAST) was deployed to the front of the structure where they assisted in the rescue of numerous members who had been operating in the interior of the structure at the time of the collapse. Battalion Chief #1, Lieutenant #1 and fire fighter #1 were freed from the debris. At approximately 1415 hours, victim #1 was removed from the debris in the basement and transported to the hospital. He died the next day as a result of his injuries. At approximately 1435 hours, victim #2 was removed from the basement and transported to the hospital where he was pronounced deceased as a result of his injuries.

NIOSH investigators concluded that, to minimize the risk of similar occurrences, fire departments should:

- ***consider the possibility of a substandard structure when building information is not available from pre-incident plans***
- ***consider the live load of water on the structure and go defensive when water load potentially compromises the structural integrity***

Additionally, municipalities should:

- ***explore means of coordinating information sharing between building and fire departments to increase safety for fire fighters and civilians***

- ***consider conducting inspections on all commercial structures where a change of occupancy has occurred or renovations are known or suspected, giving special attention to non-sprinklered commercial retail structures***

INTRODUCTION

On August 27, 2006, a 43-year-old male career Lieutenant (victim #1) and a 25-year-old male fire fighter (victim #2) died after the floor collapsed at a commercial structure fire. On August 28, 2006, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On October 3, 2006, a Safety and Occupational Health Specialist and a General Engineer from the NIOSH Fire Fighter Fatality Investigation and Prevention Program investigated this incident. Meetings were conducted with the Safety Chief Officers and Safety Technicians assigned by the department to investigate this incident and representatives from the Uniformed Firefighters Association and the Uniformed Fire Officers Association. Interviews were conducted with officers and fire fighters who were at the incident scene. The investigators reviewed the victims' training records, autopsy reports, and death certificates. NIOSH investigators also reviewed the department's fireground standard operating procedures (SOPs),[1] a transcription of the dispatch tapes, the department's report of this incident, and a draft forensics engineering evaluation of the fire structure.[2] The incident site was visited and photographed.

Fire Department

This career department consisted of approximately 11,500 uniformed fire fighters that served a population of about 8,000,000 in a geographic area of approximately 321 square miles.

Training and Experience

The department requires all fire fighters to complete the fire department's 13-week Probationary Fire Fighter's School. Candidates are trained as Certified First Responders. Probationary fire fighters are instructed in hydraulics and learn the basics of fire suppression systems and fire-fighting tactics.

Victim #1 had 20 years of experience with this department and had completed an extensive list of training courses which included: Fire Suppression and Control, Building Construction and Firefighter Safety, Tactical Roof Operations, Hazardous Material Operations, Ladder Company Chauffeur and Tactical Private Dwelling Fire.

Victim #2 had 6 weeks of experience with this department and had completed the fire department's 13-week Probationary Fire Fighter School. Probationary fire fighters must pass eight weekly tests, a comprehensive midterm, and a final examination in order to graduate.

Apparatus and Personnel

1230 hours dispatch - Initial dispatch included:

- o Engine 42 (Officer, fire fighter/driver and four fire fighters);
- o Engine 43 (Officer, fire fighter/driver and four fire fighters);
- o Ladder 44 (Lieutenant (Lt #1), fire fighter/driver, fire fighter#2 (ff#2) and three fire fighters);
- o Ladder 59 (Officer, fire fighter/driver and four fire fighters);
- o Battalion 17 (Battalion Chief (BC #1),Initial incident commander (IC), and a fire fighter/driver);
- o Engine 46 (Officer, fire fighter/driver and four fire fighters); and
- o Engine 92 (Officer, fire fighter/driver and four fire fighters).

1234 hours dispatch -

- o Squad 41 (Lieutenant (Lt#2), fire fighter/driver and four fire fighters);
- o Rescue 3 (Officer, fire fighter/driver and five fire fighters);
- o Battalion 19 (Battalion Chief and fire fighter/driver);
- o Ladder 27 (Officer, fire fighter/driver and four fire fighters);
- o Division 6 (Acting Deputy Chief (Incident Commander) and a Division Aid).

1236 hours dispatch -

- o Engine 75 (Lieutenant (victim #1), fire fighter/driver, fire fighter (victim #2), fire fighter #1 (ff#1) and two fire fighters);and
- o Ladder 33 (Officer, fire fighter/driver and three fire fighters).

