2007
07
NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A summary of a NIOSH fire fighter fatality investigation **November 16, 2007**

Volunteer Fire Fighter Dies After Falling Through Floor Supported by Engineered Wooden-I Beams at Residential Structure Fire - Tennessee

SUMMARY

On January 26, 2007, a 24-year-old male volunteer fire fighter died at a residential structure fire after falling through the floor which was supported by engineered wooden I-beams. The victim's crew had advanced a handline approximately 20 feet into the structure with zero visibility. They requested ventilation and a thermal imaging camera (TIC) in an attempt to locate and extinguish the fire. The victim exited the structure to retrieve the TIC, and when he returned the floor was spongy as conditions worsened which forced the crew to exit. The victim requested the nozzle and proceeded back into the structure within an arm's distance of one of his crew members who provided back up while he stood in the doorway. Without warning, the floor collapsed sending the victim into the basement. Crews attempted to rescue the victim from the fully involved basement, but a subsequent collapse of the main floor ceased any rescue attempts. The victim was recovered later that morning. NIOSH investigators concluded that, to minimize the risk of similar occurrences, fire departments should:

- ***use a thermal imaging camera (TIC) during the initial size-up and search phases of a fire***
- ***ensure fire fighters are trained to recognize the danger of operating above a fire and identify buildings constructed with trusses or engineered wood I-beams***

Additionally, Municipalities and local authorities having jurisdiction should

- ***develop a questionnaire or checklist to obtain building information so that the information is readily available if an incident is reported at the noted address***

Additionally, Building code officials and local authorities having jurisdiction should

- ***consider modifying the current codes to require that lightweight trusses are protected with a fire barrier on both the top and bottom***

The Fire Fighter Fatality Investigation and Prevention Program is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at www.cdc.gov/niosh/fire/ or call toll free **1-800-CDC-INFO** (1-800-232-4636).

Volunteer Fire Fighter Dies After Falling Through Floor Supported by Engineered Wooden-I Beams at Residential Structural Fire - TN

INTRODUCTION

On January 26, 2007, 24-year-old a male volunteer fire fighter died at a residential structural fire after falling through the floor which was supported by engineered wooden I-beams. On January 26, 2007, the U.S. Fire Administration notified the National Institute for Occupational Safety and Health (NIOSH) of this incident. On February 20-23, 2007, a Safety and Occupational Health Specialist, a General Engineer, and a Safety Engineer from the NIOSH Fire Fighter Fatality Investigation and Prevention Program investigated this incident. Meetings were conducted with representatives from the State fire marshal's office, the county sheriff's office, the city building code official, and fire fighters and officers of the local fire department. Interviews were conducted with crews involved in the fatal incident. The investigators reviewed training records for the victim and Incident Commander, the department's standard operating procedures (SOPs), the fire department's investigation report, and the autopsy report. The incident site was visited and photographed, and the victim's personal protective equipment was examined.

Fire Department

This volunteer department consists of 55 fire fighters in 4 fire stations that serve a population of about 30,000 in a geographic area of approximately 112 square miles.

Training and Experience

The victim was National Fire Protection Association (NFPA) Level I certified through the county and had also received additional training, including Hazardous Materials (HazMat), fire behavior, ventilation search and rescue, and building construction. He had more than 2 years of fire-fighting experience.

The Incident Commander (IC) was National Fire Protection Association (NFPA) Level I and II certified and had also received additional training, including Fire Officer I and II, Hazardous Materials (HazMat), and Incident Safety Officer. The incident commander had more than 21 years of fire-fighting experience.

Structure

The structure was built in 2004, and was a two-story, single family residence of ordinary construction which encompassed approximately 2,200 square feet of living area above grade and 2,200 square feet below grade.

The floors of the structure involved in this incident consisted of a lightweight wooden truss system of engineered wooden "I" beams. Engineered wood "I" beams are typically formed with a 2- by 3-inch or 2- by 4-inch top and bottom cord with a sheet of plywood or particle board vertically sandwiched in between as a web (Photo 1).

