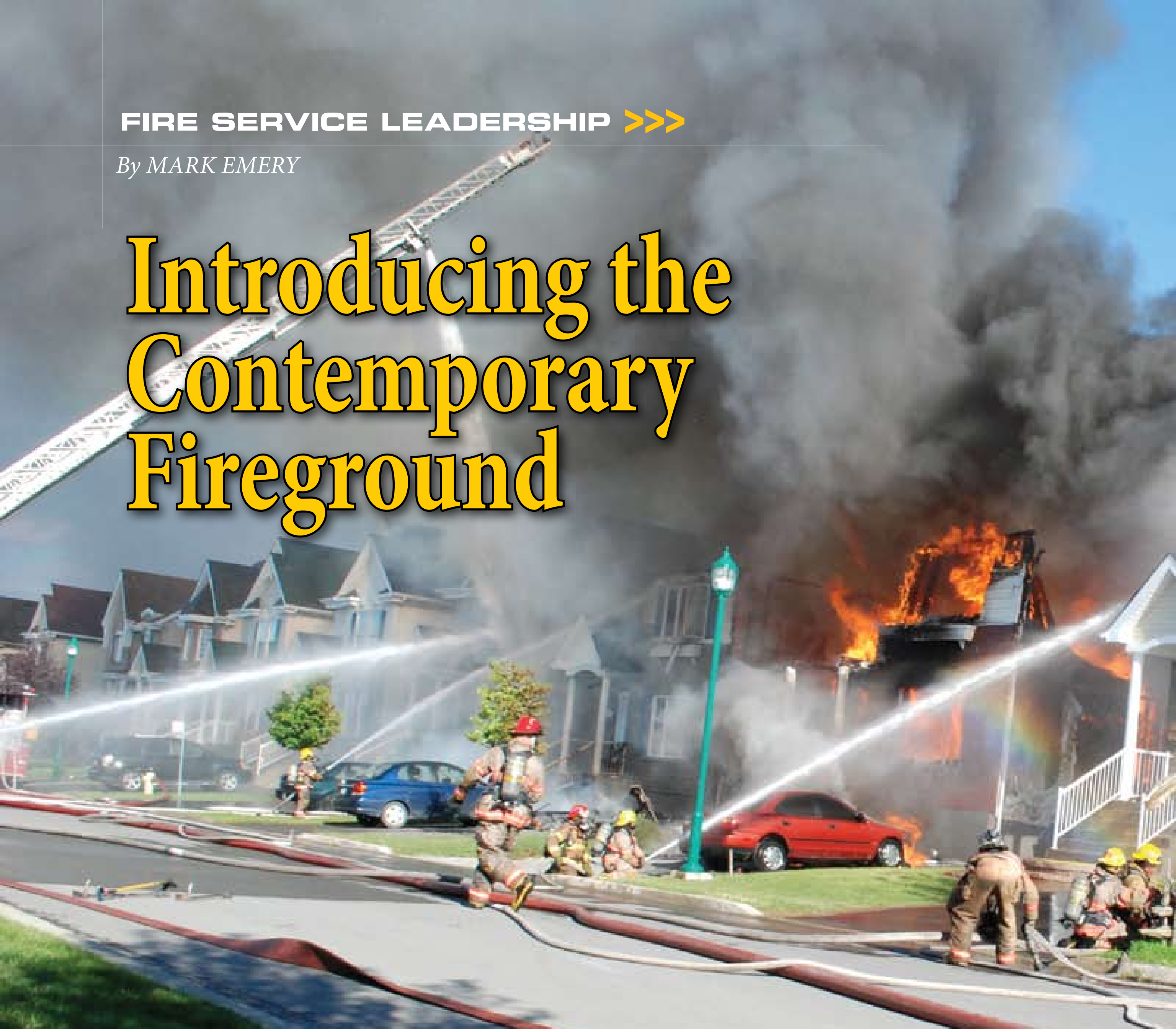
By MARK EMERY

Introducing the Contemporary Fireground



A major fire on Aug. 17, 2008, destroyed three houses and damaged three others in a modern subdivision in St-Eustace, Quebec. The first calls to 911 reported flames and smoke issuing from a residence. The fire was fueled by gas tanks that supplied the houses. Since the traditional fireground has moved on, now is the time for the fire service to become acquainted with the contemporary fireground.

Why It's Time For the Contemporary Fire Service to Adapt Strategically and Tactically

Characteristics of the structural fireground began to evolve 50 or 60 years ago. Collectively, these changes are so significant that the North American fire service should have adapted strategically and tactically. For the most part, the fire service missed or ignored the strategic significance of this transformation. Although each of these changes has been discussed individually, the strategic significance of this transformation has not been addressed collectively – as a single challenge.