Additional units were dispatched; however, only those units directly involved in the operations preceding the fatal event are discussed in the investigation section of this report.

Photo 1. Fire structure

Structure

The incident site was a one story, class III, non-fireproof structure, measuring approximately 45-feet wide and 65-feet in length (See Photo #1). The front of the structure had a double glass door entrance flanked with large storefront single-pane windows. The structure had a flat roof with several large air conditioning units mounted on top. The structure contained three separate occupancies. The store cellar could only be accessed via an interior trap door and was primarily used for the storage of merchandise.

The fire department's Bureau of Fire Investigation determined the origin of the fire to be behind the refrigeration units located along the back wall of the store, and the cause of the fire to be electrical in nature.

Weather

The approximate temperature at the time of the incident was 69 degrees Fahrenheit with an estimated average wind speed of 8 miles per hour from the south and intermittent heavy rain.

INVESTIGATION

On August 27, 2006, at approximately 1230 hours, Engine 42 (E-42), Engine 43 (E-43), Ladder 44 (L-44), Ladder 59 (L-59), and Battalion Chief 17 (BC#1) were dispatched to a reported commercial structure fire. Two additional Engine Companies, Engine 46 (E-46) and Engine 92 (E-92), were added to the call as additional reports of the fire were received by Central Dispatch. E-42 arrived on the scene at approximately 1233 hours and reported to Central Dispatch the location and confirmation of the structure fire at the one-story building. Central Dispatch added Squad 41 (Sq-41), Rescue 3 (R-3), Battalion Chief 19 (BC#2), Ladder 27 (L-27), assigned as the fire fighter assist and safety team (FAST), and Division Chief 6 (D-6) to the call. L-44 arrived on the scene followed by E-92. At approximately 1235 hours, L-59 arrived on the scene just ahead of E-43. BC#1 arrived on the scene, assumed command (initial IC), and provided Central Dispatch with his size-up of the incident. The seat of the fire was located in the rear interior of the commercial structure (a discount store that sold a variety of numerous small household commodity items). Additional units were dispatched, including the victims' Engine Company (E-75).

At approximately 1237 hours, L-44 crew members removed the front windows and glass doors of the discount store. E-42 crew members stretched a 150-foot 2 ½-inch hand line to side A of the structure and began their attack on the fire from the sidewalk. Lt#1 of L-44 stepped inside the doorway with a thermal imaging camera and reported fire in the rear of the structure from floor to ceiling. BC#1 radioed Central Dispatch and requested a 2nd alarm. BC#2 arrived on the scene and was assigned to check on side B of the building. Sq-41 arrived on the scene and was assigned to perform roof operations (vertical ventilation) and to check side B for fire extension. With no visibility on the roof, Lt#2 of Sq-41 used his thermal imaging camera and observed several fire fighters successfully ventilating the roof which allowed fire fighters on the ground to advance one of the two hand lines into the structure where they continued their attack on the fire.

The victims' engine arrived on scene at approximately 1240 hours. At this time R-3 was sent to the roof. At approximately 1244 hours, D-6 assumed incident command and requested a roof size up. L-44 reported fire in the cockloft. At approximately 1248 hours, D-6 reported that 4 lines were operating and there was fire in the cockloft. L-59 reported a hole in the roof at the back of the store and D-6 called for everyone off the roof. Sq-41 reported that the roof was getting soft and that members were backing off the roof. BC#1 called for everyone off the roof. Sq-41 and BC#2 confirmed that everyone was off the roof. At approximately 1251 hours, victim #1, victim #2 and ff #1 advanced a 2 ½-inch

hand line through the front of the structure and down an aisle toward the rear of the store (See Diagram #1). A minute later, BC#1 and Lt#1 followed the hand line to monitor the interior conditions.