Volunteer Fire Fighter Dies After Falling Through Floor Supported by Engineered Wooden-I Beams at Residential Structural Fire - TN

Equipment, Personnel, and On-Scene Arrival

Car 1606: Assistant Chief; Incident Commander (IC)—0037 hours
Engine1642: Officer, driver/operator, victim, and three fire fighters—0044 hours
Engine1654: Officer, fire fighter—0049 hours
Engine1653: Driver/operator, two fire fighters—0045 hours
Engine1652: Officer, driver/operator—0046 hours
Medic 1692: Officer—0046 hours
POV: Officer

Weather Conditions

The conditions were clear with the temperature averaging 40-degrees Fahrenheit. The wind was averaging around 3 miles per hour from the south to south west.

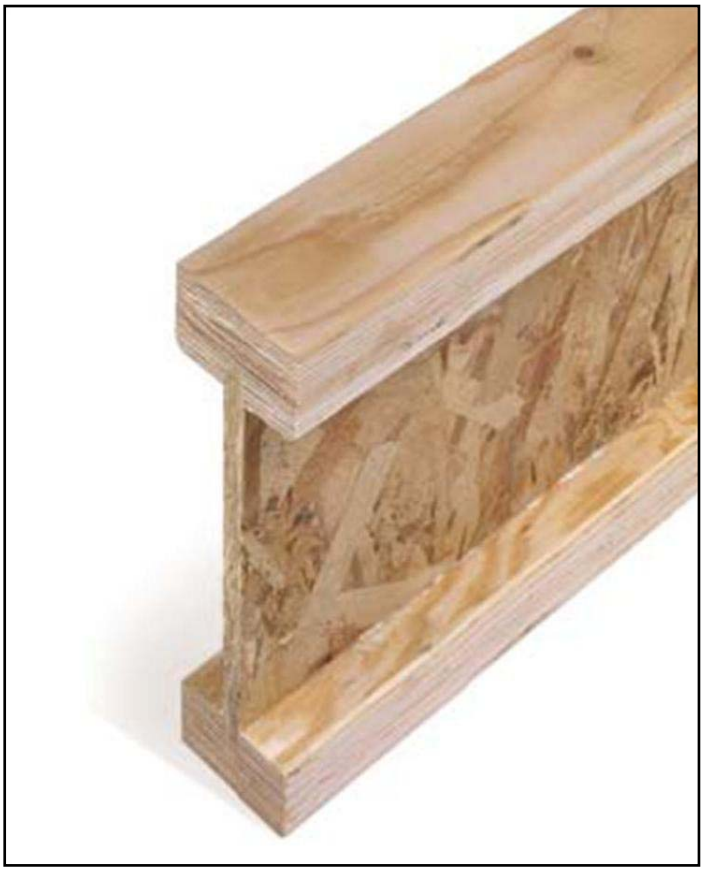

Photo 1. Engineered wood I-joist. Photo courtesy of APA-Engineered Wood Association.

INVESTIGATION

On January 26, 2007, at approximately 0031 hours, the fire department received a call from central dispatch of a possible structure fire from a wood stove located in the basement. The Incident Commander was the first to arrive on the scene in his department vehicle at approximately 0037 hours. While passing in front of the house, the IC could see fire extending from a garage door located at the C/D corner of the basement. The IC proceeded approximately 1500 feet past the house to a hydrant which he marked with a glow stick. He then told a sheriff to stand by the hydrant and returned to the house to direct the operations. Engine 1642 (E1642) arrived on the scene followed by Engine 1654 (E1654) which made a reverse lay to the hydrant to supply E1642.

The IC started to conduct a 360-degree size-up as the crew prepared to make entry through a door located in a second garage located on the main level at the A/B corner (Diagram). The IC was not aware if anyone was inside the house. The IC made it to the D-side where fire was extending from an entrance in the basement with probable extension through the first floor. He returned to the garage where the victim and his crew from E1642 were working. The crew made entry and proceeded down

Volunteer Fire Fighter Dies After Falling Through Floor Supported by Engineered Wooden-I Beams at Residential Structural Fire - TN

a hallway approximately 20 feet with zero visibility. They radioed the IC for a thermal imaging camera and for ventilation. A positive pressure ventilation fan (PPV) was set at the door in the garage where the crew made entry. The victim exited to retrieve the camera and by the time he returned, the heat conditions worsened and the floor was spongy. The crew exited the structure into the garage. The victim requested the nozzle and proceeded back into the structure within an arm's distance of one of his crew members who provided back up while he stood in the doorway. Without warning, the floor collapsed sending the victim into the basement at approximately 0059 hours.