While adhering to our traditional strategic priorities of life safety, incident stabilization and property conservation, the North American fire service needs to acknowledge these changes and discuss appropriate strategic and tactical adjustments. It is not appropriate to continue business as usual in and around a theater of action that has not been "usual" for decades.

This article will describe how the traditional square-foot (structural) fireground has

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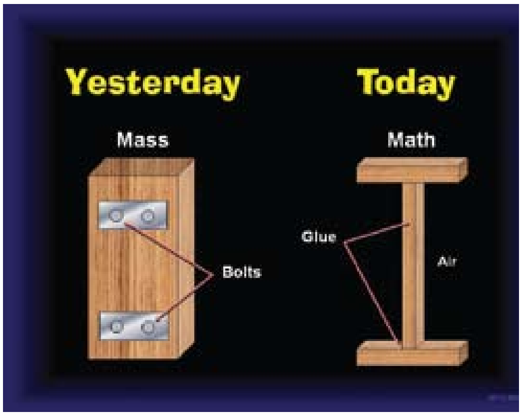
Dominic Fauteux

evolved (for the worse); perhaps the information that follows will serve as the catalyst for spirited discussion about how we can adapt to the contemporary fireground strategically and tactically.



Strategic Factors

Four key strategic factors contributed to the transformation of the *traditional* fireground of 100 years ago to the *contemporary* fireground:

1. Building construction
2. Fire load
3. Time
4. Encapsulation

It is imperative that these factors be quantified, their significance understood and that they become *routine* considerations during the development of a contemporary fireground action plan.

Prior to the 1960s and 1970s, the traditional fireground featured the following two factors: conventional building construction and low-Btu fire loads.

Building Construction

Conventional construction refers to structures that were assembled according to practices passed from generation to generation by skilled craftsmen. Conventional buildings required a lot of time and skill to assemble. Conventional, or "legacy," construction projects required a lot of dead load and time. Because they represent the greatest cost of a construction project, dead load and time are two things that developers don't like. Conventional structures filled with conventional contents offered the fire service the following general characteristics: mass, compression, few connections, low-Btu fire load, more time before failure and threshold of pain.

- **Mass** – Mass refers to dead load. Dead load includes joists, doors, columns, windows, roofing material, girders and heating, ventilating and air conditioning (HVAC) equipment. Conventional buildings relied on mass rather than on precision engineering. A heavy-timber building is perhaps the best example of a conventional building that features enormous structural members. Each load-bearing structural member was huge. An unintended benefit to the contemporary fire service is that the mass of this excessive dead load provides un-designed fire resistance.
- **Compression** – Compression refers to how the dead load and live load of a conventional structure are delivered to the earth. All loads must be delivered to the foundation as compression; loads cannot arrive at the foundation as tension. Conventionally constructed buildings relied on compression more than on tension. Simply stated, compression requires mass, tension reduces mass.

A building that relies on compression features a lot of columns and bearing walls. To achieve the large, uninterrupted spans made possible by lightweight construction in a contemporary building, heavy timber was the only option in conventional buildings. The greater the distance between columns or bearing walls,

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the deeper the girders, purlins and joists must be (think of a header spanning a door or window in a stud wall).

• **Few connections** – Structural systems fail at connections. Consider a simple chair. The pieces of the chair are connected by welds or screws. If the chair were to suddenly fail, it is unlikely to be the consequence of one of the legs buckling. It is much more likely that the cause would be failure of a connection.

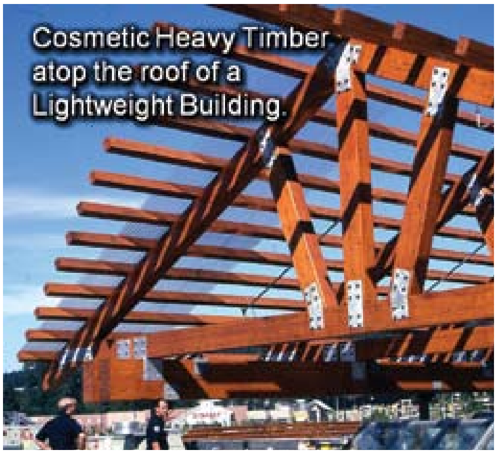
If you've ever meandered through a heavy-timber building, you were likely impressed by the gigantic structural members. Unless you are a student of building construction, however, you probably did not notice the connections. One reason you may not have noticed is that there are so few connections. A huge heavy-timber girder typically has just two connections, one at each supported end of the girder. Like the chair, it is unlikely that a heavy-timber girder will fail in the middle of the girder; failure of a heavy-timber girder will likely be the consequence of a failed connection or compressive support member. (Failure of a connection will release the girder, failure of the girder will release the floor and so on.) Likewise, an unreinforced masonry floor joist is unlikely to fail in the middle of the joist; it is much more likely that the joist will fail where it inserts into a masonry wall or rests on a ledger or corbel.

