Firefighter and FSI Continuing Education – 4 Hours
Lightweight Construction Part II

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Last module, we looked at aspects of Engineered Lightweight Structural Components. We covered various types of Truss Construction including Bow-String, Parallel-Chord and Pitched or Triangular Trusses. We also discussed issues surrounding the increased use of Engineered Products such as the "Silent Floors" or Lightweight I-Beam construction. The article discussed the hazards associated with these types of construction and their respective aspects our members need to be aware of on the fire ground that could indicate a potentially compromising situation.

This Quarter's Continuing Education will center on Ordinary Construction, (combustible construction), the types of construction used in Ordinary Construction, two National Institute of Occupational Safety and Health reviews of fire fighter fatalities and we will discuss the use of a Risk versus Reward decision making process. Let us be clear here, no department would advocate employing an all Defensive Operations approach to fire fighting. There are many times, during a Risk versus Reward assessment, that Offensive Operations will bring the incident to a conclusion in a shorter time period. This reduces the risks members are exposed to and reduces the loss realized by the community. If we can use an Offensive Attack quickly, and relatively safely, it shortens the time period a Department's members are exposed to the environmental elements, hazardous atmosphere and toxins of a fire and it also reduces the amount of time the citizens are without full coverage by the area Fire Department. The key is to make good decisions and realize when is the proper time for Defensive Operations. We will stick to the term of Offensive Operations. There are times when the Fire Service will use the term, Aggressive Attack- we heard it nine times at the Charleston Nine funeral- to explain why those firefighters died. There is a growing sense within, and outside, of the Fire Service that the term Aggressive Attack is an indication of an irresponsible attack without regard to safety. Offensive Operations connote a responsible and thoughtful approach to bringing an incident under control or to conclusion.

Lightweight Construction

A basic view of Lightweight Construction would indicate types of construction where vertical and horizontal structural elements are primarily formed by a system of repetitive wood or light gage steel framing members, or where wood products that are lighter in weight than the conventional products they are designed to replace. These would include truss and engineered construction practices.

In “Lightweight Construction Part l”, we discussed a number of tests that have demonstrated the tendency of lightweight products to fail in a time frame of four to seven minutes when tested in according to ASTM E119 test standards. Of course these tests have been done in controlled furnace tests and do not necessarily reflect actual fire conditions. In fact, recently the National Institute of Occupational Safety and Health did a series of test burns in stand alone simulated basements with lightweight I-Beam construction and achieved a Twenty-eight minute timeframe to collapse. This leads to the question, what is reality?

Traditional (Sawn Lumber) Construction

It is widely believed in the Fire Service that traditional lumber is far superior to lightweight construction. With dimensional lumber, 2” x 8” and larger, there is more substance to resist the damaging effects of fire and the structural components will perform for a longer period of time. While this has traditionally been accurate we are starting to see indications that this may not always be the case.

Many Fire Service experiences are based on homes built forty to fifty years or more ago. This was a time period where Sawn Lumber was the widely used form of construction. During this time period the Forest Industry processed trees, for the use of lumber, that were over one hundred years old and 36” inches wide. Today’s trees, that are being processed, are engineered fast growth trees that are processed when they are twenty to thirty years old and only 12" wide. This is a dramatic difference from the lumber used decades ago. The longer growth periods allowed for trees to compress and create a denser lumber product. The lumber harvested today does not enjoy this type of compression over a longer period of time. This potentially results in a softer wood product with a higher air and moisture content, which potentially translates into a lesser performance when exposed to the effects of fire.

Fire Performance Testing

Currently there are two testing agencies looking at the performance factors of various types of construction - Underwriters Laboratories and the National Institute of Standards and Technology. We can look at some of the test results that have been logged to date and compare them.