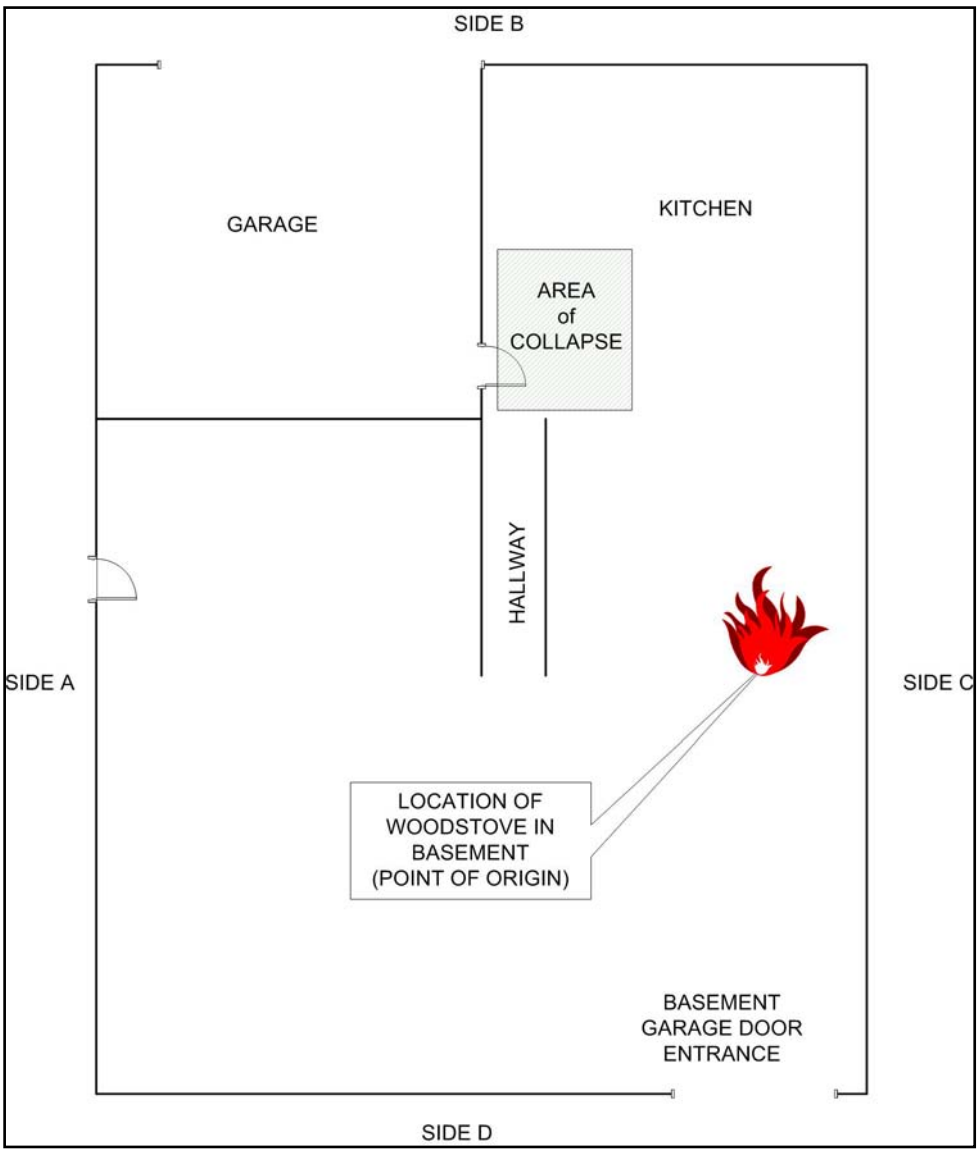

Diagram. Aerial view

Volunteer Fire Fighter Dies After Falling Through Floor Supported by Engineered Wooden-I Beams at Residential Structural Fire - TN

The IC had a crew preparing to make entry through the front door and he went back to the D-side of the structure. The flames were still concentrating and intensifying from the basement garage door. He went to the A-side as a fire fighter ran up to him and told him that the victim had fallen into the basement.