In addition, these conventional connections were usually substantial. Often, a timber purlin or girder was sandwiched between metal plates that were anchored with a bolt that extended all the way through the wood and then the bolted assembly is secured with a nut. Because of these rigid connections, many of timber assemblies provide near-monolithic behavior. The heavy-timber "self-releasing floor" is designed to eliminate girder-to-column monolithic behavior.

• **Low-Btu fire load** – Fire load (the stuff that burns) on the traditional fireground consisted of natural materials such as wood, cotton, wool and paper. If you could afford wall-to-wall carpeting in 1940, it was made of wool. If you had wallpaper, it was, in fact, paper. Sofa cushions were stuffed with cotton batting, sometimes combined with horsehair and other natural materials. The heat release potential of these natural materials averaged around 8,000 Btu per pound of stuff. For example, one-pound of wood has the potential to release around 7,500 Btu per pound. (The denser the wood, the greater the Btu potential.) In addition to relatively low Btu output, the heat was released slowly, cooperating with the gradual incline of the (now traditional) "time temperature curve."

Generally speaking, the traditional fireground featured low Btu and progressive release of heat. This gradual release of heat meant that flashover was less frequent on the traditional fireground because it took more time for a room full of stuff to heat, off-gas, and ignite.

• **More time before failure** – Because a structural component such as a heavy-timber column or girder contained more material (mass) than was necessary to support intended loading, and because there were fewer and more substantial connections holding all the pieces together, and because of gradual Btu output, fire departments had more time to operate before



structural failure. An accidental benefit of these factors was the undesigned fire resistance mentioned earlier. (Fire resistance is a measure of how long a structural component or assembly will resist the effects of fire and continue to perform its intended function – such as resisting gravity.) Bottom line: when exposed to fire, a large-dimension timber will resist the assault of fire longer than an open-web, two-by-four-inch, metal-plate-connected truss.

• **Threshold of pain** – Now in his mid-80s, my dad was a career firefighter from 1950 to 1977. During a conversation we had around 15 years ago, he recalled that how far firefighters of his day would advance into a fire building was almost entirely dependent on their *threshold of pain*. In other words, because they lacked the sophisticated encapsulation ensemble of contemporary firefighters, advancing deep into a fire area was not possible because it hurt.

Fireground Transformation

TRADITIONAL FIREGROUND	CONTEMPORARY FIREGROUND
■ Conventional construction	■ Lightweight construction
❑ Mass	❑ Math
❑ Compression	❑ Tension
❑ Few connections	❑ Exponential connections
■ 8,000 Btu per pound fireload	■ 16,000 Btu per pound fireload
❑ Wood, paper, wool, cotton, etc.	❑ Plastic, synthetics, etc.
❑ More time before flashover	❑ Less time before flashover
■ More time before structural failure	■ Less time before structural failure
■ Threshold of pain limited advance	■ Encapsulation encourages advance
■ *Traditional* strategic & tactical approach	■ *Traditional* strategic & tactical approach

The contemporary fireground (here, now, all around you) features two key strategic factors: lightweight construction and 16,000-Btu fire loads.

The term "lightweight" does not infer that contemporary structural components are weak or unimportant, in fact, pound for pound, lightweight structural members are incredibly strong and each component very important. Lightweight construction refers to structures that feature structural components with the following characteristics: math (precision engineering), reliance on tension, exponential connections and less time before failure.

• **Math** – One hundred years ago, sophisticated mathematics and precision engineering were not used when designing a building to resist loads. If you wanted a large open span in a warehouse, you had two choices: span the opening with a gigantic heavy timber (configured as a simple beam) or insert a compressive member (such as a column or bearing wall) that would divide the girder into shorter segments, thus distributing the load along the length of the beam. A third choice was to support 25-foot floor and roof joists with a load-bearing masonry wall at each end of the joists. This 25-foot simple beam span did not require heavy timber and is representative of the unreinforced masonry, Main Street U.S.A., ordinary-construction "taxpayer." (Note: A fourth option would be *suspension*, which is 100% tension.)

Reliance on math and precision engineering has significantly reduced the mass (dead load) of a building and can be assembled at a faster pace. In addition, reducing the mass means that you can reduce the number of compressive members such as columns. Developers love lightweight building construction.

