



## **Career Fire Fighter Seriously Injured from Collapse of Bowstring Truss Roof –California**

### **SUMMARY**

On May 21, 2009, a 36-year-old male career fire fighter was seriously injured while operating in a non-designated collapse zone of a commercial structure when an overhang of a bowstring truss roof system collapsed and struck him. The first arriving company officer reported a working fire in a single story Type II warehouse. The officer looked under a steel roll-up door that was raised approximately three feet off of the ground and saw heavy fire towards the rear of the structure from floor to ceiling. Per department procedures, the first arriving companies went into a “Fast Attack” mode. Crews attempted but were unable to enter the structure because the steel roll-up door wasn’t functioning and the man door was heavily secured. The department’s Deputy Chief arrived on the scene 9 minutes after the initial crew and determined that the fire should be fought defensively, however, this command was not relayed over the radio or verified with all crews. A crew was operating a 2 ½-inch handline just outside the structure approximately 20 minutes after the first apparatus arrived when the overhang collapsed and trapped the nozzleman. Key contributing factors identified in this investigation include: scene management and risk analysis, a well-involved fire in a structure with hazardous construction features, and fire fighters operating within a potential collapse area.

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

- *ensure that they have consistent policies and training on an incident management system*
- *develop, implement and enforce written standard operating procedures (SOPs) that identify incident management training standards and requirements for members expected to serve in command roles*
- *ensure that the incident commander conducts an initial size-up and risk assessment of the incident scene before beginning fire fighting operations*

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH “Fire Fighter Fatality Investigation and Prevention Program” which examines line-of-duty-deaths or on duty deaths of fire fighters to assist fire departments, fire fighters, the fire service and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with State or Federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency’s reports do not name the victim, the fire department or those interviewed. The NIOSH report’s summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency’s recommendations and is not intended to be definitive for purposes of determining any claim or benefit. For further information, visit the program website at [www.cdc.gov/niosh/fire](http://www.cdc.gov/niosh/fire) or call toll free 1-800-CDC-INFO (1-800-232-4636).



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- *ensure that the first due company officer establishes a stationary command post, maintains the role of director of fireground operations, and does not become involved in firefighting efforts*
- *implement and enforce written standard operating procedures (SOPs) that define a defensive strategy*
- *ensure that policies are followed to establish and monitor a collapse zone when conditions indicate the potential for structural collapse*
- *train all fire fighting personnel on building construction and the risks and hazards related to structural collapse*
- *conduct pre-incident planning inspections of buildings within their jurisdictions to facilitate development of safe fireground strategies and tactics*

## **INTRODUCTION**

On May 21, 2009, a 36-year-old male career fire fighter was seriously injured while operating just outside of a structure when an overhang of a bowstring truss roof system collapsed and struck him. On August 03, 2009, the local International Association of Fire Fighters (IAFF) office requested that the National Institute for Occupational Safety and Health (NIOSH) conduct an investigation of this incident. On August 9-15, 2009, two Safety and Occupational Health Specialists and a General Engineer traveled to California to conduct meetings and interviews with fire department management, IAFF representatives, representatives of the city fire marshal's office, the staff of the department's training academy, and fire fighters and officers who were directly involved with this incident. The NIOSH investigators reviewed the injured fire fighter's training records, the training records of all the officers who commanded the incident, the department's training requirements, the department's standard operating procedures (SOPs), witness statements, dispatch logs, and photos and sketches of the incident site.

## **FIRE DEPARTMENT**

This career department consists of 1,270 uniformed fire fighters. The department has 42 fire stations which operate under two divisions and serves a population of about 1,400,000 in a geographic area of approximately 49 square miles.

The department maintains well-documented written procedures covering items such as communications, Incident Command System (ICS), training, and pump operations. The department's ICS guidelines state that the first due member or unit to arrive on the scene shall assume incident command and remain in command until it is transferred or the incident is terminated.



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The guidelines describe the three different command options for the first arriving officer or member assuming incident command. These modes are recognized throughout the fire service and include: the nothing showing mode, the fast attack mode, or the command mode. The department has chosen to employ a fast attack offensive operation at all structure fires and have included only this mode of operation in their Pump Operations guidelines. Generally, fast attack offensive operations at this department involve the first arriving engine company announcing command and giving a brief description size-up. The first arriving engine company, including the officer, then attacks the fire operating a charged hoseline with a secured or planned water supply. The second-in engine company establishes a water supply. The department's ICS outlines the formal transfer of command procedures. However, at this incident a formal transfer of command did not take place between the initial arriving officer and the next officer assuming incident command, possibly due to the fast attack mode of operation.

The battalion chiefs are required to conduct one Target Hazard inspection per month. The information gathered during these inspections is submitted on a form to the Division of Emergency Communications which enters the information into the computer aided dispatch System. This information can then be transmitted to the Mobile Data Terminal available on the emergency apparatus for a particular address if there were any hazards reported for that location. A Target Hazard inspection had not been conducted for this address.

### **PERSONAL PROTECTIVE EQUIPMENT (PPE)**

The injured fire fighter was wearing a full ensemble of structural fire fighting clothing and equipment that was compliant with the current National Fire Protection Association (NFPA) standards.

The fire fighters operating at this incident were wearing their self-contained breathing apparatus (SCBA), but were not on air. This includes the injured fire fighter. The fire had self-vented through the roof and the smoke conditions were negligible on the fireground.

### **THE RESPONSIBILITY FOR SAFETY**

Since Fiscal Year 2003-2004, after the deactivation of one battalion, the responsibility of Safety Officer was transferred to the Assistant Deputy Chief of Training as the primary and on-call 24/7 responder. A battalion chief was added to every full box alarm so that the second due battalion chief on-scene would function as the Incident Safety Officer (ISO). If the second due battalion chief is given another role by the Incident Commander (IC), then the IC has to special call another battalion chief to act as the ISO. Whoever is assigned the ISO remains in this position until the Assistant Deputy Chief of Training arrives and assumes that position. It was reported by the department's division of training that all of these officers had ongoing safety officer training.

There were no formal departmental requirements for officers who might act as the ISO in terms of training or experience. The Training Chief, when handling safety matters for the department, reported



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to the Chief of Administration. Prior to Fiscal Year 2003-2004, the Chief of Safety reported directly to the Deputy Chief of Operations.