The fire fighter who was backing up the victim dropped to his stomach and was yelling for the victim to take his hand. The victim replied that he could not reach it. While the fire fighter was on his stomach his low-air alarm sounded forcing him to exit. The IC went to an apparatus and took an attic ladder to the hole where the victim had fallen through. Crew members bumped the victim with the ladder as he crawled, and they yelled for him to try and crawl up the ladder while other members retrieved a roof ladder. The victim was in full gear as he crawled out of view towards the A-side of the structure. The flames were intense as the victim came back into view within 30 seconds and crawled under the ladder. At this point, he did not have on his helmet or Nomex® hood. The members placed a roof ladder into the 10 to 15-foot void in the floor created by the collapse. A Lieutenant immediately entered the fully engulfed basement in an attempt to rescue the victim. The victim was unresponsive and in convulsions. The Lieutenant grabbed the victim's jacket and tried to move him, but was unsuccessful. He exited the basement as his low-air alarm sounded and requested additional manpower to move the victim. Two other fire fighters entered the basement. They hooked a rope to the victim and were forced to exit due to the extreme heat conditions. Members in the garage attempted to pull the victim up from the basement with the rope, but still could not move him. The remainder of the main floor collapsed as the garage collapsed around them. All the fire fighters were pulled from the structure as it collapsed. The victim was recovered later that morning.

CAUSE OF DEATH

The medical examiner's report listed the cause of death as inhalation of smoke and toxic products of combustion.

RECOMMENDATIONS/DISCUSSION

Recommendation #1: Fire departments should use a thermal imaging camera (TIC) during the initial size-up and search phases of a fire.

Discussion: During the initial size-up, information gathered from central dispatch or from face-to-face communications with the property owner is invaluable. A thermal imaging camera (TIC) can be a useful tool for initial size up and for locating the seat of a fire by assisting fire fighters in quickly getting crucial information about the location of the source (seat) of the fire from the exterior of the structure, so they can plan an effective and rapid response with the entire emergency team. Knowing the location of the most dangerous and hottest part of the fire may help fire fighters determine a safe approach and avoid structural damage in a building that might have otherwise been undetectable. Ceilings and floors that have become dangerously weakened by fire damage and are threatening to collapse may be spotted with a thermal imaging camera. The use of a TIC may provide additional information the Incident Commander can use during the initial size-up. TICs should be used in a

timely manner, and fire fighters should be properly trained in their use and be aware of their limitations.[1]

In this incident, the use of a TIC during initial size-up and entry into the structure could have confirmed a general location for the seat of the fire in the basement. This information may have influenced the fire department as to what areas were possibly structurally damaged by the fire.

Recommendation #2: Fire departments should ensure fire fighters are trained to recognize the danger of operating above a fire and identify buildings constructed with trusses or engineered wood I beams.

Discussion: The danger of being trapped above a fire is greatly influenced by the construction of the burning building. Of the five basic building construction types (fire resistive, noncombustible, ordinary construction, heavy timber, and wood-frame) the greatest danger to a fire fighter who must operate above the fire is posed by wood-frame construction. Vertical fire spread is more rapid in this type of structure. Flames may spread vertically and trap fire fighters operating above the fire in four ways: up the interior stairs, through windows (autoexposure), within concealed spaces, or up the combustible exterior siding. Extreme caution must be used in determining if the structural stability of the flooring system is adequate to facilitate the operations. [2,3]

The floors of the structure involved in this incident contained engineered wooden "I" beams. Engineered wood "I" beams are typically formed with a 2- by 3-inch or 2- by 4-inch top and bottom cord with a sheet of plywood or particle board vertically sandwiched in between as a web. Lightweight trusses that are exposed to fire may fail in less than 10 minutes. Lightweight engineered wooden "I" beams have been reported to fail in as little as 4 minutes and 40 seconds. [4] No specific time limit has been established for how long fire fighters should operate under or on truss floors or engineered wood "I" beams that are exposed to fire. Even though standard fire engineering calculations show that lightweight construction members may be expected to collapse under 10 minutes in a fully developed fire, it is not recommended that a time limit be set.[5] Fire fighters should not enter any room or structure when it has been determined that the building's trusses or engineered wood I beams have been exposed to fire. If it is determined while they are operating under or above trusses or engineered wood I beams, they should be immediately evacuated. [6] Certain materials used for interior flooring such as cement board underlayment with ceramic tile could decrease the time for structural failure by trapping the heat below the floor. [7] Fire fighters who sound the floor with a tool to determine structural integrity will likely get a false reading from these types of flooring systems.

