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NIOSH

Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A summary of a NIOSH fire fighter fatality investigation *October 27, 2006*

Two Volunteer Fire Fighters Die When Struck by Exterior Wall Collapse at a Commercial Building Fire Overhaul - Alabama

SUMMARY

On February 21, 2006, a 62-year-old male volunteer fire captain (Victim # 1) and a 23-year old male volunteer fire fighter (Victim # 2) died when they were struck by a collapsing exterior wall of a one-story commercial building during overhaul operations following a structure fire. The building was approximately 50 years old and had been renovated several times with at least two additions. The exterior walls were constructed of concrete blocks. However, multiple layers of different siding materials covering the front wall of the building hid the underlying concrete block wall from view. The fire was reported at approximately 1728 hours and fire fighters from a number of fire departments were on-scene for several hours containing the fire to the building. The heavy timber roof collapsed after burning for over 2 hours. The last mutual aid crew was released before 2100 hours. The remaining fire fighters noticed that concrete block walls on both sides of the structure were starting to lean outward so sections of the walls that were bulging outward were pulled down. At approximately 2130 hours, the two victims, along with a third fire fighter, were stretching a 1 ¾ inch handline to the front entrance to put water on hotspots when the front wall collapsed, striking the two victims. The third fire fighter was handling the hoseline a few feet behind the two victims and was struck on the foot by falling debris, narrowly missing serious injury.

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

- ***establish and monitor a collapse zone for structures that have become unstable due to fire damage.***
- ***conduct pre-incident planning and inspections of buildings within their jurisdictions to facilitate development of safe fire ground strategies and tactics.***
- ***develop, implement, and enforce written standard operating guidelines (SOGs) or standard operating procedures (SOPs) for all aspects of fire fighting operations.***
- ***train all fire fighting personnel in the risks and hazards related to structural collapse.***

Photo courtesy of the State Fire Marshal's office

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at **www.cdc.gov/niosh/fire/** or call toll free **1-800-35-NIOSH**

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- ***ensure that fire fighters wear a full array of turnout clothing and personal protective equipment (i.e. SCBA and PASS device) appropriate for the assigned tasks while participating in fire suppression and overhaul activities.***

Also, manufacturers, equipment designers, and researchers should:

- ***continue to pursue emerging technologies for evaluating and monitoring the stability of buildings exposed to fireground conditions.***

INTRODUCTION

On February 21, 2006, a 62-year-old male volunteer fire captain (Victim # 1) and a 23-year-old male volunteer fire fighter (Victim # 2) died when they were struck by a collapsing exterior wall of a one story commercial building during overhaul operations following a structure fire. A third fire fighter was struck on the foot by falling debris and narrowly missed serious injury. On February 23, 2006, the U.S. Fire Administration (USFA) notified the National Institute for Occupational Safety and Health (NIOSH) of the fatalities. On April 12, 2006, two Engineers and the Senior Investigator from the NIOSH, Division of Safety Research, Fire Fighter Fatality Investigation and Prevention Program traveled to Alabama to investigate the incident. Meetings were conducted with the Fire Chief and members of the fire department who were present during the incident; the Deputy State Fire Marshal who investigated the fire; and the local police department captain who investigated the incident. Interviews were conducted with officers and fire fighters who were at the incident scene. The NIOSH investigators reviewed the victims' training records; the Incident Commander's (IC) training records and floor plans and photographs of the structure. The incident site was visited and photographed. However, the site had already been razed and cleared of debris at the time of the NIOSH investigation so details of the actual building construction were limited. The victims' personal protective equipment (PPE) worn at the time of the incident was also examined.

FIRE DEPARTMENT

The combination fire department involved in this incident is comprised of 3 career (chief and two captains) and 18 volunteer fire fighters (including 3 volunteer officers), has 1 fire station, and serves a population of approximately 3,800 in the immediate municipality and a total population of approximately 9,500 in an area of about 136 square miles that includes part of a national forest. At the time of the incident, the department did not have any written standard operating guidelines (SOGs) or standard operating procedures (SOPs). *Note: Since the incident, a third paid fire captain has been added to the staff and a complete review of departmental operating guidelines and procedural requirements has been undertaken.*

TRAINING and EXPERIENCE

Victim # 1 had 42 years fire fighting experience, all with the same department, and held the rank of volunteer fire captain. Victim # 2 had 4 years fire fighting experience, all with the same department, and held the rank of volunteer fire fighter.

The state of Alabama does not have minimum training requirements for volunteer fire fighters. A 160-hour training session for volunteer fire fighters is offered by the state fire college but is not mandatory or required in order to serve as a fire fighter in the state. It is up to each fire department or municipality to identify minimum training requirements.

The fire department involved in this investigation has a 90-day probationary period before volunteer members are allowed to actively participate in

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structural fire suppression operations. The fire department holds regular voluntary training sessions 3 times per month except during the month of December. Both victims received regular hands-on training at the fire department which was documented by fire department records. Neither victim had completed the 160-hour state training program. Victim # 1 was a retired business owner. Victim # 2 was employed full time as a truck driver.

The Chief of the department involved in this incident had over 23 years of fire fighting experience with the department and became Chief in 2002. The Chief holds Fire Fighter I, II, and Fire Instructor 1 certification at both the state and national levels. The Chief assumed incident command (IC) when he arrived at the fire scene and remained as IC throughout the incident.