### **TRAINING and EXPERIENCE**

The state requires all career fire fighters to complete training equivalent to NFPA, 1001 Standard for Fire Fighter Professional Qualifications, Fire Fighter 1.<sup>1</sup> The department provides up to 17 months of training to certify fire fighters to NFPA Fire Fighter 1 and 2 qualifications, and a one year probationary period of supervised training for department fire fighter certification. The additional training during this probationary time focuses on driver training, pump operations, aerial ladder operations, and specialized equipment training.

#### Injured Fire Fighter

The injured fire fighter had more than six years of experience and had completed department provided classroom/field training on topics such as: live fire training, rapid intervention crew (RIC) procedures, and hazardous materials.

#### Initial Incident Commander (IC)

The first due company officer had more than 15 years of experience with the department. Six of those years were as a fire fighter, seven years as a cross-trained paramedic, and 18 months as a lieutenant in an acting and permanent appointment at the time of the incident. The initial IC had completed the department provided five four-day sessions on critical fireground topics that were required for newly appointed lieutenants. This training included the following topics: building construction, incident management system (IMS), size-up, company operations, and rapid intervention company (RIC) operations.

#### Incident Commander (IC)

The IC had more than 30 years of experience and had completed department provided classroom/field training in topics such as: health and safety 1, 2, 3 & 4; fire command; fire instructor; fire investigation; fire management; fire officer; fire prevention; incident command; incident safety officer; and RIC procedures.

#### Incident Safety Officer (ISO)

The battalion chief who was assigned as the ISO for this incident had more than 20 years of experience and had completed department provided classroom/field training in topics such as: health and safety 1,2,3,and 4; fire command; fire instructor; RIC procedures; hazardous materials; heavy rescue 1 and 2; training officer development; wildland training; and emergency vehicle operations.

### **STRUCTURE**

The building was constructed in 1954 and was a single-story warehouse of Type IV construction. The dimensions of the building were 110 feet deep by 50 feet wide, covering approximately 5,500 square feet. The height of the building was approximately 20 feet. The occupancy use of the building was



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commercial and it operated as a warehouse. The building's structural system consisted of masonry block bearing walls with four heavy timber wood bowstring trusses for a roof system. The heavy timber wood trusses had a 50-foot clear span to the bearing walls and were located 19 feet 9 inches on center. The heavy timber wood truss assemblies were 48 feet 7 inches in depth and were constructed of 4-inch x 6-inch timber cords and webs connected with bolt fasteners with a metal splice plate and bolt configuration at the bottom chord span. Solid 2-inch x 10-inch wood purlins located on 24-inch centering spanned perpendicular to the truss assembly with a ¾-inch plywood roofing deck. The roofing system assembly was exposed and did not have a membrane or other passive fire protection features.

Structural stability to the heavy timber truss units was provided by 2-inch x 6-inch wood cross bracing in conjunction with the stability provided by the wood purlins and plywood deck roofing membrane. The structure contained six skylights that were 3 feet by 6 feet (see Figure 1, Photo 1, Photo 2, and Photo 3). The overall integrity and structural stability of this type of structural support and roofing system is contingent upon all components maintaining their connections and load bearing or load transferring capacity.

The A-side was a non-load bearing wall that showed the traditional arched roof profile that is consistent with bowstring roof construction. The A-side wall also consisted of what appeared to be an overhanging or cantilevered façade that was covered by stucco (see Figure 2). The overhang was part of the original construction that tied back into the bowstring truss system. The fire building was integrated into a block of commercial occupancies so that only the A-side was accessible for interior fire fighting activities (see Photo 2 and Photo 4). The B-side exposure of the building was adjacent to a parking lot and was of masonry construction without any windows or doors. The C-side and D-side exposures were of similar size and construction and shared party walls between their respective sides. A pre-plan had not been completed for this structure.

At the time of the fire, the building was used as a place to grow marijuana illegally. The man door was heavily barricaded and a false wall was constructed to shield the operations from the exterior when the roll-up door was lifted. The electric service was severed and rerouted to circumvent the electric meter in order to conceal the operations.<sup>2</sup>

### **WEATHER CONDITIONS**

At the time of the incident, the conditions were partly cloudy with the temperature approximately 48 degrees Fahrenheit. The wind was approximately 9 miles per hour from the West.

### **EQUIPMENT and PERSONNEL**

Only the companies on the first and second alarms that were directly involved in this incident are included.



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- **0446 Hours**

**First alarm dispatched**

- **0449 Hours**

**Engine 42 on-the-scene**

Officer (Initial incident command), Driver/Operator, 2 Fire Fighters

- **0450 Hours**

**Rapid Intervention Crew (RIC) dispatched**

- **Second Alarm, Dispatch at 0452 Hours**

**Engine 32 on-the-scene**

Officer, Driver/Operator, 2 Fire Fighters

**Engine 17 on-the-scene**

Officer, Driver/Operator, Injured Fire Fighter (IFF), Fire fighter

**Rescue 2 on-the-scene**

Officer, Driver/Operator, 2 Fire Fighters

**Medic 17 on-the-scene**

2 Fire Fighter/Paramedics

**Battalion 06 on-the-scene**

Battalion Chief

- **0453 Hours**

**Incident Commander on-the-scene**

Division Chief

**Ladder 07 on-the-scene**

Officer, Driver/Operator, Tiller, 2 Fire Fighters

- **0457 Hours**

**Battalion 03 on-the-scene**

Battalion Chief



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**Engine 11 on-the-scene**

Officer, Driver/Operator, 2 Fire Fighters

- **0458 Hours**

**Ladder 17 on-the-scene**

Officer, Driver/Operator, Tiller, 2 Fire Fighters

**Engine 37 (RIC) on-the scene**

Officer, Driver/Operator, 2 Fire Fighters

**Ladder 11 on-the-scene**

Officer, Driver/Operator, Tiller, 2 Fire Fighters

**Deputy Chief on-the-scene**

Deputy Chief of Operations

- **0500 Hours**

**Battalion 09 Safety Officer**

Battalion Chief

**Engine 26 on-the-scene**

Officer, Driver/Operator, 2 Fire Fighters

**Engine 07 on-the-scene**

Officer, Driver/Operator, 2 Fire Fighters

- **0529 Hours**

**Engine 44 on-the-scene**

Officer, Driver/Operator, 2 Fire Fighters

## **INVESTIGATION**

On May 21, 2009, at 0446 hours central dispatch received an alarm for a reported structure fire with fire and smoke showing at a commercial occupancy. Engine 42 (E42) was the first apparatus on the scene at 0449 hours and the officer reported on the radio a working fire in a single story Type II warehouse. *Note: The classification of Type II was incorrect. This building was a Type IV construction due to the heavy timber bowstring trusses.* The E42 Lieutenant and a fire fighter ran to a steel garage roll-up door that was raised approximately three feet off of the ground on the left of the A-