Volunteer Fire Fighter Dies After Falling Through Floor Supported by Engineered Wooden-I Beams at Residential Structural Fire - TN

Recommendation #3: Municipalities and local authorities having jurisdiction should develop a questionnaire or checklist to obtain building information so that the information is readily available if an incident is reported at the noted address

Discussion: An effective dispatch system is a key factor in fire department operations. The central dispatch center is used for receiving notification of emergencies, alerting personnel and equipment, coordinating the activities of the units engaged in emergency incidents, and providing non-emergency communications for the coordinating fire departments.[8-10]

Municipalities and local authorities having jurisdiction should develop a questionnaire or checklist to ensure that central dispatch has pertinent information on a reported address. The questionnaire or checklist could focus on building characteristics including the type of construction, materials used, occupancy, fuel load, roof and floor design, and unusual or distinguishing characteristics. Municipalities and local authorities having jurisdiction should also include experienced fire personnel throughout any developmental process concerning life safety to the public and fire department members. The information covered on this questionnaire could possibly be gathered through local contractors obtaining a permit or homeowners applying for a fire fee. Once obtained, this information should be recorded, shared with other departments who provide mutual aid, and if possible, entered into the dispatcher's computer so that the information is readily available if an incident is reported at the noted address.

Typically, pre-incident planning focuses on commercial buildings and the specific hazards they have due to their size, construction, and contents. Rural and volunteer departments usually do not have the manpower to conduct pre-planning of structures in their jurisdiction. Modern building components, specifically engineered wood trusses, have allowed residential structures to be designed and built in sizes rivaling commercial buildings. The hazards with this type of construction are the same in both commercial and residential structures. Engineered wood trusses that are exposed to fire weaken or fail very quickly [10].

Recommendation #4: Building code officials and local authorities having jurisdiction should consider modifying the current codes to require that lightweight trusses are protected with a fire barrier on both the top and bottom.

Discussion: Trusses are typically assembled in a system to provide structural support for a roof or floor. The roof or flooring system is certified for the required fire rating by testing the entire assembly such as an attic or floor space with a roof or sub-floor covering on the top and a ceiling component on the bottom. The fire-resistance of the assembly can be viewed as the sum of the resistance of all the components used in the assembly. [10]

Volunteer Fire Fighter Dies After Falling Through Floor Supported by Engineered Wooden-I Beams at Residential Structural Fire - TN

In this incident, the floor trusses for the first floor did not have any protection on the bottom cord, which immediately exposed the trusses to fire in the basement (Photo 2). Unfinished basements are very common throughout the country. Basements typically house additional fire exposures such as alternative heating sources, hot water heaters, clothes dryers, etc.. It is critical for trusses and lightweight engineered wood I beams that are used in a load-bearing assembly to be protected with a thermal barrier such as gypsum wallboard.[10] The function of the thermal barrier is a critical factor in the fire performance of the assembly.