Contemporary structural components are precision engineered to have the least amount of material (mass) necessary to support the designed load. A century ago, structural "redundancy" was achieved by making things bigger (mass, dead load) and distributing this load with compressive members (columns, bearing walls); today, structural redundancy is achieved by multiplying the lightweight components – nothing gets bigger, you just add more pieces and more geometry (triangles). This is an important strategic consideration for fire officers: Because of precision engineering and geometry, a building can support more load by adding more pieces, more geometry – or both. In general, it is not necessary to increase the mass (size) of each individual piece of the assembly – the webs and the chords.

Remember: conventional thinking meant that you increase mass or add compressive members to support more load; lightweight thinking means that you replace mass with mathematics and geometry (triangles) and rely on segmentation by geometry rather than segmentation with compression. On the contemporary fireground, ventilating "over the seat of the fire" means being supported by geometry rather than the mass of a conventional structural system.

• **Reliance on tension** – The reason that you can add geometry without increasing the size of the individual truss members (webs and chords) is that trusses (and modern buildings) rely on tension at least as much as compression. Using tension to resist a load allows you to reduce dead load because you eliminate compressive members such as columns.

Consider a rescue rope: For its size and weight, a rescue rope is incredibly strong when resisting a tensile load. However, the rope is useless when resisting a compressive load. To resist the exact same tensile load supported by a rope, *but delivered as compression*, you would need to discard the flimsy rope; the rope would be replaced with something shorter and more rigid, and its diameter would need to be increased. In other words, to resist the load delivered as compression, the rope would need to be replaced with a column.

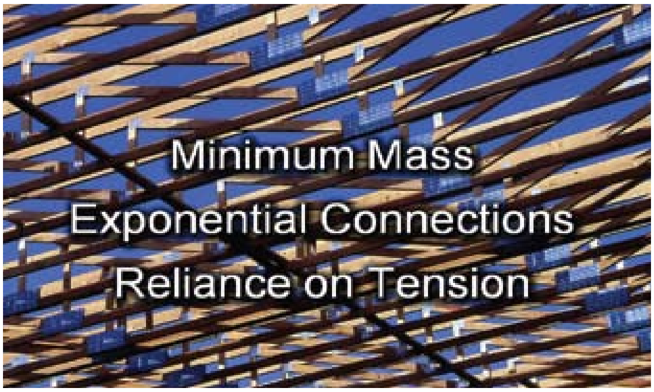
You do not need rigidity or a lot of mass when resisting a tensile load, however, when the exact same load changes to compression the diameter must increase, the length must decrease, flexibility must disappear, and more mass must be added. Bottom line: conventional construction emphasized compression, lightweight construction emphasizes tension. Developers love tension because it reduces dead load.

• **Exponential connections** – A conventional simple beam has just two connections, one at each supported end. Replace the solid, simple beam with a truss and you multiply the connections. In addition to a connection at each supported end, you have dozens of connections within the plane of the truss itself. Each web member connects at the top chord and at the bottom chord, thus each web member requires two connections. Often, these connections are shared with adjacent web members.

An important distinction between a conventional beam and a lightweight truss is that the conventional beam is a single, solid, sawn piece of lumber; an open-web lightweight truss derives its strength from the triangular arrangement of a bunch of individual pieces that comprise the truss. Each of these pieces has a connection. It is important to understand that a truss is not a beam; although a truss is engineered to do the work of and replace a conventional beam, a truss does not deflect (bend) like a beam.

If you have 50 trusses and each truss contains 20 web members, you have exponentially increased the number of connections exposed to fire. No structural engineer is going to tell you that *reducing* the mass and *increasing* the number of connections will *decrease* the likelihood of failure should the assembly be exposed to fire. Exponentialize the number of connections and you exponentialize the likelihood of connection failure when exposed to fire. Visit your local truss manufacturer and ask a truss engineer: "Should a *single* panel point (connection) fail, what is the percent reduction of the safety factor?" You should not be surprised by the answer.

• **Less time before failure** – This one is easy: When you *decrease* the mass (less building) and *increase* reliance on tension (by eliminating compressive columns and bearing walls), and you exponentially *increase* the number of connections holding the lightweight assembly together, failure will – and does – occur much sooner on the contemporary fireground. Of course,



there are ways to protect these lightweight systems (Sheetrock, sprinklers, etc.), but when unprotected and exposed to fire, it should be no surprise that the system will fail early. It should not come as a big surprise when a lightweight roof or floor fails "suddenly and without warning."