EQUIPMENT and PERSONNEL

The initial alarm resulted in the fire department dispatching all of its fire suppression apparatus to the incident site. The Chief traveled from his home to the fire station, and then proceeded to the incident site in the fire department chief's vehicle. The timeline for fire department apparatus responding to the incident included:

1728 hours
Initial Alarm
1732 hours
Engine 20 [Two career captains] left station
1734 hours
Engine 16 [Volunteer captain (driver / operator - Victim # 1) and two volunteer fire fighters (including Victim # 2)] left station
Engine 20 arrived on scene
1736 hours (approximate)
Engine 16 arrived on scene
1738 hours
Tanker 19 [Volunteer lieutenant and volunteer fire fighter] left station
Service Truck 13 [Volunteer fire fighter] left station
Chief and volunteer lieutenant left station in the Chief's vehicle
1740 hours (approximate)
Tanker 19 arrived on scene
Chief and volunteer lieutenant arrived on scene
Service Truck 13 arrived on scene
Engine 17 [Volunteer captain and volunteer fire fighter (injured)] left station
1742 hours (approximate)
Engine 17 arrived on scene
Chief radioed 911 for mutual aid

Upon arriving on scene and establishing incident command, the Incident Commander (Chief) radioed 911 dispatch to request mutual aid, including the only ladder truck in the county. A total of five mutual aid volunteer fire departments responded and provided support during the fire suppression activities.

PERSONAL PROTECTIVE EQUIPMENT

At the time of the incident, Victim # 1 was wearing personal protective clothing consisting of turnout gear (coat and pants), hood, helmet, gloves, and boots. He was not wearing a self-contained breathing apparatus (SCBA). Victim # 2 was wearing street clothing and a turnout coat but no other personal protective equipment. The department uses manual personal alert safety system (PASS) devices when wearing SCBAs. Neither victim was wearing a PASS device at the time of the incident.

STRUCTURE

The structure was a one-story class-III commercial building (ordinary construction) that was originally constructed in the 1950s as a lumber yard. The original structure consisted of concrete block walls

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with a heavy timber truss roof covered with sheet metal. The structure was renovated several times with additions at the rear and a vacant addition on the front right-side resulting in an L-shaped structure (Diagram 1). The original structure could be identified by the gabled roofline. The roofline over the addition at the front of the structure did not extend to the original roof peak. This resulted in an unevenly sloping roof over the front addition (see Photo 1). During various renovations, the front block wall was covered with brick veneer, wooden clapboard siding, and painted metal siding, resulting in a total of four layers to the front wall (see Photo 2). This resulted in the original concrete block wall being hidden from view at the front (A-side) of the structure. Total dimensions for the L-shaped structure measured 120 feet wide by 256 feet long.

An overhanging awning extended across the front of the original building. The awning was constructed of a metal frame covered with sheet metal. At the time of the incident, a large lighted sign was mounted on the awning over the main entrance. The awning extended approximately four feet outward from the front wall and was approximately 41 feet long. The awning was attached to the exterior wall and supported from below by four round metal posts approximately 4 inches in diameter (see Photo 3).

The void space within the heavy timber trusses over the original structure had been boxed in to create storage space within the trusses. This storage space contained a large quantity of office records, papers, and miscellaneous items, as well as an accumulation of wooden saw dust and debris from when the structure had been a lumber yard.

At the time of the incident, the structure was occupied by a business that sold and serviced lawn and garden power equipment, all-terrain vehicles (ATV), and paint-ball sporting equipment. The original front structure housed a showroom containing power mowing equipment, parts, and supplies such as lawn mower blades and batteries, and accessory items. A parts counter was located at the rear of the showroom. A peg-board wall separated the showroom area from the business office, employee break room and rest room facilities. Behind this was located a shop area of approximately 60 feet by 40 feet. The front portion of the structure also included a vacant storage area on the right or D-side of the building measuring 68 feet by 80 feet. The remainder of the rear portion of the structure housed ATVs, lawn mowers, and miscellaneous power equipment being repaired by the business, as well as trucks and tractors belonging to the business owner (see Diagram 1).

WEATHER

On the day of the incident, the air temperature was approximately 45 degrees Fahrenheit with cloudy skies and falling barometric pressure. The wind was originally blowing east to west then changed to a steady wind of approximately 12 miles an hour from the southeast shortly after fire fighters arrived on scene.

INVESTIGATION

On February 21, 2006, at approximately 1728 hours, the local 911 dispatch center was notified by an on-duty police officer driving past the structure that he observed smoke coming from the structure. The dispatch center immediately notified the fire department. *Note: The State Fire Marshals Office determined that the fire was likely caused by an electrical short in the storage area within the heavy timber trusses above the shop area and spread throughout the storage area reaching above the showroom. This storage area was constructed within the void*

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spaces of the heavy timber roof and contained a large quantity of paper records from the various businesses housed in the building over the years. The fire was believed to have smoldered within the storage space for several hours during the day. After the incident, three employees who had worked in the building the day of the fire reported smelling smoke during the day, but at the time attributed the smell to a wood-burning stove used for heat in the shop area (see Diagram 1).

At the time of the dispatch, one career captain was on duty at the station. Fire fighters responded to the alarm and began arriving at the station within minutes. Engine 20 (E-20) left the station with two career captains at 1732 hours and arrived on scene at 1734 hours. Engine 16 (E-16) left the station at 1734 hours, driven by Victim # 1 with Victim # 2 and another volunteer fire fighter on board. Tanker 19 (T-19) left the station at 1738 hours with a volunteer lieutenant and a volunteer fire fighter on board. Upon hearing the dispatch, the Chief traveled to the station, talked briefly with arriving fire fighters, then proceeded to the scene, accompanied by a volunteer lieutenant. A number of fire fighters reported seeing smoke in the vicinity of the structure as they reported to the station. Some responding fire fighters drove past the fire scene on the way to the fire station and reported that fire was already venting through the eaves of the roof.

Engine 20 was the first apparatus to arrive on scene and parked in the street in front of the building (see Diagram 2). Flames could be seen coming from both the B (East) and D (West) sides of the building. The career captain driving E-20 (career captain # 1) assumed initial incident command (IC). The other captain (career captain # 2) radioed 911 and gave a report on the conditions observed at the scene, then radioed E-16 (already enroute) and requested that they lay a 5-inch supply line from a nearby hydrant to E-20. Career captain # 2 then put on his SCBA and told the IC that he would enter the structure when additional fire fighters arrived. The captain # 2 pulled a 1 ¾-inch pre-connected handline from E-20 and made preparations for entering the building at the main entrance. Engine 16 arrived on scene and pulled past E-20 to lay the 5-inch supply line. Tanker 19 arrived on scene and parked just behind E-20. The chief arrived just behind T-19 and parked his vehicle in the parking lot in front of the building.

