Fire safety in mid-rise construction: Make the right choice.

Published by

STEEL FRAMING INDUSTRY ASSOCIATION

Contents

PART 1 – OVERVIEW OF TALL COMBUSTIBLE BUILDING ISSUES

Conflagration. Over the past few years, the impact of less stringent building codes across North America threatens to revive this rarely-used word.

Dozens of recent fires in mid-rise, wood-framed hotels, apartments, and other large residential buildings have been documented that resulted in total loss of the buildings and damaged of adjacent properties. The buildings in these fires would have been built of steel and/or concrete in the past, not with combustible framing as now permitted under the International Building Code (IBC), the National Building Code of Canada, and many state and local codes.

Similar large-scale fires have not occurred in steel and concrete buildings. Two main changes have occurred that permit use of combustible framing in buildings as high as seven stories, despite evidence that suggests significant increased risk.

First, the International Building code permitted the allowable stories, height, and areas to increase in exchange for adding sprinklers. This approached failed to address that certain residential sprinkler systems leave whole parts of the building, such as the attic, unprotected. Factor in that sprinklers are not operational during construction when wood framing is exposed and you have a recipe for disaster.

Second, the concept of "podium" construction introduced into building codes further increased the number of stories in buildings with combustible construction. Under this approach, codes allow an additional story to the entire building when the combustible part is constructed over top of non-combustible construction. Depending on the interpretation of the code and height of each story, a building can be as many as 7 stories under these code provisions.

Non-combustible materials are still the best and safest choice.

From a fire-safety perspective, there is little question that non-combustible materials are the best choice. No matter the arguments for taller wood buildings, the bottom line is that this practice increases risk to occupants and property. At the risk of stating the obvious -- wood burns.

Although there are a variety of proven choices among non-combustible materials, cold-formed steel offers a premium building product with advantages that can't be easily matched by other materials including:

- The best strength to weight ratio of any building material. As a building goes higher, steel becomes the most cost effective solution.
- Steel doesn't ignite. This is especially important in buildings where occupants are unable to evacuate during a fire such as with the senior housing/ care facility under construction to the right.
- Durability. Steel doesn't need constant maintenance to prevent rot or mold. It provides a peace of mind in termite infestation areas without chemicals. The coatings on cold-formed steel insure that the material will be around hundreds of years past the life of a building.
- Steel goes up fast. Cold-formed steel buildings are typically panelized off site as opposed to much slower stick or site building used for many other materials. Quicker construction leads to quicker revenue for owners.

On June 2, 2015 at 3:22 a.m., a fire broke out at this 134-unit, wood framed senior residential building. Less than three hours later, the fire had destroyed most of the central part of the multistory complex and had spread into the eastern wing, according to the Augusta Chronicle. The blaze displaced more than 80 residents and killed one elderly woman who was trapped in her third-floor apartment. This incident demonstrates three points regarding use of wood framing in buildings:

1. Devastating fires can occur in any building that used wood framing, but are especially risky in multi-story residential buildings where there are high densities of people in a relatively small area.
2. The argument that wood is as safe as non-combustible framing once the barriers such as gypsum wall and ceiling coverings is not a good one. This occupied building had been complete and occupied for more six months.
3. Sprinklers are an important part of fire safety but they are not the complete answer if the fire is fueled by combustible building materials.

- Steel provides a sustainable material. The high recycled content typical in steel products is unmatched by other framing materials. Steel is the only major building products industry to achieve over 30% reduction in energy use to produce its products since the early 1990s.

Building taller increases risk

How tall can a combustible building be and still be considered safe? Until the past few years, it has generally been understood that light-weight wood framing should be limited to 3 stories or less. As discussed previously, the most significant changes are related to podium construction and sprinkler requirements.

The new sprinkler requirements allow an additional story and 20 feet in height for residential buildings such as hotels, apartments and similar multi-family buildings. Although the extra allowable story and height applies to all types of construction, one could already build taller buildings with steel or concrete because of their non-combustible nature. Effectively, the extra story allowed by sprinkler requirements turned into permission to build taller with wood under the Type V construction designation.

Podium construction takes the number of allowable stories even higher by permitting a combustible building to be constructed on top of noncombustible construction. In this approach, the non-combustible part of the building is not counted when determining the maximum number of stories. In the actual physical world, the wood framing would be approximately 10 feet or even 20 feet above the grade than if built under prior editions of the codes. Depending on the height of each story, the total number of stories in the structure could be as high as seven when a special mezzanine provision of the code is used.

Mezzanines are not counted as stories in determining the maximum allowable number of stories. It's not unusual for a residential building to have a mezzanine level accessible from the top story. For example, you might see two story units on the top floor of an apartment building, with the second story of each unit considered a mezzanine. As long as the mezzanine floor area does not exceed 50% of the area it serves (e.g., the next lower whole story), then the mezzanine level is not counted as a story.

Taken together, the extra story or stories for sprinklers, podium construction, and mezzanines can permit a building at least seven stories above grade. That is a long way from the three story buildings traditionally considered safe for combustible construction.

When the codes allowed additional stories in exchange for sprinklers, they also allowed additional area on each floor. That's a lot of additional fuel stacked high in the air to have anywhere near other buildings or properties.