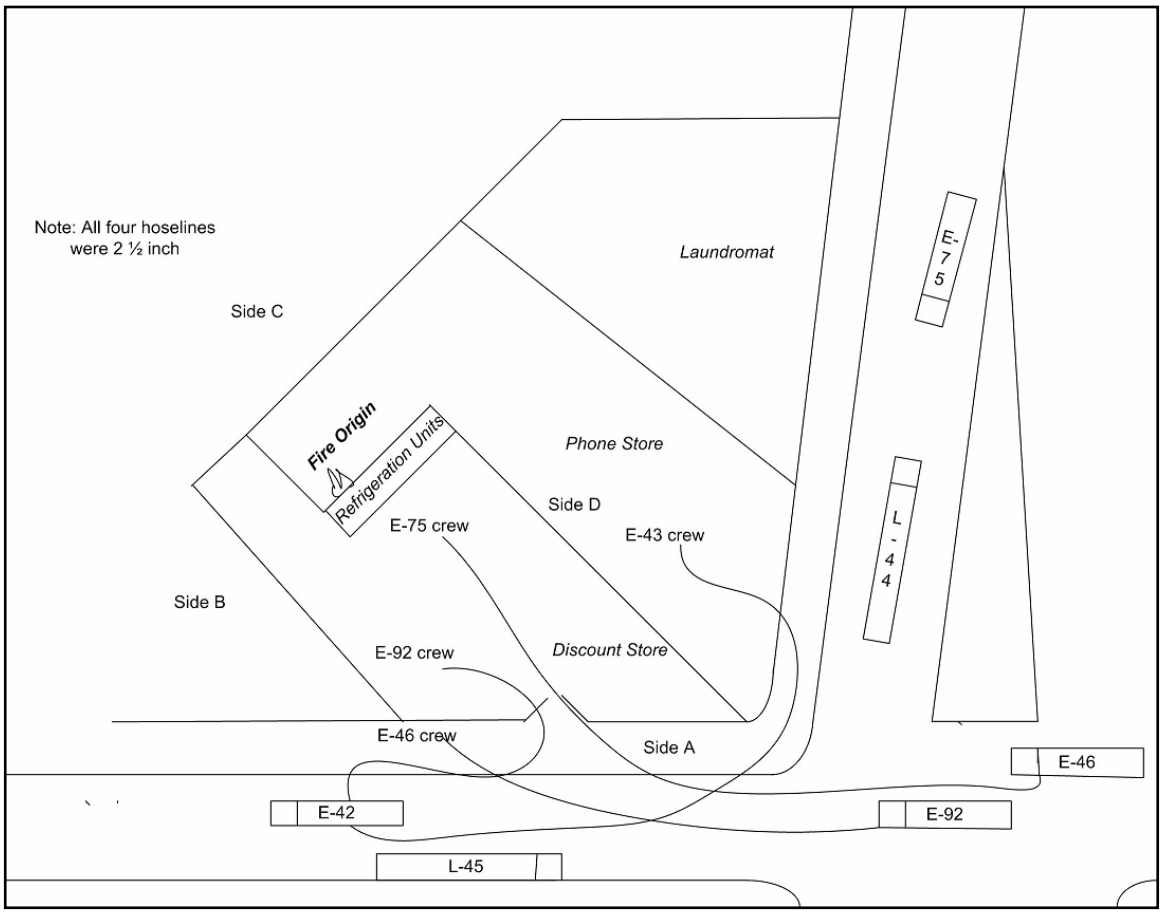

Diagram 1. Shows location of crews and hoselines in reference to fire building.

At approximately 1254 hours, the structural members supporting the floor directly below the victims failed. The V-shaped collapse of the floor caused victim #1 and victim #2 to fall into the basement and shelving stocked with merchandise to fall in on top of them. In addition, ff #1, Lt #1, ff #2, and BC #1 were caught in the debris in the middle of the collapse (See Diagram #2). *Note: a post incident investigation revealed the structural members had severe rot at the base of the timber columns. Additionally, alterations had been made to the floor system that were non-uniform and not to code.*[2] D-6 called for the fire fighter assist and search team (FAST) to the front of the structure. Several MAYDAYS were heard at this time. At approximately 1255 hours, D-6 requested 2 additional Basic Life Support and Advanced Life Support units and for all crews to back out for a roll call. At approximately 1300 hours, a third alarm was transmitted. Again, several MAYDAYS were heard and believed to have come from victim #1. At approximately 1301 hours, Sq-41 entered the exterior

sidewalk doors to the basement with a search rope. Sq-41 encountered about a foot of water on the basement floor. Both Sq-41 in the basement and the FAST team that entered from the first floor encountered difficulty getting to the victims due to many collapsed structural members and to the large volume of goods in the retail structure. There were also numerous containers and slippery substances on the floor. For approximately the next 15 minutes, fire fighters removed debris and searched for the missing fire fighters.