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side wall (Photo 4). The E42 Lieutenant looked under the door and saw heavy fire towards the rear of the structure from floor to ceiling. The E42 Lieutenant and the fire fighter attempted to raise the door but could not due to the door being dislodged from its track. Note: *The door frame had been compromised by the fire and the tracks were not attached to the wall.* They immediately went to a man door to the right of the A-side. It was locked and had heavy security bars. The E42 Lieutenant called Battalion Chief 6 for a truck company to perform forcible entry.

The E42 Lieutenant ordered the crew to prepare the multiversal, which is a master stream appliance that can be used on the ground, and 2 ½-inch handlines to attempt to attack the fire through the roll-up door. Note: *Per department policy, all first arriving companies and officers go to work in a “fast attack” mode.* At approximately 0452 hours Engine 32 (E32) and Engine 17 (E17) pulled onto the road leading to the structure within a block from the structure. Both the E32 and E17 officers immediately radioed dispatch and requested a second alarm due to the heavy fire self-venting from the roof of the structure. E32 proceeded to the front of the structure, dropped off two 3-inch supply lines for E42, and went to hook up to a hydrant to supply E42. E32 used a 10-foot section of 3-inch supply line to hook up to one side of the hydrant. They used another 50-foot section of 3-inch supply line to hook up to the other side of the hydrant.

During this same time, at approximately 0452 hours, BC6 arrived on the scene, called to ensure a second alarm, and conducted a size-up of the front of the building and the operations taking place. A division chief arrived on the scene at 0453 hours, assumed incident command (IC), and ordered BC6 to protect Exposure D. The E17 officer and fire fighters [including the injured fire fighter (IFF)] walked up to the front of the structure and saw the E42 and E32 crews attempting to deploy the multiversal and two 2 ½-inch handlines off of E42. Note: *The crews were having difficulty due to having to assemble the three 50-foot sections of 2 ½-inch handlines from a bag stored on top of each apparatus. The crew also removed the multiversal from on top of E42 and placed it on the ground for operation.* The IFF took the nozzle of one of the 2 ½-inch handlines and was backed up by an E17 fire fighter. Two additional fire fighters manned the other 2 ½-inch handline and were protecting the D-exposure by shooting water onto the roof from over 20 feet away from the structure. The E17 officer and E17 fire fighter operated the multiversal over 20 feet back from the roll-up door and attempted to shoot water through the opening where the door had pulled away from the wall. The E17 officer noticed that both handlines were ineffective and he went to check on the IFF. The IFF's handline stream was ricocheting off of the man door and the four windows above it (Photo 4). The L7 crew had assembled handtools on the ground in front of the Command Post. The E17 officer took a saw to the man door in an attempt to open it so that the handline could be effective. He quickly determined that the saw would not work due to the door being so heavily protected. Battalion Chief 09 arrived on the scene at 0500 hours and was designated by the IC as the Incident Safety Officer (ISO) at approximately 0504 hours. He instructed the E17 officer to attempt to open the door with a rabbit tool; the E17 officer informed the ISO he wasn't sure where the truck company kept it. Immediately after, BC6 ordered the E17 officer to take his saw to the roll-up door and cut an opening for access. He cut a three foot by six foot hole in the door and was attempting to cut across the door when he was tapped on the shoulder by the Deputy Chief which he assumed meant he was to quit. During this time, BC6 had received orders from the Deputy Chief to pull everyone back from the front of the building and to ensure that no one



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went inside. *Note: According to interviews conducted by NIOSH investigators, this is the first time that anyone on the scene communicated the need to go defensive to the initial arriving officers. It was reported to the NIOSH investigators that every officer who reported to the command post was given face-to-face directions that the fire was defensive and that no one was to enter the building. This tactical decision was not relayed over the radio.*

BC6 ordered the crews from E42 and E17 to set up and direct a master stream into the hole through the roll-up door from a distance. The crews fought fire from a distance with the master stream for several minutes. The IFF and the E17 fire fighter continued to fight fire with the handline moving from the roll-up door to the man door several times. *Note: This crew, along with many other members that were interviewed, reported not receiving any orders regarding a defensive operation.* BC6 noticed that the fire had compromised an electrical weather head and that the power lines were going to come down soon. He turned to order crews to vacate the area where the power lines would possibly fall when he heard a large crash. He turned back and saw that the roof overhang had fallen onto the sidewalk. The collapse trapped the IFF who was operating the handline into the windows along with the E17 fire fighter. Members immediately rushed to the scene to rescue the trapped fire fighter. The IC ordered BC6 to command the rescue crew and complete a personnel accountability report (PAR) for the fireground. A full PAR was completed and the trapped fire fighter was removed and transported to a local hospital.

### **EXTENT OF INJURIES**

The injured fire fighter suffered a fractured right clavicle, second degree burns to his left hand and forearm, a compound leg fracture of both bones in the right leg, and broken bones in his left foot.

### **CONTRIBUTING FACTORS**

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

- Scene management and risk analysis
- A well-involved fire in a structure with hazardous construction features
- Fire fighters operating within a potential collapse area.



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### **RECOMMENDATIONS/DISCUSSION**

***Recommendation #1: Fire departments should ensure that they have consistent policies and training on an incident management system.***

Discussion: NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*<sup>3</sup> and NFPA 1561 *Standard on Emergency Services Incident Management System*<sup>4</sup> both state that an incident management system (IMS) should be utilized at all emergency incidents (including but not limited to training exercises). The IMS should include written plans that address the requirements of different types of incidents that can be anticipated in each fire department's or emergency service organization's jurisdiction. The IMS should address both routine and unusual incidents of differing types, sizes and complexities. The IMS covers more than just fireground operations. The IMS must cover incident command, accountability, risk management, communications, rapid intervention crews (RIC), roles and responsibilities of the incident safety officer (ISO), and inter-operability with multiple agencies (police, emergency medical services, state and federal government, etc.) and surrounding jurisdictions (mutual aid responders).