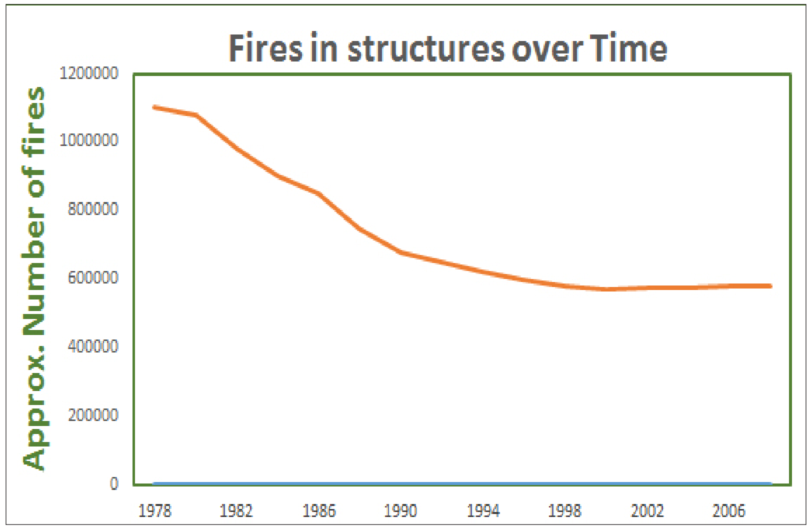
Perhaps the most important take away from code requirements that allow larger wood buildings is that there is really is no need to use combustible construction with its inherent fire safety risks. Steel framing and other non-combustible materials have a proven track record of meeting the markets need for safe and cost-effective buildings.

Wood framing over concrete "podium", Annapolis, MD

PART 2: FIRE RISK IN TALL WOOD BUILDINGS

Fortunately, advances in building code requirements over the years have radically decreased the number of fires in structures. *Figure 1* shows most of the reduction in annual structure fires occurred prior to about 1999 and has since leveled off or slightly increased.

The reduction in fires is due to a large number of code improvements working together including the use of noncombustible materials. The materials in a building are critical in reducing the number of fires that start, allowing safe evacuation, and providing for fire fighter access. With this in mind, why would codes reduce requirements for the allowable height, area, and number of stories right around the time that structure fires were declining? A better public policy would seem to be to look at ways to economically further reduce fires using proven technologies and materials.



Source of data: U.S. FIRE SERVICE, FATALITIES IN STRUCTURE FIRES, 1977-2009, Rita F. Fahy, Ph.D. June 2010, National Fire Protection Association.

The relaxation of allowable story and height requirements in codes is proving to be poor policy in retrospect. These rollbacks in proven safety practices have enabled the proliferation of residential buildings with combustible wood framing as high as 70 feet above grade. It's time to reinstate provisions that protect the public, not continue these practices that expose them to greater risk.

The Predictable Result from Taller Wood Framed Buildings

Since 2006, when the most significant changes were made to the building codes, there has been a steadily growing record of these buildings going up in flames.

Ironically, two of the first six-storey wood-frame buildings were approved under a revised British Columbia building code that raised the allowable heights on wood construction burnt to the ground in a massive fire in Richmond on May 4, 2011. The development, called "The Remy was a 188-unit condo project.

"The Remy", British Columbia, CAN
May 4, 2011

More recently, three major fires in the US in a little more than two years grabbed headlines and provided conclusive evidence that mid-rise buildings construction with combustible wood frame systems represent a significant risk to occupants and property, adjacent property, and the potential for other areas of the city to be left under-protected when massive fire-fighting resources are required for a single event.

Gables Upper Rock, Rockville, MD
April 1, 2014

This 300-unit apartment complex was a total loss due to a fire in the wood framed building. Although the building was technically under construction, it was only weeks from completion and had installed and operating fire sprinklers. This blaze required over 200 fire fighters. Fortunately, no other major events occurred during this fire. It did, however, create headaches in terms of massive traffic backups on the adjacent interstate and temporary closing of a major commuter roadway.

DaVinci Apartments, Los Angeles, CA
December 12, 2014

This major apartment fire not only destroyed this wood framed project, but also caused extensive damage to adjacent buildings and closed major highways around the building. The risk to the developer didn't end there. The city subsequently filed a $20 million lawsuit against the developer of the DaVinci, claiming nearby city-owned buildings suffered over $80 million in damage and that their insurance did not cover it all.

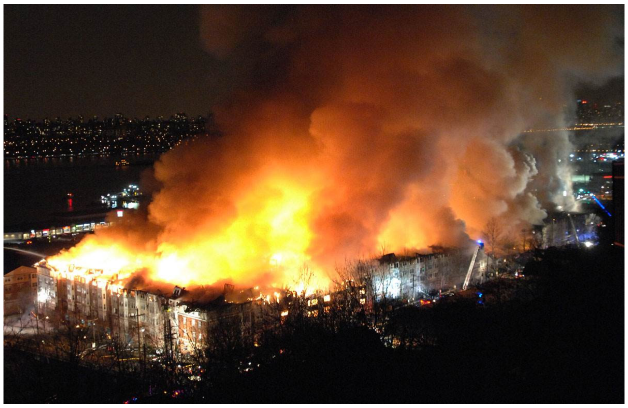
DaVinci Apartments, Los Angeles, CA
December 8, 2014

Avalon at Edgewater, Edgewater, NJ
January 21, 2015

One argument often cited by proponents of taller wood structures is that wood is as safe as fires have occurred in occupied buildings with sprinklers.
This myth was again dispelled by the enormous blaze that destroyed the Avalon at Edgewater apartments in New Jersey on January 21, 2015.