The initial size-up conducted by the first-arriving crew (career captains # 1 & # 2 on E-20) identified that a chain-link fence immediately next to the parking area in front of the structure restricted access to the D-side and the rear of the building. Another chain link fence restricted access to the rear of the building from the B-side. The Chief arrived on the scene at 1740 hours, talked with the two career captains (# 1 & # 2) in front of the building, and Incident Command was transferred to the Chief. The Chief and the volunteer lieutenant who rode with him walked around the front of the building to observe conditions on the D-side. Fire venting through the roof on the D-side was impinging upon the electrical power line supplying power to the building which crossed over the D-side (see Diagram 1). The Chief and the lieutenant observed that the power line was arcing. The Chief radioed 911 to request that the electrical utility company be dispatched to cut off power to the building. The Chief then radioed 911 and requested mutual aid, including the county's only ladder truck. The Chief designated the D-side as a hazardous area and restricted access. The fire attack was concentrated on the A (North) and B (East) sides of the building. A complete 360 degree size-up to fully evaluate building conditions was not made.

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Career captain # 2 from E-20 and one of the fire fighters from T-19 entered the building through the front entrance with the 1 ¾-inch handline. The conditions in the front showroom at this time were still relatively good with no visible flames, no heat and only light smoke. After briefly searching for fire, career captain # 2 and the fire fighter returned to the outside.

Since the fire seemed to be burning further back in the structure, it was decided to re-enter the structure through a doorway located on the B-side (see Diagram 2). This doorway was covered over by plywood on the exterior of the building. After chopping through the plywood with an axe, the fire fighters observed that the door opening had also been covered over when the interior had been renovated. A chain saw was retrieved from E-20 and used to finish opening the doorway to provide access to the interior of the building. The 1 ¾-inch handline at the front entrance was moved around to the B-side to support entry into the building.

When the ladder truck arrived on scene, it was positioned in front of the building near the A-D corner. E-16 was moved around the block and repositioned at another hydrant to the west of the building and set up to supply water to the ladder truck. *Note: Both victims worked in this area through most of the fire suppression activities. Victim# 1 was the E-16 driver/operator. Victim # 2 had been recovering from a hand injury and the Chief instructed him to take it easy at this incident so that he would not aggravate the injury*.

By this time, the fire had intensified in the front (A-side) of the building. The deck gun on the ladder truck was put into operation. A 2 ½-inch line with a gated wye-connection was pulled off E-20 and a portable monitor was set up at the A-side entrance to direct water through the doorway. Sheet metal was pulled off the front wall of the building in an attempt to make additional openings to direct water onto the fire. Wooden clapboard siding was found behind the sheet metal on the right side of the front wall (vacant addition shown in Diagram 1) so attempts to open holes in the front wall were discontinued. The responding mutual aid companies were assigned to concentrate their fire suppression activities on the A-side of the building.

The deck gun on E-20 was put into operation to direct water on the A-side. A 2 ½-inch handline was pulled around to the B-side doorway and the 1 ¾-inch handline was moved back to the A-side. A crew consisting of career captain # 2 from E-20 and two fire fighters entered through the B-side doorway and began looking for the seat of the fire. They observed a large number of 12-volt batteries stacked in a display area near the doorway and threw all the batteries outside to prevent the possibility of the batteries exploding. They also observed large cylinders of compressed carbon dioxide gas with the paintball supplies. They considered removing these cylinders but decided they might cause more damage to the cylinders by moving them so they decided to leave them in place. Career captain # 2 and fire fighters advanced the 2 ½-inch handline toward the rear of the show room where other fire fighters were pulling down a peg-board wall so that water could be directed onto fire burning behind the wall. Career captain # 2's SCBA ran low on air and his alarm began to sound so he and the fire fighter exited the building. Career captain #2 informed the Chief that he was out of air and said that the Chief would need to get someone else to go back inside the building with the other fire fighter. The career captain then went to change his SCBA air cylinder. The Chief entered the building with the fire fighter to observe the interior conditions. The Chief noted that the fire was directly overhead

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of the fire fighters working inside the building so he ordered everyone outside. After all crews were pulled out of the building, fire suppression activities changed from using handlines to concentrating on using deck guns and monitors to flow large volumes of water onto the burning building. However, defensive operations were never officially declared.

Crews worked for several hours directing water onto the burning building from the outside. The heavy timber roof collapsed about midway through the incident. As the fire burned itself out, the mutual aid crews were released. The last mutual aid crew was released before 2100 hours. The remaining fire fighters knew that they would have to monitor the smoldering debris throughout the night. Two fire fighters (the two victims) were sent to pick up pizza for the rest of the fire department. When they returned to the fire scene, the fire had died down considerably so all fire fighting activities were suspended so that the fire fighters could rehab and eat together.

After the break, the fire fighters discussed portions of the B and D side exterior walls that were leaning outward. It was decided that these leaning walls should be pulled down as a safety precaution so the fire fighters used pike poles to pull down the leaning portion of the D-side wall (see Diagram 3). They also pulled down a portion of the B-side wall. Throughout the fire suppression activities, fire fighters monitored the A-side wall because there were crews working under the overhanging awning. No indications of instability were observed. However, the sheet metal siding completely covered any sign of the underlying concrete block wall. *Note: Several fire fighters commented to NIOSH investigators that they had no idea the front wall was constructed of concrete block. Some stated that they thought the wall was stick built.*

Hot spots in the smoldering debris began to flare up. The E-16 driver / operator (Victim # 1) commented that it had been a long time since he had operated a nozzle and he would like to do it again. Victim # 1, Victim # 2, and another fire fighter began to use a 1 ¾-inch handline to hit fire along the eaves on the D-side. At approximately 2130 hours, the three fire fighters moved the 1 ¾-inch handline from the A-D corner to the front entrance of the building. Victim # 1 held the nozzle and was backed up by Victim # 2. The third fire fighter was helping move the hose and was a few feet behind the two victims when the front wall collapsed outward. The two victims were positioned underneath the overhanging awning at the main entrance when the awning gave way, pivoted downward and struck the two victims. At the same time, the exterior wall collapsed outward, burying the two victims under the falling concrete blocks, bricks, and sheet metal siding. The third fire fighter who was helping move the hose was struck on the foot by falling concrete blocks and narrowly missed being buried with the two victims. Several fire fighters were standing directly in front of the building and witnessed the wall collapse and ensuing entrapment. Other fire fighters were working on the B-side and heard the collapse.

