

# Fire Investigation Summary

## Church Fire

Lake Worth, Texas

February 15, 1999

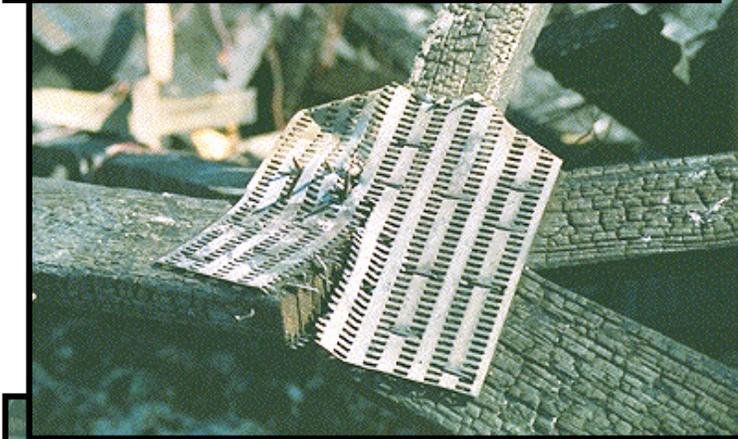


A fire in a single-story church building resulted in the deaths of three fire fighters after a collapse of the truss roof system.

The fire began in an adjacent storage shed and spread rapidly, driven by the wind, into the attic space of the church. The fire continued to spread rapidly through the concealed attic space.

While fire fighters simultaneously battled the fire from within the church and ventilated the attic space from above, the roof system collapsed. The sudden collapse trapped five fire fighters inside the building. The four fire fighters on the roof narrowly escaped.

Rescue attempts successfully removed two fire fighters from the building before conditions precluded any further attempts.



National Fire Protection Association  
Fire Investigations Department

On February 15, 1999 at approximately 10:42 a.m., a fire occurred in a church in Lake Worth, Texas. The fire resulted in the deaths of three fire fighters when the wood truss roof collapsed only minutes after the arrival of the fire department.

The fire began in a storage shed adjacent to the northeast corner of the church building. A strong wind directed the flames on the east side of the church, eventually spreading the fire into the attic space of the church. As the pastor was cleaning up the church from the previous evening services, a teenage male came to the door of the church to report the fire to the pastor. The pastor went outside to investigate and there he saw the shed ablaze, and the flames impinging on the northeast corner of the church.

Just before the male reported the fire to the pastor, a police officer from the neighboring jurisdiction of Samson Park spotted the fire and reported it to his dispatcher. (The town line is immediately adjacent to the church's property.) The dispatcher notified the Samson Park Fire Department, thinking the fire was in that jurisdiction. At the same time, a water department employee from Lake Worth spotted the fire and reported it via radio to his supervisor, whom in turn reported it to the Lake Worth Fire Department. With the dual notifications and with automatic aid a total of six fire departments responded to the reported fire.

The pastor reported hearing sirens as he returned to the building to report the fire.

The first arriving engine from Lake Worth (E210) was positioned in front of the church (Side A) on Roberts Cut-Off Road. The next arriving unit was an engine from Samson Park (E225) and was positioned on the Cowden Street (Side B), adjacent to the

church (north). Two 1 ¾-in. (44-mm) handlines were deployed from both the Samson Park and Lake Worth engines. Both the lines from the Lake Worth engine were advanced into the church, while one line from Samson Park was also deployed into the church.

An aerial tower from the Saginaw Fire Department (T14) arrived and was set up on the northwest corner of the building to provide access to the roof for ventilation. River Oaks Fire Department E13 responded and supplied E210 with water from a nearby hydrant. The crew from E13 then responded to the building to assist in battling the fire.

Crews from Lake Worth and Samson Park had advanced into the east portion of the church from the front of the church, using the center aisle toward the rear of the altar area into the sanctuary in the southern corner. They had located a fire in the attic space and were attempting to extinguish it. Two fire fighters from River Oaks entered the building and joined the crew in the sanctuary. At this time, there were five fire fighters in this area: two from River Oaks, one from Samson Park, one from Lake Worth, and one from the Eagle Mountain Fire Department

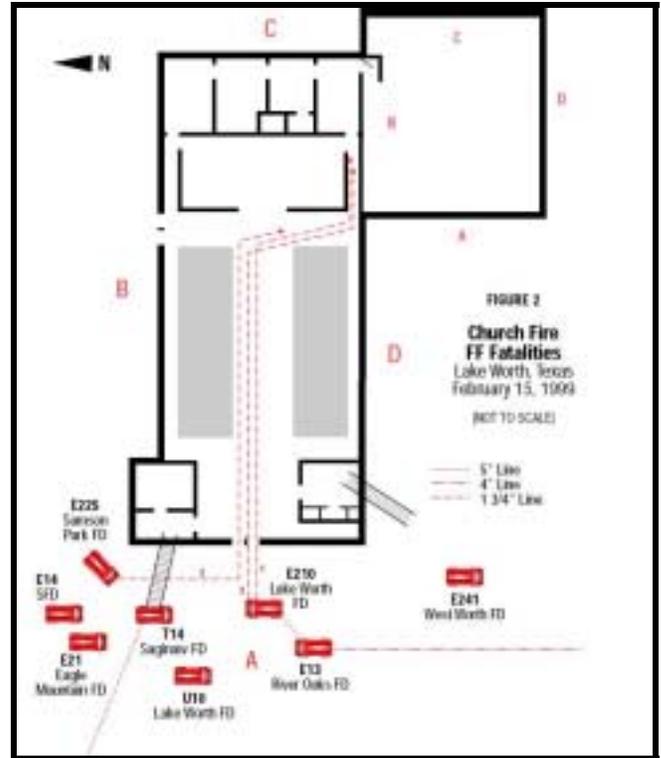
Four fire fighters accessed the roof to begin ventilation operations. One fire fighter removed the covers from the roof monitor ventilation units and reported light smoke venting from the units at first. This smoke got heavier as minutes went by. Before rooftop ventilation could be completed, the roof structure collapsed, sending one fire fighter into the main hall of the church, and leaving another fire fighter hanging by his fingers at the edge of the collapsed portion of the roof. The remaining two fire fighters

were on the only portion of the roof not to collapse. One fire fighter went to assist the fire fighter hanging by his fingers, and the three quickly exited the roof toward the tower ladder. The fire fighter who had fallen into the building was able to find the front door and exit with minor injuries.

The collapse trapped the five fire fighters in the interior of the building in the southeast corner of the church near the wall shared with the Fellowship Hall. An initial accountability check revealed that two fire fighters were trapped in the building. A rescue attempt was attempted through the Fellowship Hall, and as a fire fighter entered the hall he found a door near where the trapped fire fighters were believed to be located. He was able to remove two of the five fire fighters inside the building, but was unaware that there were additional fire fighters trapped inside. Conditions deteriorated rapidly immediately following this rescue. A second more accurate accountability check was made, and it was realized that three fire fighters were still missing, two from River Oaks and one from Samson Park.

As the fire was being extinguished, the three fire fighters were found. Two were in a short corridor adjacent to the altar and the third was found in one of the offices on the east side.

State and local fire marshals have determined that the fire was incendiary in nature. No arrests have been made in this incident at the time of this report.



Based on the fire investigation and analysis, the NFPA has determined that the following significant factors may have contributed to the deaths of the three fire fighters:

- Lack of a proper building/incident size-up (risk vs. benefit analysis)
- Lack of compatible accountability systems among mutual aid departments
- Absence of an established rapid intervention crew (RIC)
- Lack of use of Personal Alert Safety Systems (PASS)
- Lack of subdivision in combustible attic space

**Written by Robert F. Duval – Senior Fire Investigator - NFPA**

# Fire Investigation Summary

## Church Fire

Lake Worth Texas  
February 15, 1999

The National Fire Protection Association's Fire Investigations Department documents some of the most significant fires and incidents throughout the world. The objective of these investigations is to determine what lessons can be learned from these incidents. The information is then made available to the fire safety community to be used in developing future codes and standards. A complete listing of reports is available, either on request or can be viewed on our Web page.

### NFPA Fire Investigations Department

1 Batterymarch Park  
PO Box 9101  
Quincy, MA 02269-9101 USA  
1-617-984-7263 (tel)  
1-617-984-7110 (fax)  
[investigations@nfpa.org](mailto:investigations@nfpa.org)  
<http://www.nfpa.org>

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**CHURCH FIRE  
LAKE WORTH, TEXAS**

**FEBRUARY 15, 1999**



**FIRE  
INVESTIGATIONS**

**NATIONAL FIRE PROTECTION ASSOCIATION**

# **Church Fire Lake Worth, Texas**

**February 15, 1999**

**3 Fatalities**

Prepared by

**Robert F. Duval**  
Senior Fire Investigator  
National Fire Protection Association

and

**Ed Comeau**  
Principal  
writer-tech.com

# ABSTRACT

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On February 15, 1999 at approximately 10:42 a.m., a fire occurred in a church in Lake Worth, Texas. The fire resulted in the deaths of three fire fighters when the wood truss roof collapsed only minutes after the arrival of the fire department.

The fire began in a storage shed adjacent to the northeast corner of the church building. A strong wind directed the flames on the east side of the church, eventually spreading the fire into the attic space of the church. As the pastor was cleaning up the church from the previous evening services, a teenage male came to the door of the church to report the fire to the pastor. The pastor went outside to investigate when he saw the shed ablaze, and the flames impinging on the northeast corner of the church.

Just before the male reported the fire to the pastor, a police office from the neighboring jurisdiction of Samson Park spotted the fire and reported it to his dispatcher. (The town line is immediately adjacent to the church's property.) The dispatcher notified the Samson Park Fire Department, thinking the fire was in that jurisdiction. At the same time, a water department employee from Lake Worth spotted the fire and reported it via radio to his supervisor, who in turn reported it to the Lake Worth Fire Department. With the dual notifications and with automatic aid, a total of six fire departments responded to the reported fire.

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An aerial tower from the Saginaw Fire Department (T14) arrived and was set up on the northwest corner of the building to provide access to the roof for ventilation. River Oaks Fire Department E13 responded and supplied E210 with water from a near-by hydrant. The crew from E13 then responded to the building to assist in battling the fire.

Crews from Lake Worth and Samson Park had advanced into the east portion of the church from the front of the church, using the center aisle toward the rear of the altar area into the sanctuary in the southern corner. They had located a fire in the attic space and were attempting to extinguish it. Two fire fighters from River Oaks entered the building and joined the crew in the sanctuary. At this time, there were five fire fighters in this area: two from River Oaks, one from Samson Park, one from Lake Worth, and one from the Eagle Mountain Fire Department

<b>NFPA Fire Investigations Department</b> One Batterymarch Park Quincy, MA 02269 USA  <b>Phone:</b> 617-984-7263  <b>Fax:</b> 617-984-7110  <b>Email:</b> investigations@nfpa.org  <b>Web site:</b> www.nfpa.org
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Four fire fighters accessed the roof to begin ventilation operations. One fire fighter removed the covers from the roof monitor ventilation units and reported light smoke venting from the units at first. This smoke got heavier as minutes went by. Before rooftop ventilation could be completed, the roof structure collapsed, sending one fire fighter into the main hall of the church, and leaving another fire fighter hanging by his fingers at the edge of the collapsed portion of the roof. The remaining two fire fighters were on the only portion of the roof not to collapse. One fire fighter went to assist the fire fighter hanging by his fingers, and the three quickly exited the roof toward the tower ladder. The fire fighter who had fallen into the building was able to find the front door and exit with minor injuries.

The collapse trapped the five fire fighters in the interior of the building in the southeast corner of the church near the wall shared with the Fellowship Hall. An initial accountability check revealed that three fire fighters were trapped in the building. A rescue attempt was attempted through the Fellowship Hall, and as a fire fighter entered the hall he found a door near where the trapped fire fighters were believed to be located. He was able to remove two of the five fire fighters inside the building, but was unaware that there were additional fire fighters trapped inside. Conditions deteriorated rapidly immediately following this rescue. A second more accurate accountability check was made, and it was realized that three fire fighters were missing, two from River Oaks and one from Samson Park.

As the fire was being extinguished, the three fire fighters were found. Two were in a short corridor adjacent to the altar and the third was found in one of the offices on the east side.

State and local fire marshals have determined that the fire was incendiary in nature. No arrests have been made in this incident at the time of this report.

Based on the fire investigation and analysis, NFPA has determined that the following significant factors may have contributed to the deaths of the three fire fighters:

- Lack of a proper building/incident size-up (risk vs. benefit analysis)
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**Alert Bulletin (97-1) – Truss Collapse**

**NFPA Journal Article – Roof Collapse Kills Three** by Ed Comeau

## I. INTRODUCTION

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The National Fire Protection Association (NFPA) investigated the Lake Worth, Texas, fire fighter fatalities in order to document and analyze significant factors that contributed to the three fatalities.

The study was conducted by NFPA as part of an ongoing program to investigate technically significant incidents. NFPA's Fire Investigations Department documents and analyzes incident details so that it can report lessons learned for life and property loss purposes.

NFPA became aware of the Lake Worth fire the day it occurred. NFPA Senior Fire Investigator Robert Duval traveled to Texas to meet with the chief, fire officers, and fire fighters from the Lake Worth Fire Department, and investigators from the Tarrant County Arson Task Force to view the scene, interview participants, and perform an on-site study of the incident. The information gathered during the on-site activities and subsequent analysis of that information is the basis for this report. Entry to the fire scene was made through the cooperation of the Lake Worth Fire Department.

This report is another of NFPA's studies of fires having particularly important educational or technical interest. It is a project of NFPA's Fire Investigations staff intended as an aid to researchers, safety specialists and to the codes and standards development activities conducted by NFPA and other organizations. The opinions expressed and conclusions drawn are those of the NFPA staff who prepared this report and do not, therefore, necessarily represent the official position of the NFPA or of the NFPA Technical Committees that develop NFPA codes and standards. (See NFPA Regulations Governing Committee Projects at 6-1.1.)

All information and details regarding the fire safety conditions gathered in this report are based on the best available data and observations made during the onsite data collection phase and on any additional information provided during the report development process. It should be remembered that the ability of NFPA Fire Investigations staff to collect all relevant facts and draw definitive conclusions may be limited by a variety of factors, including available time and access. It is not the authors' intention to comprehensively document this fire incident for all purposes. The purpose of the report is not to pass judgment on or fix liability for the loss of life and property resulting from the fire. Rather, the report's purpose is to identify factors that may have contributed to the loss of life and property and to provide analysis that may serve to better the understanding of how to prevent these losses in the future.

Current codes and standards were used as criteria for this analysis so that conditions at the scene of the fire could be compared with state-of-the-art fire protection practices. It is recognized, however, that these codes and standards may not have been in effect during the construction and operation of the buildings. NFPA has not

analyzed the building in Lake Worth, Texas regarding its compliance with local codes and standards in existence when the buildings were constructed and during their operation.

The cooperation of the following agencies is greatly appreciated: Lake Worth, Texas Department, and the Tarrant County Arson Task Force. The Texas Fire Chief's Association provided assistance and resources during the scene examination, reconstruction, and analysis. The assistance and cooperation of Chief Shan English of the Wylie, Texas Fire Department, Chief Alan Black of the Dallas-Fort Worth Airport Fire Department, and Chief William Shanklin of the Richardson, Texas Fire Department is greatly appreciated.

## II. BACKGROUND

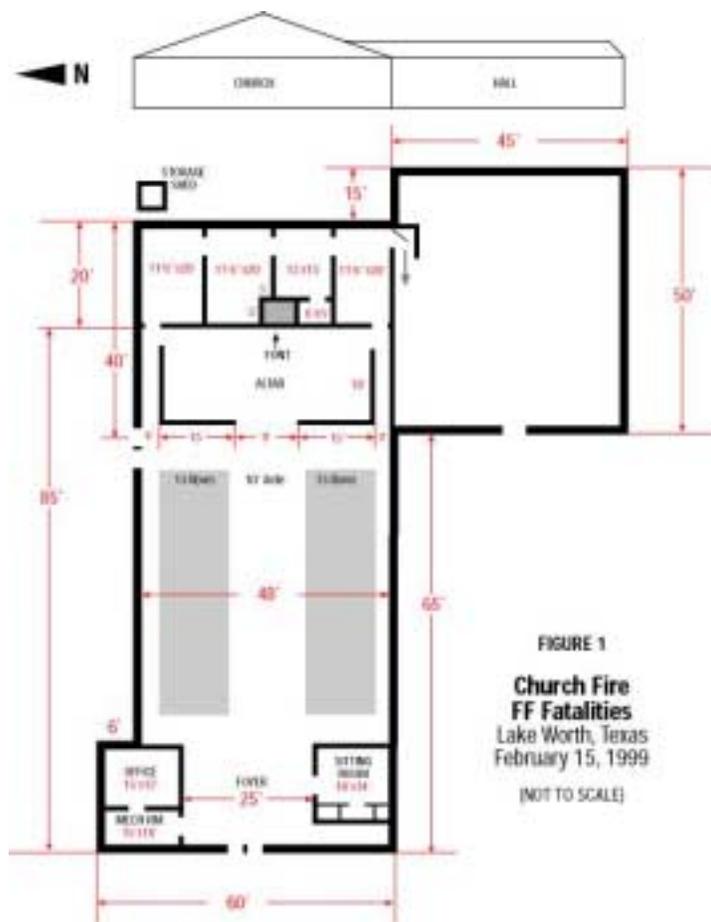
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### Occupancy Classification

The building was a stand alone structure that was used as a church. According to paragraph 6.1.2.1 of the 2000 edition of *NFPA 101*<sup>®</sup> this building would be classified as an existing assembly occupancy.

### The Building

The building was a one-story structure that had been built in three different stages.



The oldest portion of the building, which ultimately became the foyer on the west side, was built in the 1960s. It measured 21 ft×60 ft (6.4 m×18 m) and contained restrooms and other ancillary rooms.

The main portion of the building, the sanctuary, was constructed in 1978-79. It measured 58 ft×48 ft (18 m×15 m).

To enter the sanctuary from the foyer it was necessary to move down 2 steps or use an interior handicap ramp located to the south.

To the east of the sanctuary was the altar area that measured 18 ft×39 feet (5.5 m×12 m). This area was raised up approximately 1 ft (304 mm) from the floor of the sanctuary. It was separated from the sanctuary by a knee wall that measured 3 ft (1 m) high.

To the north and south of the altar were aisles that led to the series of rooms located behind the altar. These aisles measured 4 ft (1.2 m) wide and 18 ft (5.5 m) long.

The exterior walls were constructed of sand-filled masonry blocks and measured 7.5×7.5×15.3 inches (190×190×390 mm) by 8 ft (2.4 m) high.

There were no windows on any of the exterior walls.

The roof supporting structure was comprised of lightweight wood scissor trusses. The top and bottom chords were 2×6 in. and the other members were 2×4 in. Each truss spanned 48 feet (18 meters) and was supported by an exterior wall. There were no intermediate interior supporting columns.

The truss members were constructed using metal gusset plates.



**Photo 1 – Gusset plates on typical lightweight truss installation (NFPA Photo)**

It was reported that the attic space created by the scissors trusses was not subdivided by draft stops. It was also reported that there was a communicating opening between the attic space in the main church and the Fellowship Hall addition.

There was a pull-down stairway located in the southeast office that provided access into the attic space.

The ceiling of the church was attached directly to the bottom chord of the trusses. This ceiling was made up of gypsum board sheets. The ceiling height varied from a minimum of 8 ft (2.4 m) to a maximum of 14 ft (4.3 m) at the peak in the middle of the church.

### **Interior finish and contents**

The contents of the sanctuary were comprised of wooden pews that were fixed in place. There were 13 pews [approximately 12 ft (3.6 m) in length] on each side of the sanctuary, separated by an aisle 10 ft (3.0 m) wide. There was a 6 ft (2 m) aisle between the south wall and the pews, and a 6 ft (2 m) aisle between the north wall and the pews. There was a set of double doors on the north wall located adjacent to the front of the altar. The doors were located approximately 40 ft. (12.2 m) west of the northeast corner of the building. Reportedly, these doors were constructed of glass in aluminum frames.

The interior north, south, and west walls were painted gypsum board and contained no additional wall covering..

The floor was carpeted with a low-pile-type carpet.

The west wall behind the altar was covered with thin combustible paneling material.

### **Offices/Classrooms**

Behind the altar were several rooms that were all interconnected by openings on the east end. The wall between the altar area and the rooms to the east extended from the floor to the ceiling. This wall was constructed of concrete blocks.

The concrete block walls separating each of the rooms extended from the floor to the underside of the ceiling as well.

It was possible to access these rooms via aisles [4 ft 2 in. (1.26 meters) wide] located to the north and south of the altar. There was no common hallway to these rooms, and it was necessary to pass through at least one room to access the middle two.

