WORKPLACE SOLUTIONS

From the National Institute for Occupational Safety and Health

Preventing Deaths and Injuries to Fire Fighters by Establishing Collapse Zones at Structure Fires

Summary

Fire fighters are at significant risk for injury or death due to structural collapse during fire-fighting operations. Structural collapse often occurs without warning. The National Institute for Occupational Safety and Health (NIOSH) recommends that the Incident Commander establish defensive operations and collapse zones when there is potential for a structural collapse during fire-fighting operations.

Description of Exposure

The United States Fire Administration reported that 1,230 fire fighters died between 2000 and 2012. Structural collapse caused 142 of these fire fighter deaths (11.5%). Structural collapse often results in multiple fire fighter injuries and fatalities. The number of fatalities includes fire fighters killed by collapse inside and outside a structure.

Although structural collapse is a significant cause of injury and death to fire fighters, the potential for a structural collapse is one of the most difficult situations to predict. A collapse zone is defined as the area around the perimeter of a structure that could contain debris if the building collapsed. This area is often defined by establishing a perimeter at a distance from the building that is equal to 1½ times the height of the structure.

When established, a collapse zone should be identified by a fireground transmission, colored tape, signage cones, flashing beacons, fences, or other appropriate means. A "No Entry" policy should be enforced by the Incident Commander, Incident Safety Officer, Division/Group Supervisors, and company officers. When it is not possible or practical to visually mark a collapse zone, the Incident Commander should verbally identify the collapse zone area to all fireground personnel via radio or other communication methods. During structure fires, the Incident Commander should initially evaluate and continually reevaluate risk factors, including the potential for structural collapse based on direct observations, reports, and pre-incident plan information.

An exclusion zone should be established during large or extended fire-fighting operations. An exclusion zone is defined as a zone established by the Incident Commander to prohibit specific activities in a specific geographic area. If the fire is not contained and an exterior (defensive) attack becomes necessary, the exclusion zone is moved far enough away from the structure to place the fire fighters outside of the collapse zone. In large or extended fire-fighting operations, these zones must be continually adjusted as necessary, and all personnel at the scene must be made aware of the exclusion zone or collapse zone locations.

Determining when to establish a collapse zone starts with a community risk assessment program. Community risk assessments satisfy many fire department objectives, but one of the most important aspects is to evaluate the fire risk associated with occupancy and construction classifications. A

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community risk assessment program, coupled with a pre-incident planning initiative that evaluates building construction, structural integrity, fire load, and fire protection systems is a vital tool for safely fighting fires. Fire departments should ensure all members are trained in the organization's rules of engagement, risk assessment, and situational awareness procedures.

Understanding the influence that building design, construction, and conditions have on structural collapse potential has a direct correlation to safe fireground operations and fire fighter survivability. A collapse zone should be established whenever the risk of structural collapse is identified as a potential occurrence.

Fire departments should not rely solely on the amount of time a fire has been burning as a collapse predictor. External loads, such as a parapet wall, steeple, overhanging porch roof, awning, sign, or large electrical service connections may also cause structural collapse. Other factors to consider include:

- Construction type
- Age and condition of the building
- Pre-existing structural damage/deterioration
- Structural weakness caused by explosion or impact
- Presence of free-standing parapets
- Presence of wall anchor plates or stars
- Engineered load systems/lightweight construction
- Types of doors and windows
- Roof design and covering including HVAC units on fast food occupancy roofs
- Renovation/modifications to structure
- Height of the building
- Fire duration, size and location
- Fuel loads
- Fire behavior
- Fire protection features such as sprinkler systems and fire walls
- Weight of fire fighters and water used for extinguishment

Free standing parapets are often identified as a special risk factor in ordinary (brick) construction buildings (See Diagram 1 and Photo 1). In many cases, roof collapse causes a parapet to become unstable or collapse without warning.