911 was immediately called to send assistance for the two fire fighters trapped under the collapsed wall. Everyone on scene began digging through the debris to locate the trapped fire fighters. A roll call was taken to determine who was missing. Rescuers began calling out the victims' names in an effort to pinpoint their location under the debris. Airbags and jacks were used to raise heavy sections of the collapsed wall. A few minutes later, 911 was requested to activate a Medflight helicopter to the scene for air evacuation. Approximately 20 minutes after the collapse, Victim # 2 was located and

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was determined to be unresponsive. Shortly thereafter, Victim # 1 was located. Emergency Medical Services personnel checked the victims for vital signs and pronounced them dead at the scene. The request for air evacuation was cancelled at 2157 hours.

INJURIES

In addition to the two fatalities, the fire fighter who was struck on the foot by falling debris was treated at the scene.

CAUSE OF DEATH

Preliminary autopsy reports from the medical examiner list the cause of death for both victims as multiple blunt force trauma.

RECOMMENDATIONS / DISCUSSIONS

Recommendation # 1: Fire departments should establish and monitor a collapse zone for structures that have become unstable due to fire damage.

Discussion: During fire operations, two rules exist about structural collapse: (1) the potential for structural failure always exists during and after a fire, and (2) a collapse danger zone must be established.[1-6] A collapse zone is an area around and away from a structure in which debris might land or scatter if a structure fails. The collapse zone area should be equal to the height of the building plus an additional allowance for debris scatter and at a minimum should be at least 1½ times the height of the building.[7] For example, if the wall was 20 feet high, the collapse zone would be established at least 30 feet away from the wall.

Fire fighters must recognize the dangers of operating underneath or near overhanging awnings, porches, and other areas susceptible to collapse. Immediate safety precautions must be taken if factors indicate the potential for a building collapse. An external load, such as a parapet wall, steeple, overhanging porch, awning, sign or large electrical service connections reacting on a wall weakened by fire conditions may cause the wall to collapse. Other factors include fuel loads, damage, renovation work, deterioration, support systems and truss construction.[2] Whenever these contributing factors are identified, all persons operating inside the structure must be evacuated immediately and a collapse zone should be established around the perimeter. Once a collapse zone has been established, the area should be clearly marked and monitored to make certain that no fire fighters enter the danger zone. Defensive master streams should be used to soak smoldering debris and to prevent rekindling.[8] Positioning companies at the corners of the building is usually safer than a frontal attack.[9]

In this incident, the Chief (IC) ordered everyone out of the building, since the fire was fully involved in the heavy timber truss system above the interior crews. Interior fire fighting operations were terminated. However, a collapse zone was never established and crews continued to work in the vicinity of the front entrance and the overhead awning throughout the incident. Part of a defensive strategy is establishing and moving fire fighters outside of the collapse zone. A number of fire fighters reported to NIOSH investigators that the exterior walls were continuously monitored for indications of instability. Just prior to the collapse of the front wall, crews pulled down portions of the B and D-side walls that were leaning outward and threatening to collapse.

Recommendation # 2: Fire departments should conduct pre-incident planning and inspections

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of buildings within their jurisdictions to facilitate development of safe fire ground strategies and tactics.

Discussion: National Fire Protection Association (NFPA) Standard 1620 § 2-2.6.2 states "the pre-incident plan should be the foundation for decision making during an emergency situation and provides important data that will assist the incident commander in developing appropriate strategies and tactics for managing the incident." This standard also states that "the primary purpose of a pre-incident plan is to help responding personnel effectively manage emergencies with available resources. Pre-incident planning involves evaluating the protection systems, building construction, contents, and operating procedures that can impact emergency operations".[10] A pre-incident plan identifies deviations from normal operations and can be complex and formal, or simply a notation about a particular problem such as the presence of flammable liquids, explosive hazards, modifications to structural building components, or structural damage from a previous fire.[4, 6]

In addition, NFPA 1620 outlines the steps involved in developing, maintaining, and using a pre-incident plan by breaking the incident down into pre-, during- and after-incident phases. In the pre-incident phase, for example, it covers factors such as physical elements and site considerations, occupant considerations, protection systems and water supplies, and special hazard considerations. Building characteristics including type of construction, materials used, occupancy, fuel load, roof and floor design, and unusual or distinguishing characteristics should be recorded, shared with other departments who provide mutual aid, and if possible, entered into the dispatcher's computer so that the information is readily available if an incident is reported at the noted address.

A pre-incident plan for this medium-sized commercial building could have potentially identified walls constructed of multiple layers of varying materials, the awning / sign attached to the front wall over the entrance way, and occupancy and fuel load considerations. The front wall which was constructed of concrete block, brick, wood siding, and sheet metal had a 41 feet long by 4 feet wide by 4 feet high metal awning bearing a lighted sign attached over the entrance way. The pre-incident planning process could have noted this information which may have aided the Incident Commander in developing a safe and effective defensive strategy.

Recommendation # 3: Fire departments should develop, implement, and enforce written standard operating guidelines (SOGs) or standard operating procedures (SOPs) for all aspects of fire fighting operations.