### **Fellowship Hall Addition**

In 1981, an addition had been made on the southeast side of the building. Referred to as the Fellowship Hall, it measured 50 ft × 45 ft (15 m × 14 m). A metal door

connected the Fellowship Hall to the main building at the southeast corner. The door swung into the Fellowship Hall.

There was a single exterior door on the west side of the Fellowship Hall.

### **Means of Egress.**

There were two primary means of egress from the main portion of the church. The main entrance was located on the west side of the church and was comprised of two doors measuring approximately 36 in. each (0.9 m). Both doors swung outward.

On the north side of the church there was a similar set of double doors. Both of these doors also swung outward. This set of door was located approximately 60 ft (18.3 m) north of the northwest corner of the building.

Door closers and panic hardware were not apparent on either set of doors during this investigation.

There was another door in the southeast corner of the main church that led to the Fellowship Hall addition. This door measured approximately 36in. (0.9 m) and swung in the direction of the Fellowship Hall.

### **Ventilation**

Ventilation within the building consisted of ceiling-leveling registers and roof-top monitors located on the roof surface.

There were no external HVAC units located on the peaked roof of either the main church hall or the Fellowship Hall wing.

### **Fire Protection Systems**

The building was not equipped with automatic fire sprinkler or fire alarm systems.

### **Fire Department**

#### **Fire Fighter Protective Clothing**

The Texas Fire Chief's Association provided information regarding the personal protective equipment that the fire fighters were wearing. The following is a quote from their report<sup>1</sup>

An overall examination of the protective equipment ensemble showed that all victims wore modern equipment, worn properly, assembled

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<sup>1</sup> Texas Fire Chief's Association Life Safety Committee Investigation Report – Firefighter Fatality Fire Lake Worth, Texas - February 15, 1999

properly with proper liners in place, and all with discoverable NFPA standard labels reflecting proper compliance. Portions of some of the equipment were in remarkably good condition when the severity and duration of the fire that they were subjected to is considered. This was the case where the equipment was on the lower portion of the victim's body, as they were laying horizontal after their collapse. One piece of protective equipment was found on one of the victims that had not been used. A Nomex hood was in the inside pocket of one of the victims, and had not been worn on this incident. It was fully intact, protected by the victim's body and PPE jacket. There is nothing that would indicate that the outcome would have been any different if the hood had been in place. No evidence of hoods was found among the PPE articles with either of the other two victims.

Since all three victims were volunteers, they were not wearing station wear, but had on various articles of personal clothing and department issue clothing. These articles were also examined. It was observed that the content of the clothing underneath the PPE was an additional protection factor.

The report also stated that the SCBA (NFPA 1981, Standard on Open Circuit Self-Contained Breathing Apparatus for the Fire Service compliant) that the victims were wearing had failed "in a non-violent manner, with the proper, designed relief of pressure without causing any trauma to the victims. This occurred at a point in the incident where it had no bearing on survivability."

In regards to personal alert safety systems (PASS) devices, the report also stated "there was no evidence of any kind of active PASS device found with any of the victim's PPE."

### **Fire Fighter Training and Experience**

Two of the victims were full-time fire fighters with the Fort Worth Fire Department. One victim was 35 years old and had been with Fort Worth for 14 years and held the rank of lieutenant. He had been a volunteer for the River Oaks Fire Department for 16 years.

The second victim was 29 years old and had been with Fort Worth for six years and held the rank of engineer. He had been a River Oaks Fire Department volunteer for 16 years.

The third victim was a volunteer for Samson Park. He was 20 years old and had two years of experience.

## **Fire Departments**

The following is a list of the fire departments that participated in this incident.

- Lake Worth – Combination Department
- Samson Park - Volunteer
- River Oaks - Volunteer
- Saginaw – Combination Department
- Eagle Mountain – Combination Department
- Westworth Village - Volunteer
- Fort Worth (provided assistance after the initial stages of the incident, after the roof collapse)

## **Weather**

The weather at the time of the alarm was temperature 56°F (13°C), with winds from the S/SE gusting to 25 mph (40 km/h), and the relative humidity was approximately 60 percent.

### III. THE FIRE

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At approximately 10:40 a.m., on February 15, 1999, the pastor was in the main portion of the church, near the altar, cleaning. There was a knock at the door, and outside was a teenage male reporting that there was a fire in the storage shed adjacent to the church.

The pastor and the male walked outside to check, where they observed the shed on fire, consuming the building. The wind, which was gusting to 25 mph, (40 km/h) from the east, was pushing the fire toward the church, which was 6 ft away (2 m). While outside, the pastor could hear the sirens from the responding apparatus.

The pastor re-entered the church and opened the double doors on the north side, near the altar. He theorized that these would be the doors that the fire fighters would use because they were the closest to the fire area. He then exited the building to meet the arriving fire fighters. When the first engine arrived, he advised the fire fighters that there was no one inside of the building.

At approximately the same time, the fire had also been observed by two other individuals.

At 10:39 a.m., the fire was observed by a Samson Park police officer, who notified his dispatcher. An employee from the Lake Worth Water Department also saw the fire, notified his dispatcher, who, in turn, notified the Lake Worth Fire Department.

The church was right on the border between the two jurisdictions – Lake Worth and Samson Park. Since one call had gone to the Lake Worth Fire Department from the water department, and another call had gone to the Samson Park Fire Department via the Samson Park Police Department, there were two different jurisdictions responding to the incident.

In addition, both communities had automatic aid agreements with neighboring communities. Lake Worth had automatic aid agreements with the Eagle Mountain and Saginaw Fire Departments, so both of those fire departments responded. Samson Park had agreements with the River Oaks and Westworth Village Fire Departments and they also responded. All told, there were six fire departments responding to the incident:

#### Initial Call (Simultaneous)

- Lake Worth
- Samson Park

#### Automatic Aid

- Eagle Mountain
- Saginaw
- River Oaks

- Westworth Village

An engine from Lake Worth (Engine 210), staffed by three firefighters and the chief, and a Samson Park (Engine 225), staffed by three fire fighters arrived on the scene. It was reported that the fire was spreading to the church by this time. The Lake Worth engine positioned itself at the front doors of the church on the west side of the building and two members advanced a 200 ft (61 m), preconnected 1 ¾-in (44 mm) hand line that was charged, into the building. They advanced this line down the center aisle towards the altar, and then turned to the right, or south, to continue moving forward on the south side of the altar.

The fire chief from Lake Worth assumed command of the incident.

The Samson Park Engine 225 positioned itself at the northwest corner of the building. The personnel from the Samson Park engine advanced a 150 ft (46 m), 1 ¾ in. (44 mm) handline through the west door and down the center aisle of the interior of the church towards the fire, following the line advanced by the Lake Worth personnel. However, this line could not reach the fire, and was not charged.

The personnel from the Samson Park line moved forward to assist the Lake Worth personnel, who were able to advance their line further into the building toward the fire. Since the hoseline had become caught on the doors at the rear of the church while they were trying to advance it, a Samson Park fire fighter was sent back to help advance the hoseline by holding the doors open, while one of the Lake Worth fire fighters moved forward to try and identify the location of the fire.

At this point, there were four fire fighters inside of the building, two from Lake Worth and two from Samson Park.

The crews then advanced the hoseline into the east end of the building where there were various classrooms and offices. In the southeast corner, a set of fold-down attic stairs had dropped down, and the fire was seen up in the attic space. Water was directed into this space, and then the nozzle was shut down. The fire darkened down, but then flared up again. Water was again directed towards the attic.

At this point, one of the fire fighters left the building to provide the incident commander with a report. When this fire fighter returned, he noticed that the smoke level was increasing inside of the building. He rejoined the two fire fighters at the east end of the church who were still directing water into the attic space through the fold-down stair opening. At this point, one of the low-air alarm bells began to sound on one of the fire fighters SCBA. He was relieved by the fire fighter who had just re-entered, and he left the church to refill his cylinder.

It was reported that at this time one of the fire fighters was able to see an opening in the roof at the rear of the building where the fire had burned through.

Truck 14 from Saginaw, staffed by three members, arrived on the scene. The personnel were directed to establish a water supply and position their ladder on the northwest corner of the building.

Engine 13 from River Oaks arrived on the scene. This engine was directed to establish a water supply for Lake Worth Engine 210. A 4 in (100 mm) supply line was laid from the hydrant located to the south of the building to Engine 13, which in turn supplied Engine 210.

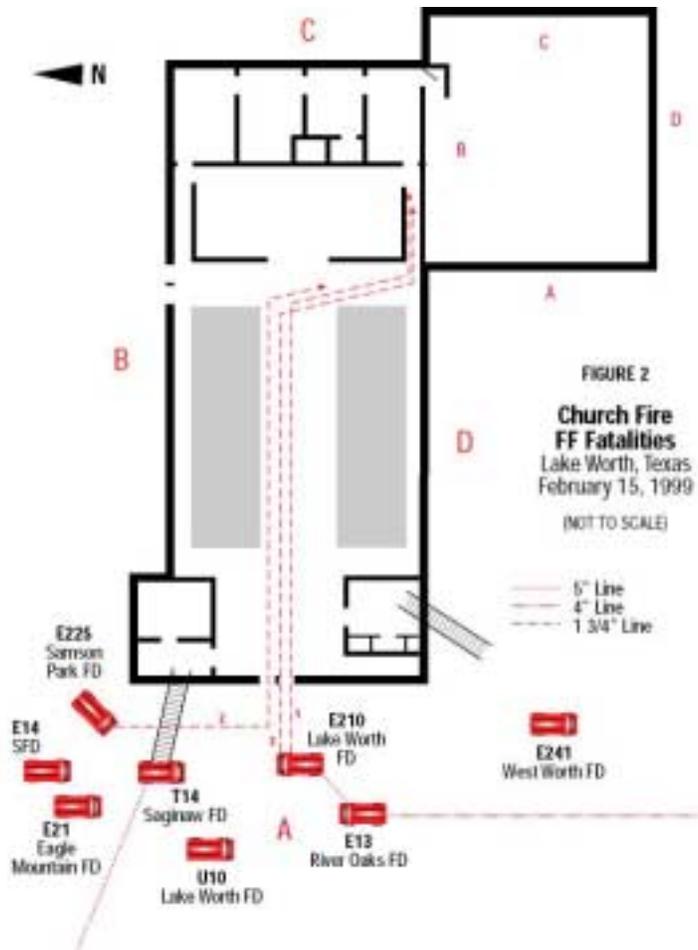
Two of the River Oaks fire fighters then entered the building via the main doors at the west side where they were directed to pull down the ceiling. They advanced to the east end of the church, where they were advised by one of the fire fighters that they would need a pike pole to remove the ceiling. One of the River Oaks fire fighters went back outside, and returned with a pike pole and an additional 1 ¾ - in. hoseline from Engine 210, which he left on the floor in the hallway.

Engine 21 from Eagle Mountain arrived on the scene. Three crewmembers were directed to enter the building and remove the ceilings. They entered through the main doors on the west side and advanced to the east end, where they met with the personnel working in that area.

It was reported that at approximately this time, the low-air alarm on one of the fire fighters working in the east end began to sound. He retreated toward the west side of the building.

At the same time, a Lake Worth fire fighter went to the roof to evaluate the conditions. When he removed the tops of the turbine ventilators he reported that there was only lazy, wisps of smoke coming out of them. The incident commander assumed, based on this report, that the fire had not yet entered the void space beneath the roof.

A Lake Worth fire fighter was directed to enter the building and evaluate conditions. As he entered, he experienced intense heat and observed heavy smoke filling the building from floor to ceiling. He reported these conditions to the incident commander. The fire fighter was directed to re-enter the building and tell the personnel to retreat.



This fire fighter re-entered the building, where he and the fire fighters from Eagle Mountain heard what has been reported as a loud popping noise. They began to rapidly move to escape from the building, yelling for the others to evacuate. As they were doing this, the roof over the sanctuary collapsed catastrophically. One fire fighter was forced to crawl under the collapsed roof, which was supported on top of the pews.

Prior to the collapse, three more fire fighters advanced to the roof with a power saw to make an opening. However, they could not get the saw to operate correctly, so they began to make an opening using axes.

While they were attempting to make this opening, the roof collapsed underneath them.

One fire fighter fell into the church, landing near the main entrance on the west side. He was able to exit the building safely through the main doors.

Another fire fighter who had been operating on the roof fell into the opening made by the collapse. However, he was able to hold onto the edge of the roof, and did not

fall into the building. A third fire fighter working on the roof was able to pull this fire fighter safely back onto the roof.

The fourth fire fighter had been knocked off his feet, but was able to remain safely on top of the roof that remained intact (over the entrance foyer). One of the fire fighters returned to the aerial and began directed water inside the building in an effort to protect those inside.

An initial accountability check was made, which indicated that there were two fire fighters unaccounted for.

Inside the building, several of the fire fighters were not immediately aware that the roof had collapsed. They did feel an intense blast of heat, and began directing the hose stream in an effort to protect themselves from the heat. The water only flowed for a short period, however. It is believed that the hoseline may have either been burned through or pinched by the collapsing roof, shutting off the flow to the nozzle.

One of the fire fighters became disoriented and was lying on his stomach attempting to escape the heat. He could hear the sound of the alarm bell on one of the fire fighter's SCBA, and felt this fire fighter's hand on his shoulder. He attempted to move towards an area where he had seen daylight earlier. He moved towards the east wall, where he crouched.

The fire fighter who had been directed to evacuate everyone reported to the incident commander that he was unable to make entry because of the conditions. The incident commander directed him to attempt to enter the building from the Fellowship Hall, which was connected to the main portion of the church on the south side. This fire fighter and another attempted to enter the area of the church where they believed the missing fire fighters were operating.

As they opened the door between the Fellowship Hall and the church, they could see the reflective trim of two fire fighter's protective clothing. These fire fighters were not incapacitated, but were disorientated by the collapse. The fire fighters that entered from the hall were able to pull the two fire fighters out of the collapsed portion of the building to safety.

According to the fire fighters who made the rescue, conditions inside of the church deteriorated rapidly as soon as the two trapped fire fighters were removed.

At this point, another accountability check was conducted, and it indicated that there were three fire fighters missing (two from River Oaks and one from Samson Park), even after accounting for the two that had been rescued. (Since each fire department had a slightly different method for maintaining accountability of their personnel, it was believed that this contributed to the original discrepancy regarding the number of missing fire fighters. It was later discovered that the Samson Park fire fighter had not placed his tag with his department's accountability board.)

Additional attempts were made to enter the church, but by now conditions inside of the church had deteriorated to a point where it was impossible to conduct any interior fire fighting operations. The fire had now spread to the Fellowship Hall and was rapidly consuming the truss roof structure of that building

The mode of operation was changed to defensive, as numerous handlines and streams from the ladder tower were directed into the burning church. However, attempts to rescue the fire fighters that remained in the building continued.

An opening was made in the south exterior masonry block wall, near where the church and Fellowship Hall connected, in an effort to gain entry and locate the trapped fire fighters. Once the wall was breached, two fire fighters were found immediately adjacent to the altar, with the third several feet away in the aisle. All three were later removed from the building.



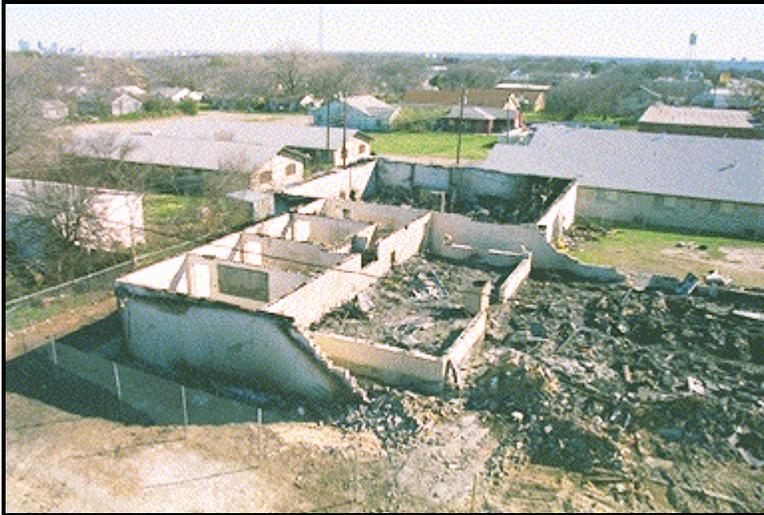
## Casualties

Three fire fighters were killed in this incident. All three died of thermal injuries and smoke inhalation. The carboxyhemoglobin levels of the three were 62.5, 52.5, and 72.5 percent.

Four fire fighters were injured.

### **Damage**

The fire completely destroyed the church. The only remaining portions of the building were the non-combustible exterior block walls and a small portion of the roof on the southwest corner of the building.



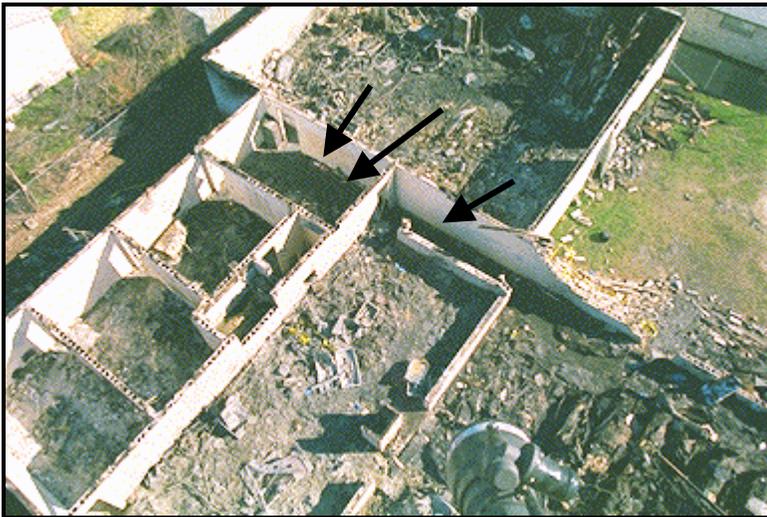
**Photo 2 - Aerial photo showing altar, classrooms, and the Fellowship Hall (NFPA photo)**



**Photo 3 - Aerial photo showing entrance and remainder of the church hall (NFPA photo)**



**Photo 4 - View showing entrance foyer and the only portion of the roof to survive the fire. Arrow points to where the fire fighter hung after the collapse. (NFPA Photo)**



**Photo 5 – Aerial view showing the classroom and altar area where fire fighters were located at the time of the collapse. The arrows show the location of the fatalities. (NFPA Photo)**

#### IV. TIME LINE

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<u>Actual Time</u>	<u>Elapsed Time</u>	<u>Activity</u>
10:42 a.m.	0:00	Time of call
10:44 a.m.	2:00	Samson Park Engine E225 & Lake Worth Engine E210 arrive.
10:52 a.m.	10:00	Roof collapse. Second alarm sounded.
11:00 a.m. - Noon	18:00 - 1.18:00	Fire extinguishment continues as search for three missing fire fighters begins.
1:00 p.m.-	2.18:00	Support agencies begin to arrive (Arson Task Force, Red Cross, counselors)
2:53 p.m.	4.11:00	Recovery of victims begins.

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## V. ANALYSIS

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### Cause and Origin

The fire originated in the shed located 6 ft (2 m) to the east of the church. Investigators determined that the fire was incendiary in nature. At the time of this report, the investigation continues.

### Fire Growth and Spread

Once the fire was ignited, winds blowing at 25 mph (40 km/h) from the east fanned the flames and spread them to the church. They were able to enter the church through the combustible eaves on the east side of the building, and then into the void space created by the lightweight wood trusses.

### Size Up

Risk management is addressed in NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, 1997 edition.

#### 6-2.1.1\*

The concept of risk management shall be utilized on the basis of the following principles:

- (a) Activities that present a significant risk to the safety of members shall be limited to situations where there is a potential to save endangered lives.
- (b) Activities that are routinely employed to protect property shall be recognized as inherent risks to the safety of members, and actions shall be taken to reduce or avoid these risks.
- (c) No risk to the safety of members shall be acceptable when there is no possibility to save lives or property.

#### A-6-2.1.1

The risk to fire department members is the most important factor considered by the incident commander in determining the strategy that will be employed in each situation. The management of risk levels involves all of the following factors:

- (a) Routine evaluation of risk in all situations
- (b) Well-defined strategic options
- (c) Standard operating procedures
- (d) Effective training
- (e) Full protective clothing ensemble and equipment
- (f) Effective incident management and communications
- (g) Safety procedures and safety officers
- (h) Back-up crews for rapid intervention
- (i) Adequate resources

- (j) Rest and rehabilitation
- (k) Regular evaluation of changing conditions
- (l) Experience based on previous incidents and critiques

#### 6-2.1.2\*

The incident commander shall evaluate the risk to members with respect to the purpose and potential results of their actions in each situation. In situations where the risk to fire department members is excessive, as defined by 6-2.1.1 of this section, activities shall be limited to defensive operations.