Built in 2002, the four-story wood framed building had been constructed to code and with sprinklers for fire suppression. Twelve years after it was first occupied, maintenance workers who were doing a plumbing repair ignited the fire that rapidly spread inside the walls and ultimately throughout the building. The 7-alarm fire took 15 hours to contain. More than 1,000 residents were displaced by the fire, but fortunately, all the residents were able to escape unharmed.

In the New Jersey case, the building had also burned down years before while under construction. The fire has inspired several bills moving through the state legislature that aim to reduce the risk from wood-framed buildings in New Jersey.



Avalon at Edgewater, Edgewater, NJ
Source: NJ.com

A Growing Catalog of Fire in Wood Framed Multi-Story Buildings

In just the past 5 years there have been a significant number of blazes that have occured as local jurisdictions adopt the new, relaxed building codes. This section highlights just a few of these incidents. All the fires recorded in this section were bult with combustible light frame wood systems, and resulted in nearly complete loss of the buildings in almost all cases. Frequently, adjacent buildings suffered damage, along withand autos and other property on streets.

Cambria Hotel and Suites, Phoenix, AZ August 2, 2016

- Four story, 121 unit hotel under construction
- Eighty firefighters required at the scene.
- Forced evacuation of guests and employees from a nearby hotel. Windows blown out on side facing burning building and sprinklers inside activated.
- A second adjacent hotel that had to be closed for repairs.

The Intersection, Emeryville, CA July 6, 2016

- 5-story, 105 unit apartment under construction was a total loss
- Sprinkler system was installed and working.
- 100 firefighters required from Oakland and nearby communities.
- Utility had to increase water pressure at the scene to help firefighters.

South Pointe Terrace, Winnipeg, CAN October 22, 2015

- Four story wood framed apartment complex with 276 units
- Under construction at time of fire.
- Surrounding homes were evacuated and some were left with cracks on their windows.
- Pallets of lumber posed additional threat to adjacent home.
- 75% of units reduced to charred rubble.

Apollo Way, Madison, WI August 8, 2014

- Four-story, 105-unit wood –frame apartment complex
- Entire building destroyed
- Melted parts of a city fire truck
- Damaged more than a dozen nearby homes
- Under construction at time of fire
- Fire was large enough to be observed on weather radar

Axis Apartments, Houston, TX March 25, 2014

- 5 story, 396 unit apartment
- Under construction at the time of the fire.
- All workers were reported safe, although one worker who was trapped on a fourth floor balcony had to be rescued by a truck ladder just before that part of the structure collapsed.
- More than 400 firefighters were called to the scene.

Mission Bay 360, San Francisco March 11, 2014

- 5 story, 172 unit apartment project
- Under construction at the time of the fire
- Embers caused roof fires on nearby buildings
- The $227 million project was a complete loss.
- 150 firefighters were called to the scene.

Student Apartments, Kingston, Ontario, CAN December 17, 2013

- Designed as a 6-storey, 144-unit building, the structure was framed only up to 4 stories at the time of the fire.
- Firefighters used 8.67 million gallons of water to put out the fire.
- Two workers at the top floor had to be rescued, including a crane operator who was plucked off by a rescue helicopter.
- 273 firefighters from 21 stations wre on scene, leaving only 50 fighfighters available to respond to other emergencies in the city.

A more comprehensive list of multi-story wood framed projects that have been destroyed during construction and while occupied is available at: www.cfsteel.org/ fire-and-multi-story-wood-frame-structures.

Time for change to building codes: A career professional fire fighter's perspective

By Stephen Lohr, Chief, Hagerstown, MD Fire Department

To put it plain and simple, building codes have been relaxed too far in multi-story apartment buildings especially those that are only partially protected with 13-R sprinklers. I have seen this first hand in Montgomery County Maryland, where I recently retired as chief after a long career in the fire services before taking my current position as Chief in neighboring Hagerstown.

Changes to the IBC and other codes that allow taller and larger wood-framed buildings have created risks that are not acceptable. It's difficult to understand why these changes were approved given our nation's experience with large wood fires in the past.

To make matters even worse, justifying taller combustible buildings based on the use of sprinkler systems that are not designed to adequately protect these types of buildings and their occupants. Further, many communities have inadequate water pressure/supply to fight fires in large combustible buildings that can ignite and spread quickly. When the sprinklers don't protect the entire building and the water supply isn't available, what is the alternative?