Discussion: Written standard operating guidelines (SOGs) or standard operating procedures (SOPs) enable individual fire department members an opportunity to read and maintain a level of assumed understanding of operational procedures. Conversely, fire departments can suffer when there is an absence of well developed SOGs or SOPs. The NIOSH Alert: "Preventing Injuries and Deaths of Fire Fighters" identifies the need to establish and follow fire fighting policies and procedures.[11] Guidelines and procedures should be developed, fully implemented and enforced to be effective. Periodic refresher training should also be provided to ensure fire fighters know and understand departmental guidelines and procedures.

The following NFPA Standards also document the need for written documentation to guide fire fighting operations:

NFPA 1500, *Fire Department Occupational Safety and Health Program, 2002 Edition,* Chapter 4.1.2 states that fire departments shall prepare and maintain policies and standard operating procedures that document the organization structure, membership, roles and responsibilities, expected functions, and training requirements, including the following….(4) The procedures that will be employed to initiate and manage operations at the scene of an emergency incident.[12]

NFPA 1561, *Standard on Emergency Services Incident Management System, 2005 Edition*, Chapter 5.1.4 states that standard operating procedures (SOPs) shall include the requirements for implementation of the incident management system and shall describe the options that are available for application according to the needs of each particular situation.[13]

NFPA 1720, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Volunteer Fire Departments, 2004 Edition*, Chapter 4.1.1 states that the authority having jurisdiction shall promulgate the fire department's organizational, operational, and deployment procedures by issuing written administrative regulations, standard operating procedures, and departmental orders.[14]

At the time of the incident, the department did not have any written SOGs or SOPs. *Note: Since the incident, a third paid fire captain has been added to the staff and a complete review of departmental operating guidelines and procedural requirements has been undertaken.*

Recommendation # 4: Fire departments should train all fire fighting personnel in the risks and hazards related to structural collapse.

Proper training is an important aspect of safe fire ground operation. Both officers and fire fighters need to be aware of different types of building construction and their associated hazards.[4, 6, 8] For example, collapsing roof systems can exert pressure on supporting exterior walls, increasing the potential for wall collapse. Different roof systems may collapse at different rates.[8] While heavy timber roof systems will withstand more degradation by fire than lightweight engineered roof trusses, both types are subject to failure and will ultimately collapse.[8] Different phases of the fire suppression activities, such as the initial attack, offensive, defensive, and overhaul phases will have different hazards. However, the potential for collapse exists in any fire-damaged structure.[8]

Establishing priorities is another primary factor in safe fire ground operation that should be included in fire fighter training programs. The protection of life should be the highest goal of the fire service. When there is no clear danger to civilians, the first priority of firefighting should be the protection of fire fighters' lives and when no other person's life is in danger, the life of the fire fighter has a higher priority than fire containment.[15]

Recommendation # 5: Fire departments should ensure that fire fighters wear a full array of turnout clothing and personal protective equipment (i.e. SCBA and PASS device) appropriate for the assigned task while participating in fire suppression and overhaul activities.

Discussion: Chapter 7.1.1 of NFPA 1500, *Fire Department Safety and Health Program, 2002 Edition*, states protective clothing and protective

equipment shall be used whenever a member is exposed or potentially exposed to the hazards for which the protective clothing (and equipment) is provided and that the protective clothing and equipment shall be suitable for the tasks that the member is expected to perform.[12] The incident commander should establish the level of protective clothing necessary to enter the fire zones (hot, warm, and cold). A tendency to dress down during the overhaul phase of an operation can lead to unnecessary injuries.

Even after airing out the structure, removing the SCBA facepiece is questionable.[9] A NIOSH Health Hazard Evaluation (HHE) investigation involving air monitoring at actual fire scenes immediately following fire suppression identified formaldehyde concentrations exceeding the NIOSH exposure limit of 0.1 ppm [parts per million] and exposures to several PAHs [polycyclic aromatic hydrocarbons] which are suspected of having carcinogenic potential in humans.[9, 16] Recent investigations at a large metropolitan fire department include a special task force appointed by the city mayor and assisted by a team of NIOSH medical doctors. The task force is looking into the prevalence of cyanide poisoning of fire fighters at structural fires.[17] Hydrogen cyanide is emitted from smoldering and burning plastics (often found in common household goods), polyurethane foam cushions, and many other common building materials. Hydrogen cyanide gas is colorless and may be odorless to some while others may detect a slight almond smell or taste. Cyanide interferes with the body's ability to utilize oxygen at the cellular level and may be a contributing factor in smoke inhalation fatalities. Low level exposure can produce neurological effects such as confusion, ataxia[a], or impaired judgment.[18] Fire fighters may be most at risk of cyanide exposure when working outside burning structures and during overhaul operations when not wearing a breathing apparatus. Fire fighting experience alone cannot predict or determine cyanide exposure at a working fire. Accurate, low-cost, properly calibrated, detection equipment needs to be readily available during both the working fire and overhaul. Although cyanide poisoning is not suspected as a contributing factor in the two fatalities occurring at this incident, a number of fire fighters were in close proximity to the burning structure during both fire suppression and overhaul activities without the protection of an SCBA. Exposures to these types of respiratory hazards can be reduced by the mandatory use of SCBA during both fire suppression and overhaul operations.

NFPA 1500 *Fire Department Occupational Safety and Health Program,* Chapter 7.13.2 states "each member shall be provided with, use, and activate his or her PASS devices in all emergency situations that could jeopardize that person's safety due to atmospheres that could be immediately dangerous to life or health (IDLH), incidents that could result in entrapment, structural collapse of any type, or as directed by the incident commander or incident safety officer." Chapter 7.13.1 of NFPA 1500 states that "PASS devices shall meet the requirements of NFPA 1982 *Standard on Personal Alert Safety Systems (PASS)*."[12, 19] Current design standards require the integrated PASS to be activated automatically when the SCBA air supply is turned on. Support personnel such as arson investigators who don't normally wear an SCBA should consider utilizing a manual PASS device

a The inability to coordinate voluntary muscular movements that is symptomatic of some nervous disorders

when tasks are performed in hazardous areas. The use of SCBA with integrated PASS devices or a manually-activated PASS device may aid in more quickly locating fire fighters who are buried under debris following a structure collapse.