#### A-6-2.1.2

The acceptable level of risk is directly related to the potential to save lives or property. Where there is no potential to save lives, the risk to fire department members must be evaluated in proportion to the ability to save property of value. When there is no ability to save lives or property, there is no justification to expose fire department members to any avoidable risk, and defensive fire suppression operations are the appropriate strategy.

In sizing up any fire, it is critical to make decisions based on the risk. In the Lake Worth fire, the only occupant of the building (the pastor) had safely evacuated the building and had advised the first arriving responders that the building was empty. While this fact must always be verified, there are some reasonable assumptions that can be made based on the time of day and the day of the week. A church, on a Monday morning, would have a lower probability of being occupied than perhaps on a Sunday, when religious services might normally be held.

Once it has been determined that the building is vacant, the incident commander can turn his focus to the risk vs. benefit of combating the fire from the interior or exterior of the structure.

There have been several tragic fires recently where fire fighters were killed in buildings that were later determined to be vacant.

- In 1995 in Seattle, Washington, four fire fighters died in a warehouse fire when the floor collapsed underneath them, dropping them into the fire.
- Two fire fighters died in Chesapeake, Virginia, in 1996, while attempting to fight a fire in an auto parts store. This building was supported by a lightweight wood truss that collapsed 21 minutes after the time of the call.
- A fire fighter was killed in Branford, Connecticut, also in 1996, at an arson fire in a carpet store on Thanksgiving Day. The building owner was on the scene and reported to the incident commander that the building was vacant. The collapse occurred approximately 22 minutes into the incident.

- In 1997 a fire fighter died in Washington, DC, at an early morning fire in a convenience store that had not opened for the day. The owner, who lived above the store, had safely escaped the fire and reported that there was no one remaining in the building. The collapse occurred 30 minutes after the time of the call while the crews were attempting to attack the seat of the fire in the basement.
- Six fire fighters perished in Worcester, Massachusetts, in December 1999, while performing a search of a vacant warehouse. Initially, two fire fighters became disoriented. Four additional fire fighters attempted to locate them, and all six were trapped by the collapsing structure.
- Two fire fighters were killed in Houston, Texas, in an early morning fire in February 2000, in a fast-food restaurant that was closed (the roof on this building was supported by lightweight wood trusses).

Unfortunately, in some cases, the only way to definitively determine that there are no occupants in a building is to conduct a primary and secondary search. In the case of Worcester, even though the warehouse was closed and had not been used for many years, it was known to be a place where homeless people would take refuge.

The degree to which resources are to be deployed at a fire must be evaluated on a number of factors that include the following:

- Civilian lives that are endangered
- Location of the fire
- Building construction and condition of the building
- Ease of interior access to the seat of the fire
- Availability of fire department resources

At any time, if there is an unacceptable risk to fire fighter's lives, a defensive strategy should be employed.

Another part of the size up is to evaluate all sides of the structure to determine factors such as construction type and fire spread. If the incident commander is not capable of directly performing this function, it should be delegated to other personnel who can report on these conditions.

At the church fire incident, if there had been an officer assigned to evaluate the exterior conditions on the east side of the building, it might have been possible to observe the fire spread into the attic space of the church. (The only information the incident commander had to go on, was sketchy reports from the interior of the building about the fire spread throughout the attic space.) This critical information could have aided the incident commander in formulating his fireground strategy and caused him to reconsider the advisability of placing personnel inside of the structure.

It is very important to determine if and when the fire enters the truss (void) space. If fire is in this space, then the trusses have begun to weaken, and appropriate action should be taken to get fire fighters out of the potential collapse zone.

Since the fire had spread to the exterior of the church on the northeast corner, and it was observed in the attic space on the interior southeast corner of the building, the fire had certainly entered the attic space and was in all likelihood spreading throughout the space created by the scissors trusses. Although there was not a significant amount of smoke emerging from the rooftop turbine ventilators, fire was spreading throughout and weakening the roof's support system.

It is also important for personnel operating on the interior of a structure to be able to identify routes of emergency egress from the building. The fire fighters were operating in an area of the church that was remote from both of the identified means of egress (the main entrance at the west side and the other exit on the north side). Although they were operating in the vicinity of another door that would have taken them into the Fellowship Hall, they apparently were not aware of this door.

In a windowless building where there are no lives endangered and the only operation is property conservation, placing personnel in positions where they cannot easily exit the building under emergency conditions should be seriously evaluated.

In this incident, personnel would have had to retreat approximately 70 ft (21 m) to exit through the set of doors on the north side, or over 100 ft (30 m) to exit out the main entrance on the west side where they entered the building. Making a rapid exit out of either of these doors would have been difficult.

## **Trusses**

The roof collapsed approximately 10 minutes after the time of the call. Because of the speed with which truss construction can fail in a fire, fireground strategy must take this construction feature into account.

According to statistics compiled by NFPA, in 1999, 24 fire fighters were killed when they were entrapped. This is the second leading cause of fatal fire fighter injuries, following heart attacks.

Trusses have been used in a variety of configurations and materials for many years, and their use is becoming more common in a wide variety of construction types and occupancies. From a building designer's point of view, trusses have a number of desirable features, including relatively low cost, ease of installation, and the span that they can support. It is important to identify that a building is supported by a truss when formulating a fireground strategy.

The presence of a truss-supported structure is not often readily apparent. Some of the common indicators that can provide clues to the fact that a structure may be supported by trusses include the following:

- Long spans with few, or no, interior columns supporting the roof or floor or,
- A rounded roof which is an indicator of a bowstring truss.

However, a lack of these indicators does not necessarily mean that the building does not incorporate trusses into its design.

The best time to identify buildings that are supported by trusses is during their construction. The type of material being used, the spacing of the trusses, and other important features can be identified. Another time to identify truss construction would be during pre-fire planning. During a tour of the building or complex, examine the roof and floor construction and determine if trusses are being used. The pre-fire plan should be modified to account for the presence of trusses in roof or floor structures.

The behavior of trusses when exposed to fire can vary dramatically, depending on several different factors. One factor is the size of the truss members. Trusses are used in place of solid beams because they can support an equivalent load over greater spans, but with less material.

The individual members (whether they are the top or bottom chords or the members that join these chords) are much smaller in dimension than a comparable solid supporting beam. This results in a higher surface-area to mass ratio, which means that the member can reach its failure point during a fire sooner than the solid beam.

Failure of a single truss member does not always mean that the entire truss will fail. There is some inherent redundancy in the design of a truss. If one member fails, the other members may “pick up” the load that was being carried by that truss. Furthermore, the location of the member is an important consideration. A top or bottom-chord failure can be more critical than failure of a connecting web member.

Another consideration in truss failure is the manner in which the truss is loaded. A truss system, that is supporting, for example, air-conditioning equipment is under a localized load that is greater than a roof system that has no equipment above it. Should the system supporting the air-conditioning equipment be weakened by fire, failure will occur more rapidly than the truss system without this type of load.

There are other factors that must be considered in evaluating the “fire-worthiness” of a truss system.

Is there fire-resistant sheathing, such as fire-rated gypsum wallboard between the truss and the occupied space below? Even though this sheathing may exist, it frequently may have unsealed penetrations and unprotected openings in it, such as for the passage of utilities, that will negate its fire resistance.

Failure of a single truss may or may not result in catastrophic failure of the roof or floor. One of the factors contributing to this is the horizontal spacing of the individual trusses. Building designers attempt to maximize the distance between trusses to a point where the least amount of trusses are required to support the expected load on the roof or floor. In the northeast United States, the expected loads are greater (snow) than those in the southwest United States. Therefore, the spacing between the trusses may be less.

The trusses are connected to each other by the roof or floor sheathing. This sheathing, which can be in the form of many materials such as plywood, strand board, metal panels, and so forth, provides the horizontal surface needed to form a roof or floor. It also serves to distribute the loads among the trusses.

When one truss fails, for whatever reason, the load supported by that truss is transmitted to the adjacent truss via the sheathing. Failure of the horizontal structure will depend on the load on the structure, and the integrity of the sheathing material. If the fire has damaged the sheathing as well as the truss, then its ability to transmit the load to adjacent trusses is compromised.

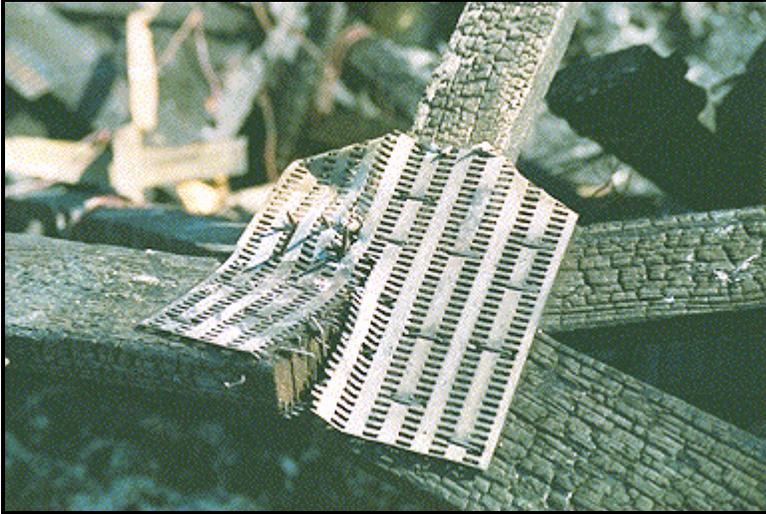
An important failure point of trusses is the connections between the individual members. As stated by one expert, “A truss’ integrity depends on the integrity of its metal connector plates.”<sup>2</sup>

These members are often connected together by a mechanism known as “gang plates” or “gusset plates.” Trusses using these connection methods may be referred to as “metal plate connected trusses.” Other connection mechanisms include plywood gusset plates and staples.

These connections may fail before the members themselves lose their ability to carry the load. Since a single metal plate or plywood gusset may connect a number of members together, loss of the integrity of one plate may result in a catastrophic failure of the entire truss.

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<sup>2</sup> Smulski, Stephen, Ph.D., “Metal Plate Connected Wood Trusses for Residential Roofs,” 1996  
<http://www.umass.edu/bmatwt/metal.html>



**Photos 6 and 7 – The remains of gusset plates from the Lake Worth church (NFPA photos)**

The importance of taking wood truss and other construction features into account in developing fireground strategy has been emphasized in a number of previous NFPA Fire Investigations reports and alert bulletins. These include the following:

- Hackensack, New Jersey
- Branford, Connecticut
- Chesapeake, Virginia
- Alert Bulletin (97-1), Truss Collapse

## **Accountability system**

It is critical that the incident commander be aware of the location of the personnel on the fireground and the tasks that each has been assigned.

In this incident there were two accountability checks made, one immediately following the collapse. This first one indicated that only two fire fighters were missing, when in reality there were five trapped inside of the building. When the second check was made after two fire fighters had been rescued, it was realized that there were still three fire fighters missing, two from River Oaks and one from Samson Park. Some of this uncertainty was due to the fact that the identity of the Samson Park fire fighter was not immediately known. This was due to the fact that he had not placed his accountability tag with the Samson Park accountability (passport) board.

This confusion in terms of missing fire fighters has been attributed to slightly different accountability systems used among the six fire departments that responded to the incident. There are two main reasons it is imperative that all responding personnel use a consistent system.

The first is that the incident commander is ensured that everyone working on the fireground has an assignment and is not freelancing.

The second is that in the event of an emergency, it is possible to identify the areas where personnel were operating and the number that may be missing. This information is critical when mounting any rescue operations. An accountability system will indicate the number of personnel on the scene and their identities, while a comprehensive Incident Management System (IMS) will indicate where those personnel are located on the fireground.

In this incident, it was fortunate that the fire fighter who did rescue two of the trapped fire fighters was aware of where they were working and that there was a possible point of entry to reach them.

In a number of fire fighter fatality incidents, the lack of an accountability system has lead to a delay in locating and extricating the trapped fire fighters. These include the following:

- Pittsburgh, PA
- Washington, DC
- Branford, CT
- Marks, MS

The presence of an accountability system is certainly no guarantee of fire fighter safety because of a number of other factors. At a fire in 1995 in Seattle, Washington, four fire fighters were killed when the floor on which they were operating collapsed into the basement. Because of a well-established and implemented accountability

system, the identity and location where the fire fighters had been operating was quickly known. There were other significant contributing factors, however, that led to the loss of these fire fighters. Accountability was not one of them.

A problem that was identified in the fire investigation report from Branford, Connecticut, was the lack of a consistent accountability system. That problem also existed in Lake Worth. There were six different fire departments operating on the fireground, and there was no single accountability system common to all of them. This led to the confusion regarding how many fire fighters were missing when the roof collapsed.

NFPA 1500 Standard on Fire Department Occupational Safety and Health Program, 1997 edition, (Section 6-3) outlines the use of accountability systems.

#### 6-3.1.1

The fire department shall consider local conditions and characteristics in establishing the requirements of the personnel accountability system.

#### 6-3.3

The incident commander shall be responsible for overall personnel accountability for the incident. The incident commander shall initiate an accountability and inventory worksheet at the very beginning of operations and shall maintain that system throughout operations.

#### 6-3.3.1

The incident commander shall maintain an awareness of the location and function of all companies or units at the scene of the incident.

#### 6-3.4

The personnel accountability system shall be used at all incidents.

Section 2-6 of NFPA 1561, Standard on Emergency Services Incident Management System (2000 edition), also covers accountability systems.

#### 2-6 Resource Accountability.

#### 2-6.1

The incident management system shall provide for resource accountability at the incident scene.

#### 2-6.2\*

The ESO (emergency services organization) shall adopt and routinely use a system to maintain accountability for all resources assigned to the incident. This system shall also provide a process for the rapid accounting of all personnel at the incident scene.

#### A-2-6.2

One purpose of the system is to provide rapid determination if any personnel are missing in the event that an area should be required to be evacuated, or if a structural collapse or other unplanned event occurs.

#### 2-6.3\*

All supervisors shall maintain a constant awareness of the position and function of all personnel assigned to operate under their supervision. This awareness shall serve as the basic means of accountability that shall be required for operational safety.

#### A-2-6.3

The incident management system should account for the degree of danger that is involved in specific activities and should provide more direct supervision over personnel exposed to greater risks.

#### 2-6.3.1

The incident management system shall maintain accountability for the location and function of each company or unit at the scene of the incident.

#### 2-6.3.2

Fire department personnel who respond to the incident on fire apparatus shall be identified by a system that provides an accurate accounting of those personnel actually responding to the scene with each company or on apparatus.

#### 2-6.3.3

Personnel who arrive at the scene of the incident by means other than emergency response vehicles shall be identified by a system that accounts for their presence and their assignment at the incident scene.

#### 2-6.4

The system shall include a specific means to identify and keep track of personnel entering and leaving hazardous areas, such as confined spaces or areas where special protective equipment is required.

### **Rapid Intervention**

Because of the potential for rapidly changing conditions on the fireground, it is important that the incident commander have a team of fire fighters available that can be quickly deployed to rescue trapped personnel.

The need for a rapid intervention crew (RIC) has been outlined in several NFPA documents including:

- NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, (1997 edition)
- NFPA 1561, Standard on Emergency Services Incident Management System (2000 edition)
- NFPA 1521, Standard for Fire Department Safety Officer (1997 edition)

as well as the OSHA Standard 29 CFR 1910.134, Standard on Respiratory Protection (Section g 4), commonly known as the “Two-in/Two-out Rule”.

From the initial stages of an incident, NFPA 1500 specifies that there should be personnel prepared to initiate rescue operations. As the size of the incident grows, and more personnel arrive on the scene, then a formal team, properly equipped, shall be assigned.

#### NFPA 1500

##### 6-4.4.4

When only a single team is operating in the hazardous area in the initial stages of the incident, this standby member shall be permitted to assist, or if necessary perform, rescue for members of his/her team, providing abandoning his/her task does not jeopardize the safety or health of the team. Once a second team is assigned or operating in the hazardous area, the incident shall no longer be considered in the “initial stage,” and at least one rapid intervention crew shall be required.

##### 6-5.2

A rapid intervention crew shall consist of at least two members and shall be available for rescue of a member or a team if the need arises. Rapid intervention crews shall be fully equipped with the appropriate protective clothing, protective equipment, SCBA, and any specialized rescue equipment that might be needed given the specifics of the operation under way.

##### 6-5.6

At least one rapid intervention crew shall be standing by with equipment to provide for the rescue of members that are performing special operations or for members that are in positions that present an immediate danger of injury in the event of equipment failure or collapse.

In this incident the fire fighter who was able to make entry through the Fellowship Hall rescued two of the fire fighters. This fire fighter was not part of a formal RIC, nor was he working as part of a team. While he was successful in his attempt to rescue the fire fighters, he was not operating as part of the RIC team that had been established.

## NFPA 1561

### 4-1.9

The emergency services organization shall provide personnel for the rescue of individuals operating at emergency incidents if the need arises. A rapid intervention crew shall consist of at least two individuals and shall be available for rescue of personnel if necessary.

The lack of an RIC has been a factor in several incidents investigated by NFPA, including the following:

- Branford, Connecticut
- Marks, Mississippi
- Keokuk, Iowa

### **Personal Alert Safety System (PASS)**

The Personal Alert Safety System (PASS) has become another important component of the fire fighters protective equipment. The PASS device is to be used every time a fire fighter enters into a hazardous environment or situation. The device is intended to sound an audible alarm if the fire fighter becomes incapacitated or needs assistance. The sound of an activated PASS device warns all others on the fire ground of a fire fighter in distress and assists the rescuers in locating the missing or trapped fire fighter. In many cases the PASS devices are not activated by the fire fighters prior to entering the hazardous area. The fire fighters then can become unable to manually activate the unit once they become trapped.

PASS devices come in two basic types: (1) integrated, which is an integral part of the breathing apparatus and is automatically activated when the air cylinder is opened, and (2) stand-alone, which has to be activated initially by the fire fighter. Fire fighters who become trapped or lost, or are otherwise in distress can activate both units manually. The units will also sound if a fire fighter is motionless for 30 seconds.

The design, performance, and certification requirements and test methods for PASS devices are covered in NFPA 1982, Standard on Personal Alert Safety Systems (PASS), (1998 edition). The use of PASS devices is discussed in NFPA 1500, Section 5-8.

#### 5-8 Personal Alert Safety System (PASS).

##### 5-8.1\*

Each member shall be provided with and shall use a PASS device in the hazardous area. PASS devices shall meet the requirements of NFPA 1982, Standard on Personal Alert Safety Systems (PASS) for Fire Fighters.

##### A-5-8.1

The mandatory use and operation of a PASS by fire fighters involved in rescue, fire suppression, or other hazardous duty is imperative for their safety. The primary intent of this device is to serve as an audible device to warn fellow fire fighters in the event a fire fighter becomes incapacitated or needs assistance.

Past fire fighter fatality investigation reports document the critical need to wear and operate PASS devices when fire fighters operate in hazardous areas. Investigation results show that fire fighters most often failed to activate the PASS unit prior to entering a hazardous area.

Technology has provided the integration of PASS devices with SCBA. When the SCBA unit is activated to an operational mode, the PASS device is activated. Fire departments are encouraged to utilize this technology.

The use of PASS devices must be coupled with a solid incident management system, a personnel accountability system, and adequate communications to properly ensure for the safety of fire fighters.

#### 5-8.2

Each PASS device shall be tested at least weekly and prior to each use, and shall be maintained in accordance with the manufacturer's instructions.

During this incident, the fire fighter that rescued the two fire fighters after the collapse reported that he did not hear any PASS devices sounding in the area as he found and removed the two fire fighters. It is reported that all three of the fire fighters that were killed were equipped with PASS devices. However, no devices were found during the protective equipment inventory as noted in the Texas Fire Chiefs Association report.

### **Subdivisions in Concealed Spaces**

Concealed spaces pose a significant threat to building occupants and responding fire fighters when the space becomes involved in fire. The fire, hidden from view, can spread rapidly undetected for extended periods, weakening the structure as the minutes pass. Combustible construction or storage in such a space only increases the potential hazard. Subdividing these spaces slows the spread of fire and limits damage in the concealed areas. Section 8.2.7 of the 2000 edition of the NFPA 101<sup>®</sup> - Life Safety Code<sup>®</sup> discusses this.

