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Entering Through the Door, Falling Through the Floor: Catastrophic Structural Collapse

by Azarang (Ozzie) Mirkhah and Sean DeCrane

Concern about the poor performance of the engineered lightweight wood construction under the fire conditions is nothing new. We have known about it for more than a couple of decades. Obviously, the first name that comes to mind when talking about this subject is the legendary Francis Brannigan and his famous book, *Building Construction for the Fire Service*. There are many great reports, but just a handful of them are mentioned here. Back in 1992, United States Fire Administration (USFA) did a report, titled "Wood Truss Roof Collapse Claims Two Firefighters (December 26, 1992)"; National Institute for Occupational Safety and Health (NIOSH) did a report on April 2005 titled "Preventing Injuries and Deaths of Firefighters due to Truss System Failures"; National Institute of Standards and Technology (NIST) did a report on January 2007 titled "A Study of Metal Truss Plate Connectors When Exposed to Fire".

Through his writings and all his presentations, Brannigan tried for years to teach us about the importance of having a good working knowledge of building construction and repeatedly advised us to "know your enemy." Fire service members have not fully grasped this concept yet, at least not as well as we should. This year, it seems that there wasn't a month that went by without reports of firefighter fatalities and injuries resulting from catastrophic structural failures under the fire conditions.

On April 4, 2008, a veteran Colerain Township, Ohio Fire Capitan Robin Broxterman and Firefighter Brian Schira were killed in the line of duty when they fell through the first floor of a working house fire. The fire was in the basement of a two story, four-bedroom house built in 1991. Reports indicate that the alarm came in shortly after 0600 hours. Captain Broxterman and firefighters Kenny Vadnais and Brian Schira went into the burning building. Three went in, but only one came out. Firefighter Kenny Vadnais believes he is alive today because Robin and Brian helped him escape the fire's death grip. No other injuries were reported. The two occupants of the house made it out before the firefighters arrived on scene (see http://firefighterclosecalls.com/fullstory.php?63098)

When a firefighter dies in the line of duty, the National Institute for Occupational Safety and Health (NIOSH) will respond and conduct an investigation into the event. NIOSH's intent is not to find fault or lay blame. Their intent is to learn lessons from the mistakes or events, and to release a report with the results of their investigation. The report is a public document and fire departments are encouraged to review the report and learn from the events that led to the firefighter's death.

To get a perspective of the real world performance and its effect on firefighter safety, let's look at two relatively recent incidents investigated by NIOSH. Below are the summaries of these two reports and the recommendations published as a result.

Incident - 1: "Volunteer Fire Fighter Dies After Falling Through Floor Supported by Engineered Wooden-I Beams at Residential Structure Fire - Tennessee"
http://www.cdc.gov/niosh/fire/reports/face200707.html

On January 26, 2007, a 24-year-old volunteer firefighter died at a residential structure fire after falling through the floor which was supported by the engineered wooden I-beams. The victim's crew had advanced a handline approximately 20 feet into the structure with zero visibility. They requested ventilation and a thermal imaging camera (TIC), in an attempt to locate and extinguish the fire. The victim exited the structure to retrieve the TIC. When he returned, the floor was spongy as conditions worsened which forced the crew to exit. The victim requested the nozzle and proceeded back into the structure within an arm's distance of one of his crew members, who provided back up while he stood in the doorway. Without warning, the floor collapsed, sending the victim into the basement. Crews attempted to rescue the victim from the fully involved basement, but a subsequent collapse of the main floor halted any rescue attempts. The victim was recovered later that morning. NIOSH investigators concluded that, to minimize the risk of similar occurrences, fire departments should:

- Use a TIC during the initial size-up and search phases of a fire
- Ensure firefighters are trained to recognize the danger of operating above a fire and identify buildings constructed with trusses or engineered wood I-beams
- Consider modifying the current codes to require that lightweight trusses are protected with a fire barrier on both the top and bottom.