Recommendation # 6: Manufacturers, equipment designers, and researchers should continue to pursue emerging technologies for evaluating and monitoring the stability of buildings exposed to fireground conditions.

Discussion: The National Institute of Standards and Technology has recently been researching different technologies that offer the potential for evaluating structural stability of fire buildings.[20-22] This research may lead to more accurate and reliable means of predicting building collapse. Much of this research has focused on field-based monitoring techniques that utilize measurements of fire-induced vibration within the fire building. Such devices should be further researched, refined, and hardened for possible use in the fire service with the ultimate goal of having low-cost, reliable and more accurate methods for predicting building collapse available to all fire departments and fire fighters across the country.

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INVESTIGATOR INFORMATION

This incident was investigated by Timothy Merinar, Safety Engineer; Richard Braddee, Senior Investigator; and Matt Bowyer, General Engineer with the NIOSH, Division of Safety Research, Fire Fighter Fatality Investigation and Prevention Program. The report was authored by Timothy Merinar.

Two Volunteer Fire Fighters Die When Struck by Exterior Wall Collapse at a Commercial Building Fire Overhaul - Alabama

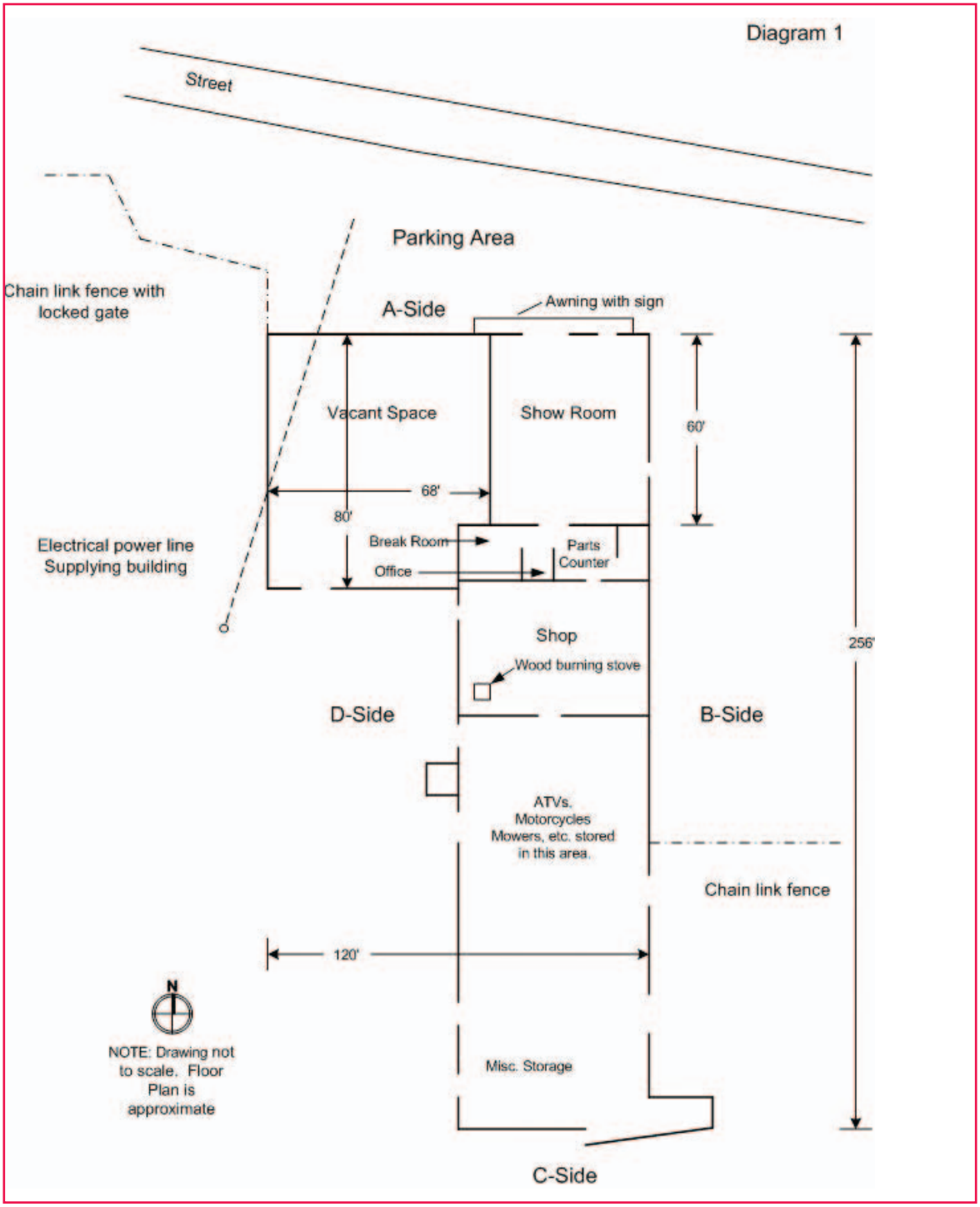

Diagram 1.