## 8.2.7 Concealed Spaces.

### 8.2.7.1\*

In new Type III, Type IV, or Type V construction, any concealed space in which materials having a flame spread rating greater than Class A (as defined in Section 10.2) are exposed shall be effectively firestopped or draftstopped as follows:

- (1) Every exterior and interior wall and partition shall be fire-stopped at each floor level, at the top story ceiling level, and at the level of support for roofs.
- (2) Every unoccupied attic space shall be subdivided by draftstops into areas not to exceed 3000 ft<sup>2</sup> (280 m<sup>2</sup>).
- (3) Any concealed space between the ceiling and the floor or roof above shall be draftstopped for the full depth of the space along the line of support for the floor or roof structural members and, if necessary, at other locations to form areas not to exceed 1000 ft<sup>2</sup> (93 m<sup>2</sup>) for any space between the ceiling and floor and 3000 ft<sup>2</sup> (280 m<sup>2</sup>) for any space between the ceiling and roof.

*Exception No. 1: This requirement shall not apply where the space is protected throughout by an approved automatic sprinkler system in accordance with Section 9.7.*

*Exception No. 2: This requirement shall not apply to concealed spaces serving as plenums. (See NFPA 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.)*

### A.8.2.7.1

The area limitations are based on life safety considerations and are not intended to suggest that changes should be made in local building codes having similar or more restrictive requirements that are based on other reasons. Building codes generally contain detailed information on the proper selection and installation of draftstopping and firestopping materials.

The vertical spread of fire through shafts, chases, and hollow wall construction, and the horizontal spread of fire through plenums and open attics are phenomena common to many serious fires. Where such spaces are protected with automatic sprinklers, the risk of unseen fires is minimized. Certain additional precautions are required where this protection is not installed in new buildings of other than Type I or Type II construction as defined by *NFPA 220, Standard on Types of Building Construction*, as provided in the commentary following 8.2.1, and where the materials used have a flame spread rating of more than 25 (that is, not Class A interior finish).

Draftstopping of attic spaces is particularly important in shopping centers comprised of one story and an attic and in two-story apartment buildings or row houses. Experience has shown that fires starting in one of these occupancy units frequently breaks into the attic space, spreads through the attic, and travels down into adjoining units.

Numerous fires in garden-type apartments have demonstrated two common weaknesses that relate to the lack of adequate firestopping and draftstopping. The following two areas are frequently not firestopped:

- (1) Between the underside of the roof deck and the top of fire barriers that do not extend through the roofline
- (2) Inside the pipe chase that contains the plumbing vent stack. The vent stack is of particular concern, because it frequently is located between two mirror-image apartment units and interconnects all the floors of the apartment building. A fire that travels into this concealed space can spread to the attic and soon involve the entire structure.

Chapter 3 (Life Safety Code<sup>®</sup>) defines a draft stop as: “a continuous membrane used to subdivide a concealed space to restrict the passage of smoke, heat, and flames.”<sup>3</sup>

There was no evidence of draftstopping in the attic space at church building in Lake Worth.

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<sup>3</sup> Cote, *Life Safety Code<sup>®</sup> Handbook* Eighth edition, 2000

## **VI. SUMMARY**

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All fireground incidents involve a complex set of factors that must be taken into account by the incident commander when formulating a strategy. Furthermore, a number of these factors are constantly changing during the incident, requiring an ongoing process of evaluating conditions.

The decisions made should be based on a risk management philosophy that balances the ability to save lives or property versus that of the risk to the safety of emergency personnel. Building construction, occupancy, fire growth and fire spread are only some of the few factors that must be evaluated in making this risk/benefit evaluation.

There have been a number of incidents that have demonstrated the risk to fire fighters operating above or below truss construction. When a fire occurs in a structure that may use this supporting mechanism, the fireground strategy should evaluate the necessity of placing personnel at risk.

Given the fact that the fireground is a constantly changing environment, it is critical to incorporate procedures that will enhance the level of fire fighter safety. These include the use of a consistent accountability system, PASS devices and the implementation of a rapid intervention crew. The absence of these has been a contributing factor in a number of fire fighter fatality incidents over the years.

## VII. NFPA DOCUMENTS

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The following NFPA documents were referenced in this report:

<p><b>NFPA 101<sup>®</sup>, <i>Life Safety Code</i><sup>®</sup> 2000 edition</b></p>	<p>This Code addresses life safety from fire. Its provisions will also aid life safety in similar emergencies. The Code addresses those construction, protection, and occupancy features necessary to minimize danger to life from fire, including smoke, fumes, or panic. The Code identifies the minimum criteria for the design of egress facilities so as to permit prompt escape of occupants from buildings or, where desirable, into safe areas within buildings.</p> <p>The Code recognizes that life safety is more than a matter of egress and, accordingly, deals with other considerations that are essential to life safety.</p> <p>The Code does not attempt to address all those general fire prevention or building construction features that are normally a function of fire prevention and building codes.</p>
<p><b>NFPA 1500, <i>Standard on Fire Department Occupational Safety and Health Program</i> 1999 edition</b></p>	<p>The purpose of this standard is to specify the minimum requirements for an occupational safety and health program for a fire department and to specify safety guidelines for those members involved in rescue, fire suppression, emergency medical services, hazardous materials operations, special operations, and related activities.</p>

<p><b>NFPA 1561, <i>Standard on Emergency Services Incident Management Systems</i></b>  <b>2000 edition</b></p>	<p>This standard establishes minimum performance requirements for an incident management system based on concerns for the safety and health of fire department personnel. Many of the requirements of this standard could be satisfied by adopting a “model” system (such as the Incident Command system) that is intended to provide for a uniform approach to incident management while providing for some variations to meet local requirements.</p>
<p><b>NFPA 1982, <i>Standard on Personal Alert Safety Systems (PASS)</i></b>  <b>1998 edition</b></p>	<p>This standard shall specify minimum design, performance, and certification requirements and test methods for all Personal Alert Safety Systems (PASS) to be used by fire fighters and other emergency services personnel who engage in rescue, fire fighting, and other hazardous duties.</p>

## APPENDIX

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The following are summaries of NFPA fire fighter fatality investigation reports. Each of these incidents contains factors that are common to those seen in the Lake Worth fire fighter fatality incident.

- Hackensack, NJ
- Chesapeake, VA
- Branford, CT
- Marks, MS
- Pittsburgh, PA

A copy of the NFPA Alert Bulletin on truss collapse is also included. Furthermore, a copy of the article on the Lake Worth incident that appeared in NFPA Journal is included with this report.

Copies of the full NFPA Fire Investigations reports on each of the incidents listed are available from the NFPA Charles S. Morgan library. Please contact the library at 1-617-984-7445, or [library@nfpa.org](mailto:library@nfpa.org).

## **Hackensack, NJ**

### **Fire Investigation Report Summary**

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Five fire fighters from the Hackensack, New Jersey, Fire Department were killed while they were engaged in interior fire suppression efforts at an automobile dealership when portions of the building's wood bowstring truss roof suddenly collapsed. The incident occurred on Friday, July 1, 1988, at approximately 3:00 p.m., when the fire department began to receive the first of a series of telephone calls reporting "flames and smoke" coming from the roof of the Hackensack Ford Dealership.

Two pumpers, a ladder truck, and a battalion chief responded to the first alarm assignment. The first arriving fire fighters observed a "heavy smoke condition" at the roof area of the building. Engine company crews investigated the source of the smoke inside the building while the truck company crew assessed conditions on the roof. For the next 20 minutes, the focus of the suppression effort was concentrated on these initial tactics.

During this time, however, little headway appeared to have been made by the initial suppression efforts, and the magnitude of the fire continued to grow. The overall fireground tactics were shifted to a more "defensive" posture (exterior operation) and the battalion chief gave the order to "back your lines out." However, before suppression crews could exit from the interior, a sudden partial collapse of the truss roof occurred, trapping six fire fighters. An intense fire immediately engulfed the area of the collapse. One trapped fire fighter was able to escape through an opening in the debris. The other five died as a result of the collapse.

This incident and an earlier similar incident at a supermarket fire in Brooklyn, New York, provide important lessons to the fire service regarding the fireground hazards of wood truss roof assemblies.

## Chesapeake, VA Fire Investigation Report Summary

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At approximately 11:30 a.m. on Monday, March 18, 1996, fire fighters in Chesapeake, Virginia, responded to a fire in an auto parts store. No fire was visible from the exterior of the building when the fire fighters arrived. Two fire fighters entered the building and located a small fire at the rear of the store. The fire fighters extinguished the fire and began checking for fire extension. Approximately 20 minutes after their arrival, the roof of the building collapsed and the two fire fighters were trapped inside. The fire fighters both died of burns, with smoke inhalation being a contributory factor.

The building involved was approximately 12 years old. Two of the building's



exterior bearing walls were constructed with unprotected steel frames and two were constructed with masonry block. Lightweight wood trusses with a clear span of 50 ft (15.2 m) supported the store's roof. Because the facility was an auto parts store, it contained a wide variety of combustible and noncombustible materials, flammable auto paints (liquid and aerosol), and other flammable and combustible liquids. Most packaging materials and some shelving materials were also combustible.

The fire occurred when a utility worker damaged the electrical service drop conductors on the outside of the store. Electrical arcing inside the store ignited fires that quickly involved the wood trusses supporting the roof and ignited a fire in the area of an electric hot water heater. Though some of the fire was visible to anyone in the occupied area of the building, much of the fire was hidden in the concealed space above the store's ceiling, and the fire was able to spread in that area.

The fire fighters who died in this fire probably did not know that the building was constructed with lightweight wood roof trusses. Approximately 7 minutes after they had arrived on the scene, the crew inside the building radioed their battalion chief to report that they had found the fire. They asked for a second crew to come into the building and requested a pike pole. Approximately 13 minutes after this transmission, the roof collapsed, intensifying the fire and trapping the fire fighters inside the building. The trapped fire fighters radioed for assistance but, for an undetermined reason, the incident commander did not understand the transmission. Two other chief officers who were responding to the scene did hear the transmission

and relayed the information to the on-scene commander. By the time the on-scene commander realized that fire fighters were possibly trapped inside the building, the fire had become too intense to attempt rescue operations.

On the basis of the it's investigation and analysis of this fire, NFPA determined that the following factors contributed significantly to the loss of the two Chesapeake fire fighters:

- The presence of lightweight wood roof trusses.
- Fire officers and fire fighters unaware that the roof of the Chesapeake auto parts store was constructed with lightweight wood trusses.
- The lack of a fire attack strategy that could minimize the risk to fire fighters while suppressing a fire involving lightweight wood trusses.
- The lack of automatic sprinklers.

## **Branford, CT**

### **Fire Investigation Report Summary**

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At approximately 4:30 p.m. on Thursday, November 28, 1996, a fire occurred in a Branford, Connecticut, carpet store and warehouse. The fire started in the store's office area, damaged the ceiling assembly and ignited the building's wood roof trusses. Seven fire fighters were making the initial attack when the roof collapsed. Five of seven fighters were able to find their way out of the building. The sixth fire fighter was unconscious and had to be rescued, and the seventh died before he could escape.

The building was 60 ft (18.3 m) wide and 120 ft (36.5 m) long. It had wood-frame exterior bearing walls in one section and masonry block exterior bearing walls in all other areas. Lightweight wood trusses carried the store's roof over a clear span of 60 ft (18.3 m). The building did not have any fire detection or suppression systems.

The Branford fire fighters responded to a report of smoke coming from the roof of a carpet store and found light smoke showing near the roof eaves at the front of the building, on arrival. On the basis of the observed conditions, the fire officers believed that the fire was located somewhere in the showroom area. Six fire fighters advanced two hoselines to the front of the building. Another Branford fire fighter entered the building without the knowledge of the incident commander and the officer in charge of interior operations bringing the total number of fire fighters in the building to seven.

The fire fighters found fire in a corner of a showroom and attempted to extinguish that fire. At approximately the same time, the incident commander who was outside of the building and the interior officer realized that there was fire above the fire fighters. The interior officer ordered every one out of the building and the incident commander radioed the interior crews also ordering them out. Before the fire fighters could leave the building, the roof collapsed. This was approximately 17 minutes after the fire fighters arrived on the scene.

Four fire fighters escaped out of the front of the building, and the officer and two fire fighters were trapped toward the center of the building. These fire fighters freed themselves from the debris and began spraying the burning rubble with a hoseline. The officer then told the two fire fighters that they would have to move to the rear of the building where two overhead doors were located. The officer and one fire fighter began moving toward the rear of the building and became separated from the other fire fighter.

Before reaching the door, the fire fighter who was with the officer ran out of air and collapsed. Unable to help the fire fighter, the officer continued on, found a door, and left the building. Once outside, the officer could not get assistance from other fire fighters, so he reentered the building. The fire officer found the collapsed fire fighter even though the fire fighter had not turned on his PASS (Personal Alert Safety System) device. The officer dragged the fire fighter out of the building.

Once the incident commander learned that six fire fighters had escaped, he believed that everyone was out because he was not aware that a seventh fire fighter had entered the building. After a brief discussion of the events that had occurred, the officers determined that one fire fighter had, in fact, not escaped. The missing fire fighter was found approximately 20 ft (6 m) from the position where he was last seen by the officer. The cause of the fire fighter's death was listed as smoke inhalation.



On the basis of its investigation and analysis of this fire, the NFPA determined that the following factors contributed to the loss of the Branford fire fighter:

- Fire officers and fire fighters were unaware that the roof of the Branford carpet store was constructed with lightweight wood trusses.
- The ineffective use of an incident management system and no formal fire fighter accountability system.
- The absence of a Rapid Intervention Crew (RIC).
- The lack of automatic sprinkler protection.

## Marks, MS

### Fire Investigation Report Summary

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At approximately 12:58 a.m. on Saturday, August 29, 1998, a fire was reported to the rear at the florist shop on Main Street in Marks, Mississippi. The fire reportedly began in a pile of cardboard and other combustible materials in the rear of the florist shop. The fire then spread through the open eaves of a storage building behind the florist shop. The 20-ft × 30-ft (6.1-m × 9.1-m) storage building was used to store floral packing and display materials and also contained a 6-ft × 6-ft (1.8-m × 1.8-m) cooler unit. The building was connected to the main florist shop through a steel frame door. The florist shop was located in the middle of a block of buildings that contained a restaurant, a liquor store, a dry cleaner, and a lounge. The block of buildings was approximately 140 ft (42.6 m) in length and 60 ft (18.3 m) deep.

Upon arrival of the first fire units, at 1:05 a.m., smoke and flame were showing from the eave line of the storage building. The fire department gained access to the storage building and began to extinguish the fire from within the building. An additional hoseline was deployed to protect a youth club building located 15 ft (4.6 m) south of the fire building. The Marks fire chief requested mutual aid from the Lambert Fire Department at 1:09 a.m.

With the fire in the storage building extinguished, salvage and overhaul was begun in the storage building and the adjoining florist shop. When the Marks fire chief entered the florist shop with the owner at about 1:25 a.m., he reported light smoke in the building. Further investigation revealed smoke showing from the attic space of the florist shop. The chief then returned to the rear of the shop and ordered two Marks fire fighters to access the roof and check on conditions to determine if ventilation would be necessary.

The two Marks fire fighters placed a ground ladder at the rear of the liquor store and began to climb to the roof. One fire fighter was equipped with breathing apparatus, and the other was not. As they reached the roof, smoke conditions worsened, and the fire fighter without breathing apparatus returned to the ground to find breathing apparatus to don. The fire fighter remaining on the roof then proceeded to walk over to the area of the florist shop. When he stepped from the roof of the restaurant onto the roof at the rear of the florist shop, at approximately 1:40 a.m., the weakened roof structure collapsed and he fell into the store, landing in the southeast storage room in the shop. No one on the fireground witnessed his falling through the roof. His location was unknown to the others on the fireground.

At the front of the florist shop, with smoke conditions worsening, a hoseline was stretched from the Lambert engine that had been positioned in the front of the restaurant. Two fire fighters (one from Marks and the other from Lambert) donned breathing apparatus and prepared to enter the front of the shop at about 1:55 a.m. The Marks fire fighter had also participated in the attack on the fire in the storage building and was on his third air cylinder. Within seconds of the two fire fighters' entry into the building, witnesses on the outside reported seeing the hoseline "jump." Immediately following this, the Lambert fire fighter stumbled out of the door and

onto the sidewalk, stating that the fire fighter from Marks was still in the building. Fire fighters outside the shop, including the fire fighter who had just exited, entered the building and began searching for the Marks fire fighter lost at the front of the shop.



Numerous attempts were made to locate the fire fighter. Rescue efforts were hampered due to a lack of full air cylinders at the scene. A police officer had been dispatched to travel approximately 20 miles (32.2 km) to Batesville to refill the cylinders already depleted. The hose line that was used was located. The fire fighter, however, was not with the line.

During the rescue attempts, the Marks fire chief was injured by broken glass in an effort to ventilate the florist shop.

Additional mutual aid was requested from the Batesville Fire Department at 2:03 a.m. Upon arrival of the Batesville units at 2:25 a.m., fire fighters from Batesville began to assist in the search for the lost fire fighter in the front of the florist shop. The injured Marks fire chief turned command of the scene over to the Batesville chief while he sought medical attention for his injuries. At this point, additional mutual aid was requested from surrounding communities to assist in the search for the missing fire fighter and for help in the extinguishing the fire.

Batesville fire fighters located the missing Marks fire fighter during the second search of the store, after 3:00 a.m. His body was found under a pile of debris within 24 ft (7.3 m) of the front entrance.

During the search efforts, the fire spread to the adjoining establishments. When the body of the fire fighter lost in the front of the florist shop was located and removed, the focus was again turned to extinguishment of the fire. At this point, it was determined that another fire fighter was missing, the Marks fire fighter who had gone to the roof in the rear of the block to ventilate. It was thought that he might be in the rear of the florist shop. Efforts were put forth to extinguish the fire in that and adjoining areas so that another search effort could be mounted.

The fire in the rear of the block was under control at about 5:30 a.m., and the second missing fire fighter's body was found in a rear storage room of the florist shop around 6:00 a.m.

On the basis of the fire investigation and analysis, NFPA has determined that the following significant factors directly contributed to the deaths of the two fire fighters:

- Lack of a fireground accountability system.
- Ineffective use of an established incident management system (IMS).
- Failure to equip fire fighters with personal alert safety systems (PASS).
- Lack of knowledge of the construction features of the building and how these features would affect the spread of fire in the concealed spaces, including the attic.
- Insufficient resources [such as personnel and equipment self-contained breathing apparatus (SCBA) and spare cylinders] to mount interior fire suppression and rescue activities.
- Absence of an established Rapid Intervention Crew (RIC) and the lack of a standard operating procedure requiring a RIC.

## Pittsburgh, PA Fire Investigation Report Summary

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Tuesday, February 14, 1995, a fire in a one-family dwelling resulted in the deaths of three Pittsburgh, Pennsylvania, fire fighters. Three other fire fighters were injured.

The building involved was a three-story, wood-frame structure with a basement and was constructed on a sloping grade that caused the building to have a different appearance depending on the side being viewed. Fire fighters entering the building saw only one side and were not aware of the building's actual arrangement. The fire fighters' distorted perception of the building may have impaired their ability to assess alternate escape routes.

During interior fire fighting operations, the stairway used by fire fighters to enter a room collapsed. Sometime after that collapse, fire fighters outside the building realized that other fire fighters were trapped inside. Since fire fighters from several companies were working at the scene, fireground supervisors were not able to quickly assess which companies and individual fire fighters were working in the building. After several trapped fire fighters were rescued through an exterior window, a full accounting of all fire fighters was not performed. Unknown to the incident commander, three other injured fire fighters remained trapped in the building. These fire fighters were discovered after most of the fire had been extinguished and smoke had been removed from the building, about 1 hour and 10 minutes after they originally entered.

Adherence to procedures that allow for quick accounting of fire fighters on the fireground and the use of rapid intervention teams are precautions that can reduce risks to fire fighters during structural collapse and other unplanned events that can threaten fire fighters during suppression operations. The importance of these precautions is evident in two NFPA documents, that is, NFPA 1561, *Standard on Emergency Services Incident Management System*, and NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*. Both have complete sections containing specific accountability requirements. In addition, NFPA 1500 contains requirements for rapid intervention crews.

## **Alert Bulletin (97-1)**

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An Alert Bulletin was issued by NFPA illustrating the dangers of truss collapses based on two incidents. The following is the text of this bulletin.

### **Truss Collapse**

In 1996, two fires that resulted in the collapse of lightweight wood trusses claimed the lives of three fire fighters. The first fire and collapse occurred on March 18, 1996, in Chesapeake, Virginia, and resulted in two fire fighter fatalities. The other collapse of lightweight wood trusses occurred during a fire on November 28, 1996, in Branford, Connecticut, and resulted in the third firefighter death.