NFPA 1561, Chapter 5.3.6 states, "SOPs shall define the circumstances and procedures for transferring command to another on-scene officer/member and shall specify to whom command shall be transferred." Annex A states "the fire department of the emergency services organization (ESO) should establish a protocol of command authority based on rank structure, assignments, and qualifications to define a hierarchy for transferring command." The qualifications required to perform as incident commander should increase with the size and complexity of the incident. SOPs should define the circumstances under which an officer at a higher level should respond to an incident and whether the transfer of command to an officer at a higher level is mandatory or discretionary.

The fire department in this incident had a standard operating procedure covering the implementation of the IMS which directs the first arriving officer to establish command, conduct a size-up, initiate tactics, and transfer command. This was not followed. In the department's everyday training and their Pump Operations guidelines, it instructs the first arriving company officers to employ a fast attack offensive operation at all structure fires which precludes the transfer of command.

Utilizing a fast attack at all fires eliminates tactical guidance that should be provided by the first arriving company officer. The building construction and amount of fire involvement at this incident required defensive tactics upon arrival. In this incident, initial companies were utilizing department recognized defensive tactics, such as operating the multiversal, but were being directed to use them offensively such as using the multiversal within the collapse zone and attempting to force the door and make entry with the large diameter handlines.

The department's guidelines for fast attack at all structure fires precludes the fire department from following recognized tenets of IMS, such as risk assessment and management, establishing a stationary command post when warranted, and ensuring that the first arriving officer is in command of the incident and not involved in fire fighting operations unless necessary for civilian rescues.



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Additionally, in this incident there were issues with communication that resulted in fire fighters and officers being unaware of defensive attack mode.

***Recommendation #2: Fire departments should develop, implement and enforce written standard operating procedures (SOPs) that identify incident management training standards and requirements for members expected to serve in command roles.***

Discussion: NFPA 1561 *Standard on Emergency Services Incident Management System*, Chapter 4.8.3 states “responders who are expected to perform as incident commanders or to be assigned to supervisory levels within the command structure shall be trained in and familiar with the incident management system and the particular levels at which they are expected to perform.”<sup>4</sup> NFPA 1001 *Standard for Firefighter Professional Qualifications*,<sup>1</sup> NFPA 1021 *Standard for Fire Officer Professional Qualifications*,<sup>5</sup> NFPA 1500 *Standard on Fire Department Occupational Safety and Health Program*,<sup>3</sup> NFPA 1521 *Standard for Fire Department Safety Officer*,<sup>6</sup> and NFPA 1026 *Standard for Incident Management Personnel Professional Qualifications*<sup>7</sup> are just a few examples of recognized standards addressing fire fighter and officer qualifications.

One of the fire officer’s primary responsibilities is safety both on the fireground and during normal operations. A partial list of officer qualifications (knowledge, skills, and abilities) necessary to accomplish the primary responsibility of fireground safety identified in these standards include: fire behavior; building construction; conducting pre-incident planning; development of applicable codes, ordinances, and standards; identification of fire and life safety hazards; supervising emergency operations; and, deploying assigned resources in accordance with the local emergency plan.

In this incident, the bowstring truss roof assembly should have been identified by the first arriving companies. Training on the construction type and associated hazards should have allowed for the identification of the need for defensive operations and the establishment of a collapse zone.

***Recommendation #3: Fire departments should ensure that the incident commander conducts an initial size-up and risk assessment of the incident scene before beginning fire fighting operations.***

Discussion: Among the most important duties of the first officer on the scene is conducting an initial size-up of the incident. This information lays the foundation for the entire operation. It determines the number of fire fighters and the amount of apparatus and equipment needed to control the blaze, assists in determining the most effective point of fire extinguishment attack, the most effective method of venting heat and smoke, and whether the attack should be offensive or defensive. A proper size-up begins from the moment the alarm is received and it continues until the fire is under control. The size-up should also include assessments of risk versus gain during incident operations.<sup>8-14</sup> Retired Chief Alan Brunacini recommends that the arriving IC drive partially or completely around the structure whenever possible to get a complete view of the structure. While this may delay the IC’s arrival by a few seconds, this drive-by may provide significant details not visible from the command post.<sup>11</sup> The size-up should include an evaluation of factors such as the fire size and location, length of time the fire



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has been burning, conditions on arrival, occupancy, fuel load and presence of combustible or hazardous materials, exposures, time of day, and weather conditions. Information on the structure itself to include size, construction type, age, condition (evidence of deterioration, weathering, etc), evidence of renovations, lightweight construction, truss construction (bowstring trusses), loads on roof and walls (air conditioning units, ventilation ductwork, utility entrances, etc.), and available pre-plan information are all key information for risk assessment and profiling for the strategic and tactical development such as whether an offensive or defensive strategy is employed.<sup>12</sup> The size-up and risk assessment should continue throughout the incident.

Fires in commercial structures are typically more dangerous than residential building fires. Retired Assistant Chief Vince Dunn states that defensive operations should be used more often at special occupancy and commercial buildings. Chief Dunn cites statistics that 4 fire fighters die for every 100,000 residential fires compared to 9 fire fighter deaths for every 100,000 commercial structure fires.<sup>12</sup>

Heavy fire showing from the roof upon arrival, inability to obtain entry to hit the seat of the fire, bowstring truss construction, and no known occupants/entrapments, were all indicators that could have prompted consideration of initially deploying defensive tactics.