In tests performed by the WTCA, tests results of exposing structural components to the ASTM E119 Assembly Test at Full Design Load shows that a traditional 2x10 structural member failed in 12 minutes and 6 seconds while a 12" truss failed at 10 minutes and 12 seconds when exposed to the same identical test. That is a difference of two minutes. Remember that these tests are done in a controlled environment so testing applications can be duplicated. They also use a dead load on top of the structural components. This does not simulate the live load and the accompanying vibration factors of fire fighters actively working on the fire scene.

Below are some pictures of a sample test facility and results of the tests on lightweight construction.

The photo on the left shows a floor system prepared for a live fire test. Fire will be introduced underneath. The test includes adding the simulated weight of two firefighters. Lightweight I-Beam construction

The picture on the right depicts the underside of the floor system from the picture on the previous page. Note the lightweight I beam construction in this case made of a top and bottom member and OSB. The floor is also OSB.

To the left is a picture from above of the resulting floor system collapse.

To the right is the collapse from below.

The photos below are from the testing of the same floor area built with 2x10 structural components.

The photo on the left shows the underside of the floor system to be tested. Notice the 2x10 joists, bridging, and plywood flooring.

The post-test resulting collapse.

Now here is a picture from the fire in New Collerain, Ohio where two fire fighters lost their lives when they fell through a floor into the basement, yes, that is 2x10 construction with a wood foundation and plywood subfloor in a house built in 1991.

Notice the total collapse.

NIOSH Studies

Whenever a fire fighter fatality occurs, the National Institute of Occupational Safety and Health conducts an investigation into the causes of death. Their task is not to find fault or penalize individuals or jurisdictions, but they render recommendations that are made public. The intent of these investigations is to create a learning process so the Fire Service as a whole can learn from these events. All reports are available on their web site www.cdc/niosh.gov. Let us briefly look at two examples.

Report #F2006-26:

Summary: On August 13, 2006, a 55-year-old male career Engineer (the victim) died and another fire fighter was injured after falling through the floor at a residential structure fire. The victim and fire fighter had arrived in their ambulance and assisted the first-due engine attach a 5-inch supply line at approximately 1227 hours. The engine company was conducting a fast attack on a suspected basement fire, while the 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 injured fire fighter proceeded to conduct a left hand search at approximately 1234 hours. They took a couple of 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 into a fireball when the floor collapsed. The victim fell into the room of origin while the injured fire fighter fell on the other side of a basement door into a hallway. The injured fire fighter was able to eventually crawl out of a basement window. The victim's body was recovered the next day.

Type of construction: The structure was built in 1999, was a two-story, single family residence of ordinary construction. The floors of the structure involved in this incident consisted of a lightweight wooden parallel-chord truss system and engineered wooden "I" beams.

Recommendations included: Ensure fire fighters are trained to recognize the danger of operating above a fire and identify buildings constructed with trusses. Also, consider modifying the current building codes to require that lightweight trusses be protected with a fire barrier on both the top and bottom.

Report #F2005-09:

Summary: On February 19, 2005, a 39-year-old career fire Captain (the victim) died after being trapped by the partial collapse of the roof of a vacant one-story wood frame dwelling. The house was abandoned and known by residents in the area to be a "crack house" at the time of the incident. The victim was the captain on the first-arriving engine crew, which was assigned to perform a "fast attack"- to take a hoseline into the house, locate the seat of the fire, and begin extinguishment. The one-story wooden ranch-style house was built in the 1950's and additional rooms had been added at the rear in at least two phases following the initial construction. Crews arriving on scene could see fire venting through the roof at the rear of the house. The victim and a fire fighter advanced the initial attack line through the front entrance and made their way toward the rear of the house. Visibility was good in the front of the house but conditions quickly changed as they advanced towards the rear. The fast attack crew had just begun to direct water onto the burning ceiling in the kitchen and den areas when the roof at the rear of the structure (over the building additions) collapsed, trapping the captain under burning debris. The collapse pushed fire toward the front of the house, which quickly ignited carbon and dust particles suspended in the air along with combustible gases, sending a fireball rolling toward the front of the structure. Prior to the time of the collapse, two other crews had entered through the front entrance. The rapidly deteriorating conditions following the collapse quickly engulfed the other crews with fire and five fire fighters received burns requiring medical attention.