The Chesapeake and Branford fires are only two of many incidents involving wood trusses that have resulted in fire fighter fatalities. NFPA statistics show that from 1977 through 1995, thirty fire fighters were killed in sixteen incidents where wood truss roofs failed while the fire fighters worked on or below them. The NFPA Fire Investigations Department has prepared reports regarding the August 2, 1978, collapse of wood trusses in a New York City supermarket that claimed the lives of six fire fighters and the July 1, 1988, collapse of wood trusses in a Hackensack, New Jersey, automobile dealership that claimed the lives of five fire fighters. Both of these incidents are included in the NFPA statistics. The NFPA statistics also show that one fire fighter was killed when a steel truss roof collapsed in the period from 1977 through 1995.

This bulletin summarizes the Chesapeake and Branford fires and presents many of the NFPA findings following the investigations of both fires. We hope that the information contained in this bulletin will aid the fire service in recognizing the importance of understanding wood truss assemblies, identifying such assemblies before a fire occurs, and developing strategies that will minimize the risk to fire fighters when they must suppress fires in buildings constructed with lightweight wood truss assemblies.

### **The Chesapeake Fire**

The building involved in the Chesapeake incident was approximately 12 years old and housed an automobile parts store. Two of the building's exterior bearing walls were constructed with unprotected steel frames and two were constructed with masonry block. Lightweight wood trusses with 2-in. × 6-in. top and bottom chords and 2-in. × 4-in. webs carried the store's roof over a clear span of 50 ft (15.2 m). Metal gusset plates were used as fasteners to hold all the trusses' joints together. Because the facility was an auto parts store, it contained a wide variety of products made of combustible and noncombustible materials, flammable auto paints (liquid and aerosol), and other flammable and combustible liquids. Most packaging materials and some shelving materials were also combustible. The building had no fire detection or suppression systems.

The fire occurred when a utility worker damaged electrical service drop conductors feeding the auto parts store. Failures in electrical equipment ignited fires in the combustible concealed space created by wood trusses supporting the roof and in the area of an electric hot water heater. Although a small amount of the fire was visible in the occupied area of the building, most of the fire was hidden in the combustible concealed space above the store's ceiling and spread in that area.

At approximately 11:30 a.m. on Monday, March 18, 1996, Chesapeake fire fighters responded to the fire. Upon arrival, they found nothing showing on the exterior of the building. Two fire fighters entered the building and found a small amount of fire at the rear of the store. The fire officer initially felt that his crew could handle the fire and reported this to the incident commander. The incident commander released the other responding units and placed them back in service. Approximately 7 minutes after the first fire fighters arrived on the scene, the fire officer inside the building radioed to the incident commander and asked for a second crew to come into the building. He also asked for a pike pole. Approximately 8 minutes after this transmission, the roof collapsed, intensifying the fire and trapping the fire fighters inside the building. This collapse occurred approximately 15 minutes after fire fighters arrived on the scene.

The trapped fire fighters radioed for assistance but, for reasons still unknown, the incident commander did not understand their transmission. Two other chief officers who were responding to the scene heard the call for assistance and one chief radioed to the other that he would relay the information to the incident commander once on the scene. By the time the on-scene commander realized that fire fighters were possibly trapped inside the building, the fire had become too intense to attempt rescue operations. The two fire fighters died of burns and smoke inhalation.

### **The Branford Fire**

The Branford fire occurred in a 35-year-old building containing a carpet store and warehouse. The building was 60 ft (18.3 m) wide and 120 ft (36.6 m) long. The front third of the building was constructed with wood-frame exterior bearing walls and contained the store's carpet showroom. The rear two-thirds of the building contained the ceiling and tile showroom and a warehouse area. This part of the building had masonry block exterior bearing walls. Lightweight wood trusses with 2-in. × 8-in. top chords, 2-in. × 6-in. bottom chords and 2-in. × 4-in. webs carried the store's roof over a clear span of 60 ft (18.3 m). Metal gusset plates were used as fasteners to hold all the trusses' joints together. Because the facility was a carpet store and warehouse, it contained racks for carpet samples in the store and bulk quantities of carpet in the warehouse. The carpets were made of combustible materials. The warehouse also contained five service vans with gasoline engines, a propane lift truck, and other flammable and combustible materials. The building did not have any fire detection or suppression systems.

At approximately 4:30 p.m. on Thursday, November 28, 1996, Branford fire fighters responded to a report of smoke coming from the roof of a carpet store. Upon arrival, they found light smoke showing near the roof eaves and light smoke coming from

roof vents. When they approached the building and looked in the building's front doors, the fire fighters saw a heavy layer of smoke in the building's showroom. The smoke was coming down from the ceiling and was approximately 3 ft (0.9 m) above the floor. On the basis of the observed conditions, the incident commander and other fire fighters believed that the fire was located somewhere in the showroom area.

Two crews of fire fighters brought hose lines to the front of the building. The first crew, composed of three career fire fighters, had a 1- $\frac{3}{4}$  in. (44 mm) hose line. The second crew made up of three volunteer fire fighters from the Branford Fire Department had a 2- $\frac{1}{2}$  in. (65 mm) hose line that was to be used as a "backup" hose line for the first crew. Both crews entered the building at the same time and advanced their hose lines through the showroom toward the ceiling and tile room. While the fire fighters were still searching for the location of the fire, a Branford volunteer fire fighter entered the building without the knowledge of the incident commander and the officer in charge of interior operations. The volunteer joined the crews who were still moving toward the rear of the showroom.

The first crew found fire in a corner of the ceiling and tile room located on the back side of a masonry block interior wall located near the center of the building. Using their 1- $\frac{3}{4}$  in. (44 mm) hose line, the fire fighters knocked down that fire. The officer in charge of the interior crews then had everyone stop their activities for a moment so he could listen for sounds that might indicate that the fire was still burning. The noises that the officer heard, however, suggested that the fire was above their heads and he ordered everyone out of the building.

At approximately the same time, part of one shingle fell off the exterior roof surface and the incident commander, who was outside the building, saw a bright glow inside the attic. He immediately knew that there was a large body of fire above the crews inside the building. At about the time that the interior officer realized that fire was above their heads, the incident commander radioed the interior crews to order them out of the building. In addition, the incident commander had vehicle operators sound the air horns on their vehicles as a signal for an immediate building evacuation. Before the fire fighters could leave the building, the roof collapsed. This was approximately 9 minutes after the fire fighters arrived on the scene.

Four fire fighters escaped out of the front of the building, and three fire fighters were trapped toward the center of the building. The officer was the first to free himself from the debris and after standing up, the officer saw that other fire fighters appeared to be trapped in the rubble as they were attempting to escape out the front showroom doors. The officer located the 1- $\frac{3}{4}$  in. (44 mm) hose line and began spraying water onto the pile of burning debris in the area of the other fire fighters. Moments later, the volunteer fire fighter freed himself and the officer began planning their escape. The officer then discovered a third fire fighter in the fallen debris. The officer ordered the volunteer fire fighter to protect him with the hose line as he uncovered and removed the trapped fire fighter. The interior officer then told everyone that they would have to move to the rear of the building in an attempt to locate the two overhead doors. The officer and career fire fighter began moving toward the rear of

the building. They had to feel their way through the display racks and debris in the ceiling and tile showroom because the heavy smoke was now obscuring their vision.

The last time the officer saw the volunteer fire fighter he was still discharging water onto them and the fire.

The officer and career fire fighter continued to feel their way through the warehouse. Approximately 40 ft (12.2 m) away from a door on the side of the building, the fire fighter ran out of air and took his SCBA facepiece off. After breathing the smoke, the fire fighter collapsed. The fire officer realized that he could not help the downed fire fighter so he continued on in an attempt to find his way out of the building and to get assistance. The officer found a personnel door, opened it, and left the building. However, he was unable to get the assistance of other fire fighters, so the officer reentered the building alone. The fire fighter who collapsed in the warehouse was wearing a PASS (Personal Alert Safety System) device, but he had not turned it on before entering the building, so it did not operate when the fire fighter stopped moving. Even though the fire officer had no PASS alarm signal to guide him back to the injured fire fighter, the fire officer was still able to find the fire fighter and dragged him out of the building to safety.

Since the volunteer fire fighter had entered the building without the knowledge of the incident commander and interior officer, the incident commander initially believed that all fire fighters had escaped because he could account for the six fire fighters who originally entered the building. However, as the officers discussed the events over time, they realized one fire fighter did not escape from the building.

The volunteer fire fighter was found approximately 20 ft (6 m) from the position where he was last seen by the officer. The cause of the fire fighter's death was listed as smoke inhalation. At the time that this bulletin was prepared, the cause of the fire was being investigated by state and local fire investigators. They determined that the area of fire origin was most likely in a normally occupied area of the building, but no information regarding the cause of the fire was released.

## **Analysis**

Current architectural design and building construction practices promote the use of lighter materials that will reduce both material requirements and construction costs. One such practice is the increasing use of trusses. Trusses are construction elements that can carry loads over wide spans, reduce the size and weight of the load-carrying member, and ultimately reduce costs without compromising performance under non-fire conditions. The trusses used in building construction can be made of wood, metal, or a combination of both materials. Both the shape of trusses and the size of the material used to make the trusses can vary greatly according to individual truss design. Each of these variables will affect the performance of a truss under fire conditions. As a result, this Alert Bulletin focuses on lightweight wood trusses, the type of truss that was in the Chesapeake auto parts store and the Branford carpet store and warehouse.

In both incidents, the wood trusses and the wood sheathing materials were the primary fuels that supported the fire spreading in the concealed space. The ability to be a fuel is a characteristic of wood trusses that make them more hazardous than metal trusses in concealed spaces. Had the trusses and sheathing materials been made of metal, virtually all of the fuels in the concealed space above the ceilings in both stores would have been eliminated. Consequently, the potential for the severe fire that occurred in the Chesapeake auto parts store would have been almost eliminated. Similarly, the roof structure in the Branford store would have been only exposed to the fire that spread through a damaged area in the building's gypsum wallboard ceiling. This is because the initial fire started in the normally occupied area of that building.

By the nature of their design, trusses have open areas through which fire can spread. Fire service construction expert Francis Brannigan refers to this area as a truss void or truss loft.\* The trusses in the Branford building, for example, were 8 ft (2.4 m) high and 60 ft (18.3 m) wide triangular trusses constructed with 2-in.×8-in. top chords, 2-in.×6-in. bottom chords and 2-in.×4-in. webs. This design created a profile that was open and created a structural member that did not act as a barrier against horizontal fire spread. The height of the trusses covering the Chesapeake auto parts store is not known because all the trusses were destroyed in the fire. Even without knowing the height of the Chesapeake trusses, one can still safely assert that there were large openings in these trusses and that these holes allowed the fire to spread quickly through the combustible concealed spaces above the ceiling in this building. As the wood trusses in both buildings burned, they lost mass and strength, increasing the potential for collapse under the truss' own weight and the weight of the roofing materials. The increased potential for collapse equated directly to an increased threat to fire fighters who were working below these trusses.

One of the most important steps that fire fighters can take to improve their chances of survival during fire fighting operations in buildings constructed with lightweight wood trusses is to improve their general knowledge regarding truss construction. Fire fighters should develop a basic knowledge of why trusses are used in buildings and how to identify buildings that might be constructed with trusses. Fire fighters should also clearly understand how trusses can affect their fire fighting operations and their safety. This knowledge should be similar to the knowledge that many fire fighters have regarding balloon-frame construction. Through experience and training, fire fighters have learned how to identify buildings that are likely to be of balloon-frame construction, what effect that type of construction can have on fire spread, and what fire fighting tactics may be needed to safely suppress the fire.

NFPA recognizes that fire fighters must have an understanding of building construction as they advance in the fire service. Thus, NFPA has established requirements intended to develop that understanding. Section 4-23 of NFPA 1001, Standard for Fire Fighter Professional Qualifications, 1992 edition, requires Fire Fighter II candidates to be familiar with building construction. The candidates are required to identify the general fire behavior involving the five types of construction, i.e., wood frame, ordinary, heavy timber, noncombustible, and fire resistant. The candidates are also required to know how the spread of fire can affect the safety of

the building, occupants, and fire fighters. Section 4-23 of NFPA 1001 specifically requires Fire Fighter II candidates to describe at least three hazards of truss and lightweight construction and five indicators of building collapse.

In addition to improving their own general knowledge about truss construction, fire fighters can benefit by identifying specific buildings in their jurisdiction that have been constructed with trusses. The existence of trusses can be recorded on pre-fire plans or in other ways that will allow fire fighters to quickly retrieve the information when developing a safe fire attack strategy. Following the loss of five fire fighters during the collapse of a bowstring truss in Hackensack, New Jersey, on July 1, 1988, the state of New Jersey adopted a law requiring all buildings that are constructed with trusses to be marked with a placard. Placards can be another means to bring the presence of trusses to the attention of responding fire fighters. Once aware of trusses, the fire fighters can account for the trusses in their fireground attack plans, tactics, and strategies, and can minimize the risk to fire department members. A recent fire in New Jersey that was reported to NFPA revealed that a truss placard on the outside of the building made responding fire fighters aware of the presence of trusses. Once aware of the trusses, the incident commander immediately began taking them into consideration when developing his fire attack strategy.

Between 1977 and 1995, thirty-fire fighters were killed in sixteen incidents where wood truss roofs have failed.

NFPA investigators traveled to both communities and worked closely with the local fire departments during the data gathering and report preparation activities. This NFPA Alert Bulletin was prepared in order to raise the awareness of members of the fire service and others regarding the performance of wood trusses involved in fire. It is not NFPA's purpose to pass judgment on, or fix liability for, the loss of life and property during either fire. This NFPA Alert Bulletin, and the lessons contained therein, may be reproduced freely with the customary source credit.

\* Brannigan, F. L., Building Construction for the Fire Service, National Fire Protection Association, 1992, 3<sup>rd</sup> edition, pp. 542.

## Roof Collapse Kills Three

**Three more firefighters are lost when a truss roof in an evacuated building collapses during a fire.**

by Ed Comeau

The following article appeared in the July/August, 1999 issue of NFPA Journal®.  
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Hackensack, New Jersey. Chesapeake, Virginia. Branford, Connecticut. In each of these towns, lightweight wood truss roof collapses have killed and injured firefighters. And now, in Lake Worth, Texas, another wood truss roof fire has killed three more firefighters and injured four.

On February 15, 1999, shortly after firefighters Brian Collins, Phillip Dean, and Gary Sanders went inside the Precious Faith Chapel, the roof failed and dropped on them. NFPA sent Fire Investigator Robert Duval to examine the scene and speak to crew members involved in the incident. Thanks to these firefighters and their chief, Mark Cone, Duval came back with facts that NFPA hopes will help prevent other tragedies in buildings with wood truss roofs.

### **The dangers of wood trusses**

Wood trusses are by no means new. Though they were once found only in certain parts of the country, builders nationwide now use them in all types of occupancies, from industrial to storage to residential. According to the Wood Truss Council of America, 46 percent of single-family homes and 60 percent of multifamily homes built in the United States from 1992 to 1997 used wood truss roofs. Since they're becoming so common, it's more important than ever that incident commanders understand how they behave in a fire.

Trusses, which are made up of chords and webs joined in a series of triangles, can span floors or roofs without any vertical supports, except at the ends. By creating one large structure, wood trusses cover long distances more efficiently than conventional wood beams or wood beams supported by columns. The strength of this configuration relies on a system of interdependent members.

Though the loss of one member affects the load-carrying capability of the entire truss, it doesn't always lead to structural collapse because adjacent trusses pick up some of the load. Roof sheathing and interior gypsum wallboard ceilings help connect the trusses and also spread the load, making the truss efficient, from an engineering standpoint.

However, these same features raise serious fire safety concerns. Each truss component exposes more of its surface to a fire than a large wood beam does, and because the truss components have less mass than such beams, they're more quickly consumed by fire. According to Paul Fiset, director of the Building Materials and Wood Technology Program at the University of Massachusetts, Amherst, a wood truss will lose some of its load-carrying capacity whenever fire destroys a chord or web member. However, the metal plates, also known as gusset plates, that frequently hold the truss members together are of greater concern because of their potential to fail during a fire. NFPA investigators have learned from building collapses during earthquakes that such connections, and not the members themselves, are often the weakest parts of the structure.



These metal connectors have short teeth that bite into the wood, creating a strong, stable connection. In a fire, though, they may help weaken the wood. When the U.S. Forest Products Laboratory conducted limited fire tests on gusset plates, researchers found that they reflected the heat away from the connection during the initial stages of a fire,

but as the fire progressed, they transmitted heat into the wood, charring it. Examining the wood underneath and next to the plate after the tests, researchers found similar damage and concluded that it wasn't the plate itself that had failed—it was the wood the plate's teeth had penetrated.

An additional concern in a fire is that a number of truss components are affected simultaneously, making it difficult to predict the type of failure that might occur. According to Professor Alexander Chajes of the University of Massachusetts at Amherst's Civil Engineering Department, how the roof fails depends on whether the

cause of failure is a weakened chord or web member and which way the failed member is oriented in the overall truss configuration.

On the fireground, other factors compound the danger posed by a burning truss. The weight of the firefighters themselves on a roof adds stress to an already weakened structure. And when crews vent roofs or open up ceilings to search for fire spread, they inadvertently impair the interconnected building components that keep the truss stable.

### **The Lake Worth fire**

In the fire at Lake Worth, the roof in the main portion of the church was supported by scissor trusses made up of 2-by-4-inch and 2-by-6-inch wood chords. A layer of gypsum wallboard attached to the lower chords formed a ceiling between the occupied space and the truss space. At its peak, the roof, which consisted of a layer of asphalt shingles over plywood, was approximately 20 feet (6 meters) high.

The one-story building measured approximately 60 feet by 120 feet (18 meters by 36 meters) and had a masonry block wall exterior. The oldest part of the building, a west side foyer, had been built some time before the main portion of the chapel, which was approximately 20 years old. The Fellowship Hall on the southeast corner was about 15 years old. The church had no suppression or detection systems.

At approximately 10:40 a.m. on Monday, February 15, 1999, the pastor was in the church when a teenager knocked on the front door to report a fire outside the back of the building on the east side. When the pastor went out back with him to look, the teenager said he'd called 911, and the pastor heard the sirens of the responding apparatus. At this point, the fire only involved the 6-by-6-foot (1.8-by-1.8-meter) shed, 10 feet (3 meters) from the building. However, wind blowing from the east to the west at approximately 30 miles per hour (48 kilometers per hour) pushed the flames toward the church.

The rear of the church abutted the town line between Lake Worth and Samson Park. A police officer on patrol in Samson Park saw the fire and reported it to his dispatcher, who, in turn, notified the Samson Park Fire Department. Because two separate fire departments received the reports, units were dispatched from six communities.

Meanwhile, the pastor went inside the church and opened the double doors on the north side, thinking the firefighters would use these doors to enter the building and fight the fire. In fact, they used the west door, which was further from the fire. When he met with the first-responding company and told firefighters where the fire was, he also told them that no one was inside.

By this time, the fire had spread to the church, and a crew from the Lake Worth engine, which was positioned at the front door, and a crew from the Samson Park engine, which was parked further away on the northwest corner of the building,

advanced 1 ¾ - inch handlines through the west door and down the right side of the church to fight the blaze. Unfortunately, however, the Samson Park engine's line didn't reach the fire and was never charged.

As the crews advanced to the rear of the building, they pulled down the ceilings, checking for fire extension. They saw that the fire was in the building's northeast corner.

At about the same time, a firefighter went onto the roof to evaluate conditions. He removed the tops of the turbine ventilators and reported that only lazy, wispy smoke was coming out, which the incident commander interpreted as proof that there was no fire in the attic.

Soon after, the engine from River Oaks arrived on the scene, and two firefighters, Collins and Dean, advanced a third handline into the building. At any given time, about five firefighters from River Oaks, Lake Worth, and Samson Park were operating inside the church.



Despite their efforts, the fire kept growing, and the incident commander ordered a ventilation hole cut in the roof. The aerial apparatus from the Saginaw Fire Department arrived and was positioned on the northwest corner of the building. Four firefighters climbed up to the roof and started cutting a hole with a power saw, but they had problems with

the saw and had to continue working with axes. Approximately 10 minutes after the initial call, the roof suddenly collapsed underneath them.

One of the men rode the roof down into the church, landing near the front of the building, and was able to scramble out. Another firefighter on the edge of the collapsed area hung on with his hands until a third firefighter reached over and pulled him back up. The collapse knocked the fourth man down, but he remained on top of the roof. When he regained his footing, he and the other two firefighters on the roof made their way back to the aerial platform.

Though all the rooftop firefighters were accounted for, an immediate head count indicated that two others were missing. Two appeared to have been found shortly afterward, when a firefighter opened a door connecting the church to the adjacent Fellowship Hall and found two uninjured firefighters trapped inside the church just

behind the door. All three went out through the Fellowship Hall just as the fire started to spread into it.

Unfortunately, a second count showed that three firefighters were still missing. At this point, the building was too well involved for firefighters to enter, so they directed master streams into the building to knock down the flames. When this had been done, crews made a hole in the exterior wall where they thought the missing firefighters were. Two—Collins and Sanders—were found near this hole, and the third, Dean, was found about 20 feet (6 meters) away. All three firefighters were removed from the building.