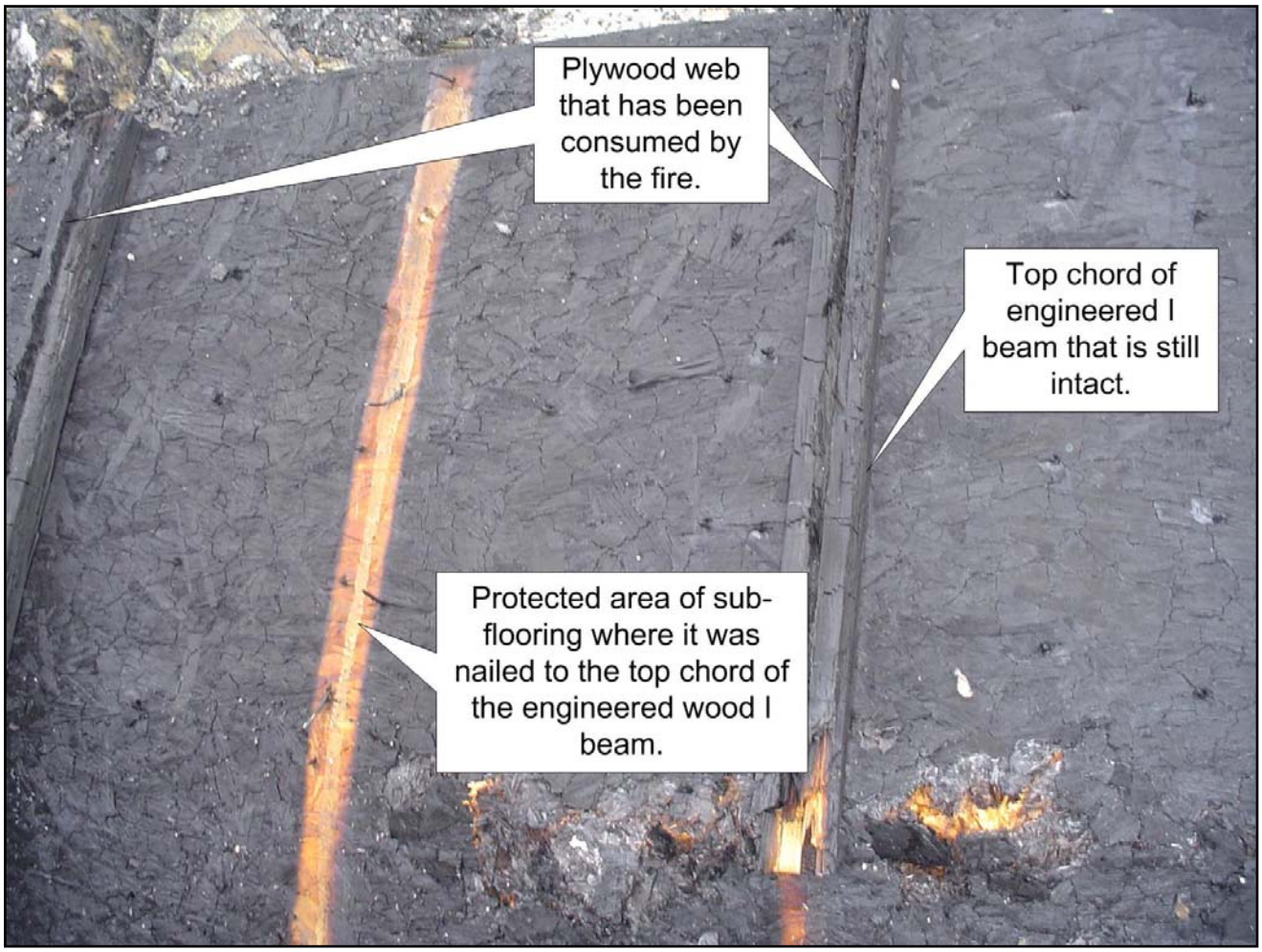

Photo 2. Engineered Wood I-Beam Webs Consumed by Fire

Volunteer Fire Fighter Dies After Falling Through Floor Supported by Engineered Wooden-I Beams at Residential Structural Fire - TN

REFERENCES

1. Corbin DE [2000]. Seeing is believing. Dallas, TX: Occupational Safety and Health, Aug 69 (8): 60-67.

2. IFSTA [2001]. Essentials of Fire Fighting. Fire Protection Publications, Oklahoma State University. Stillwater, OK. International Fire Service Training Association. 4th Edition. P. 74.

3. Dunn V [1999]. Command and control of fires and emergencies. Saddle Brook, NJ: Fire Engineering Books and Videos, p. 245.

4. Straseke J, Weber C [1998]. Testing Floor Systems. Fire Command. June 1988. pp 47-48.

5. Dunn V [1988]. Collapse of burning buildings, a guide to fireground safety. Saddle Brook, NJ: Fire Engineering Books and Videos

6. NIOSH [2005]. NIOSH alert: Preventing Injuries and Deaths of Fire Fighters due to Truss System Failures. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2005-132

7. Bénichou, N.; Sultan, M.A.[2004]. Fire resistance behavior of lightweight-framed construction. [http://irc.nrc-cnrc.gc.ca/pubs/fulltext/nrcc46891/]. Date accessed: October 2007.

8. NFPA [1997]. Fire protection handbook. 18th ed. Quincy, MA: National Fire Protection Association.

9. NFPA [2001]. NFPA 1720, standard for the organization and deployment of fire suppression operations, emergency medical operations, and special operations to the public by volunteer fire departments. Quincy, MA: National Fire Protection Association

10. Forest products laboratory. 1999. Wood handbook-Wood as an engineering material. Gen. Tech Rep. FPL-GTR-113. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory.

INVESTIGATOR INFORMATION

This incident was investigated by Jay Tarley, Safety and Occupational Health Specialist; Matt Bowyer, General Engineer; and Tim Merinar, Safety Engineer, Division of Safety Research, NIOSH.