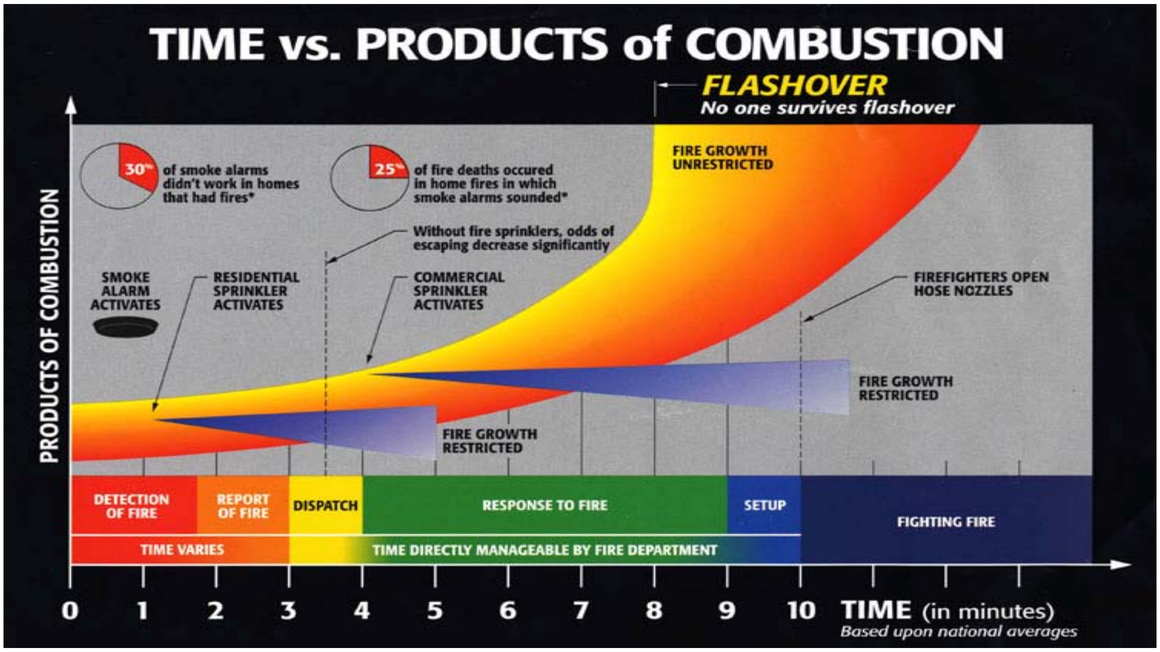
Type of construction: The structure was a one-story wood frame ranch style house that was originally constructed in the 1950's. The house was stick built over a pier and beam foundation.

Recommendations included: Ensure the Incident Commander continuously evaluates the Risk versus Gain when determining whether the fire suppression operation will be offensive or defensive.

The results are the same, it's just a matter of what is the length of time getting to the result. How much time is a matter of debate, we have seen that according to a number of Furnace Tests, building components fail anywhere from four to thirteen minutes. Yet in a simulated basement, NIST determined the lightweight construction performed for Twenty-eight minutes. What do we believe and what do we actually know? Our experiences have taught us we have less time in unprotected lightweight construction and laboratory testing has confirmed there are some differences but we must guard against developing a sense of complacency in newer construction. Today's Sawn Lumber products do not seem to perform to the levels we are accustomed to.

This is what we do know. Standard furnace tests use the ASTM E119 Test Standard for Fire Performance of Building Materials. The E119 test is typically an hour-long test established to judge how a product will perform when exposed to fire. The test uses a gradual increase of a temperature curve reaching 1,700º (F), yet with the furnishings in today's residence we have documented cases of temperatures reaching in excess of 2,300º (F) in three minutes. This will cause a substantial strain on any unprotected structural component.