Investigators have determined that the fire was deliberately set. As of this writing, however, no suspects have been charged.

### **Risk management**

One of the troubling aspects of this fire, as well as those that occurred in Hackensack, Branford, and Chesapeake, is that firefighters put their own lives at risk in buildings known to have been evacuated.

According to NFPA statistics, 40 of the 91 firefighters who died in 1998 died on the fireground. This figure sends a message to firefighters that there's a real need to mitigate risk on the fireground.

According to NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, the incident commander is required to integrate risk management into the regular functions of incident command. He or she must thus limit aggressive firefighting to situations where lives are endangered and can possibly be saved, which means reducing risks to firefighters operating to protect property only. The standard goes so far as to say that no risk to firefighters' safety is acceptable when there's no possibility of saving lives or property.

The incident commander is also charged with evaluating the risk to members in terms of the purpose and potential results of their actions in each situation. Where the risk to firefighters is excessive, the standard calls for use of defensive operations only. And when fire involves a wood truss, the risk is compounded by the fact that flames may stay hidden inside the truss structure, taking firefighters by surprise when the roof or floor fails.

Unfortunately, firefighters continue to risk their lives unnecessarily, and not just at fires involving wood trusses. On January 1, 1995, four firefighters died in a fire in Seattle, Washington, when the floor of a building that appeared to be of heavy timber construction collapsed underneath them, dropping them into the flames. This section of the floor had been modified using 2-by-4-inch supports, which were destroyed before the fire weakened the heavy timber structural components. The collapse occurred 36 minutes into the fire. There were no civilians inside the building.

In another incident, a fire officer died when the floor collapsed and he fell into the basement of a corner store in Washington, D.C., on October 24, 1997. This tragedy occurred despite the fact that the fire happened very early in the morning, before the store had opened, and the store owner, who lived in the apartment above the store, told firefighters no one was inside. Firefighters had to force entry, and a number of crews tried to locate and suppress the blaze. The fire started in the basement, but crews couldn't get into it, either from the exterior or interior. Nonetheless, at least four crews continued to operate in the building above an uncontrolled fire until the floor failed.

It's vital that incident commanders placing firefighters in hazardous situations ask themselves one fundamental question: "What are we trying to accomplish?" If lives can be saved, then calculated risks may be taken. If the building and its contents are the only things in danger, the fireground strategy must take this into account. Incident commanders with qualms about taking a less aggressive approach should ask themselves whether they should put their firefighters at risk for a building owner who hasn't protected his or her property with a sprinkler system. Why risk irreplaceable lives to save replaceable property?

Two days after her husband's death in the Lake Worth church fire, Phillip Dean's wife gave birth to a baby boy, Elijah Phillip Dean, who, like the children of many firefighters killed each year, will grow up without his father's guidance. Hopefully, this child will come of age in a safer world because of the lessons learned in Lake Worth and at other similar tragedies.

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## **Wood Truss Collapse Fatality Reports**

Among NFPA's fire investigations reports are several detailing fires that involved wood truss roof collapses. Tragically, incident commanders aren't always aware that they're dealing with a truss roof fire until the structure fails. Smoke and flames can hide inside a truss, allowing fire to gain strength unseen.

All of these factors were present on July 1, 1988, in Hackensack, New Jersey, when an attic fire in an automobile dealership involved five bowstring trusses spaced 16 ft (4.9 m) apart and spanning 78 ft (23.7 m). According to NFPA's report, the collapse occurred 37 minutes after the first alarm, while firefighters were working on the roof and inside the building to save property, not lives. The roof failed and trapped five firefighters, two of whom were in a tool room. All five died. The building had no automatic sprinkler system.

On March 18, 1996, a fire in an occupied auto parts store in a strip mall in Chesapeake, Virginia, began in the space above the suspended ceiling inside the store after the bucket of a service truck struck the overhead electrical lines and quickly involved the wood trusses, which spanned 50 ft (15 m). First-arriving firefighters didn't notice heavy fire conditions inside the unsprinklered store, so they canceled the rest of the incoming units. Within minutes, however, they discovered

fire in the concealed space over their heads and requested additional units. Thirteen minutes later, the roof collapsed on two firefighters, who died of burns and smoke inhalation.

Later in 1996, a fire broke out at approximately 4:24 p.m. on Thanksgiving Day in an unoccupied carpet store in Branford, Connecticut. Upon arrival, firefighters reported light smoke at the front of the building near the eaves of the roof, which was composed of lightweight wood trusses spanning 60 ft (18 m). Approximately 17 minutes later, the wood truss roof collapsed, trapping two of the seven firefighters who had entered the building. One of the men died. The building had no detection or suppression systems.

**National Fire Protection Association  
Fire Investigations Department  
PO Box 9101  
1 Batterymarch Park  
Quincy, MA 02269 USA  
(617) 984-7263 (tel)  
(617) 984-7110 (fax)  
e-mail: [investigations@nfpa.org](mailto:investigations@nfpa.org)**

**[www.nfpa.org/Research/Fire\\_Investigation/fire\\_investigation.html](http://www.nfpa.org/Research/Fire_Investigation/fire_investigation.html)**

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**Special Data Package  
Fire Fighter Casualties as a Result  
of Roof or Floor Collapses**

**Fire Analysis and Research Division  
National Fire Protection Association  
1 Batterymarch Park, PO Box 9101  
Quincy, MA 02269-9101**

**March 1998**

**Special Data Package  
Fire Fighter Casualties as a Result of Roof or  
Floor Collapses in Wood-Frame Buildings**

**Fire Analysis and Research Division  
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Quincy, MA 02269-9101**

**March 1998**

## **Fire Fighter Casualties as a Result of Roof or Floor Collapses in Wood-Frame Buildings**

### **Case Histories**

These case histories were selected to show the range of fires investigated by or reported to NFPA. It should not be construed, however, that particular causes or other characteristics are represented in the same proportion as they occur in all fire-related incidents in the subject or property use classes.

Source: National Fire Protection Association  
Fire Analysis and Research Division

A special analysis was done in 1990 that looked at fire fighter deaths and injuries as a result of roof or floor collapses in wood-frame buildings. The analysis was updated in 1993 and 1995 to add an additional 29 incidents. The analysis was most recently updated in 1997 to include another two incidents, the first was in December of 1996, and the second occurred in February of 1997. The focus of the analysis was on, but not limited to, the performance of wood truss roofs. The fire incidents included in this analysis were selected from the NFPA's Fire Incident Data Organization (FIDO). The incidents selected had to meet certain criteria for inclusion in this report. They had to (1) occur in buildings of heavy timber, protected wood-frame or unprotected wood-frame construction, (2) involve a roof or floor collapse, (3) result in at least one fire fighter fatality or three fire fighter injuries, and (4) happen in 1980 or later. These criteria were established to make the size of the report manageable. The incidents may not be nationally representative.

Fires involving truss roof collapses, roof collapses and floor collapses are identified in our incident data base by the use of special FIDO code words. The type of building construction can be identified by using codes in NFPA 901, *Uniform Coding for Fire Protection*.

The attached narratives provide the following information: type of building construction; events leading up to the collapse; fire fighter fatality and injury information; and direct property damage incurred in the fire. Although not specifically requested, the narratives also cite the cause and origin of the fire and include detection and suppression information.

In the original analysis, there was a total of 38 fire incidents identified in FIDO which fit the requirements previously mentioned. Of these incidents, 24 mentioned roof collapse and 18 mentioned floor collapse. There was an overlap because some fires experienced both a roof and floor collapse. Ten wall collapses and seven ceiling collapses were also mentioned in these incidents but there may be more in the data base. In the 29 incidents added to this report in 1993 and 1995, 22 involved roof collapses and 11 involved floor collapses. Again, there was some overlap as both could have occurred in a single incident. In the two incidents from 1996 and 1997, both were keyworded as roof and floor collapses.

This report is divided into two sections. The first deals with incidents where fire fighter fatalities and injuries were the direct result of a collapse. The second section consists of all other incidents where a floor or roof collapse occurred where the cause of the injuries were either unknown or not related to the collapse. While the latter section might seem irrelevant, there may be some usefulness in comparing the events leading up to collapse injuries vs. non-collapse injuries.

## **Part I.**

### **February 1997, California Single-Family Dwelling**

A fire was detected, in a single-family dwelling by a neighbor who called 911. The residence was a two-story, wood-frame structure, with wood-joint floor framing, and a wood roof deck with asphalt shingles. The residence had been remodeled in the early 1950's, therefore, was not supported to today's codes/standards.

An electric blanket which smoldered for approximately 3-4 hours, was reported to be the cause of the fire. Two firefighters and a civilian were killed, while a third firefighter was severely burned and injured. While putting out the fire on the first floor, the second story addition collapsed without warning.

The estimated loss to the structure and contents was \$185,000. There were no fire protection systems in the dwelling.

### **December 1996, Georgia Apartment Building**

One fire fighter was killed and six were injured at a fire occurring in an apartment building. A tenant detected the fire and notified the fire department via telephone. The fire was reported to have been caused by someone trying to thaw water pipes by using a lighter and candles. The fire originated in a basement storage room in the building which contained 12 apartment units.

The fire apparently spread so quickly that the building collapsed trapping a fire fighter.

Smoke detectors were present and did operate. Estimated property loss was not reported.

### **February 1994, Michigan Single-Family Dwelling**

Occupants who escaped from a two-story dwelling called 911 from a neighbor's house to alert the fire department. The dwelling was an unprotected, wood-frame structure with wood-joint flooring. The roof was wood sheeting and asphalt shingles. Approximately one-half hour passed between ignition of the fire and detection. The fire was incendiary and started in the basement.

The dimensions of the dwelling were 26 feet by 34 feet. The majority of the first-level floor collapsed into the basement. One fire fighter died when the floor collapsed underneath him causing him to fall into the basement. It is believed that

this fire fighter was the lead man in a three-man fire fighting team that was advancing a charged hose into the dwelling. The team was in the area of the basement staircase when the floor began to collapse. Two fire fighters escaped to safety. Two fire fighters were injured at the scene. One fire fighter sustained minor burns while attempting to rescue the fire fighter. Another fire fighter experienced minor frostbite.

There were no suppression systems present and the presence of detection equipment was not known. The direct property damage was estimated at \$131,800.

### **April 1993, Arkansas Single-Family Dwelling**

A fire in a single-family dwelling was discovered by a neighbor who called 911. There was no one in the house at the time of the fire. The structure was a four-room, wood-frame house with wood joist flooring and a wood roof deck with asphalt shingles. Electricity to the house was supplied by a temporary meter connected to an extension cord running into the attic of the house. The fire was caused by a short in the extension cord.

Two fire fighters entered the dwelling through the front door and were several feet inside when the back porch roof collapsed, causing fire to roll to the front of the house. Both fire fighters were knocked down by the sudden intensity of the fire due to the collapse and became disoriented. One fire fighter was rescued after being exposed to intense heat for about one minute. The other fire fighter had crawled into an adjoining room, thinking he was heading toward the door. It took fire fighters two to three minutes to find him and pull him out. Both trapped fire fighters received severe burns and three other fire fighters received burn and smoke inhalation injuries during rescue attempts.

Property damage was estimated at \$10,000. There were no detection or suppression systems in the dwelling.

### **December 1992, Texas Apartment Building**

A 328-unit apartment building was the scene of a \$1.2 million fire. An occupant of a third-floor apartment was lighting a fire in the fireplace. He had used a large amount of newspaper to start the fire and then left the room. When he returned, an overstuffed chair located two feet from the fireplace was on fire. The occupant tried to put the fire out but was unsuccessful and began to notify other occupants of the

situation. The occupant did not notify the fire department right away, resulting in a 10-minute delay as he attempted to extinguish the fire.

The building was wood frame with brick veneer. The roof was wood with asphalt shingles. When fire fighters arrived at the scene, fire was visible through the roof. Fire damaged eight of the third floor units. Heat, smoke and water caused damage to several units on the second and third floors.

Four fire fighters were injured at the scene. Three of the injuries occurred when the third floor collapsed into the second floor. The three fire fighters had entered the room of origin after the fire was extinguished to perform overhaul operations. It is believed that water, debris from the roof trusses, and roof material created an excessive load on the floor, causing failure and collapse of the floor joist.

The building was not equipped with an automatic suppression system. There were smoke detectors in each apartment and they operated. Property loss was estimated at \$1.2 million.

### **October 1992, Pennsylvania Vacant Manufacturing and Storage Mill Complex**

A passerby dialed 911 to notify the fire department of a fire in a vacant mill complex. The 250 by 500-foot complex was constructed of heavy timber with steel beams. The walls were brick, the floor framing was heavy timber, and the roof framing and deck were wood with a built-up covering. The building was four to five stories in height.

Nine fire fighters were injured. Floor collapse was cited as the cause of injury in two cases. No specifics were given as to what led up to the collapse or the injuries. According to news accounts, the third floor collapsed causing two fire fighters to fall to the first floor.

Property damage was estimated at \$2,000,000. The complex was not equipped with a detection or suppression system.

### **December 1992, Tennessee Church**

A church fire resulted in the deaths of two fire fighters. The church was a 92 foot by 40 foot, wood-frame structure, with a brick exterior and a concrete floor. The roof was two inch by four inch wood trusses, with a wood roof deck covered with asphalt shingles.

A burglar set fire to a sofa in the pastor's study to conceal his crime. The fire spread and entered the attic, rolled beneath the roof and started to burn through. The wood trusses were weakened and the entire roof collapsed. Several fire fighters were inside the church when the roof collapsed. All but two made it out safely. The two fire fighters who were trapped by the collapsed roof succumbed to burn injuries. They sustained second and third degree burns over 75% of their bodies.

### **February 1992, Maryland Apartment Building**

A fire occurred in a first-floor unit of a two-story, four-unit apartment building of wood-frame construction. An occupant attempted to extinguish a fire in a sofa. When this attempt failed, the occupant called 911. The probable cause of the fire was children playing with matches. As the residents fled their apartment, they left the door open which contributed to rapid fire spread. The fire spread throughout the structure, eventually causing the second-floor apartment to collapse into the first floor, followed by collapse of the first floor into the basement.

It was reported that six fire fighters received injuries, due mostly to the floor's collapse. It was reported that these injuries included various strains, sprains and punctures. No other details of the injuries were provided. It was not known what the fire fighters were doing when the collapse occurred.

The property loss was estimated at \$120,000. The building was not equipped with suppression equipment but did have operating smoke detectors.

The estimated property damage was \$275,000. There were no fire protection systems.

### **December 1991, Oregon Single-Family Dwelling**

A fire in a single-family dwelling of unprotected, wood-frame construction resulted in six fire fighter injuries. The cause of the fire was undetermined, but it started in either the basement or the kitchen. There was a hole burned through the kitchen floor that went down to the basement. The partition next to the hole had been completely consumed by the fire, which provided direct flame impingement up into the attic area.

Two of the fire fighters injured were inside the house carrying out suppression activities when an area of the roof collapsed. A third fire fighter fell through the

roof during overhaul operations and another fire fighter stepped in a hole in the roof during ventilation activities. A fifth fire fighter was hit by a charged hose line while trying to advance it. The last fire fighter was pulling down the ceiling when debris fell in his eye.

There were no other details regarding the events that led up to the collapse.

The property loss was estimated at \$30,000. There were no suppression systems. It was not known if the home had smoke detectors.

### **September 1991, California Office Building**

An electrical short in the central processing unit of a personal computer (PC) caused a fire in an office building which was closed for the weekend. The two-story office building was constructed of heavy timber, with wood joist floor framing and a wood-frame roof with a built-up roof deck and rolled asphalt roof covering.

The section above the area of origin collapsed roughly one hour into the fire. Three of the fire fighters were carrying out suppression activities on the second floor when the floor beneath them gave way. Two fire fighters were pinned beneath rubble after the collapse and received multiple burn injuries. The third fire fighter's face mask came off as he fell through the floor, resulting in minor smoke inhalation injuries. He was not trapped by debris and was able to summon help.

A fourth fire fighter sustained injuries from smoke inhalation and heat exhaustion when the hose line to his mask became tangled while he was helping to rescue his trapped co-workers. A fifth fire fighter suffered from smoke inhalation and heat exhaustion while ventilating the roof when, without warning, his Self Contained Breathing Apparatus (SCBA) ran out of air.

There were no fire protection systems in the building. The property loss was estimated at \$3,750,000.

### **February 1991, Massachusetts Single-Family Dwelling**

A fire in a single-family dwelling was caused by some sort of electrical arcing which ignited wood framing. The dwelling was a wood-frame, 1-1/2-story structure with wood and brick walls and wood floor framing.

The fire originated near an electrical panel in the basement of the home. At some point in the fire, a floor collapsed and resulted in one fire fighter injury. There were no specifics on what led up to the collapse or the injury. There were two other fire fighter injuries where the circumstances surrounding the injuries were unknown. The natures of these injuries were overexertion and smoke inhalation.

There was no suppression system in the home, but there was a working smoke detector in the room of fire origin. There was no one home at the time of the fire. Estimated damage to the home was not reported.

### **January 1991, California Commercial Mini-Mall**

One fire fighter was killed and six were injured at a fire in a commercial strip mini-mall. The mall was closed at the time. A passerby detected the fire and called the fire department. At some point in the fire, a decorative facade and a section of the roof collapsed into a second-floor walkway, trapping fire fighters. All but one fire fighter were able to free themselves from the debris. The fire fighter who was unable to extricate himself succumbed to injuries sustained in the collapse. The nature and severity of the non-fatal injuries were not reported.

The mall was ordinary wood-frame construction, with wood joist floor framing and a non-rated, wood-truss roof. The exterior was stucco. The property damage was estimated at \$1,500,000. There were no fire protection systems in the building.

### **January 1991, Washington Vacant Warehouse**

During a vacant warehouse fire, a section of the wall and roof fell outward, trapping three fire fighters. When the collapse occurred, fire fighters were extending a hose line close to the building. One fire fighter was able to free himself and assisted a second fire fighter out from the debris. In order to free the remaining fire fighter, the collapsed roof had to be lifted and rescuers had to saw through wooden members to get to him.

It was not clear how the other two fire fighters received their injuries. The nature of the five injuries was as follows: two fire fighters suffered smoke inhalation; one fire fighter had a bruised knee; one fire officer broke his ankle, sustained a compression fracture of the spine, and received burns; and another fire officer

received bruises, suffered from smoke inhalation and subsequently had a heart attack.

The one-story warehouse of protected ordinary construction was 130 feet by 54 feet. Construction characteristics of the roof were not reported.

The fire was incendiary in origin.

### **February 1990, Oregon Cardboard Box Manufacturing Plant**

A fire in a cardboard box manufacturing facility occurred when accumulated paper dust at the bow-truss level of the roof was ignited by an overhead natural-gas space heater. The building was a one-story (33 feet in height) wood-frame structure, with concrete walls. The roof consisted of 2" by 10" stringers supported by hangers from bowstring trusses. The facility was closed for the weekend.

Roughly 20 minutes into the fire, two trusses collapsed, followed by the failure of an additional 80 feet of trusses which caused a general roof collapse. Nine fire fighters were injured, four due to the collapse of the roof. Three others were injured in falls, one received a puncture wound, and the last suffered smoke inhalation. There were no details on the events leading up to these injuries.

The facility did have wet-type sprinklers with a water flow alarm, but the sprinkler heads were painted and covered with paper dust. The poor condition of the heads delayed operation of the sprinkler system. During this delay, the fire grew and overpowered the system. The fire sprinkler flow alarm was received by a central monitoring station.

Most of the \$12,000,000 damage to the structure was caused by the roof collapse.

### **January 1990, Pennsylvania Single-Family Dwelling**

A living-room television set was reported as the probable cause of a fire in a single-family dwelling. None of the occupants were home at the time. Five fire fighters were injured during the incident. The fire fighters were standing under a porch roof putting out hot spots in the interior of the structure, when the roof collapsed on them. Specifics were not given on the nature or extent of the injuries.

The dwelling was a two-story, wood-frame structure, with wood-joint floor framing and a wood roof deck covered with asphalt shingles. The loss to the structure and contents was \$30,000. There were no fire protection systems in the dwelling.

### **December 1989, Illinois Single-Family Dwelling**

Fire fighters entered the first floor of a burning single-family dwelling. They noticed the floor was getting hot and observed flames coming from the floor heater vents. At this time, they were ordered to leave the building and as fire fighters were crawling toward the front door, the foyer floor collapsed. One fire fighter fell into the basement where he received fatal burns. Another was injured but avoided death by hanging on to some flooring until he was rescued by co-workers. A third fire fighter was injured, but no other information was given on the circumstances.