Two Volunteer Fire Fighters Die When Struck by Exterior Wall Collapse at a Commercial Building Fire Overhaul - Alabama

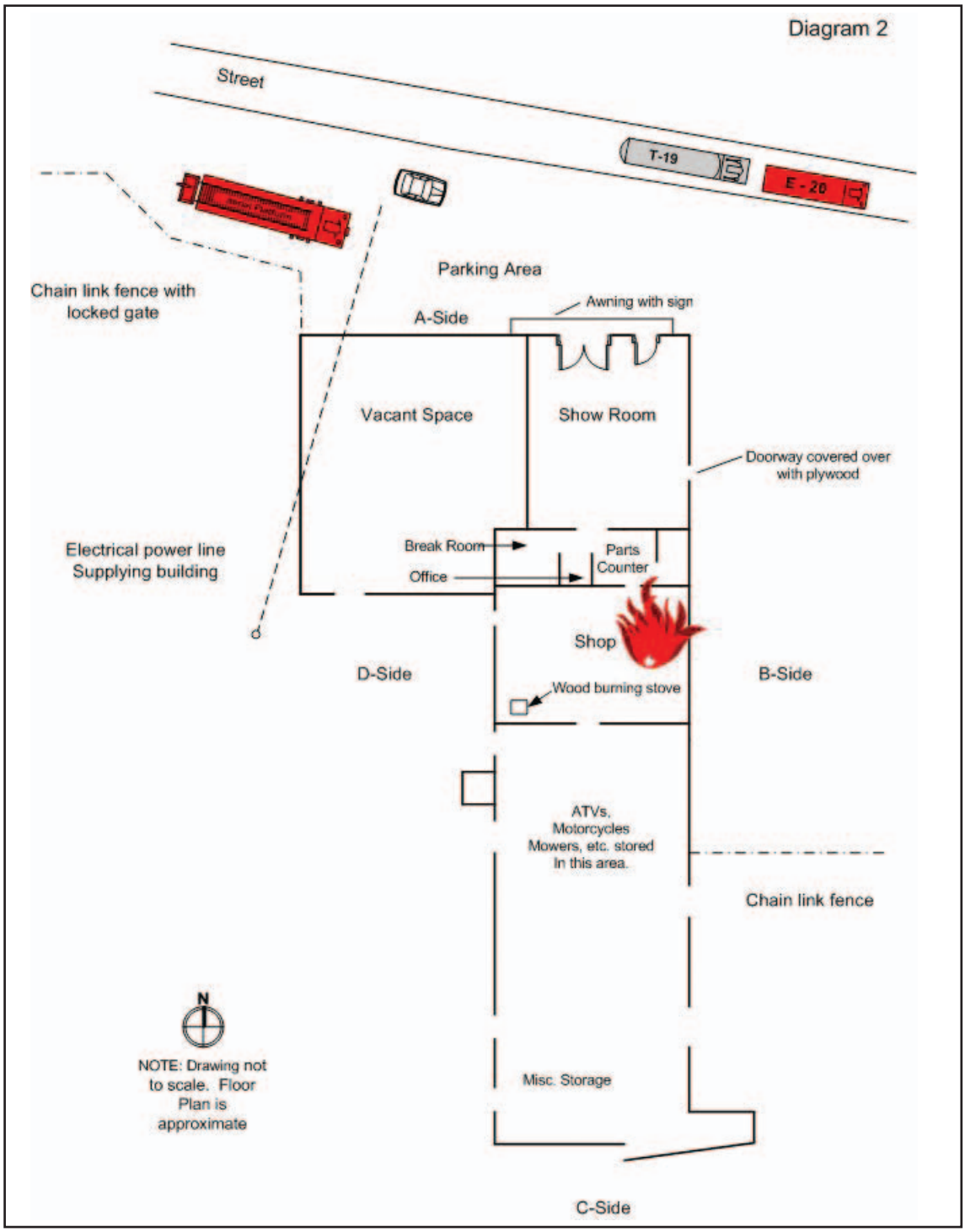

Diagram 2.

Two Volunteer Fire Fighters Die When Struck by Exterior Wall Collapse at a Commercial Building Fire Overhaul - Alabama