Effects of Encapsulation

Contemporary firefighters are festooned with a sophisticated protective ensemble that allows them to advance deep into a hazard environment. While this level of protection is remarkable, it fails to factor structural and environmental changes into which the firefighters advance – including zero visibility.

If you were around the fire service in the mid-1970s to early 1980s, you may have experienced the subtle philosophical shift when it became "important" for firefighters to have an intimate relationship with a fire within a building. For some reason, it became just as important to have firefighters mingle with the heat as it was to have water mingle with the heat.

We need to return to our traditional roots of ensuring that gpm mingles with Btu as quickly and efficiently as possible. So long as firefighters ensure that water does mingle with the heat, they do not need to be located where the actual mingling occurs. (A firefighter mingling with heat does not enhance Btu removal.) Remember: an intelligent and safe fireground operation is not about seeking opportunities for tactical entertainment; an intelligent and safe fireground operation is about seeking opportunities to achieve beneficial strategic outcomes – outcomes that include firefighters returning to quarters unharmed.

On the traditional fireground, it was common to flow between 125 and 150 gpm through handlines. Often, this flow was adequate to control a traditional fire load of 8,000 Btu per pound of stuff. Fast forward to the contemporary fireground. Due to the predominance of petrochemical-based fire load, the average Btu potential has doubled to 16,000 Btu per pound of stuff. It is remarkable that many fire departments upgraded from 1½-inch hose to 1¾-inch hose, yet still charge their handlines to 150 gpm – or less!

I'm not gifted with the mathematics gene, but if contemporary fireground Btu potential has doubled, it makes sense that gpm on the contemporary fireground be doubled. The recent emergence of low-pressure/high-flow nozzles is a positive step toward addressing this heat-removal inadequacy. My personal opinion: *No hoseline on the contemporary offensive fireground should be charged to flow less than 200 gpm.*

There are many gee-whiz nozzles that make this possible when attached to the business end of a 1¾-inch handline; a small handful are easy to handle as well. One example is the Vindicator Heavy Attack nozzle. Attached to a 1¾-inch handline and charged to 50 psi at nozzle pressure, you will be flowing 250 gpm. And here's the amazing feature: you can handle the hoseline with one hand – while standing, by yourself, without a hose strap. (This is not fantasy, I've done it.) Increase the nozzle pressure to 100 psi and you'll be flowing 425 gpm through your 1¾-inch hoseline!

There are many very nice low-pressure/high-flow nozzles, do some homework and make your own judgment. (All hose and all nozzles are not created equal. Test each nozzle using calibrated flow metering equipment and make sure you're using low-friction-loss hose.)

I'm sure you've heard the traditional maxim "do not pass fire." That caveat still holds water (no pun intended): If fire is venting out a window, do not *pass* the fire, *blast* the fire. (Tactical caveat: do this using a solid stream or straight stream; never do this with any degree of fog. Make sure the stream is bounced off the ceiling, shooting the water through the flames will provide no strategic benefit. The goal is stream conversion.)

This *offensive benefit* from a defensive position squirt can reliably turn-back the fire-growth clock, will often confine the fire and often extinguish the fire. If you've ever watched video of FDNY tower ladders blasting fire through windows, you know how effective this can be. Offensive benefit from a defensive position is a brilliant strategy that was employed 100 years ago – on the traditional fireground.

Final Thoughts

Just as a competent physician or paramedic must possess a knowledge foundation of human anatomy and physiology, a competent fire officer must possess a knowledge foundation of structural fireground anatomy and physiology: *building construction*. Building construction knowledge and a solid understanding of fire behavior are essential for a master craftsman fire officer to make *informed* fireground decisions and *proactively* manage fireground risk.

This article described how the traditional square-foot fireground has evolved – for the worse; my hope is that this information will serve as the catalyst for a spirited discussion about how we will adapt to this transformation strategically and tactically. It is not appropriate to continue doing business as usual in and around a fireground that has not been "usual" for decades.

Master craftsman fire officers must continuously seek contemporary tactical alternatives that will achieve traditional strategic benefits. (One example is positive-pressure ventilation.) I hope I'm around long enough to hear the traditional "we are an aggressive, interior fire department" (emphasis on *tactics*) replaced by the contemporary "we are a fire department that ensures our fireground operations are intelligent and safe as possible" (emphasis on *strategy*).

Finally, there is something that hasn't changed during the last 50 years: *Great tactics* have always been, and will always be, easier than *good strategy*.

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Look for an upcoming series, "Building Construction: The Anatomy and Physiology of the Structural Fireground," by Mark Emery that will explore many of the words and concepts discussed within this article. The series will make the engineering principles of building construction easy to understand and applicable to pre-incident planning and the development of a three-in-the-morning fireground strategy.