The home was of brick and wood construction and was under renovation. It was a two-story unprotected wood-frame structure approximately 69 feet in length by 35 feet wide. The floor framing was wood joist.

The fire started in the basement, but the cause was unknown. It was determined that the avenue of smoke travel was an opening in construction. There were no automatic detection or automatic sprinkler systems present. A neighbor notified the fire department.

No other information regarding flame spread and construction of the building was reported.

### **September 1989, Maryland Dwelling Under Construction**

A vacant, two-story wood-frame house under construction was destroyed by a fire causing \$150,000 in damage. It was determined that this fire was deliberately set.

Seven fire fighters were injured when a second floor wall and outside deck collapsed onto a first floor deck. Two fire fighters were standing on the second story deck and five were on the first floor deck when the collapse occurred. No other information about the construction of the dwelling or fire spread was provided.

**July 1989, Massachusetts**  
**Single-Family Dwelling**

Three fire fighters were injured while battling a single-family home fire. They were standing on the porch roof when it suddenly collapsed, sending them 10 feet to the ground.

The fire was determined to be suspicious and it originated in a lounge area. The form of material first ignited was the interior wall covering.

Fire caused \$100,000 damage to this 2-story unprotected wood-frame dwelling. No information was given as to how the fire spread or what caused the roof to collapse.

The roof framing and deck were wood and covered with asphalt shingles. The floor framing was wood joist.

It was not reported if the house was occupied when the fire broke out. There were no automatic detection or suppression systems present.

**March 1989, Indiana**  
**Single-Family Dwelling**

An accidental fire caused an estimated \$55,000 in total property damage to a single-family, one-story home. The house was constructed of wood frame and truss with a stone veneer. The cause of the fire was undetermined.

Six fire fighters were injured when the roof collapsed. Two fire fighters were ventilating the roof, two were inside the house for search and rescue and the last two were on an attack line when the collapse occurred. A seventh fire fighter was injured outside the home when he received burns on his face from falling hot tar.

The flames traveled through a concealed ceiling or attic space and may have been fed when a door of an attached garage was opened. A civilian heard dogs barking in the garage and opened the door to let them out.

There was no one home when the fire broke out. The dwelling was not equipped with detectors or sprinklers.

No other information on fire spread with relation to the construction of the dwelling was reported.

## **January 1989, California Single-Family Dwelling**

Five fire fighters were injured while extinguishing a fire at a two-story, multi-gabled Victorian-style home. An electrical short caused the fire which began in the attic area. Residents noted that there had been electrical problems prior to the fire.

While the fire progressed and spread throughout the attic, a portion of the ceiling collapsed in a second-floor room. The entire room became involved which caused the window to fail. The fire then spread to the exterior of the structure. Some time later, four fire fighters were ventilating the roof when it collapsed. Three of the fire fighters made it safely to an aerial ladder. The last fire fighter slid to the gabled area, but fell as he reached for a ladder that was being directed towards him. Also, a portion of the collapsed roof struck the helmet of a company officer who was directing interior operations. The exact causes of three of the fire fighter injuries were not clear. In all, three fire fighters received facial burns, one received neck injuries, and the last received burns to his hands.

The roof of the house was lightweight construction with two by four inch rafters and no ridge board. The roof was already weakened by the fire prior to the fire department's arrival. The dollar loss was \$128,000.

There was no information provided on fire protection systems.

## **January 1989, Wyoming Church**

A church fire, caused by a malfunctioning furnace, resulted in one fire fighter fatality and four fire fighter injuries. The fire fighter died from injuries sustained when the roof he was ventilating collapsed. At least one fire fighter injury was the result of falling from the roof as it collapsed. The activities and locations of the three remaining injured fire fighters were not reported.

The church was of wood-frame construction with wood walls, wood roof framing and a wood roof deck. The floor frame was concrete and there was no basement. The roof was covered with asphalt shingles. It was reported that the roof structure was complex and was actually several roofs connected together using normal construction practices. This allowed several avenues of fire spread beyond what the average roof permits. Although not specifically identified as such, a section of the roof may have been truss.

The roof collapse was nearly total and a good portion of the exterior walls collapsed. The estimated loss for this fire was \$1,250,000.

There were no automatic detector or sprinkler systems present.

**September 1988, Michigan  
Department Store**

A two-story clothing and shoe store was a protected wood-frame structure with a ground floor area of 3,000 square feet. The walls were brick, the floor framing was wood joist and the roof deck and framing were wood. The building had a flat, built-up, covered roof similar to those of adjacent buildings.

The fire, of electrical origin, was believed to have started in a concealed space between the first floor ceiling and the second floor. Structure and content loss was estimated at \$150,000.

During the course of the fire fighting activities two fire fighters were injured and one was killed when the second floor collapsed onto the first floor causing the first floor to collapse into the basement. The fire fighter who was killed was pinned between a structural beam and a display case and died from crushing injuries and asphyxia. Two others escaped fatal injury in the collapse. A fourth fire fighter sustained injuries during the early stages of the fire when dense smoke contributed to his fall down a flight of stairs.

The fire was first noticed at the ceiling level by a store clerk. When the fire department arrived, they were unable to enter the building due to intense heat and smoke. As the fire was brought under control, they cautiously advanced into the store. The collapse occurred shortly thereafter.

In addition to the loss of the building and contents, adjacent structures also suffered damage.

**July 1988, Indiana  
Single-Family Dwelling**

An incendiary single-family dwelling fire resulted in three fire fighter injuries and \$45,000 in direct property damage. The fire spread throughout the hallway, where it had been set, and into a bedroom.

When the fire department arrived, there was heavy smoke issuing from the dwelling. Two fire fighters proceeded into the home and were fighting the fire with hose lines when the floor collapsed. One of the fire fighters fell through into the basement and sustained knee injuries while the other fought off flames to protect the injured fire fighter. Because his air supply was running low, the fire fighter

who did not fall through the floor suffered mild smoke inhalation. A third fire fighter was also treated for mild smoke inhalation when he assisted in removing the injured fire fighter from the basement; he was not equipped with SCBA.

The dwelling was a wood-frame structure with wood joist floor framing and an asphalt shingle roof. It was not reported if the roof was wood truss. The owner was not home when the fire occurred.

No other flame spread or construction information was reported. There were no automatic detection or automatic sprinkler systems present.

### **February 1988, Indiana Single-Family Dwelling**

An electrical short resulting from a nail striking an aluminum wire caused a fire in a single-family dwelling. The dwelling was a wood-frame structure with stone veneer walls, wood joist floor framing, wood roof framing and a wood roof deck. Asphalt shingles covered the roof. It was not reported if the roof was wood truss.

Two fire fighters making their way through the kitchen were searching for the location of the fire when the floor collapsed suddenly, sending one fire fighter into the basement. His body was recovered one hour after rescue attempts were initiated. He died of smoke inhalation. The second fire fighter had been standing on the other side of the kitchen table when the collapse occurred. He was able to back out of the structure.

The fire was started by wiring in a furnace room. An interior decorating business was operating in the basement next to the furnace room and three occupants were present. The door to the furnace room was closed so no one noticed the fire for about ten minutes.

The estimated property damage was \$245,000. The house was totally destroyed and had to be demolished as a result.

Heavy smoke on all floors of the house hampered fire fighting efforts. The fire moved throughout the structure via heating duct work.

### **January 1988, Massachusetts Church**

Seven fire fighters were injured at this church fire. A deteriorated BX cable located in the interior wall space between the second and third floor overheated and ignited

the wooden structure. The four-story church was constructed of heavy timber with brick walls and a slate roof. The roof framing was wood and was not identified as truss.

One fire fighter injured his back when the roof caved in. Six other fire fighters sustained various injuries, including falling on ice, but none of them were directly linked to the roof collapse. Specifics were not reported on how or where the fire fighters were injured.

Details on the spread of the fire were not reported. The estimated total fire loss was \$1.65 million. The church was not equipped with an automatic sprinkler system. There was partial coverage of smoke and heat detectors but not enough to detect the fire. An employee of a day care center in the church notified the fire department.

### **Manitoba 1988 Hospital**

Two of 11 fire fighter injuries occurred when an eave in the front of the building collapsed during the fire. One injured fire fighter was on a ladder which was leaning against the eave, and the other was holding the ladder. When the eave collapsed, the ladder fell forward and hit a wall, causing the fire fighter on the ladder to crack and bruise his ribs. The fire fighter at the base of the ladder pulled muscles in his shoulder when the ladder twisted.

Nine others were injured, but the circumstances surrounding their injuries were not reported.

The accidental fire was caused by an electrical or static spark igniting oxygen in an oxygen storage room. The structure was wood-frame with a ground floor area of 15,000 square feet. The one-story, 16-bed hospital had wood walls, concrete slab floor and an asphalt shingle roof covering. It was not reported if the roof was wood truss.

The total estimated loss was \$3 million.

The hospital did not have a sprinkler system, but they did have standpipes. Smoke and heat detectors were present and operated properly. The patients and staff were safely evacuated.

The fire spread from the oxygen supply room into the attic possibly through an exhaust fan. The roof over the supply room located in the rear of the building was burning, and fire spread from there to the front portion. At this time the eaves at the end of the building collapsed. Sections of roof over the administration area also collapsed.

## **December 1987, Maine Five-Unit Apartment Building**

Careless smoking led to a fire which resulted in three fire fighter injuries and an estimated loss of \$100,000. The two-and-a-half story apartment building was of wood frame, balloon construction. The floor framing was wood joist and the roof framing was also wood. It was not reported if the roof was wood truss. Asphalt shingles covered the roof.

Two tenants who lived on the second floor of the building came home intoxicated. One went to bed while the other sat on the sofa in the living room and lit a cigarette. He dropped the cigarette onto the sofa, igniting it. The fire spread from the living room to the kitchen and bedroom. There was an open door in the bedroom which led out to the porch. Fire spread up to and throughout the third floor.

One fire fighter was injured when he tried to break open a window on the third floor and the roof and ceiling collapsed on him. Another fire fighter sustained smoke inhalation injuries while attempting to rescue the fire fighter pinned under the rubble. The third fire fighter experienced second degree burns to his leg, but how he received his injuries was not reported.

The apartment building was not equipped with automatic detection or automatic suppression equipment.

## **October 1987, Ohio Tool and Die Manufacturing Plant**

Six fire investigators (three from the fire department, two from the police department and one from the county sheriff's office) were injured at a manufacturing plant fire. After the fire was deemed under control, then investigators entered the building and were searching through debris when a brick wall collapsed. One investigator was completely covered by rubble and sustained a fractured hip, a broken leg and knee damage. The other investigators received bruises and abrasions from falling debris.

The three-story manufacturing plant was a heavy timber structure with brick and wood walls, heavy timber floor framing and an asphalt shingle roof covering. The roof was not identified as wood truss. The wall that collapsed extended from the second floor to the third floor.

The fire started on the second floor in the center of the building. The cause was undetermined. The fire vented out the windows in the rear of the building, ignited the roof and spread to the first floor.

The tool and die plant was not equipped with automatic detection or automatic suppression equipment.

### **March 1987, Michigan Abandoned Building**

Two fire fighters were killed in a paper and supply company when a wall and floor collapsed during a fire. A fire wall collapsed first which caused the floors under the fire fighters to collapse. The fire fighters fell from the third to the first floor and were buried under debris. The complex which housed the paper and supply company was actually 21 adjoining buildings and was primarily ordinary construction. Some areas more closely resembled heavy timber or mill construction. All but three of these buildings were one- or two-stories in height.

The fire started in an adjacent abandoned warehouse and later spread to the paper and supply company complex. One additional fire fighter died when he was driven from a window in the warehouse to escape intense fire conditions.

The initial fire was deliberately set by a vagrant. Property damage estimates were not reported.

### **December 1986, New York Single-Family Dwelling**

An accidental fire, possibly electrical in nature, destroyed a single-family home resulting in \$1 million in damage. The fire started in the rear of a 30-foot one-story wing of the home. The house was a two-story (except for the wing) wood-frame structure with an asphalt shingle roof. It was not reported if the roof was wood truss.

Eight fire fighters suffered minor injuries. Five of these fire fighters received minor strains and burns when a section of a ceiling collapsed on them.

The fire spread from the rear wing up a staircase to the second floor of the main section of the home to the beams and insulation under the roof. The entire roof was involved and a section collapsed, then fell in to the first floor.

This house was not equipped with automatic detection or automatic suppression equipment.

### **June 1986, South Carolina Church**

An estimated loss of \$310,000 was the result of a fire in a two-story church. The church, resembling a "T" shape, was a brick veneer building with a high ceiling sanctuary in front. The roof was wood truss. There were classrooms across the rear section of the church.

Lightning started the fire in the attic area of the classroom section. Fire fighters' suppression efforts were hindered by lack of access to the attic and the tongue and groove slatted ceiling construction.

Fire fighters were ordered out of the building when pieces of wet sheet rock from the ceiling in the sanctuary started falling. Just as evacuation was ordered, the roof and ceiling collapsed. A ladder, which had been used to reach the ceiling, helped to hold up a section of the ceiling, which enabled several fire fighters to escape without serious injury. One fire fighter, who was on the ladder at the time, was pinned to the ladder by sections of the fallen ceiling and roof. After being freed he was pronounced dead at the local hospital of smoke inhalation and asphyxia. Two other fire fighters also sustained smoke inhalation injuries but survived. Investigators determined that the end truss of the sanctuary had failed, resulting in the collapse of the ceiling and roof.

There were no automatic detection or automatic suppression systems present in the church.

### **December 1985, Florida Vacant Dwelling**

A vacant dwelling was donated to the fire department for training purposes. A live training fire was set in a second-floor room using burning paper. Two fire fighters and an instructor were advancing a line up a stairwell while two other fire fighters and an instructor stayed on the first floor.

The first-floor instructor was told of the collapse by fire fighters outside of the structure. He ordered the two student fire fighters out of the building and proceeded up the stairs to warn the three remaining fire fighters. As they began backing down the stairway, a large section of the burning ceiling collapsed,

temporarily trapping them. Another instructor extinguished the fire in the immediate area enabling all four fire fighters to escape.

The two instructors and one of the students received first-and second-degree burns to their arms and face. The remaining student fire fighter suffered a sprained knee with torn cartilage.

The building was a two-story wood-frame structure with wood joist floor framing and asphalt shingle roof covering. It was not reported if the roof was wood truss.

Property damage estimates were not reported.

Flame spread information or details leading up to the collapse also were not reported.

### **December 1983, New York Restaurant and Bar**

Fire caused an estimated \$90,000 in damage to a building which housed a combination bar and restaurant on the first floor and three apartment units on the second floor. The fire started in a waste basket, spread up and along the walls and floor and up a stairway to the second floor. After ashtrays were carelessly emptied into the waste basket, the heat from smoldering cigarettes ignited papers and trash.

The two-story building was a wood-frame structure, with wood joist floor framing and an asphalt shingle roof covering. It was not reported if the roof was wood truss. The bar was knotty pine boards stained with lacquer.

One fire fighter was killed. He entered the building looking for possible fire victims, fell through the floor and became trapped between the beams that held up the floor. Cause of death was inhalation of products of combustion. He had been trapped between the beams for about an hour then he fell through to the basement. Rescue attempts were very difficult because of the small space in which fire fighters had to work.

One of the injured fire fighters received cuts and the other was hit in the head with a fire hose.

No other information regarding flame spread or construction type was reported. There was no automatic detection or automatic suppression equipment present.

**August 1981, Texas**  
**Single-Family Dwelling**

Some type of electrical malfunction caused a \$1 million fire in a 23-room, single-family dwelling. The fire spread from the southern portion of the house to the north and was well involved when the fire department arrived. Fire was coming out of the windows and showing through the roof in the southern section of the building.

The two-story house was constructed of wood joist floor framing, brick walls, a wood roof deck and had wood shingles covering the roof. It was not reported if the roof was wood truss. An open attic contributed to the spread of the fire. The house was under construction, but nearly complete, when the fire broke out.

Three fire fighters entered the building for a search-and-rescue operation unaware that the dwelling was vacant. One fire fighter left because he was running low on air and barely escaped the worsening fire conditions. Two others were trapped in the building because a section of the roof had collapsed blocking their escape route. Both were overcome by smoke and died.

The house was equipped with an operating fire alarm system which was monitored by a private security company. There was no automatic suppression equipment present.

## **Part II.**

### **September 1994, Massachusetts Supermarket**

A neighbor telephoned the fire department to notify them of a grocery store fire. The fire originated in a dumpster in the rear of the store and spread to an overhang of the building. The exterior of the unprotected, wood-frame building was sheets of plywood. The store's dimensions were 100 feet by 50 feet. The building was closed for the night.

Five fire fighters were injured in the fire which was determined to be incendiary. A suspect was arrested and confessed to setting the fire. Fire fighters were ordered off the roof early in the fire before the collapse occurred. Injuries were caused mostly by slipping, strains and smoke irritation. No other information was provided on what led up to the collapse.

The fire resulted in \$1 million in direct property damage. There was no suppression system. It was reported that the building was equipped with smoke detectors tied into central monitoring but the performance was not known.

### **July 1994, Virginia Church**

A passerby notified the fire department of a church fire by calling 911. During a thunderstorm, witnesses observed lightning strike the steeple of the church and travel down the roof line. The construction of the church was heavy timber with some steel supports. The walls were brick and the roof was tin. The dimensions of the two-story church were 150 feet by 135 feet.

There were no sprinklers in the church area. There was a limited system in the educational section only. There were fusible link doors which did activate. Three fire fighters received minor injuries, but the cause and nature of those injuries were not given. The fire resulted in \$7 million in direct property damage.

The sanctuary portion of the building was destroyed. The roof failed despite an aggressive interior attack by fire fighters. No other information was given on the roof collapse. The following factors contributed to fire travel: large open areas; hard to reach areas; lack of sprinkler systems and fire alarms; and the combustibles used in construction.

**July 1993, New Jersey  
Stores and apartments**

Hardwired smoke detectors alerted tenants to a fire that originated in a store in the same building as their apartments. Tenants notified the fire department via telephone. The fire was ruled accidental but the cause was undetermined. The protected, wood-frame building was three stories and consisted of a laundromat, a confectionery store and apartments. The building's dimensions were 63 feet by 80 feet. The walls were wood and brick and the roof was wood with asphalt shingles. The stores were closed for the night but the apartments were occupied.

A dozen fire fighters were injured from various causes. Five of the fire fighter injuries were strains and four were from falling (two off ladders, one on a wet surface, and one on stairs). The last three were contact injuries; one with heat, one with fire and one with glass. A partial roof collapse occurred but details of the collapse were not given. No property loss estimate was provided. There was no sprinkler system in the building, but fire extinguishers and fire walls were present.

**June 1993, Massachusetts  
Apartment Building**

A three-story, wood-frame tenement building with a flat roof and asphalt siding was the scene of a fire in which three civilians died and three fire fighters were injured. A passerby saw the fire and telephoned the police. The cause of the fire was undetermined.

The entire roof of the building, as well as the entire front third of the building from the second floor up, were totally consumed by the fire or collapsed into the first floor. The three fire fighters' injuries were reported as constriction of the throat after fire suppression; hit with a nozzle; and struck by debris from the roof. The injuries were not directly attributed to the roof collapse.

There were no sprinklers present and although smoke detectors were reported present, their performance was unknown. Estimated total dollar loss was \$150,000.

**May 1993, New Jersey  
Single-Family Dwelling**

Two civilians died and three were injured in a single-story house fire. The dwelling was protected wood-frame construction. The exact cause was not known. Seven fire fighters were injured and all injuries were attributed to contact with heat while searching for victims.

At some point in the fire, there was a roof collapse over the north portion of the structure. It was not clear how the collapse occurred, but fire fighter injuries were not related to the collapse. No property damage estimates were provided. There was no suppression system present. There was an operating detector but it was not in the location of fire origin.

### **July 1992, New Hampshire Barn/Cold Apple Storage**

Seven fire fighters were injured during overhaul operations at a incendiary orchard fire. They were treated for heat exhaustion and smoke inhalation.

The fire involved a barn, cold apple storage building, and a packing house with attached cold storage. The barn was a one-story wood frame structure which was located about 10 feet from the packing house. The packing house was two stories and constructed of block walls and a truss roof. A controlled atmosphere apple storage facility was directly in back of the packing house and was separated by a 15-foot wide alley. This building was also constructed of block walls.

Property damage was estimated at \$1.5 million. The buildings were a total loss.

### **April 1991, New York Single-Family Dwelling**

Five civilians died and six fire fighters were injured during a fire in a wood-frame dwelling. The fire started in the first-floor dining room and extended through open doorways to the foyer. The fire then spread vertically up the stairway and exposed the second floor, attic and roof. Eventually, the roof collapsed onto the top floor and porch, portions of the stairways collapsed, and there were partial ceiling collapses in various locations.