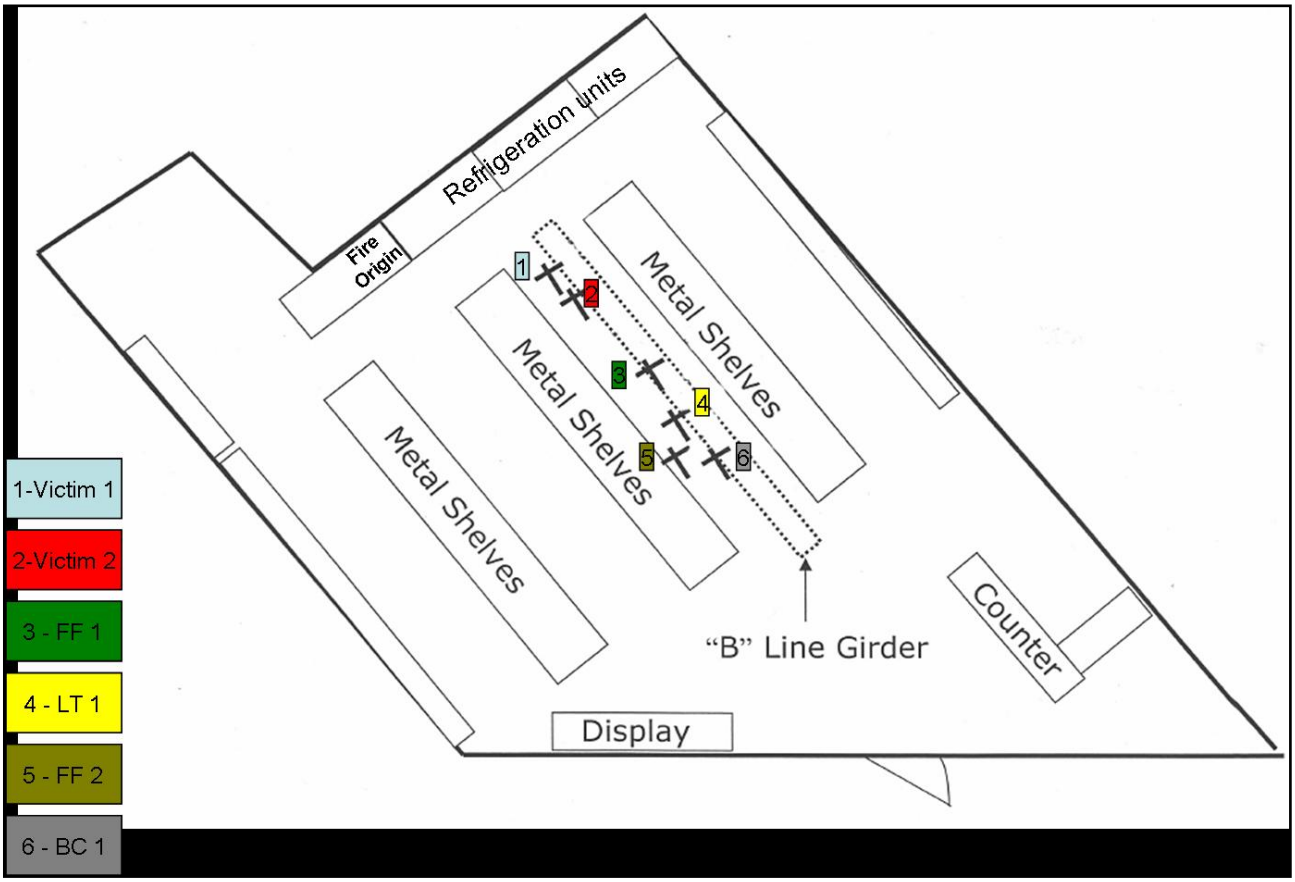

Diagram 2. Shows location of victims on the structure's floor above the girder that failed.