Below are some of the major issues that most fire departments will have difficulty addressing due to changes in building codes that allow taller wood construction:

- Failure of newer code provisions to not count some stories when determining a buildings height or number of stories. The first (and sometimes second) floor in podium construction does not count as a floor or story. In addition, if a loft or mezzanine is less than 1/3 of the area of the finished floor, it doesn't count either. These are real stories. They need to be counted. From the fire department's perspective, these buildings are for all intents and purposes a high rise that many communities are not prepared to protect.
- Concerns over the fire departments ability to fight fires in taller wood buildings during construction and post occupancy. I see the fires that are occurring around the county and had firsthand experience with these concerns on a large multi-family wood structure fire in Montgomery County in 2014 that quickly got out of control. How many communities have the underground water supply to deliver 10,000 gpm for 3-4 hrs? How many fire departments can assemble five or more elevated master systems in a timely fashion? What happens when this construction arrives in under- resourced suburban and rural areas?"
- The use of NFPA 13R sprinkler systems in combustible buildings. The Fire Department does not have a fighting chance when the fire reaches the unprotected spaces in these buildings. The sprinkler systems being used in residential buildings do not require sprinklers in combustible spaces that are not used for living, storage or fuel-fired equipment, or in baths less than 55 square feet in area. Fire departments need to be concerned with fires that originate outside of protected spaces including large volume areas such as attics. Once a fire starts in unprotected spaces and rapidly spreads to the rest of the building, it leads to early collapse, unacceptable risk to responders and potential for wind-driven conflagrations.

As I stated at the start of this article, it's time to address these roll-backs in building codes that have created higher risk both during and after construction. I have several recommendations to prevent or reduce the risk of fires in combustible buildings. These include eliminating the extra allowable height and stories given to buildings over a first floor pedestal, lengthening allowable horizontal separation distances from combustible construction, and assuring fire department access and water supply at all phases of the building's construction and operation. Last, it is important for citizens and officials in jurisdictions that allow taller wood buildings to adjust their expectations and accept that fire departments cannot deploy adequately for the larger fires that will result from these buildings.

I am continuing to work with fire departments throughout Maryland to convince our state legislature to make changes and encourage other fire fighters to do the same. We need to take steps to undo some of the impacts that we now face due to relaxation of codes with regard to the use of combustible framing in larger and taller buildings.

Tall wood buildings, an insurance industry professional's perspective

By Charles Specht, independent insurance consultant at Constructive Risk, Exeter, California

In early 2015 a major fire raced through an apartment community in Edgewater, New Jersey, destroying several hundred units and displacing the residents of the luxury development in the middle of winter.

As dramatic as this enormous fire was, it was by no means a singular event. The proliferation of wood-framed construction in mid-rise buildings is making these types of fires a recurring problem across the country.

Insurers have long been wise to these risks. "Wood" construction has a greater likelihood to burn or be damaged by fire and will be a total loss versus a partial one. Loss history for wood construction has been poor, and carriers are very restrictive of the amount of risk they will take. This drives up the cost to the builder, and actually weakens the frequently-promoted argument that wood is less expensive than other materials. The recent major wood frame fires calls for a need to look at cost savings and particularly insurance more closely.

Insurance is more than a line item, and can seem to have as many variables as a project itself. That's because a single commercial building project requires a range of insurance products, including property insurance, workers compensation, course-of-construction liability insurance and builders risk insurance. Complicating matters further, the cost of each of these types of insurance depends on factors unique to each individual project.

Because insurance is necessary, even if a builder shops for insurance with close attention to cost, the prevailing attitude may be to "bite the bullet" and accept insurance expenses as the "cost of doing business."

But for a range of low- and mid-rise construction projects, there are a few options. Builders may be missing a major opportunity to trim their insurance costs where they might least expect it—through the use of cold-formed steel framing.

The simple reason is that cold-formed steel is non-combustible: It simply does not burn or contribute to the spread or intensity of a fire.

One insurer, the US Assure Builders Risk Plan insured by Zurich American Insurance Co., for example, offers a builders risk insurance plan specifically designed for steel-framed projects. The firm says the plan is the first offering explicitly based on the non-combustibility of steel versus wood.

According to the company, the plan establishes builders risk insurance rates for cold-formed steel framing in commercial and multifamily construction projects that are significantly lower than the premiums available for wood-framed projects. Of course, all this is subject to underwriting.

For insurance purposes, a noncombustible designation for a commercial project depends largely on the classification of the load-bearing material used to support walls, floors and roofs. This is key, because insurers look at the individual parts of the project, which for underwriting purposes may be classified under one of five other designations—frame, joisted masonry, masonry non-combustible, modified fire resistive and fire resistive.

This is an important consideration for builders, because although a project may contain a majority of noncombustible components—like walls and floors—if the roof trusses are made from wood, the entire project cannot be classified as noncombustible. Each component matters in an insurer's eyes.

Once a project is properly qualified as noncombustible by an underwriter, it may also qualify for discounts on other kinds of insurance, such as property insurance.

Of course, while the potential for savings by using cold-formed steel framing is there, other factors also affect the cost of builders risk insurance, including geographic location, catastrophic surcharges, deductibles, the contractor's history of loss, and so forth. The same holds true for the cost of property insurance, which may be affected by intended building use, fire protections, adjacent risks, geographic location and other factors.

But cold-formed steel offers more than an insurance advantage. It has the highest strength-to-weight ratio of any construction material. And it enjoys definite advantages over wood in terms of durability, moisture- and mold-resistance and recyclability.

Most builders who have followed the recent trend toward using wood in nonresidential construction often use "cost" as their motivation. That is certainly understandable in today's tough economic and competitive construction market. However, there can be substantial savings associated with noncombustible materials, and they could be selling themselves short if they're not exploring the impact of lower insurance costs. As the market adjusts to the upswing in major claims from the recent fires, this could be even more important in the future.