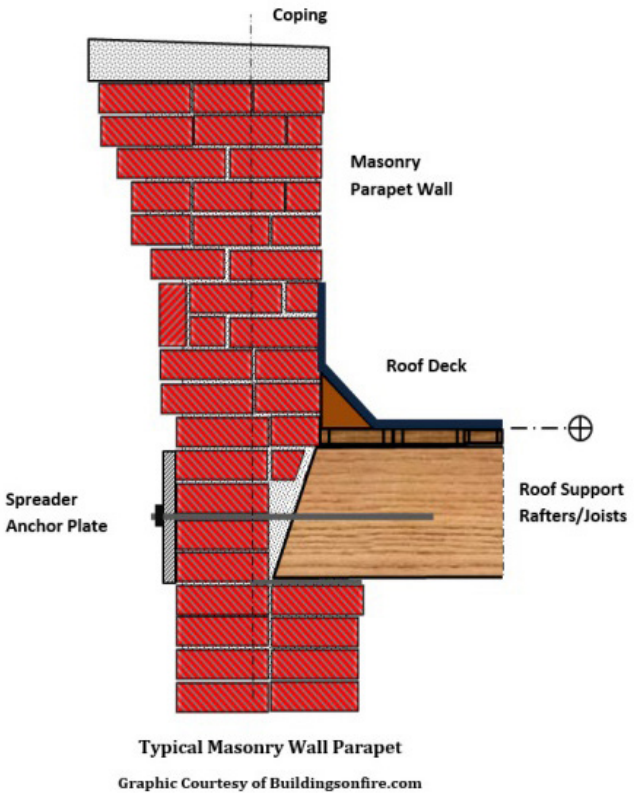

Diagram 1. An example of a parapet wall.

Photo 1. Building with parapet wall (Courtesy of Buildingsonfire.com)

Case Studies

Case Study 1

On June 17, 2011, a 22-year-old male paid on-call fire fighter received fatal injuries when he was struck by bricks and falling debris during an exterior wall collapse at a commercial structure fire. Crews were operating in a defensive mode for about 45 minutes attempting to extinguish a fire in a 96-year-old brick and masonry structure. The building housed an antique store with living quarters located in a rear addition. At the time of the collapse, the victim and another fire fighter were moving a 35-foot aluminum ground ladder that had been placed during initial fire-fighting operations (See Photo 2). No other fire fighters were injured in the collapse.

Contributing factors included fire fighters with limited experience entering a collapse zone to move a ground ladder, entering a collapse zone in close proximity to master stream operations, limited visibility at the side and the rear of structure possibly obscuring signs of pending collapse, and limited training on structure collapse hazards.

Case Study 2

On May 21, 2009, a 36-year-old male career fire fighter was seriously injured while operating on the outside of a structure when the front overhang of a bowstring truss roof system collapsed and struck him.

The department's Deputy Chief arrived on the scene nine minutes after the initial crew had arrived and determined the fire should be fought defensively. However, this order was not relayed over the radio or confirmed with all crews and a collapse zone was not established. 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 trapping the nozzleman (See Photo 3).

Members immediately rushed to rescue the trapped fire fighter. A Personnel Accountability Report (PAR) was completed and the trapped fire fighter was removed and transported to a local hospital.

Note: *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 communicated over the radio.*

Contributing factors that led to the injury included inadequate incident management and risk analysis, a well-involved structure with hazardous structure features, and fire fighters operating in a potential collapse area or zone.

In both cases, collapse occurred without warning, reinforcing the need to consider building construction, fire involvement, length of time the fire had been burning, and other factors when evaluating the risk of collapse.

Controls

NIOSH recommends the following precautions and actions to minimize hazards and risks to fire fighters due to structural collapse during fireground operations.

Pre-Incident

- Every fire department should implement a community risk assessment program that includes occupancy type and construction classifications.

Photo 2. Defensive operations at structure fire just after the collapse on "Side D" in Case Study 1.

Photo 3. The front overhang that collapsed injuring a fire fighter as described in Case Study 2.

- Every fire department should implement a pre-incident planning program that complies with NFPA 1620, Standard for Pre-Incident Planning. This includes initial and periodic review, testing, updating data, and refining the process.
- States, municipalities, and authorities having jurisdiction should design and implement a placarding system to identify high risk collapse prone buildings to support a timely size-up and Incident Action Plan development for initial arriving companies.
- All fire fighters and fire officers should be trained in building design and construction in relation to structural collapse potential.
- Fire departments should implement clear rules of engagement and initial scene size-up which include risk assessment and situational awareness.