Incident - 2: "Career Engineer Dies and Fire Fighter Injured After Falling Through Floor While Conducting a Primary Search at a Residential Structure Fire - Wisconsin"
http://www.cdc.gov/niosh/fire/reports/face200626.html

On August 13, 2006, a 55-year-old career engineer died and another irefighter was injured after falling through the floor at a residential structure fire. The victim and the injured firefighter had arrived in their ambulance and assisted the first-due engine to attach a five-inch supply line at approximately 1227 hours. The engine company was conducting a fast attack on a suspected basement fire while a ladder company conducted horizontal ventilation. The ambulance crew had advanced to the front of the structure when the incident commander requested them to conduct a primary search. The victim and the injured firefighter proceeded to conduct a left hand search at approximately 1234 hours. They took a couple steps to the left just inside the front door to conduct a quick sweep. Visibility was near zero with minimal heat conditions. Because of the smoke conditions, they kneeled, sounded the ceramic tile floor, and took one crawling step while on their knees. They heard a large crack just before the floor gave way, sending them into the basement. The basement area exploded in a fireball when the floor collapsed. The victim fell into the room of origin while the injured fell on the other side of a basement door into a hallway. The injured firefighter was able to eventually crawl out of a basement window. The victim was recovered the next day. The NIOSH investigators concluded that, to minimize the risk of similar occurrences, fire departments should:

- Conduct preincident planning and inspections of buildings within their jurisdictions to facilitate development of safe fire ground strategies and tactics
- Use a TIC during initial size-up and search phases of a fire
- Ensure firefighters are trained to recognize the danger of operating above a fire and identify buildings constructed with trusses

- Consider modifying the current building codes to require that lightweight trusses be protected with a fire barrier on both the top and bottom.

Three lessons should be taken from these two reports. One, these types of dangers impact all firefighters, both career and volunteer. Fire does not know the difference or care; it is an equal opportunity killer. Two, both reports emphasized the importance of firefighters knowing the dangers of operating over a fire and identifying buildings with trusses. Third, both reports recommend that the fire departments should modify the current building codes to require that lightweight trusses be protected with a fire barrier.

During the recent International Code Council's (ICC) Final Action Hearings in Minneapolis for the 2009 edition of the building construction codes, by actively participating in modifying the deficiencies in the current building codes, the fire service attempted to address lesson three. There was a code proposal that would have required lightweight construction in residential properties to be protected with a 30-minute barrier.

The attendance at the final action hearings set a record in the number of fire service attendees. The majority of those attendees were there to support the proposed requirement of residential fire sprinklers in one and two-family homes. As you know, that proposal passed with a strong 73 percent majority, receiving 1,282 votes.

The proponents of the code change to require the protection of lightweight construction hoped for success because of the large fire service attendance. Another encouraging sign was the fact that the code change to require the barrier was scheduled to be heard immediately following the residential fire sprinkler proposal. Surely the fire service would remain to vote on such a critical safety issue.

Unfortunately, during the debate on the code proposal for the protection of lightweight construction. we could see large numbers of firefighters leaving the room. In the subsequent vote, the proposal requiring the fire barrier received a majority of the votes, but fell fifty votes shy of the required 2/3 majority required to be accepted into the codes. The proposal received over 700 votes. That means approximately 500 firefighters left the room after the sprinkler vote. We were not as coordinated and organized as we should have been, and the fire service attendees were not well informed about the code hearing process and procedures. As a result, they believed their work was successfully done and there were no more fire-related proposals to be voted on, so it was time to leave; just as they are used to returning to the fire station right after responding to an incident and putting out the fire. But if only 60 fire fighters would have stayed for the vote, we could have passed the requirement to protect lightweight construction--exactly what NIOSH had recommended numerous times.

We will not give up our efforts to protect our firefighters. The fire service will be back in force, and we will be much better organized and more prepared. We are in it for the long run. In March 2009, another code proposal will be submitted in the ICC code process attempting to address this issue once again at the Code Action Hearings in October 2009 in Baltimore.

But remember that all these efforts would only enhance safety in the new houses being built in the future, and will not have any impact at all on the exiting homes. Now let's take a look to see what we in the fire service can and must do to reduce our firefighter fatalities in the exiting homes. That is especially important when you consider that there is an inventory of more than one hundred million existing homes around our country, and that a majority of those built in the last twenty years were constructed with those lightweight wood trusses.