What does this mean to us? It means we cannot rely on lessons learned over the years in regards to time frames and structural stability. Today's fires are burning hotter because of the BTU's released by the increasing use of thermoplastics and petroleum based products, and insulation materials used to conserve energy allow the fire to retain heat and reach flashover in a shorter time frame. In newer construction it is increasingly more difficult to contain a fire to one room. Unprotected lightweight structural components and engineered fast growth lumber are more susceptible to the effects of today's fires. As the diagram below indicates, ten minutes is a best-case scenario to being able to place water on the fire from the moment of ignition. With the increased temperatures, the structural components of the building are being compromised, in some cases even before we respond.



The above information may seem to indicate that the Fire Service is advocating for an attitude of Defensive Operations at structure fires. This is not the case. The Fire Service is advocating a responsible approach to decision making. Are we risking too much and what are we attempting to gain?

Risk versus Reward Decision Making "Dynamic Risk Assessment"

Purpose:

The purpose of a Risk versus Reward decision-making process is to formalize the practice of a continuous Dynamic Risk Assessment as a component of incident size up, incident management and operational training. The procedure takes into account identification, assessment, and control of hazards arising from the changing circumstances of an operational incident or during training. The objective is to recognize and reduce risks and maintain a high level of fire fighter safety while continuing to manage the incident or activity.

Scope:

The scope of this procedure should apply to health and safety hazards associated with emergency response and operational training activities.

Responsibilities:

Incident Commander:

The IC is Responsible for the determination of the overall strategy and response to the incident. This may involve the direct supervision of the performance of tasks or the delegation of functions to other officers

Safety Officer:

The Incident Safety Officer is responsible for monitoring fire ground safety and environmental conditions, including use of appliances, equipment and implementation of safety related procedures.

Officers and Fire Fighters:

Have a professional responsibility and duty of to fulfill their duties to their department, their colleagues and the community they serve in accordance with accepted Industry Safety Standards and associated operational procedures and directions.

All Members:

Each individual must accept responsibility for his or her own safety. This is achieved by making informed decisions about the appropriate use of available resources, to ensure that the control of risk is effective at all times. Every person needs to ensure they are:

- Capable of performing the tasks assigned;

- An effective member of the team;
- Self disciplined to work within accepted guidelines;
- Adaptable to changing circumstances;
- Vigilant for his or her own safety, vigilant for the safety of their colleagues and others; and
- Able to recognize and express his or her own limitations.

Definitions:

Dynamic Risk Assessment:

The continuous assessment of risk during emergency response activities, and training, taking into account changing environments and circumstances, whereby personnel can rapidly and effectively identify hazards, assess risks and decide on appropriate actions.

Hierarchy of Control:

The hierarchy provides a method and sequence for defining the most effective and appropriate control for risks or hazards. Each of the controls in the hierarchy must be considered when attending an incident. The options descend from the most effective to the least effective in controlling hazards:

- Elimination
- Substitution
- Engineering Controls
- Administrative Controls
- Personal Protective Equipment

Risk:

A measure of the likelihood that the harm from a particular hazard will occur, taking into account the possible severity of the harm.

Risk Assessment:

Risk assessment involves determining the likelihood and consequence of the hazard being realized using the dynamic risk assessment matrix. Determining risk level will assist in the selection and prioritization of appropriate control measures.

Dynamic Risk Assessment Process

Step One: Evaluate the Situation, Tasks and Persons at Risk:

Consider questions, such as:

- What information is available e.g. call information, pre-plans, familiarity with structure?
- What tasks must be carried out?
- What hazards are there in carrying out the tasks in this situation? What risks are associated with these hazards to fire fighters or the public?
- What is the level of risk (low, medium, high), determined by considering the consequence of an adverse event and the likelihood of the event occurring?
- What resources are available e.g. personnel, appliances, equipment or specialist advise?

Step Two: Select Tactics:

- Consider the possible tactics and choose the most appropriate for the situation;
- The starting point for consideration must be procedures that have been established in pre-planning and training.