***Recommendation #4: Fire departments should ensure that the first due company officer establishes a stationary command post, maintains the role of director of fireground operations, and does not become involved in firefighting efforts.***

Discussion: According to NFPA 1561 *Standard on Emergency Services Incident Management System*, §5.3.1, “the incident commander shall have overall authority for management of the incident.”<sup>4</sup> In addition to conducting an initial size-up, the incident commander must establish and maintain a command post outside of the structure to assign companies and delegate functions, and continually evaluate the risk versus gain of continued fire fighting efforts. In establishing a command post, the IC shall ensure the following (NFPA 1561, §5.3.7.2):

1. The command post is located in or tied to a vehicle to establish presence and visibility.
2. The command post includes radio capability to monitor and communicate with assigned tactical operations, command, and designated emergency traffic channels for that incident.
3. The location of the command post is communicated to the communications center.
4. The incident commander, or his or her designee, is present at the command post.
5. The command post should be located in the incident cold zone.<sup>4</sup>

The use of a tactical worksheet can assist the IC in keeping track of various task assignments on the fireground. It can be used along with preplan information and other relevant data to integrate information management, fire evaluation and decision making. The tactical worksheet should record unit status, benchmark times, and include a diagram of the fireground, occupancy information, activities checklist(s), and other relevant information. This can also aid the IC in continually



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conducting a situation evaluation and maintaining accountability.<sup>10</sup> To effectively coordinate and direct fire fighting operations on the scene, it is essential that the IC does not become involved in fire fighting efforts. A delay in establishing an effective command post may result in confusion of assignments and lack of personnel and apparatus coordination which may contribute to rapid fire progression. The involvement of the initial IC in fire fighting also hampers the collection and communication of essential information as command is transferred to later arriving officers.

The department in this incident utilizes a fast attack mode at all structure fires; therefore, an initial command post was never established and separate and uncoordinated activities were taking place in multiple locations. This had a diminishing effect on: the size-up of the overall incident scene, properly evaluating risk versus gain, communicating and evaluating fireground operations, transfer of command, and maintaining accountability on the fireground.

***Recommendation #5: Fire departments should develop, implement and enforce written standard operating procedures that define defensive fire fighting operations.***

Discussion: The IC must consider, upon arrival and throughout the incident, whether the operation is to be conducted in an offensive or defensive mode. According to the International Fire Service Training Association, offensive and defensive strategies are defined as:

**Offensive Fire Attack (Offensive Mode)** - Aggressive, usually interior, fire attack that is intended to stop the fire at its current location. As a general rule, the IC should extend an offensive attack only where and when conditions permit, and adequate resources are available.

**Defensive Fire Attack (Defensive Mode)** - Exterior fire attack with emphasis on exposure protection. The commitment of a fire department's resources to protect exposures when the fire has progressed to a point where an offensive attack is not effective.<sup>8</sup>

The offensive versus defensive command decision is an ongoing one, requiring the IC to reconsider these major factors throughout the attack. For example, the decision to begin a defensive attack may be based on the fact that the offensive attack strategy has been abandoned for reasons of personnel safety, and/or the involved structure has been conceded as lost. In addition to an interior attack, a fire fighting strategy should be considered offensive when manual suppression activities are being conducted within the boundaries of a collapse zone.<sup>13</sup> In this incident, conditions reported from the initial attack, and continual evaluation of the risk factors, may have indicated the need for establishing a collapse zone and defensive operations. The department operating at this incident employs a fast attack mode at every structure fire, which takes the tactical decision away from the initial arriving company officer. Strategies and tactics must be decided and initiated by the initial arriving company officer. A key component for fire fighter safety while developing fireground tactics is predicting the performance of the building under fire conditions. Modern building components such as lightweight trusses are not predictable. Today these tactical decisions must be based on construction risk versus construction type and must be carried out in a manner that accounts for presumed fire behavior.



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Engine company operations and fire suppression theory for today's fire fighters needs to develop beyond the pragmatic approach of automatically making an offensive attack on every fire with the "Big Fire-Big Water principle."<sup>15</sup>

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 or property conservation.<sup>8</sup> In this incident, there were no indications of civilians in danger inside the structure.

***Recommendation #6: Fire departments should ensure that policies are followed to establish and monitor a collapse zone when conditions indicate the potential for structural collapse.***

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 zone must be established.<sup>16-20</sup> A collapse zone is an area around and away from a structure in which debris might land 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. In this incident, the structure was estimated to be 20 feet high at the top of the parapet wall so the collapse zone should have extended at least 30 feet from the structure.

Buildings can collapse due to the structural damage directly caused by a fire, or the activities of fire fighting operations. A fire department's familiarity with types of construction in their community is an important tool in safely fighting fires. Once a collapse zone is established, fire departments should enforce a "no entry" policy unless approved by the IC.

Command and fire fighters need to recognize the dangers of operating near parapet walls or underneath 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 a wall to collapse. Other factors include fuel loads, damage, renovation work, deterioration caused by the fire as well as pre-existing deterioration, support systems and truss construction.<sup>21-23</sup> Fire departments should not rely solely on time as a collapse predictor.<sup>23</sup> In this incident, the presence of the bowstring truss roof, the overhanging roof at the front of the structure, and full fire involvement should have been indicators of a collapse hazard. The bowstring truss roof that collapsed in this incident consisted of heavy timbers (Photo 3).



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***Recommendation #7: Fire departments should train all fire fighting personnel in building construction and in the risks and hazards related to structural collapse.***

Discussion: 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.<sup>16, 21-23</sup> 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.<sup>21</sup> While heavy timber roof systems will withstand more degradation by fire than lightweight engineered roof trusses, both types are subject to failure.<sup>21</sup> 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.<sup>21</sup>

Establishing priorities is another primary factor in safe fire ground operation that should be included in fire fighter training programs. One source of training on different structure types and their associated risk is available on the internet at Fire Fighter Close Calls in a downloadable power point file titled “Operational Safety Considerations at Ordinary & Heavy Timber Constructed Occupancies”<sup>24</sup>

***Recommendation #8: Fire departments should conduct pre-incident planning inspections of buildings within their jurisdictions to facilitate development of safe fireground strategies and tactics.***

Discussion: NFPA 1620 *Standard for Pre-Incident Planning*, states “The purpose of this document shall be to develop pre-incident plans to assist responding personnel in effectively managing emergencies for the protection of occupants, responding personnel, property, and the environment.” 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.<sup>12, 14, 23</sup>

Building characteristics including type (or more importantly risk) 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.<sup>14</sup> Since many fire departments have tens and hundreds of thousands of structures within their jurisdiction, it is a challenge to establish an effective preplanning system. Priority should be given to those having elevated or unusual fire hazards and life safety considerations.