The question fire service leaders must ask is: What can we do to reduce our firefighter fatalities resulting from such structural failures?

As a rule, in the fire service "we risk a lot to save a lot, and risk a little to save a little." Looking at it from the firefighters' safety perspective, then: We have the option of staying out protecting exposures with defensive operations. Although contrary to our current aggressive "interior attack" mode of operations, is a viable option that fire service members should seriously consider. Simply stated, when it comes to the lightweight wood truss construction, it might be best to stay out from the get go and protect our own firefighters.

Considering our professional obligation and deep commitment to saving lives, this might be a lot easier said than done. We would still be charging in full force if we believe that someone might be trapped inside and a life could be saved. But we should also remember our commitment is to save lives, including our own.

Simply stated, we should not be risking firefighters lives for houses built without much fire resistive rating and no active fire protection systems if there are no civilian lives to be saved in the first place. Buildings are disposable. Lives aren't, and that goes the same for our firefighters' lives.

To get a clear picture of why we should stay out and keep our firefighters safe when there are no lives to be saved, take a look at the latest Underwriters Laboratories (UL) report released on October 1, 2008. Last year, UL received a fire grant from the Department of Homeland Security (DHS) to do a research study on the performance of the lightweight construction under the fire conditions. UL conducted a series of tests, and just this month posted the results of their study titled "Structural Stability of Engineered Lumber in Fire Conditions" on their UL University Web site http://www.ul.com/fire/structural.html.

This is a great online course, free of charge and available to all. This course is essential for all firefighters and an absolute must for all incident commanders and fire safety officers across the land. It is only 52 minutes long but it is absolutely worth it. Please take the time to educate yourself and the staff under your command. The lives that they save could be their own.

Just to give a brief overview, UL did six tests and videotaped them all. They had two firefighter mannequins in full gear with TICs on these test floors and roof assemblies. Watch the videos and see if you can predict when the mannequins will fall through.

It is interesting to see that the difference in the temperature reading of the TIC at the top assembly compared to the inferno below. In one test, after five minutes, the TIC temperature showed a comfortable 73 degrees on the floor level above the fire; meanwhile, the temperature below was 1,378 degrees. This was not because TIC was not working or reading inaccurate temperatures; but because the flooring and carpets do not transfer that temperature, so the TIC doesn't see it.

Briefly stated, based on this report, the lightweight construction, the increased fuel load, and the synthetic petroleum-based materials in modern structures all contribute to much greater fire growth. Needless to say, faster fire growth significantly increases the probability of sudden catastrophic structural failure in these buildings. Time is working against us when fighting fires, and delayed response times could have direct adverse impact on the outcome of the call. Time is a luxury we don't have when responding to these lightweight construction fires; catastrophic structural collapse and firefighter fatalities could be the end result.

Close

Porches: Not As Inviting As You May Think

by Kriss Garcia

You have been dispatched to a one-story, single-family dwelling with occupants reporting that their bedroom is on fire. On arrival, you see fire and smoke showing from two windows on the B side under a fairly large and inviting porch. The relatively small, single room-and-contents fire is on the main floor and seems to be fairly routine. Just after crews enter the front door on the A side and make their way to the main body of fire, the smoke exhausting the windows ignites. What a moment ago was a fire well within your threshold of control is now a fully involved building, and the entrance that firefighters used for their initial attack is severely compromised, jeopardizing the interior crew. Similar scenarios are occurring with increased frequency throughout our current fire service delivery environment.

After reviewing several near-miss videos and National Institute of Occupational Safety and Health reports, it is clear from the fires I have reviewed that fire exhausting from a window or a door under a covered porch appears to be a common factor in some rapid and extreme structure fire behavior. After a recent visit and brainstorming session in Australia with some of our more analytical international friends, it became apparent that, when looking at fire behavior, we have to consider incidents where fire is exhausting into an open covered porch as different from other fires.