Incident

- An incident management system should be used from the beginning of each incident to the completion of all operations.
- The Incident Commander should appoint division/group supervisors (tactical level management) to ensure the safety of members operating in an immediately dangerous to life or health (IDLH) environment.
- The Incident Commander should appoint a Safety Officer to monitor conditions and operations to ensure the conditions and operations fall within the parameters of the department's rules of engagement.
- Assistant Safety Officer(s) should be appointed and assigned as needed.
- The Incident Commander should always assess the survivability profile for civilians and fire fighters when determining whether offensive or defensive operations should be conducted.
- The initial size-up should consider the type and condition of the structure and location of the fire, and any indications of potential structural weakness or collapse.
- In buildings of Type III Ordinary (unreinforced masonry or reinforced masonry) or Type IV Heavy Timber construction including Mill and Semi-Mill construction, the Incident Commander should be focused on the high probability of internal and external collapse, establish defensive operations, establish and control collapse zones in multiple divisions and possibly in exposure properties, and expect collapse to occur.
- When conditions become unsafe or are judged to be unsafe, the Incident Commander should immediately direct the Dispatch Center to transmit an audible evacuation tone (emergency traffic tone) or alert to notify fire fighters to abandon the structure and conduct a Personnel Accountability Report (PAR). Also multiple air horn blasts should be used to warn fire fighters to abandon the structure.
- When a structure is abandoned during fireground operations, all members should withdraw to safe positions outside the building, the Incident Commander should perform a PAR, and a collapse zone should be established. The structure should not be re-entered without orders from the Incident Commander and a risk assessment performed by the Safety Officer.
- When a collapse zone is established, all fire-fighting operations should be conducted from positions outside the collapse zone using master streams (e.g. deck guns and ladder pipes) or large volume hose streams.
- All fire fighters should maintain situational awareness and conduct continuous risk assessments throughout the incident. Unsafe or changing conditions should be immediately reported to their company officer, Division/Group Supervisor, and the Incident Commander.
- Whenever possible, the collapse zone should be marked by visible barriers or warning devices. A standard system should be established to mark a collapse zone. (Red "HAZARD ZONE – DO NOT ENTER" barrier tape is recommended for this purpose.)
- The collapse zone perimeters must be continuously monitored to ensure that no one enters the collapse zone. Marking and/or monitoring of the hazard zone is particularly important for incidents when the transfer of "Command" occurs multiple times, incidents of long duration and in situations where the incident scene covers a large geographical area.
- After a fire is under control when a structural collapse has occurred or has the potential to occur, the structural stability of the building should be thoroughly evaluated prior to any further operations.

Post Incident

- Every fire department should conduct a post incident analysis for incidents involving a near-miss, injury, or fire fighter fatality.
- Every fire department should periodically update their community risk assessment program and pre-incident planning process based on recommendations from post incident analysis reports.

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Training Materials and Additional Sources of Information

The National Institute of Standards and Technology, Building and Fire Research Laboratory's Fire Research Division, maintains a website with links to publications on fire safety topics: http://www.fire.nist.gov/.

NIST [2003]. Early warning capabilities for fire fighters: testing of collapse prediction technologies [http://www.fire.nist.gov/bfrlpubs/fire03/art072.html].

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NEHRP Consultants Joint Venture [2010]. Program plan for the development of collapse assessment and mitigation strategies for existing reinforced concrete buildings. NIST GCR 10-917-7. Redwood City, CA: NEHRP Consultants Joint Venture. Contract number B134107CQ0019 for U.S. Department of Commerce, Building and Fire Research Laboratory, NIST [http://www.nehrp.gov/pdf/nistgcr10-917-7.pdf].

Underwriters Laboratories maintains a website with information targeted specifically to fire fighter safety. Building construction materials, exposure hazards, ventilation practices and other topics that could influence structural collapse are covered: http://www.ul.com/global/eng/pages/offerings/industries/buildingmaterials/fire/fireservice/

United States Fire Administration.
http://www.usfa.fema.gov/fireservice/firefighter_health_safety/safety/building_construction/

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For More Information

For more information, please visit the NIOSH Fire Fighter Fatality Investigation and Prevention Program website at http://www.cdc.gov/niosh/fire

To obtain information about other occupational safety and health topics, contact NIOSH at:

Telephone: **1–800–CDC–INFO** (1–800–232–4636)
TTY: 1–888–232–6348
E-mail: cdcinfo@cdc.gov

or visit the NIOSH website at **www.cdc.gov/niosh**.

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