A Mayor's Perspective on the Impact of Taller Wood Buildings on the Community

By Mike Poellinger, La Crescent, MN

As the mayor of a town with a population of roughly 5000, I have a responsibility to carefully evaluate how our town grows and to maintain the safety and prosperity of our residents and property owners. Anything that increases risk needs to be taken seriously.

The advancement of combustible wood framing into taller buildings (above 3 stories) is one of those issues we need to approach with particular caution. As mayor, I see the potential costs and drain on our resources. I am also an active member of the fire department in our community and understand the type of risks these taller wood-framed buildings pose to life safety and property. My dual role gives me a unique vantage point to address some serious concerns.

Safety is the most important responsibility of a public official. Within many small to medium towns like we have here in La Crescent, we don't have the capability to fight the large fires that have occurred in recent times with combustible buildings, particularly during the construction stage when the wood framing is exposed. Taller buildings pose problems for our firefighters and their ability to access and safely fight a fire. We don't have the resources to fight fires in tall buildings like they have in larger cities. Our best approach is to make sure they don't happen to begin with.

Smaller wood-framed buildings already pose a challenge to our firefighters. A recent fire in a two-story, 24 unit apartment we experienced in town is a good example. The fire started on the second floor but because of the combustible framing in the attic, it quickly spread throughout the building.

The building was located close to other structures and would have put our firefighters in a risky situation to access a critical area necessary to fight the fire. Fortunately, we were able to borrow some equipment from another nearby town and get an unmanned hose stream into tight quarters to protect adjacent property. It was fortunate that another community wasn't using their equipment at the time but that isn't always the case. Despite tremendous effort, the building was a total loss and had to be demolished. Adjacent roofs also suffered some damaged. Thankfully, no one was seriously injured although it hammered home the seriousness of allowing even taller or larger buildings of combustible construction.

Water supply is another important constraint on the capabilities of smaller jurisdictions. Fighting a fire in a large building requires water pressure and flows that just don't exist in many places. In arid regions with frequent droughts, the tremendous amount of water to fight a large fire takes away a precious resource from our residents. That water also isn't available to protect other building should a fire develop elsewhere. We need to consider these impacts carefully before approving taller wood buildings.

Putting my firefighter hat on, I can tell you that fighting a fire in a building the likes of which you have not seen before is a frightening situation. The use of wood in town has been minimal historically, mostly limited to single family homes. Very few fire departments have the training or experience to battle a large fire of the type we have seen across the county with combustible buildings over the past few years.

We also need to recognize that the financial risk to a community doesn't stop when the fire is out. There are few forensic engineers in the country who are qualified to access the fire damage to a large combustible building as to its structural condition. Yet the town is faced with the need to make a quick decision as to what to do with the building. Who gets stuck with paying for the analysis until the situation is cleared up? Communities should consider this question closely, especially those with few resources. You can't just leave a building in a precarious state when it poses a risk to neighbors. On top of that, it is not unusual for the owner's insurance coverage to fall short of the amount needed to tear down and/or rebuild. Building with materials that minimize fire risk in the first place is a much better option from a community resource perspective.

Long-term implications

A builder or developer often needs to be concerned with building a structure that meets appropriate health and safety codes, making a marketable product, and having an economically-viable project. Our town has to be concerned over a much longer time frame. How will the building stand up physically over time, long after the building has been sold, often multiple times? Will it contribute positively to the community for its lifetime? Are passive fire-protection systems durable enough to overcome building changes? Large combustible framed buildings raise some practical and significant concerns in these areas.

Buildings change over time whether intentionally through occupancy/use changes or through unintended modifications. Likewise, our codes are always improving to better protect our citizens. We want buildings that are flexible to accommodate market changes, but we also want them to meet the latest safety requirements when they do face a use change. A community should not have to be put in a position of granting waivers to buildings because they can't be economically changed to a different use otherwise. We should build for the future from the start. The flexibility to address fire safety increases just isn't there with wood framed buildings. This is not an unusual situation to encounter when buildings go condo from apartments.

In the 24 unit apartment fire I mentioned earlier, the fire spread easily across the attic because the fire stops had been repeatedly damaged during routine maintenance and other work and never repaired. Passive systems are not a reliable system when the underlying structure is combustible. We've seen this happen recently in a devastating fire in Edgewater, New Jersey where the fire in a large residential building started behind the walls and quickly spread throughout the building.

When our buildings are not durable, another long-term issue arises that is important to maintaining high quality buildings in our community. We have seen numerous cases of down-branding occur in our town and nearby areas. These mid-rise hotels were built of wood but due to issues such as sound transmission, moisture issues, cracking due to movement, and similar durability issues, the owners were reluctant to spend the money to continuously address the buildings' ongoing maintenance needs. When the building isn't able to meet the standards for the higher end hotel chain it stared out as, the buildings were down-branded to lesser quality hotels. That is not what we signed up for when the building was originally approved.