Every firefighter understands that the fire loading in today's structures consists of combinations of synthetics, which make the products of combustion much more toxic and volatile than fires of just a few years ago. As these products of combustion exhaust from the building, they readily expand. Generally speaking, although all smoke may be considered fuel, the darker the smoke, and the more rapid it expands as it exhausts from the structure, the more dangerous it is, or the more potential energy is stored within it.

While studying the reproduction of backdraft fires in models and large-scale evaluations, it was not simply the color of the smoke that indicated imminent extreme fire behavior but also the smoke's texture. Smoke that did not have a clean and clear outline or appeared to be fuzzy had the highest possibility of predicting aggressive fire growth. The higher the interior pressure, the fuzzier the smoke appeared. Under these conditions, the fuzzy appearance is more identifiable because of the rapid expansion from this area of high pressure to the low pressure on the exterior.

In direct correlation to the synthetics of today's fire loads is the direct relationship to the potential energy those products of combustion contain. When this element of highly volatile products of combustion is combined with the structural component of a covered porch, everything necessary for extreme fire behavior and rapid, or even explosive, fire behavior exists.

Over the years, more firefighters have come to realize that smoke is a fuel. That consideration alone is not enough to keep firefighters from being injured during fireground operations. We must also consider where that smoke/fuel is and if an ignition source is associated with it. It is this ignition source or heat sink that porches may contain that is spelling disaster for some of today's firefighting operations. These areas of retained heat may not always be porches: Large overhangs and carports are also examples of areas that

can retain temperatures well above the ignition temperature of the exhausting fuel.

While inside the structure, products of combustion will actually be less likely to ignite because the mixture is too rich and too oxygen-deprived for ignition to occur. The interior pressure of the structure also limits the ability of these products of combustion to ignite. The presence of a porch may signify a large surface area of retained ignition temperature. As this very hot and highly flammable environment exhausts from the building, it rapidly expands. As this expansion occurs, what was once an environment that was too rich to ignite is now free to expand and attain the optimum mixture as it reaches the unlimited supply of oxygen under the porch. As this environment full of extreme potential energy heats the underside of the porch, ignition temperatures are easily reached.

Without the presence of the porch, heat would naturally rise and exhaust away from the dwelling. Smoke, or the fuel, is also free to expand away from the structure, without the associated temperature that the covered porch may retain. However, when this exhaust is under a porch, expansion occurs, and it is associated with the increased temperatures on the underside of the porch. The incident commander should fully appreciate that this situation, which combines an optimum flammable mixture plus an ever-increasing ignition temperature, has all the makings of an event with the potential for extreme fire behavior. Relatively speaking, the larger the porch, the larger the potential for disaster, since the larger the surface area of the porch, the more heat is retained. More covered square footage also means a larger area of possible optimum mixture of the smoke/fuel we are worried about. These two items spell increased potential for extreme fire behavior, which will jeopardize firefighter safety.

As this potential energy is ignited by the high temperatures retained on the underside of the porch, the products of combustion rapidly expand. . As this rapid expansion happens, ignition moves toward the interior much like a fuse being lit. The interior pressure is increased at an explosive rate because of the rapid expansion in an enclosed space, which, in turn, causes a dramatic increase of interior pressure to the point where window failure will occur. As windows fail, more oxygen becomes available to the fire, causing it to grow rapidly. When this takes place, interior firefighters relate similar descriptions of the task in which they are involved. Firefighters in several of these situations relate that they were "blown off the line." Often, this ignition occurs after the interior fire has been extinguished and crews have let their guard down.

So, what do we do about this problem? First and foremost, firefighters and incident commanders must have an increased level of appreciation for fires at structures with covered porches. Remember, the larger the porch, the greater the potential for disaster. It is not enough to consider the interior of the building on fire: You must also include the porch as a significant element in your size-up. This element creates so much potential for aggressive fire development that it warrants the same level of concern as any other hazard on the fireground. Often, you hear incident commanders or safety officers announce to all members on the fireground safety concerns such as imminent collapse or downed power lines. Porches warrant the same level of respect and communication. We have to have the ability to decrease the ignition temperature the porch retains. If the area of concern is in close proximity to the attack entrance, the first interior crew should wet down the porch prior to entering the structure.