At approximately 1325 hours, R-4 was in contact with the Lieutenant (victim #1). At approximately 1331 hours, victim #1 informed R-4 that his nozzle man (victim#2) was underneath him. At approximately 1337 hours, the FAST team extricated ff #1 from the debris. At approximately 1349 hours, a fast pak (oxygen cart) was called for victim #1. At approximately 1350 hours, Lt #1 was extricated and was placed on the immobilization board (stokes). At approximately 1354 hours, BC #1 was extricated and removed to the street. At approximately 1415 hours, victim #1 was removed from the rubble and debris in the basement. At approximately 1417 hours, victim #1 was removed from the building and transported to an area hospital where he died the next day as a result of his injuries. At

approximately 1419 hours, victim #2 was found unconscious and had to be extricated. Both a fast pak and stokes were employed. At approximately 1435 hours, victim #2 was removed from the basement and transported to the hospital where he was pronounced deceased at 1517 hours.

INJURIES

In this incident, BC #1, Lt #1, and ff #1 were injured and required medical treatment. All three members suffered from carbon monoxide (CO) exposure and Lt #1 received second- and third-degree burn injuries to his left leg.

CAUSE OF DEATH

The autopsy report listed victim #1's cause of death as positional asphyxia and aspiration of blood due to blunt impact of the head with fracture of the cribriform plate.

The autopsy report listed victim #2's cause of death as asphyxiation due to compression of the chest (compression from weight of shelving and commodity materials).

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Fire departments should consider the possibility of a substandard structure when building information is not available from pre-incident plans, and implement a defensive strategy when no occupants are at risk.

Discussion: The threat of a collapse of some type (i.e. roof, ceiling, floor or wall) is a possibility in any structural fire due to the effects of fire, water application, age, insects, and alterations. It is a high probability that a fire department is unaware of structural defects caused by age, insects and alterations. To minimize the risk of injury or death to fire fighters during structural operations, the size-up and risk assessment includes many factors, which include: age of the building (deterioration of structural members, evidence of weathering, use of lightweight materials in new construction), occupancy, and renovations or modifications to the building.[3,4,5]

Pre-incident plans are an effective tool in preventing injuries and deaths of fire fighters due to structural collapse. They allow fire departments to determine factors, such as, age of the structure, structural integrity, type of materials used in the structure, and amount of load on the roof that could weaken the supports, etc. However, in numerous cities and towns where buildings number in the hundreds of thousands, fire departments lack the manpower to pre-plan all buildings under their protection. Often fire departments are limited to targeting buildings that have a unique construction or pose a known hazard.

In floor collapses that have occurred, such as those at a New York City drug store (October 17, 1966) and at a Boston hotel (June 17, 1972), there were no warning signs, and no time to act and withdraw fire fighters to safety. At both of these floor collapses, unauthorized alterations on the structure contributed to the structural failure.[5]

"The potential for structural collapse is one of the most difficult factors to predict during initial size-up and ongoing fire fighting. Structural collapse usually occurs without warning."[3] When pre-incident plan information on the fire structure is not available, occupants have been evacuated, and evidence of structural deterioration and/or modification cannot be determined, a defensive strategy should be implemented. A defensive strategy would help ensure fire fighter safety and is warranted in structures that lack pre-incident plans, no occupants are at risk, and where the potential for numerous unrecognized hazards exists, such as substandard construction and building deterioration.

Fire departments operating in older businesses and homes should be suspicious of potential alterations and renovations which could result in unsupported loads and unusual voids. These alterations may be hidden by sheetrock (drywall) or flooring and built up flooring which is difficult to detect during inspections and virtually impossible to detect during firefighting operations. The older the structure, the greater the possibility of renovation or remodel.

In this case, there were no current pre-incident plans for the structure; the occupants had evacuated upon the fire department's arrival, and compromised structural integrity was not immediately evident. Structural alterations had been made to the girders, columns, and floor in order to presumably level and support the floor. A post incident inspection showed 2 x 4 boards being used inappropriately (in orientation and stability) as a floor joist. A cluster of nails were used in lieu of bolts to attach gusset plates to the columns and girders. Sheets of plywood were added to the floor with no structural support around the sheet's edges nor at 12", 16" or even 24" intervals in accordance with standard building codes. Subflooring (i.e., plywood, wafer board, etc.) needs to be fastened around the sheet's edges and at interval spacing (generally every 16 inches, but spacing may vary according to load requirements) to support floor joists. The interior support members of the structure suffered from severe rot at the base of the timber columns.