These are just a few of the issues that smaller communities face with taller and larger wood framed construction. In the rush to approve the use of wood framing in buildings where they were not permitted for decades under building codes, perhaps it is time to re-examine the risks. It appears that many unintended implications have not been well thought out by building code and standards developers. As an elected official, I would encourage other town officials to closely examine their limited financial and water resources, their fire-fighting capabilities, and the quality of construction in the long term. Proven materials offer a route that can give elected officials piece of mind. Consider the risk of taller wood buildings very carefully.

We often see unsupported statements that wood is as much as 30% less expensive than non-combustible construction. While wood and steel are both generally less expensive than concrete or masonry, comparing wood to steel is complex and can't be distilled down to general statements.

First cost is obviously important and a good starting point. However, other real costs should not be ignored such as maintenance/replacement costs, insurance, and revenue streams.

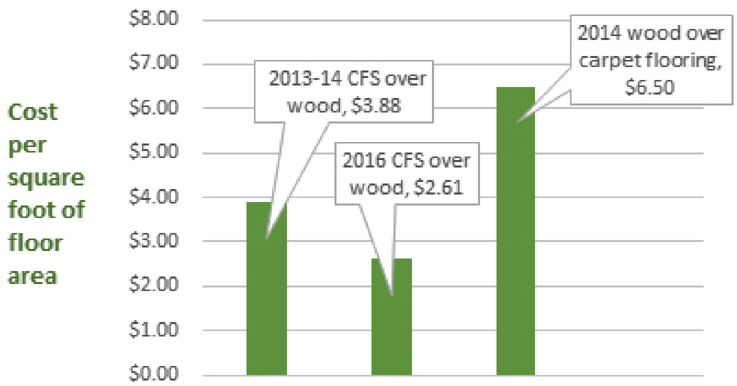
One should also be wary when percentages are used to justify a product decision as they are often misleading. For example, the cost of a framing material that promises to be 10% less expensive than other framing systems usually means the materials themselves, not the total building. That 10% will likely be a couple of percentage points relative to the entire building cost. A more realistic approach is to determine a cost per square foot impact on the total building cost.

Figure 3 shows the cost increase for CFS compared to wood from an analysis of four actual mid-rise projects that were bid with both CFS and wood frame construction in the 2013-14 timeframe. Because material cost are volatile, Figure 5 also shows the same cost difference adjusted to materials prices as of January 2016. To materials costs in perspective, the figure also shows that much less critical decisions on safety such as the choice in carpet versus wood flooring tend to have much higher cost impacts.

Figure 3 does not adjust for labor cost changes between 2013-14 and 2016, only materials. One contractor on the jobs involved in the 2013-2014 buildings believes any overall cost difference between wood and CFS has all but disappeared due to the revival of the housing market that has caused wood carpenter rates to spike.

It is important to stress again that material and labor costs change all of the time. Figure 4 illustrates this based on data collected by American Metal Markets magazine for galvanized steel and the Random Lengths composite lumber prices. Steel material prices have been on a downward trend since January of 2014 versus much more unstable wood prices.

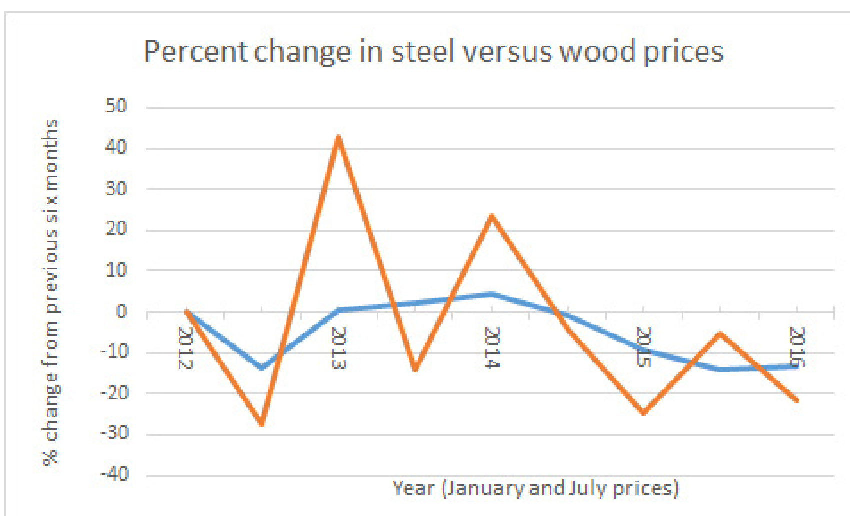
Figure 3. Difference in first (installed) costs



Steel Prices are Stable Relative to Wood Framing

Considering the fire-safety risks, especially during construction where there are plenty of examples of wood buildings being built twice because of fires, is it really worth a few dollars/sf at most to endanger lives and property? Consider for example, the following issues that further impact cost:

- Steel is a very efficient structural material due to its inherent strength and the industry's ability to roll it into shapes that best carry and transfer loads. It's hard to beat a C-shaped stud in terms of its efficiency (balance of costs, structural capacity, and weight) in carrying loads. When a taller building is constructed resulting in heavy loads on the lower stories, a CFS designer has many options to carry those loads.