It was not known whether any of the injuries sustained by the fire fighters were related to collapses. The injuries were mainly strains and sprains. One fire fighter received burns to his neck. There was no dollar loss reported. There were no protection systems in the home.

## **January 1991, Pennsylvania Restaurant**

A malfunctioning gas-fueled furnace caused a fire in a restaurant. Three fire fighters were injured in the incident; two were hurt in falls and one pulled a muscle while dragging a hose.

The restaurant was a three-story, brick- and wood-frame building, with a flat wood roof covered with tar paper. The building sustained heavy fire damage when the second and third floors collapsed into the center of the building. The property damage was not reported. The only protection system present was a CO<sub>2</sub> system over the grill in the kitchen.

There were no details regarding the collapse of the floors.

## **November 1990, New York Garment Manufacturing Facility**

A fire in a seven-story garment manufacturing facility resulted in minor injuries to 16 fire fighters. There was no further information provided on these injuries. The origin of the fire was unknown.

The building was constructed of brick and heavy timber. The walls were brick with a plank-on-timber floor and roof. The entire main building collapsed into the basement, except for the facade. No dollar loss estimate was reported. There was some type of sprinkler system, but the type and coverage was unknown.

## **July 1990, Pennsylvania Single-Family Dwelling**

Six fire fighters were injured in a single-family dwelling fire. The dwelling was a one-story structure with a brick exterior. The walls were wood and the floor framing was wood joist. The joists were burned completely through.

The fire was reported to have started in the finished basement of the home. The cause of the fire was not determined. The fire department was notified by a neighbor. The floors of the dining room and living room collapsed at some point in the fire. The causes and types of the fire fighter injuries were not reported.

The property damage was estimated at \$115,000. There were no fire protection systems.

**April 1990, New Jersey  
Vacant Apartment Building**

Very little information was provided on an incendiary fire in a vacant six-family apartment building. The building was a three-story, wood frame structure. The building's dimensions were 45 feet by 25 feet.

A passerby notified the fire department. By the time the fire department arrived, there were flames showing on all floors of the building. Five fire fighters were injured in the fire, but there was no information on how the injuries occurred.

Property loss was estimated at \$100,00. There were no fire protection systems.

**February 1990, New Jersey  
Automobile Dealership**

A suspicious fire at an automobile dealership resulted in seven fire fighter injuries. Four of the fire fighters were injured when they slipped on ice, two were injured while pulling hoses, and one fire fighter's injuries were attributed to general fire conditions. No other details were given regarding those injuries.

The fire originated in a display area on the first floor of the two-story building. The dealership and offices were located in a brick-faced, wood-frame building, with a built-up roof covering. During the fire, the roof collapsed and pushed out part of a wall.

There was no other information concerning the collapse. Property damage was estimated at \$1,000,000. There were no fire protection systems.

**December 1989, Rhode Island  
Manufacturing Complex**

Five fire fighters were injured in a suspicious fire in a manufacturing complex. The causes of these injuries were not given, but they were reported as minor.

The fire involved a multi-occupancy manufacturing complex consisting of nine buildings. The building of origin was four stories in height; was heavy timber and mill construction, with brick walls, wood roof framing and deck; and had dimensions of 900 feet by 300 feet for a total square foot area of 270,000.

No information was provided on the collapse. Eight out of the nine buildings in the complex were destroyed, totaling \$17,000,000 in property damage. There was a sprinkler system throughout the complex, but for unknown reasons, it was inoperative at the time of the fire.

**December 1989, Maine  
Single-Family Dwelling**

The dwelling was a 2-and-a-half story wood-frame structure used as rental property. The roof covering was asphalt. The floor framing was wood joist and the roof framing was wood. The exact ignition sequence was unknown. Fire originated on the first floor and extended up to the second floor and attic. The third floor and roof collapsed onto the second floor.

Three civilians were killed and 11 fire fighters were injured in this fire. One fire fighter suffered smoke inhalation while the remaining ten received bruises, cuts, strains and pulls. It was not reported if any of these injuries were associated with the collapse since little information was given regarding fire fighter suppression activities. Locations and activities of fire fighters at the time of injury were not reported.

The total estimated loss was \$80,000 in direct property damage. There were three battery operated smoke detectors, but for unknown reasons, they did not operate. There were no automatic sprinkler systems present.

**December 1989, Texas  
Two-Family Dwelling - Duplex**

Two civilians died, one civilian was injured and four fighters were injured in this duplex fire. Total dollar loss was estimated at \$250,000.

The duplex was constructed of wood frame and brick veneer. The walls were wood, the floor framing was pre-fab two-inch by four-inch wood joist and the roof deck was four-foot by eight-foot plywood sections. The roof was not identified as wood truss. Asphalt shingles covered the roof.

Heat from an improperly installed flue pipe ignited wood framing. The fire moved into the space between first and second floor levels. The pre-fabricated floor joists allowed the fire to spread and grow in size. The fire moved upward by way of the chimney chase to an attic space and then spread throughout the attic. The joists between the first and second floor failed and fell down, spreading the fire to the first

floor level. The fire then spread upward from the first floor to the second floor through an open stairwell. The second level collapsed onto the first floor level.

Two civilians died of smoke inhalation and a third civilian suffered non-fatal injuries from smoke inhalation and burns. The four fire fighters sustained injuries, including cuts and sprains, during fire fighting activities. It was not reported if the fire fighter injuries were connected with the collapse of the second floor.

### **September 1989, Washington Vacant Warehouse**

An incendiary fire completely destroyed a vacant lumber warehouse which was constructed of heavy timber during the 1920s. This was a 100-foot by 200-foot, 1-story structure separated into four areas by fire walls and fire doors. The foundation of the building was pier and post.

Walls and sections of the roof collapsed about 20 minutes after the fire department arrived. These collapses did not directly contribute to the one fire fighter fatality and two injuries that occurred. The fire fighter death was caused by inhalation of products of combustion. One fire fighter was seriously injured from carbon monoxide poisoning, burn injuries and heat exhaustion, and the second fire fighter injury resulted from heat exhaustion alone.

The building itself was the primary source of fuel for the fire since there was not a considerable amount of material in the building. The fact that the fire was set in multiple areas hampered fire fighter efforts to locate and size up the fire. The entire building was involved within one hour and ten minutes of fire department notification.

The total loss was estimated at \$150,000.

### **July 1989, California Condominium Complex**

Eighteen fire fighters were injured while fighting a fire in a 20-unit condominium complex. The fire started with an appliance in the kitchen of one of the units. A passerby alerted the fire department. The injuries were listed as smoke inhalation and heat exhaustion, but no information was given regarding the cause of these injuries. Three civilians were also injured in the incident.

The fire spread both vertically and laterally throughout the condominium. At first signs of a roof collapse, fire fighters were ordered to evacuate the building. No details were provided on the collapse.

The structure was a three-story, wood-frame building, with a stucco exterior. The roof was some type of rolled composition material over a wood roof frame and deck. All of the air conditioning units were located on the roof, which added to the weight. The property loss was estimated at \$5,000,000.

The building was equipped with local pull stations in corridors and smoke detectors in each dwelling unit. There were no suppression systems. There were no draft stops in the roof or corridors, and walls and doors did not comply with the proper rating.

### **June 1989, New York Manufacturing Facility**

An occupant of a manufacturing facility notified the fire department of a fire in the building. The fire, which was caused by lightning, resulted in 13 fire fighter injuries. Three of the fire fighters and an assistant chief were assaulted by civilians at the scene while trying to restrain them from reentering the building. Nine other fire fighters sustained injuries during normal operations. The cause and severity of these injuries were not reported.

The 2-1/2-story building was used for light manufacturing and had been converted from an old lumber mill. The structure was wood frame, with a truss roof. The dimensions of the building were 300 feet by 200 feet, for 60,000 total square feet in area. There were approximately 15 shops in the building. The trusses failed at some point during the fire, causing the roof to collapse. No other information was provided on the collapse.

The property damage was estimated at \$3,250,000. There were no fire protection systems in the complex.

### **May 1989, Massachusetts Two-Family Dwelling**

Faulty wiring was the cause of a fire on the second floor of a two-family dwelling. The three-story house was a wood-frame structure of balloon construction, with wood joist floor framing. The type of roof framing was not identified.

About 45 minutes after the fire department arrived at the scene, the roof collapsed. Three civilians died in this fire. Fire fighters had to gain access through the second floor bedroom window where two of the victims were located. The stairs leading to the second floor were impassable. After the victims on the second floor were located, attempts were made to get to the victim on the third floor. Fire fighters had to back off due to intense heat. At the same time, the roof was collapsing so everyone was ordered out of the building.

After the fire was knocked down, fire fighters removed the body from the third floor. No other information regarding construction type of the dwelling or flame spread was reported. Six fire fighters and a police officer were injured. Locations and actions of those injured were not reported.

### **May 1989, Missouri Retail Hardware Store**

An accidental fire originating in the ceiling and attic area caused an estimated \$130,000 in property damage to this combination hardware store and one bedroom apartment. The 24-foot-high structure was constructed of wood walls, wood joist floor framing, wood roof framing, a wood roof deck and tin sheeting for the roof covering. The roof was not identified as wood truss. The building was 125 years old.

Heat from a fluorescent light fixture ballast ignited ceiling material. Fire spread through the attic area and propagated into attic structure members. The ceiling collapsed but did not cause the three fire fighter injuries that occurred. Two fire fighters suffered from smoke inhalation and one fell from the back of a pumper while removing equipment from the vehicle.

The store was closed and the owner, who resided in the apartment, escaped without injury. There were no automatic detection or automatic sprinkler systems present.

No further information concerning fire spread was given.

### **May 1989, Missouri Agricultural Supply Storage - Barn**

An accidental fire of undetermined cause resulted in an estimated \$40,000 in direct property damage to an agricultural storage barn.

The 2-story barn was a wood-frame, heavy timber structure. It was not reported if the roof was wood truss.

Six fire fighters sustained injuries during the fire. No injuries were connected with the collapse of the hay loft floor. Four fire fighters were outside of the structure operating hose lines when they suffered heat exhaustion. The remaining two fire fighters became dizzy and weak while transporting water to the fire.

Little was known about the spread of the fire. The barn was fully involved when the fire department arrived.

The barn was not equipped with any detection or suppression systems.

### **October 1988, Hawaii Condominium Complex**

A 45-unit condominium apartment complex was partially destroyed by a fire caused by the careless disposal of smoking materials. Only a few first floor units escaped fire damage. The result of the fire was an estimated \$5.5 million in property damage.

One of the occupants dumped his ashtray into a paper sack while the cigarettes were still smoldering and placed the sack near the patio. Tissues in the sack were ignited by the cigarettes and a light breeze blowing through the apartment fanned ignition. Fire spread sideways and upwards, catching the balconies of additional units and other parts of the building. Eventually, the fire spread to the roof and throughout the upper floors of the building, causing the upper floors to collapse. The collapsed floors spread the fire into the first floor units.

The three-story building was constructed of a wood frame, wood joist floor framing and a wood shake roof. It was not reported if the roof was wood truss. The building was not protected with an automatic suppression system and the smoke detectors did not operate because of missing batteries.

It was reported that four fire fighters were injured in the fire, but the details surrounding these injuries were not addressed.

### **July 1988, Nevada Restaurant**

Fire started in and spread throughout the attic area of a one-story restaurant. The cause was unknown but was possibly electrical in nature. It may have resulted from an electrical failure or an overheated circuit.

The one-story restaurant fire was determined to be electrical in origin. The fire started in and spread throughout the undivided attic. The attic collapsed into the

restaurant area and caused light fire damage to the contents of the building. The loss of the contents and structure was estimated at \$550,000.

Thirteen fire fighters were injured battling this fire - eight from smoke inhalation and heat exhaustion, and five from sprains and strains. These injuries may or may not have resulted from the collapse. Specifics on fire fighting operations and injuries were not reported.

Factors which may have contributed to the spread of the fire were the presence of an undivided attic area, tongue and groove paneling which hampered fire fighters from getting into the attic from the inside of the building and the absence of automatic sprinklers.

The restaurant was a wood-frame structure with stucco block partitions and a Spanish-style clay tile roof. It was not reported if the roof was wood truss.

### **June 1988, California Apartments Under Construction**

The accidental ignition of wooden structural members by flames from a plumber's torch was the probable cause of a fire that destroyed an apartment complex. The total dollar loss was estimated at \$10 million.

The wood-frame structure covered two square city blocks and was under construction when the fire occurred. The floor framing was wood joist and the roof framing was wood. The roof was not identified as wood truss. Reportedly, the roof, walls and floors collapsed. Four fire fighters were injured during unspecified suppression activities, but none of these was linked with structural collapses.

The fire quickly spread throughout the structure and started spot fires in nearby buildings and homes. The buildings were not equipped with automatic sprinkler systems.

### **May 1988, Michigan Manufacturing Complex**

Lightning struck a wire in a breaker panel at a manufacturing complex, resulting in a fire which eventually caused the roof towards the rear of the building to collapse. Not long after the fire department arrived, the collapse occurred and fire spread throughout the building in a matter of one minute. The fire fighters working inside the building escaped the collapse without injury.

Nine fire fighters suffered from smoke inhalation. Materials used for fiberglass manufacturing stored at this complex gave off a toxic chemical in the smoke which was absorbed through the skin of the fire fighters.

The property damage was estimated at \$3,000,000, and the building was a total loss. It was a one-story wood-framed pole building with a ground floor area of 50,000 square feet. The walls were metal, the floor was cement and the roof covering was asphalt shingle. The roof framing was wood, but it was not reported if it was a wood truss roof. The building was not equipped with automatic detection or suppression systems.

No other information concerning construction of the building or flame spread was given.

### **April 1988, Wisconsin Apartments and Stores**

A paint store fire was detected by a passerby, who notified the fire department. An explosion occurred, followed by a swiftly spreading fire and minutes later the collapse of the building. The cause of the fire was unknown.

One civilian and five fire fighters were injured.

The store was a wood-frame, 2-and-a-half story structure. The roof was wood framing, but it was not reported if it was wood truss. The direct property damage was estimated at \$1,132,000. The fire spread to nearby apartments, a tavern and a single-family dwelling.

Details of how the fire fighter injuries occurred were not reported. No other pertinent information was given.

### **March 1988, Illinois Multiple Building Warehouse Complex**

A night watchman and a patrolling police officer detected a fire at a chemical storage warehouse complex, and both contacted the fire department. It could not be determined how long the fire had been burning.

The buildings had brick walls and roofs made of plank boards on joists on wood truss. About 29 buildings were totally destroyed in the fire. Several buildings housed liquid and solid chemicals, including powdered phosphates, polypropylene glycol, ethylene glycol, hydrazine solution and sodium methyl ate.

The fire was incendiary. High winds caused the fire to spread very quickly from building to building. Roof and walls reportedly collapsed but it was not reported if these collapses were related to the injuries to four fire fighters who suffered from smoke inhalation. No other information was reported as to the location or activities of the injured fire fighters.

An estimated \$7.8 million dollars in direct property damage occurred. No other information concerning the construction of the building or fire spread was given.

Some of the buildings were equipped with an automatic sprinkler system, but several did not operate because the water had been shut off.

### **March 1988, Texas Apartments Under Construction**

Four apartment buildings were destroyed in an incendiary fire. A flammable liquid was poured throughout the bottom floor of one of the two-story buildings and ignited. The outside frame of the building was completed but had not been sheet rocked. The fire spread from this structure to adjacent buildings.

The apartment was constructed of wood walls, wood floor joists, and a wood roof covered with asphalt shingles. It was not reported if the roof was wood truss. Roof, wall, and floor collapses were reported, but fire spread information was not given.

Specific details regarding three fire fighter injuries which occurred some time during fire suppression activities were not reported.

The unfinished apartments were not furnished with smoke detectors or automatic sprinklers.

### **1988, Nova Scotia Business and Apartments**

Three separate buildings were completely destroyed in a fire which originated in a kitchen in a ground floor apartment of one of the buildings.

The fire was determined as accidental and possibly could have involved a pot of fat left on the stove.

The buildings were two-story, wood-frame structures with wood walls and wood joist floors. The roof framing and deck were wood and covered with asphalt shingles. It was not mentioned if the roof was wood truss. Three fire fighters were

injured from smoke inhalation and a fourth from frostbite. Reportedly, the roof, walls and floors collapsed but were not connected with any injuries. Specifics on the locations and activities of the injured fire fighters were not reported.

No automatic sprinkler systems or detection systems were present. No other fire spread or construction type information was provided.

### **December 1987, New Jersey Boardwalk Stores**

A suspicious fire broke out in a store located in the middle of a boardwalk. The store was a wood-frame structure of balloon construction. The fire spread to adjacent structures, in part because there were no fire stops in the block of stores. Only two of the buildings were of masonry construction. The rest were of balloon construction, built in the 1920s, which shared a common roof and floor. It was not reported if any of the buildings had wood truss roofs. All of the businesses were seasonal.

When the fire department arrived, they noticed fire rolling under the floor. Flame spread information was not reported but it was noted that the roof of the building of fire origin collapsed into the building.

Three fire fighters were injured, but specifics on the injuries were not provided.

The direct property damage was estimated at \$2.3 million.

### **October 1987, British Columbia Custom Lumber Cutting**

A passerby detected a fire in a sawmill involved in custom cutting of lumber. When the fire department arrived, the roof had already collapsed. The main mill was totally destroyed, but the surrounding stacks of lumber were not damaged. The fire started in an outside utility shed adjacent to the mill. The cause of the fire was undetermined.

The mill was a manufacturing plant for previously milled lumber and was 45 feet wide, 200 feet long and 20 feet high. It was a gable roof, wood-frame building with some laminated steel beams. The roof was trussed wooden rafters on wooden beams.

Three fire fighters suffered smoke inhalation and one sustained a knee injury. Specifics on these fire fighter injuries were not reported. Total dollar loss was estimated at \$1.9 million.

The mill was not equipped with automatic detection or automatic suppression equipment. Standpipes and portable fire extinguishers were present but not used.

### **September 1987, Connecticut Church**

A \$2 million church fire was attributed to an electrical short caused by a breakdown in the wiring system near the center of the attic. The fire ignited wood rafters spreading upward and engulfing the roof area. It was not specified if the roof was wood truss.

The sixty-foot-high church was a heavy timber, wood-frame structure. It was over 100 years old. The walls were brick and the roof covering was metal sheeting. The roof area was under rehabilitation but workers had left before the fire started.

Six fire fighters were injured, but the cause of these injuries was not reported.

The ceiling and roof partially collapsed, leaving large holes in the roof. Also, large pieces of scroll-work, which sat on top of columns, dropped to the floor.

The church was not equipped with automatic detection or automatic suppression equipment.

### **May 1987, New York Single-Family Dwelling**

A natural gas explosion leveled a one-and-a-half-story dwelling and damaged adjacent houses and property. One civilian was killed and five others were injured from the blast. Two structures adjacent to the residence of fire origin had walls blown out, and one had a second-floor collapse. The cause was believed to be a disconnected hose to a gas dryer. Natural gas was released and filled the basement. The heat source for ignition could have been a pilot light, match, spark or electric switch.

Six fire fighters sustained various injuries, including punctures, lacerations and contusions. Fire fighting activities at the time the injuries were sustained were not reported.

Information regarding the construction of the dwelling was not reported. No property damage estimates were given.

### **April 1986, New York Office**

A fire of undetermined cause started at or just below ceiling level in a public works office. Failure of an electrical lighting fixture was viewed as the most probable cause. The fire spread through a space above the suspended ceiling and then down combustible wall panels and studs.

The building was a one-story structure, with a wood frame, brick walls, concrete floors and a steel deck roof. It was not protected by automatic suppression equipment. Smoke and or heat detectors which were connected to a local alarm were provided in various locations throughout the office.

Four fire fighters were treated for smoke inhalation, one was treated for an eye injury and a sixth was treated for first and second degree burns. How these injuries occurred was not reported.

Roughly 10 percent of the roof and three-quarters of the south wall collapsed during the fire. Loss estimates exceeded \$1 million but an actual figure was not reported.

### **March 1985, New Jersey Meeting Hall and Public Bar**

Heat from a stove ignited cooking grease residue and caused a kitchen fire in a meeting hall. The fire spread horizontally from the kitchen to the function hall and vertically to the second floor. Eventually, it burned through the roof of the building.

The building consisted of two sections. One was a one-story wood-frame structure and the other was a two-story cinder block structure. The floor was wood joist, the walls were paneled with wood and the roof was covered with rolled tar. It was not reported if the roof was wood truss. The building contained a kitchen, bar and two function halls.

The roof on the two-story section burned through and the roof on the one-story section over a dining area collapsed. The exact cause of the collapse was not reported. Eight fire fighters were injured while operating hand lines. No other information regarding these injuries was given.

Detectors were present and operated properly. This building was not equipped with an automatic suppression system.