One tool for fire departments to use in assessing their risks for structures within their jurisdictions is the mnemonic, BECOME SAFE:

- Building
- Evaluation
- Construction/occupancy



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- Operational hazards
- Manage time and elements
- Engagement
- Situational awareness
- Assessment and risk analysis
- Fire behavior and effects
- Evaluate and execute <sup>25</sup>

In this incident, the presence of the bowstring truss presented an elevated life safety consideration in the event of a fire. A thorough building inspection and pre-incident plan for a single-story, bowstring truss occupancy in this area could have potentially identified the hazards typically associated with this type of construction such as: ceiling voids, fuel loads, non-permitted renovations, roof construction, HVAC location, and exit locations. Evaluating the construction features and layout of the structure allows the fire department the opportunity to determine a response protocol for the specific identified hazards and to develop fireground strategies and tactics (ventilation strategies, avenues of fire spread, proper attack line selection, etc.) before an incident occurs. The construction features of occupancy (bowstring truss), possible commercial fuel loads and access restrictions suggested large volumes of water would be necessary to fight a major fire at the site. A more complete pre-planning process, involving individual fire companies within their response territory could have noted this information which may have aided the IC in developing a safer and more effective offensive or defensive strategy. In order to facilitate open communication, fire department personnel and building code officials should be cross-trained on each-others' duties and responsibilities. Fire fighters should have a basic understanding of what a code violation is and how to report them during a pre-plan, and building code inspectors should have a basic understanding of fire fighter safety issues during their inspections. The relay of this information could be used to facilitate dynamic risk management and enhanced command and control.

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### **INVESTIGATOR INFORMATION**

This incident was investigated by Stacy Wertman and Jay Tarley, Safety and Occupational Health Specialists and Matt Bowyer, General Engineer, Division of Safety Research, NIOSH. The report was authored by Jay Tarley. An expert review was provided by Christopher J. Naum, SFPE; Chief of Training, Command Institute, Washington, DC. and member of the Board of Directors, International Association of Fire Chiefs (IAFC) Safety, Health & Survival Section and Second Vice-President, International Society of Fire Service Instructors (ISFSI). A technical review was also provided by the National Fire Protection Association, Public Fire Protection Division. Some text provided by expert reviewers was incorporated into the final report.



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**Photo 1. Picture of structure from B-side parking lot exposure prior to fire.**  
*Photo courtesy of Alfredo Ruiz.*



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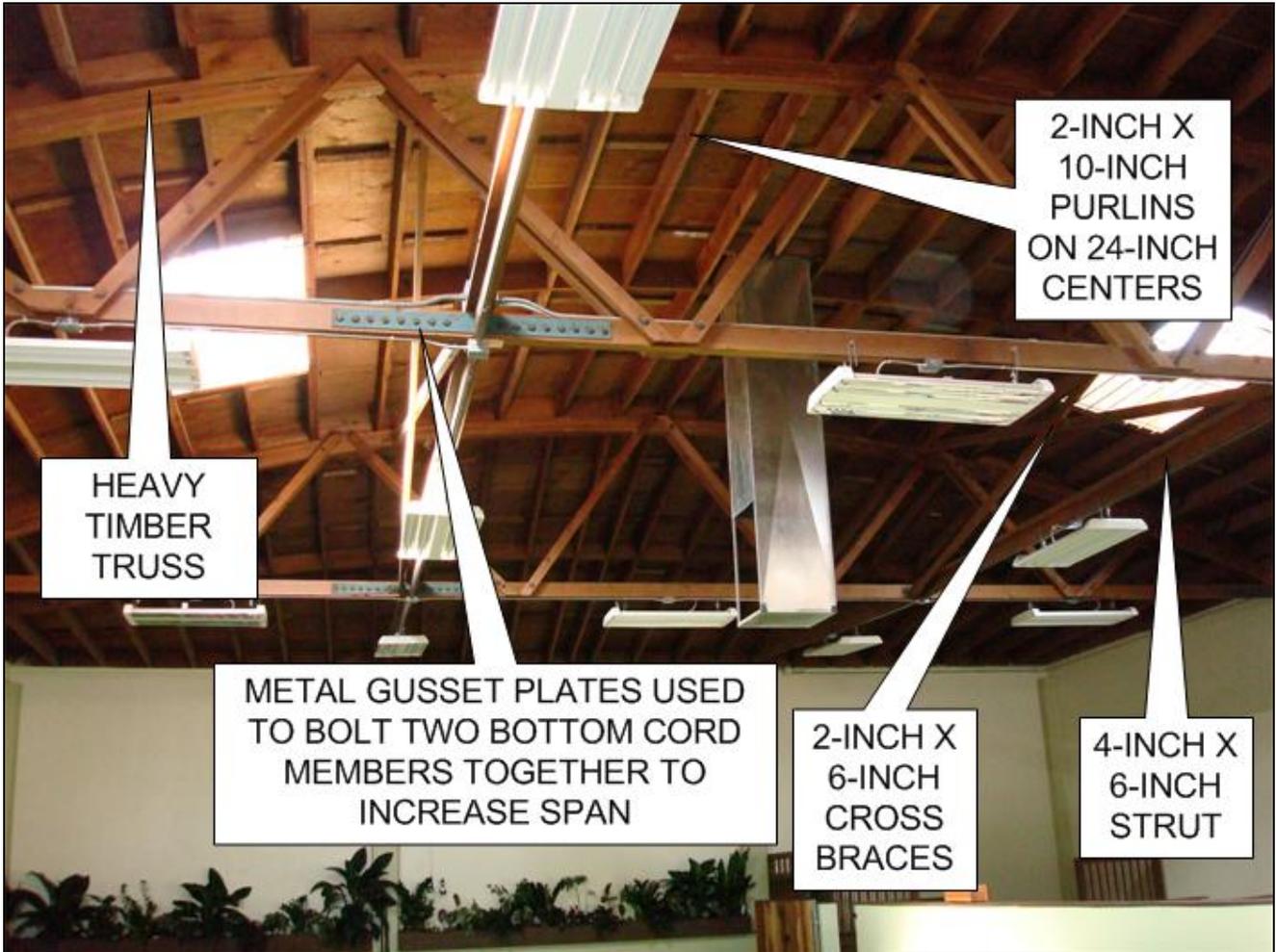
*Career Fire Fighter Seriously Injured from Collapse of Bowstring Truss Roof – California*