- With lumber, close spacing of conventional studs along with deeper studs is almost always necessary to reach beyond three stories. Extrapolating costs from low-rise construction will seriously underestimate overall costs.
- Tall wood buildings require expensive fire-retardant-treated lumber for buildings that provide medical treatment or housing for people often incapable of caring for themselves, or with Type III construction where the IBC requires noncombustible materials in the exterior wall assemblies.
- Because of its stable nature and the choice of screws over nails, CFS construction is inherently resistant to nail pops and cracks in gypsum board that are commonplace when wood shrinks and swells. Steel trusses don't rise in attics as with wood trusses, avoiding frequent and repetitive repair costs.
- An August 2007 article in Structure magazine, showed that the cumulative potential shrinkage due to wood framing would be approximately 4 inches in a five story building. Imagine the impact this would have on finishes, plumbing (including sprinkler piping), door and window operation, and even elevators.
- Air leakage is critical to energy use in buildings. The constant and potentially large movement in wood-framed buildings needs to be evaluated in terms of the cost to heat and cool a building. Similar issues exist for acoustic performance where "flanking" movement of sound through cracks and gaps can defeat an otherwise well-designed assembly.
- The insurance industry rewards builders and building owners with lower rates for those who use noncombustible construction. On a recent 400 unit hotel in Ohio, the builder's risk insurance savings were over $1.3 million. An additional $66,000 will be saved by the owners with property insurance over the first ten years of operation. Most insurers also limit their capacity or risk to between $5 million and $7.5 million for wood framed buildings, requiring the use of multiple insurers and higher cumulative premiums for mid-rise buildings.

The table on this page shows the range of cost savings of various insurance products that impact the builder, developer, and owner when choosing CFS over wood.

- Cold formed steel goes up fast, shaving as much as 5 to 8 weeks off the construction schedule. This delivers lower soft costs for construction stage insurance, debt servicing, and overhead and labor. Perhaps as important, it creates revenue streams much sooner than with systems that are site-built such as with most wood framing or masonry. On a recent 40-unit apartment building in Ontario, the owner's representative realized $100,000 in rents due to the quicker construction schedule with CFS construction.

When taking all of costs of mid-rise buildings into account and the performance and safety issues, noncombustible construction such as steel is still the better choice to deliver cost-effective and safe buildings for the public.

Insurance Savings with CFS vs. Combustible Construction

Insurance product	Range of premium savings
Builders risk	25 to 72%
Workers compensation	15 to 60%
General liability	up to 50%
Surety/bonds	5 to 15%

Appendix A – Building heights in the IBC - 2105 requirements

Determining the allowable height of a building under the base 2015 IBC requirements depends on three key variables: Type of construction, occupancy type, and use of and type of sprinkler system. All of these variables are required to determine the allowable height and number of stories for a building using Tables 504.3 and 504.4 of the code. As discussed later, additional increases in the number of stories and allowable height are permitted for certain occupancy types under "Special Provisions" conditions covered in Section 510 of the code.

Building codes are often developed in piecemeal fashion through incremental changes over multiple code change cycles. Thus, locating specific requirements is not always intuitive. With building heights, perhaps the best place to start is with the classification of occupancy type in Chapter 3 of the IBC, then move to Chapter 6 on construction type, and finally on to Chapter 5 for the maximum allowable height and story requirements based on each of the first two variables. The sprinkler and special provisions related to height and stories are also contained in Chapter 5.

Occupancy (Use group)

Chapter 3 of the IBC classifies buildings according to 10 different occupancy types (see box at right below). Each major use "Group" addresses an occupancy type that reflects the primary use of the building. Within most every use group, there are subcategories. For example, Group R addresses four different types of residential buildings ranging from large hotels or apartments to small lodging houses. Likewise, Group I has several subcategories depending on the abilities or situation of occupants, for example, prisons where security is important or nursing homes where the abilities of the patient is important for egress or other needs.

In order to determine the allowable height and number of stories from the requirements in Chapter 5 of the IBC, one has to determine the use group and any subcategory that applies from the descriptions in Chapter 3 of the code. Once the group classification is identified, the next piece of necessary information comes from Chapter 6 of the code.

Type of Construction

Section 602 of the 2015 IBC classifies buildings according to the type of materials used for their construction. At one end of the range are Type I and II buildings that are completely constructed of noncombustible materials. CFS construction can be used in either of these construction types. At the other end of the range are Type V buildings that can be constructed of any material permitted by the code but which typically rely on a significant use of wood framing and sheathing. CFS can be used in a Type V building but there are advantages to use other types of construction because of the limitations on height and stories in Type V requirements.

The middle range construction types are Type III and Type IV. Type III requires the exterior wall materials to be noncombustible but allows any type of material for interior elements. Type IV governs heavy timber construction. At this point, it is important to know that the type of construction (and the occupancy type) govern more than just building height and number of stories. There are other provisions throughout the code that are specific to these classifications that are not addressed in this paper. For example, Table 601 in the IBC provides requirements for fire-resistance ratings of elements such as walls, columns, floors, and roofs based on type of construction. Chapter 4 contains requirements for specific occupancy types related to egress, fire safety, and other issues. The code user or designer should be familiar with all code requirements that may impact their building or rely on a professional who has this knowledge.

Once the type of construction is identified in Section 602, this information can then be used along with the use group classification from Chapter 3 to move on to the height and story allowances in Chapter 5.

