

WORKPLACE SOLUTIONS

From the National Institute for Occupational Safety and Health

Preventing Deaths and Injuries of Fire Fighters Working Above Fire-Damaged Floors

Summary

Fire fighters are at risk of falling through fire-damaged floors. Fire burning underneath floors can significantly degrade the floor system with little indication to fire fighters working above. Floors can fail within minutes of fire exposure, and new construction technology such as engineered wood floor joists may fail sooner than traditional construction methods. NIOSH recommends that fire fighters use extreme caution when entering any structure that may have fire burning beneath the floor.

Description of Exposure

Fire fighters are at risk of falling through fire-damaged floors. Floors may fail within minutes of flame contact. Carpet, ceramic tile, lightweight concrete, and similar floor coverings may increase the danger to firefighters because of the added weight being supported by the floor system and the insulation these ma-

terials provide that may cause the floor to not feel warm, despite the fire underneath.

All wood-based construction materials are subject to failure when exposed to fire. Experimental studies and NIOSH investigations suggest that engineered wood floor systems may fail sooner than traditional sawn lumber floors. The difference in times to failure appears to be a matter of minutes, and fire fighters will seldom know how long a fire has been burning when they arrive on scene. Consequently, fire fighters must use extreme caution when operating on any flooring system potentially exposed to fire.

Engineered wood I-joists represent a rising technology in the building sector; they offer several advantages over traditional construction methods. Engineered wood I-joists are typically prefabricated using sawn or structural composite lumber for the top and bottom flanges (usually 1 ½ to 3 ½ inches wide) and plywood or oriented strand board (OSB) sheathing for the vertical web (3/8 to 7/16 inches thick) (see Figure 1). Engineered wood I-joists are lighter, stiffer, and will not warp, twist, or shrink like traditional framing materials.



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

Engineered wood I-joists also reduce total construction time and labor costs by their ease of installation.

Engineered wood I-joists have grown in use since the early 1990s and by 2005 were estimated to be used in more than half of all wood-frame construction [APA 2005]. Changes in the building construction industry driven by technological advancements and societal needs suggest that the use of engineered wood products will continue to grow.



Figure 2. Traditional floor joists.

The engineered wood I-joist has a different cross-sectional profile than a standard solid sawn wood joist (see Figure 2) and in testing, burned more quickly. Typically, the thinner web was consumed first (see Figure 3). Time-to-failure testing has been conducted by several groups, most recently Underwriters Laboratories (UL) [2008]; [Strasleske and Weber 1988; Weyerhaeuser 1986]. The UL tests show that unprotected lightweight engineered floor joist (I-joists) assemblies can fail in as little as 6 minutes, and that traditional unprotected residential floor construction assemblies failed in less than 19 minutes. Previous studies that used different test methods suggested even shorter times-to-failure. These study results indicate that any floor system can fail quickly, and that unprotected engineered wood I-joists may fail sooner. Results from experiments conducted by the National Institute for Standards and Technology (NIST) are expected in the spring of 2009, and will be available at www.fire.gov/. The NIST experiments were conducted in ventilation limited conditions meant to represent an actual basement fire.

Fire fighters who operate on fire-damaged floors of all types have fallen through the weakened floor and been trapped in the fire below [NIOSH 2005]. Similar hazards exist when fire fighters work under fire-damaged floor systems that collapse onto them. The following is a NIOSH case investigation involving an unprotected engineered wood floor system. **The weakened floor was undetectable from above, although outside conditions indicated the possibility of a basement fire.**

Case Study

On August 13, 2006, a 55-year-old male career engineer (the victim) died and his partner was injured after they fell through the floor at a residential structure fire. The house was built in 1999, and the first floor contained a



Figure 3. Fire-damaged I-joists where victim fell through floor. Note how the vertical web is almost completely consumed [NIOSH 2006a].

heated flooring system consisting of a hot water piping system encased in lightweight concrete supported by engineered wood I-joists and trusses. The basement was unfinished and the bottom sides of the I-joists and floor trusses were exposed. An engine company was conducting a fast attack on a suspected basement fire, while a ladder company conducted horizontal ventilation. The victim and his partner were conducting a primary search on the ground floor. Smoke filled the ground floor and made visibility near zero, but little heat was detected as the victim and his partner conducted a left-hand search. They sounded the ceramic tile floor and took one crawling step forward on their knees when the floor collapsed. The partner fell on the other side of a basement door into a hallway and crawled out of a basement window. The victim fell into the room of fire origin and was recovered the next day. The floor collapsed about 11 minutes after the initial 911 dispatch [NIOSH 2006].