**Photo 2. Aerial photo of fire building and exposures.**  
*Adapted from Google Maps® satellite image.*



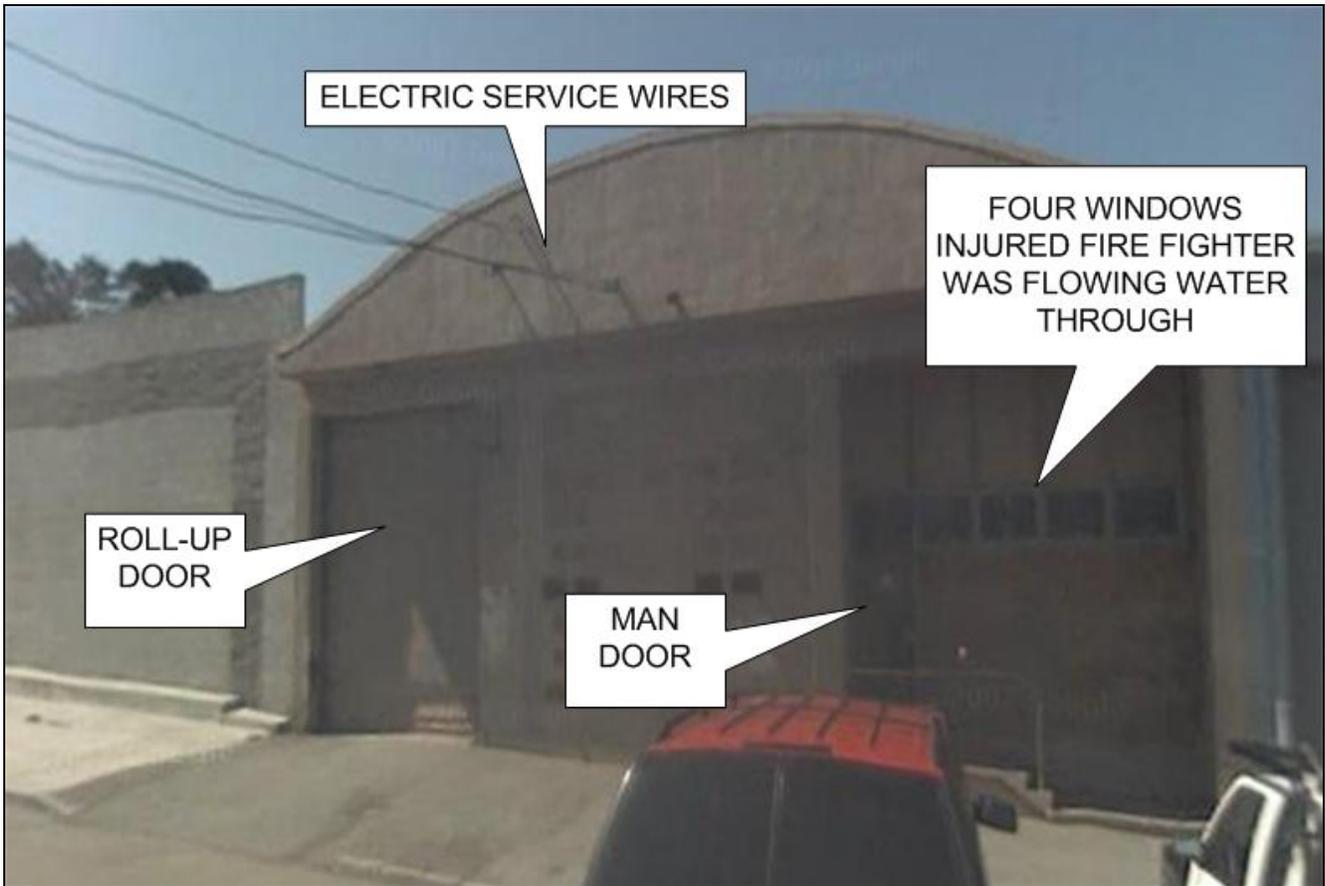
*Career Fire Fighter Seriously Injured from Collapse of Bowstring Truss Roof – California*