Recommendation #2: Fire departments should consider the live load of water on the structure and go defensive when water load potentially compromises the structural integrity.

Discussion: A forensic engineering analysis of the fire building demonstrated that the weight of water added to the building from the fire fighting operations was approximately 50% of the rated structural

capacity of the floor.[2] As noted previously, however, timbers that supported the ground floor had rotted. Thus, the actual structural capacity of the floor was less than rated. Although the ultimate cause of the collapse was the rotted timbers, the weight of the water applied during the fire fighting operations, in addition to the weight of fire fighters, store merchandise, etc., likely contributed to the collapse. Given the many unknowns during fire fighting operations, including in most incidents the rated capacity of floors, incident commanders need to continuously consider the impact of water weight on structural integrity, and shift to defensive strategies when structural integrity is potentially compromised.

Firefighting operations can drastically increase the live load on the fire building. This can be due to the weight of:

1. the firefighters with their protective equipment and tools,
2. the hose-line brought into the fire building, and
3. the water used to attack the fire[6].

A 2 ½ -inch hose-line can deliver approximately 250 gallons of water per minute. [5] This adds about 2,082 pounds per minute into the fire building. If multiple hose-lines are operating, the weight of the water can be tremendous.

When operating in an offensive mode, a buildup of water within a building requires that immediate action be taken to alleviate these conditions. [6] The remedy may be as simple as controlling the excess flow from the hose-line or moving fire debris that is restricting runoff. When using large amounts of water, it is always advisable to provide for drainage when necessary. This can be accomplished any number of ways from chutes with traps to actual holes drilled to provide relief. [6]

It must be recognized that at the same time that this additional weight is being introduced into the fire building, the fire and water are weakening the structure. Under these conditions, a defensive strategy is best when no civilians are in the structure. [5]

In this case, civilians had evacuated the fire building upon the fire department's arrival. The structures' configuration only enabled an initial attack through the front of the structure and down narrow aisle ways to the rear of the structure where the origin of the fire was located. Prior to the collapse, three 2 ½-inch hose-lines (operating 17 minutes, 8 minutes, and 2 minutes, respectively) were flowing water through and into the rear of the structure. The added weight and flow of the water could have contributed to the floor collapse because of the rotted support columns decreasing the timber frame system's ability to equalize the water load across the floor.

Additionally,

Recommendation #3: Municipalities should explore means of coordinating information sharing between building and fire departments to increase safety for fire fighters and civilians

Discussion: Information on building construction, renovations, and alterations can help Incident Commanders develop strategies and tactics that effectively fight fires while attending to fire fighter safety. Pre-incident plans are a useful tool for ensuring that fire departments and Incident Commanders have information on building construction and contents to guide decision-making on the fireground. In urban areas with large numbers of existing structures, it may not be feasible to develop pre-incident plans for all or most structures, and for fire departments to regularly revisit structures to update pre-incident plans. Municipal building departments that issue building permits and conduct code inspections may collect, or be in position to collect, information that may be useful to fire departments.

Municipalities should consider exploring mechanisms by which building information relevant to fire fighter and civilian safety can be collected and shared between building and fire departments. As one example, building departments could notify fire departments when building permits are issued. This would result in fire departments being aware of these building alterations, and to possibly target these buildings for a pre-incident plan. Priority should be given to sharing such information for targeted hazards identified by fire departments.

Recommendation #4: Municipalities should consider conducting inspections on all commercial structures where a change of occupancy has occurred or renovations are known or suspected, giving special attention to non-sprinklered commercial retail structures

Discussion: Occupancy changes understandably occur with great frequency. However, every effort should be made as new permits are issued to aggressively inspect any occupancy change. It is critical that municipalities assess that any renovations or remodeling meets current codes, and that original and renovated supports are capable of supporting the new occupancies. These building inspections should specifically consider the loading or redistribution of stock to ensure that flooring can handle dead and live loads.

REFERENCES

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INVESTIGATOR INFORMATION

This incident was investigated by Mark McFall, Safety and Occupational Health Specialist, and Matt Bowyer, General Engineer, Surveillance and Field Investigations Branch, Division of Safety Research, NIOSH. An expert technical reviews were provided by Deputy Chief Colleen Walz, Pittsburgh Bureau of Fire and Chief Robert Halton, retired, Editor in Chief, Fire Engineering Magazine.