In training scenarios, this technique seems to decrease the temperature of the underside of the porch as evaporation takes place. If the area under the porch is not near the attack entrance, assign additional crews to cool the underside of the porch, being careful not to direct hose streams into the building through the exhaust. Give the same tactical priority to decreasing the possibility of the porch's igniting as the possibility that utilities might ignite. In a practical sense, this means that backup crews deployed as an immediate rapid intervention team or additional crews can be assigned to keep the underside of the porch cool.

Where does ventilation fall into the equation? We have not done full-scale testing to evaluate this, but we can answer it based on past practice and theory. If possible, crews should exhaust the interior structure through windows that are not under a covered porch. If you have no choice, backup crews should commit to the porch area in an attempt to keep the temperature on the underside of the porch as low as possible. I don't believe using pressurization during the attack or post-knockdown should change the dangers associated with porches, except for the fact that the crews will have less time to get to the main body of the fire, decreasing the time frame during which this potential exists. Regardless, if windows and doors are exhausting under a large covered porch, give special consideration to keep the temperature low enough to avoid ignition.

Without the ability to do full-scale or even limited-scale evaluations of the conditions I am describing, models appear to be a great means of demonstrating this theory. The four-compartment fire-training model uses the 3-D or Compartment Fire Based Training (CFBT), which can easily be modified to include covered porches. With these models, it is also easy to modify the porch size to represent the more dramatic potential larger porches create. The plans can be downloaded, without charge, at http://www.cfbt-us.com

The best means of preventing injury associated with extreme fire behavior is to continually focus on situational awareness. The large porch many find so inviting and comfortable can and will spell disaster for firefighters and those we are sworn to protect. As we operate in these types of conditions, we have to look at porches as a significant element in the extreme fire behavior equation. We know we have a tremendous amount of potential energy in the smoke/fuel. We must consider the ignition temperature that large covered porches and other exterior heat sinks may add to the potential for fire.

Kriss Garcia served in the fire service for 25 years and recently retired as battalion chief with the Salt Lake City (UT) Fire Department and chief of the Tooele City Volunteer Fire Department. He has a bachelor's degree in public administration, is a licensed engineering contractor and paramedic, and is an NFA instructor. He serves on the NFPA 1021 committee and is a voting member of the Air Movement Control Association.

- **More Roundtable**
- **Post your response in 'Roundtable Revisited'**

Subject: Fire behavior, fire dynamics, structural firefighting, building construction, porches, ventilation

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To access this Article, go to:
http://www.fireengineering.com/fireengineering/en-us/index/articles/generic-article-tools-template.articles.fire-engineering.firefighting.structural.2009.9.porches-not-as-inviting-as-you-may-think.html

Take a look at the "Time versus Products of Combustion" illustration posted on the United States Fire Administration (USFA) Web site. You can clearly see that the increase in time directly correlates to the magnitude of fire and significantly increases the hazards facing our firefighters. This USFA's illustration underlines the impact of response time and the importance of residential sprinklers in early suppression of fires: http://www.usfa.dhs.gov/downloads/pdf/coffee-break/time-vs-products-of-combustion.pdf

It is positive to see that, slowly but surely; the fire service is finally realizing the importance of their active participation in the code development process. This participation will not only protect our communities and provide for the safety of our citizens, but also the firefighters putting their lives on the line day in and day out. Organizing the fire service to actively participate in the code development process is our task, as identified by Strategy 5 of the Vision 20/20 National Strategies for Loss Prevention, which is focused on this very important issue.

We were successful in getting the residential fire sprinklers into the codes, which was a big gain, but we failed to get the 30-minutes lightweight construction protection. We will keep on fighting for it and will undoubtedly succeed in future. We owe it to Robin Broxterman and Brian Schira and all of our other brothers and sisters who gave their lives fighting fires.

- **Hear Sean DeCrane and Jack Murphy's radio show on building construction, 'Taming the Fire Environment'**
- **Join Sean and Jack's Community group**