**Photo 3 . Exposure D building with similar bowstring roof construction.  
*NIOSH photo.***



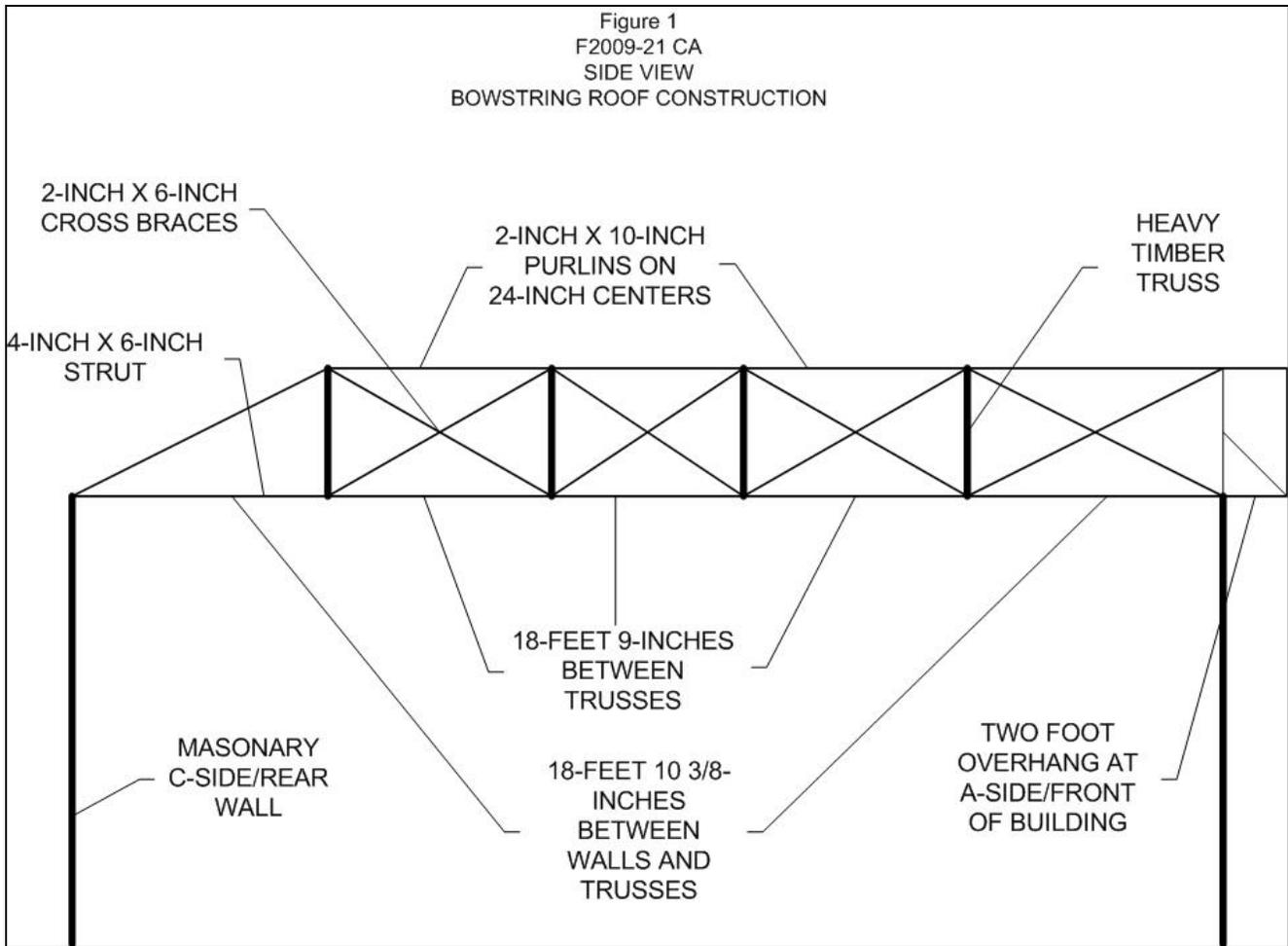
*Career Fire Fighter Seriously Injured from Collapse of Bowstring Truss Roof – California*



**Photo 4. A-Side of fire building.**  
*Adapted from Google Maps® satellite image.*



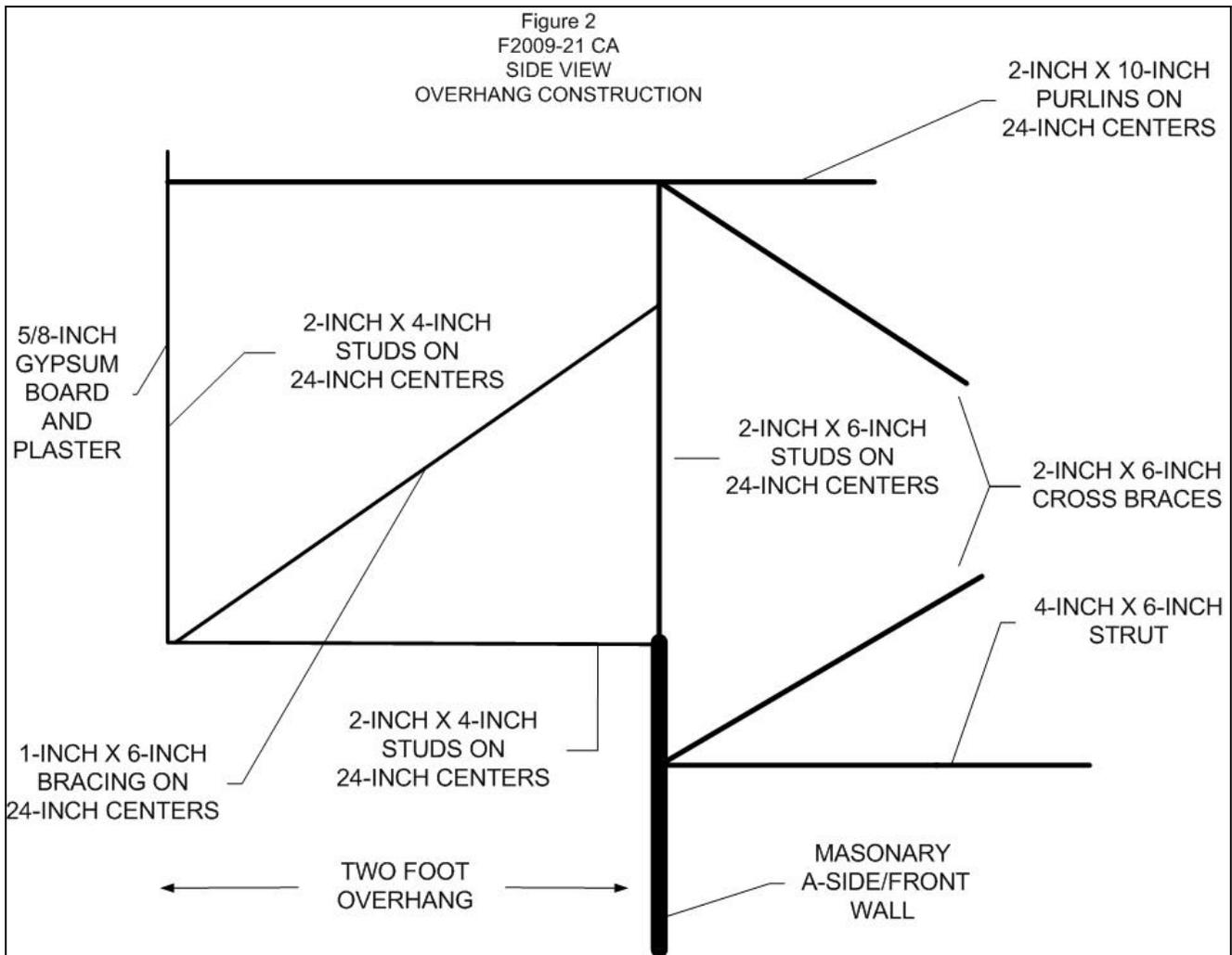
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**Figure 1. Side view of building components.**



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**Figure 2. Side view of overhang construction.**