Controls

To minimize risk when working above fire-damaged floors, NIOSH recommends that fire departments and fire fighters take the measures identified below. Many of these prevention measures are from the *NIOSH Alert: Preventing Injuries and Deaths of Fire Fighters due to Truss System Failures* [2005]. Lightweight truss systems and engineered wood floor joists have similar fire degradation risks.

- Conduct a thorough fire size-up and communicate the findings to all personnel on-scene before entering the building. Incident commanders and company officers

should be trained and experienced in structure fire size up to avoid putting fire fighters at unneeded risk of working above fire-damaged floors.

- Do not enter a structure, room, or area when fire is suspected to be directly beneath the floor or area where fire fighters would be operating, or if the location of the fire is unknown.
- Never assume structural safety of any floor (regardless of the construction) having a significant fire under it.
- Conduct pre-incident planning inspections during the construction phase to identify the type of floor construction. If pre-planning is not conducted, assume residential construction and small commercial buildings built since the early 1990s may contain engineered wood I-joists.
- Report construction deficiencies noted during pre-planning to local building code officials. For example, engineered wood floor joists should only be modified per manufacturer specifications—usually limited to cutting to length and removing pre-cut knockouts for utility access. Report damaged or cut chords or webs to building officials.
- Develop, enforce, and follow standard operating procedures (SOPs) on how to size up and combat fires safely in buildings of all construction types. Rapid intervention teams (RIT) should include a portable ladder with their RIT equipment when deployed at basement fires.
- Provide training on identifying signs of weakened floor systems (soft or spongy feel, heat transmitted through floor, downward bowing, etc.). Make fire fighters aware that all floor types can fail with little or no warning.
- Use a thermal imaging camera to help locate fires burning below or within floor systems, but recognize that the camera cannot be relied upon to assess the strength or safety of the floor. Fire fighters should be trained on the use of thermal imaging cameras, including limitations and difficulties in detecting fire burning below floor systems.
- Immediately evacuate and, if possible, use alternate exit routes when floor systems directly beneath the floor where fire fighters would be operating are weakened by fire.
- Use defensive overhaul procedures after fire extinguishment in structures containing fire-damaged floor systems of all types.
- Consider becoming active in the building code process and influence requirements for fire resistance of floor and ceiling systems to further fire fighter safety and health.

In addition, NIOSH recommends the following:

- Trade associations and building contractors should consider providing education and training to fire service

organizations on the hazards fire fighters face when fighting fires that have weakened all types of structural members. An example of such training is available at www.woodaware.info.

- Builders, contractors, and owners should consider protecting all floor systems, including engineered wood I-joists, by covering the underside with fire-resistant materials [Underwriters Laboratories 2008].
- Builders, contractors, and owners should consider incorporating sprinkler systems into residential construction. Sprinkler use reduces the chances of both residential and fire fighter fatalities [USFA 2008].

Acknowledgments

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For More Information

The NIOSH Alert: *Preventing Injuries and Deaths of Fire Fighters due to Truss System Failures* includes relevant information and prevention recommendations. Construction truss systems and engineered floor joists have similar collapse hazards associated with fire degradation. The NIOSH Alert is available at <http://www.cdc.gov/niosh/docs/2005-132/>

The American Forest and Paper Association (AF&PA) and the U.S. Fire Administration have developed the following Web site with information for the fire service about traditional and engineered wood products: <http://www.woodaware.info/>. A CD entitled *Awareness Level Firefighter Training for Modern Wood Products* developed in cooperation with the Illinois Fire Service Institute is available from fire@woodaware.info.

Underwriters Laboratories, with funding from the Department of Homeland Security, has developed an on-line course for fire professionals, "Structural Stability of Engineered Lumber in Fire Conditions" available at <http://www.uluniversity.us/>

The National Institute of Standards and Technology (NIST), Building and Fire Research Laboratory maintains a Web site with links to publications on fire safety topics: <http://www.fire.nist.gov/>. Information on engineered wood I-joist research at NIST can be found at http://www.nist.gov/public_affairs/techbeat/tb2007_0830.htm#firetest.

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