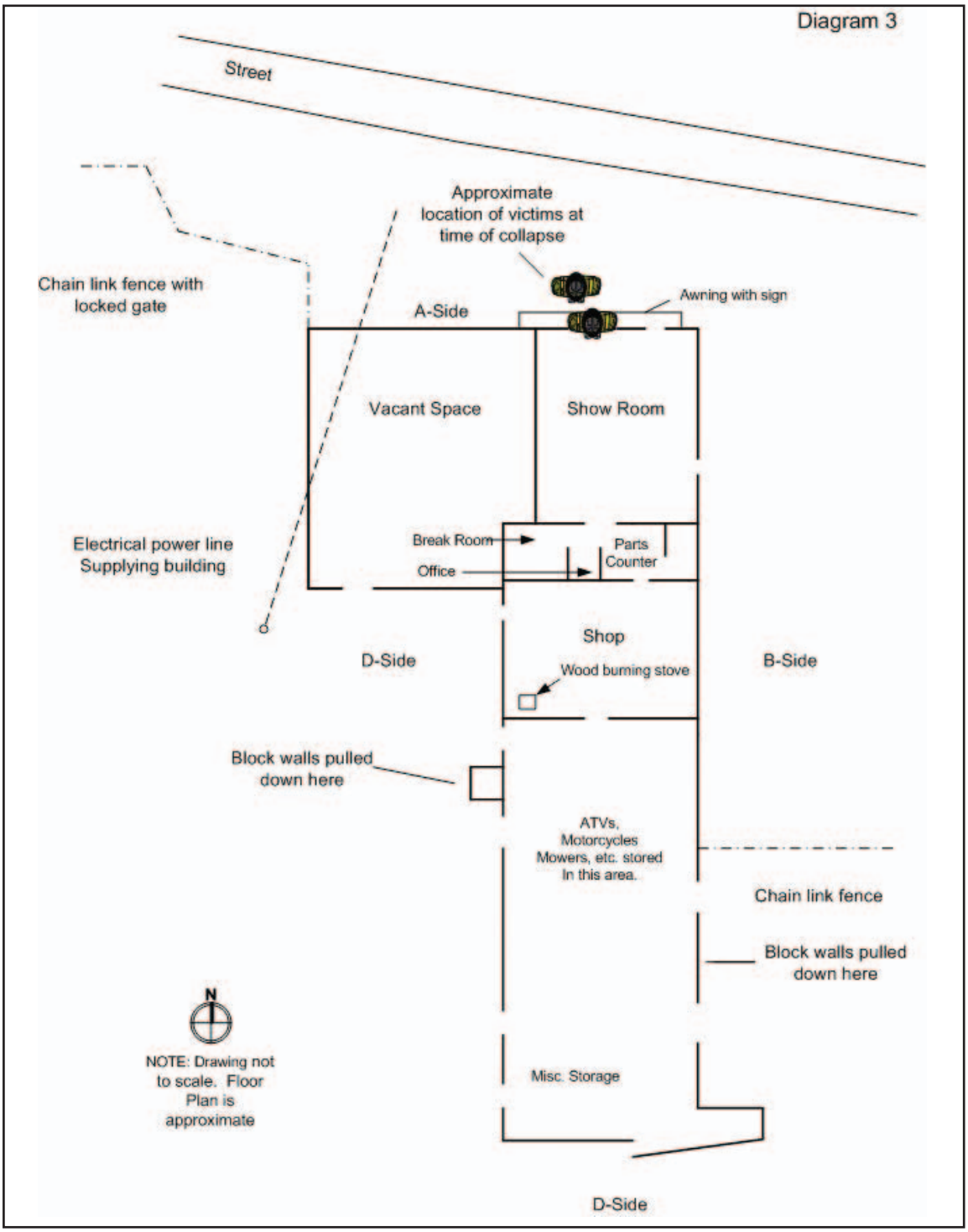

Diagram 3.

Two Volunteer Fire Fighters Die When Struck by Exterior Wall Collapse at a Commercial Building Fire Overhaul - Alabama

Photo 1. Photo taken four months prior to the incident. Note the front of the building and the awning over the entranceway. The sheet metal siding completely hides the presence of the underlying concrete block wall covered over with brick veneer and wooden clapboard siding. At the time of the incident, a large lighted sign was mounted on the awning above the entranceway. Photo courtesy of state fire marshal's office.

Two Volunteer Fire Fighters Die When Struck by Exterior Wall Collapse at a Commercial Building Fire Overhaul - Alabama

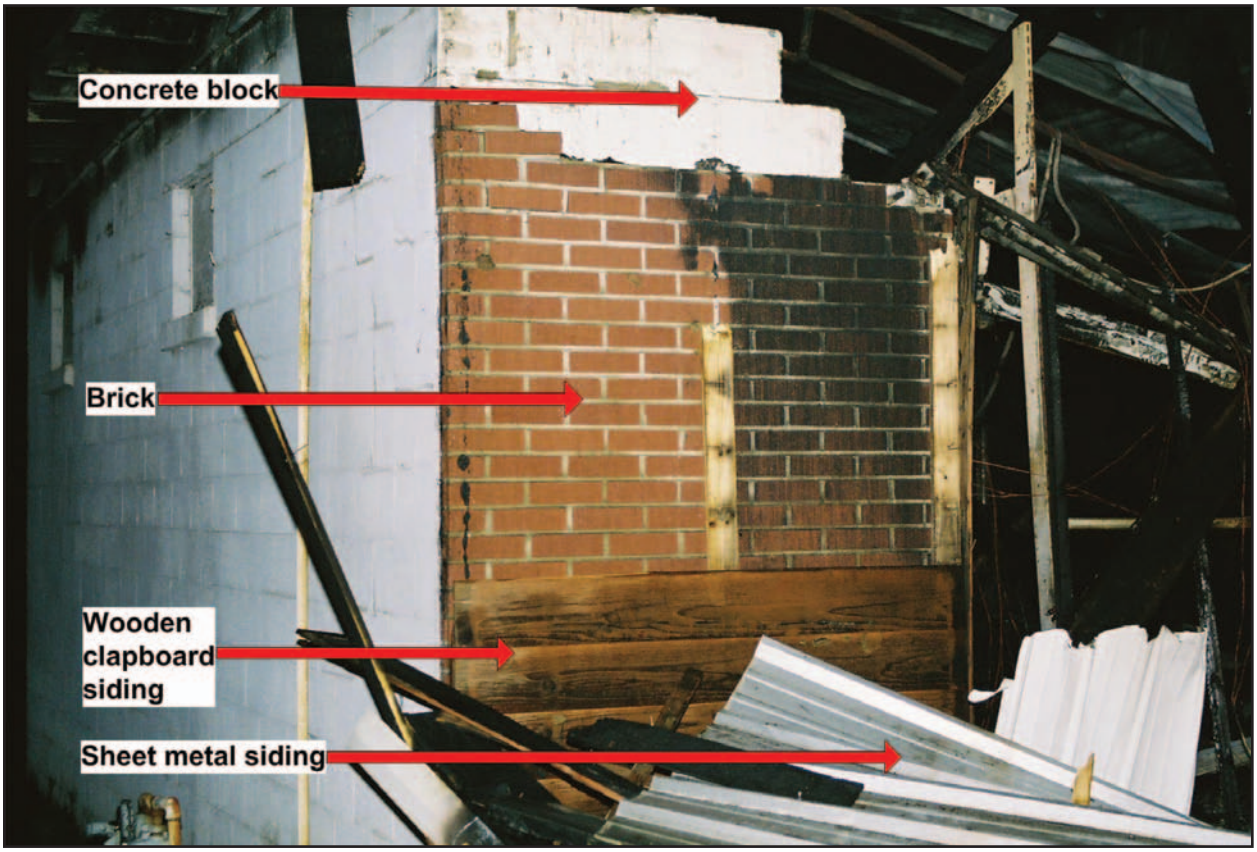

Photo 2. Photo shows the left front corner of the fire building. The 4 different layers of construction materials used on the front wall can be clearly seen. Collapse area is to the right. Photo courtesy of state fire marshal's office.

Two Volunteer Fire Fighters Die When Struck by Exterior Wall Collapse at a Commercial Building Fire Overhaul - Alabama

Photo 3. Photo of A-side of the structure taken four months prior to the incident. Note the overhanging awning over the entranceway. Note the metal pipe posts supporting the front of the awning. A total of 4 metal pipe posts supported the awning. Photo courtesy of state fire marshal's office.

U. S. Department of Health and Human Services
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
4676 Columbia Parkway, MS C-13
Cincinnati, OH 45226-1998

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