Step Three: Assess The Chosen Tactics:

The acceptable level of risk will depend on a range of factors including, but not limited to:

- Information on whether there are lives at risk that can be saved;
- The potential risk to fire fighters;

- The real value of the asset involved;
- The likely cost (financial, social, community) arising from the incident or the potential escalation of the incident.

Are the risks proportional to the benefits?

If **YES** proceed with the tasks after ensuring that:

- Goals, both individual and team are understood.
- Responsibilities have been clearly allocated.
- Safety measures and procedures are understood.
- Risks are continually monitored.

If **NO** continue as below:

Step Four: Introduce Additional Controls:

Consideration should be given to the following:

- Eliminate or minimize remaining or additional hazards as far as is reasonably practicable using the hierarchy of controls.
- Can safer equipment/tools be used to further minimize risk given the progression of the incident?
- Can additional specialist resources be used (e.g. aerial ladder platform, rescue or Haz Mat, etc.)?
- Can additional PPE be used?
- Has consultation occurred with the Incident Commander, Sector Officers, Safety Officer or specialists to review decisions?

Step Five: Re-Assess Tactics and Additional Control Measures:

- If any risks remain, does the benefit gained from carrying out the tasks outweigh the possible consequences if the risks are realized?
- If the benefits outweigh the risks proceed with tasks.
- If the risks outweigh the benefits, do NOT proceed with the tasks, but consider alternative tactics.

Ascertaining the Risk Level

The principal of Risk versus Gain must be considered in determining the level of risk associated with an identified hazard and the proposed control. The following methodology is adopted in determining the level of risk steps:

- Identify the Consequence of a Hazard:
  - Identify hazards associated with the particular operational activity or task on the fire ground, for example: building structural collapse or firefighters exposed to traffic at the scene of a vehicle extrication, etc. Once the hazard is identified, determine the consequence as a result of the hazard being realized utilizing the following table:

Consequence Category	**Definition**
Catastrophic	Death
	Multiple/excessive injuries
	Severe loss of operational capability
Major	Loss of consciousness
	Injuries requiring time off work
	Loss of significant equipment – time lost
Moderate	Injuries requiring First Aid and medical follow up
	Repair to equipment required – may result in time lost
Insignificant	Minor Injuries requiring on scene First Aid
	Minor equipment loss/damage – no time lost

- **Determine the Likelihood:**
  - Once the consequence has been ascertained, the likelihood of the risk or hazard being realized is determined using the following table:

Likelihood Category	**Definition**
Certain	Will Happen
Very Likely	Will probably happen
Unlikely	Could happen
Rare	Could happen only in exceptional circumstances

- **Determine the Level of Risk**
  - Once the likelihood and consequence have been determined, the level of risk is ascertained (rated) using the following risk assessment matrix. Advice is provided on the actions required:

Assessing the Risk Rating

Likelihood	**Consequences**			
	Catastrophic	**Major**	**Moderate**	**Insignificant**
Certain	Extreme	Extreme	High	Medium

Very Likely	Extreme	High	High	Medium
Unlikely	High	High	Medium	Low
Rare	High	Medium	Medium	Low

Risk Rating	**Actions Required**
Extreme	Do not proceed/Alternative tactics required
High	Close supervision/back up required
Medium	Normal procedures should suffice
Low	Monitor for escalation

- **Risk versus Gain and Tolerable Risk**
  - Due to the nature of fire service operations, Fire Officers and Fire Fighters are required to make rapid assessments of incidents to which they respond. These assessments are often initially based on limited or incomplete information. Strategies and tactics employed need to be revised as additional facts become known. In this context, decisions on the tolerable level of risk can only be made taking into account all information available at the time.
    The tolerable level of risk is directly related to the potential to saves lives or property. Where there is no potential to save lives, the risk to Fire Fighters must be evaluated in proportion to the ability to save property of value. When there is no ability to save lives or property, there is no justification to expose Fire Fighters to any avoidable risk and defensive fire suppression or low risk operations are the appropriate strategies.