Occupancy types in the 2015 IBC

Group A – Assembly
Group B - Business (includes office buildings)
Group E – Educational
Group H – High hazard
Group I – institutional
Group M – Mercantile
Group R – Residential
Group S – Storage
Group U – Utility and misc.

2015 International Building Code, Section 302, International Code Council

Height and Area Limits

The starting point to determine the allowable height and number of stories is Section 504 of the IBC. Table 504.3 provides the allowable maximum building height according to the type of construction and occupancy classification. There are three options based on sprinkler use for all occupancies. "NS" is limited to existing buildings. A second category, "S," is applicable to all buildings and refers to buildings with a specific type of sprinkler system that protects the entire building. Except for residential buildings, the "S" option is the basic criteria that will apply to new building construction. For example, a group R building with a Type II designation has a height limit of 85 or 75 feet depending on whether it is a Type IIA or Type II B classification, respectively. A Type IA residential building has a height limit of 180 feet under the "S" option.

The third option that applies only to residential buildings is designated as "S13R." The S13R sprinkler system provides a lesser amount of coverage than the full "S" sprinkler system. For example, it does not require attics to have sprinklers. Despite the higher risk of these lesser systems, the IBC and other codes permit their use in apartments and other buildings.

Once the allowable height is determined, the building design must also meet the limitations on number of stories in the IBC. This is covered in Table 504.4 of the code and follows a similar structure as the allowable heights table based on sprinkler systems use. However, Table 504.4 breaks down the use group into many more subcategories than the height table. For example, heights in Table 504.3 are addressed for residential uses (Group R) as a whole, but Table 504.4 on allowable stories has requirements for four Residential subgroups (R-1, R-2, R-3, and R4). Note that the height and story requirements both must be met. It is not one or the other.

Special provisions

The IBC doesn't stop with the base height and story limits in Tables 504.3 and 504.4. Section 510 of the code contains special provisions that allow further adjustments to height and stories based on specific conditions. This section is frequently used to build higher structures than in the base tables. Unfortunately, it also allows for higher buildings with combustible construction.

Podium construction – Section 510.2 addresses an allowance for taller buildings but is limited to Group A, B, M, R, and S occupancies. It is based on the presence of a horizontal separation at the lowest floor level of the combustible building, with a minimum 3-hour fire-resistance rating. The building below this level has to be of Type IIA construction and have a full sprinkler system. These buildings are often called podium buildings because they consist of a concrete "podium" with additional stories of other materials above it. Section 510.2 allows the building above to have the maximum number of stories for that building type as long as the overall height does not exceed the allowable height of the building below or above the horizontal separation, whichever is shorter. Because the height of a story has a wide range in actual buildings, Section 502.1 adds just enough flexibility that many buildings can be expanded in their number of stories without exceeding the height limit.

Section 510 addresses several other special cases where the number of stories and height are increased over the base requirements in either Table 504.3 or 504.4. Section 510.3 addresses parking structures in S-2 buildings. Section 510.4 can allow an increase in number of stories similar to the podium provision for residential buildings over an enclosed parking structure. It allows the same for a Type V buildings when a single story open parking structure is used. The other subsections in Section 510 allow similar variations to the number of stories for certain buildings with parking structures. However, the two sections at 510.5 and 510.6 are two of the most important given they addresses hotels, apartments, and other Group R buildings.

APPENDIX B. SUSTAINABILITY

Just about every building material trade association or major manufacturer has commissioned a study that proves their product is the most sustainable. How can everyone have the most environmentally-friendly product? The answer depends on how one measures "sustainable."

Newer analysis methods that try to take into account multiple variables associated with a product, such as life cycle analysis (LCA), are important to manufacturers as tools in optimizing their manufacturing processes. However, despite their popularity, LCAs, EPDs (Environmental Product Declarations) and other similar tools come up short in actually determining a product, assembly, or a whole building's impact on the environment. It may be important for transparency reasons to conduct these types of studies and release appropriate declarations but they should not replace measurable characteristics with clear outcomes as a more reliable way of assessing impacts. An EPD for cold-formed steel is available from the Steel Recycling Institute at https://www.scscertified.com/products/cert_pdfs/SCS-EPD-03838_SRI_CFS-Stud-Track_011916_web.pdf?r=1.

Sustainability focused on measurable impacts is an area where steel really does shine. Measures such as production energy, material usage in buildings, recycled content, and durability are easily connected to environmental impact.

Energy

The increasing use of electric arc furnace technology combined with high recycling rates since the late 1980s has positioned the steel industry for incredible gains in energy and emission reductions. It would be hard to find another industry, yet alone one that is central to the nation's infrastructure and defense that has achieved the gains steel has in reducing its environmental impact over the last few decades. The Steel Recycling Institute tracks recycling rates and other sustainability characteristics for the North American steel industry and has documented "reduced energy intensity per ton of steel produced by 31 percent and CO2 emissions by 36 percent per ton of steel shipped since 1990 (http://www.recycle-steel.org/sustainability.aspx).

Manufacturing energy is important but tanother question that always seems to be asked is "how does steel impact the energy use in a building?" The short answer is that CFS has been used and continues to be used in buildings that meet the most stringent energy codes. In fact, CFS components have been used in many high-performance designs that meet LEED and other similar requirements.

In addition to the use of conventional CFS sections in high preforming buildings, the industry has and is continuing to develop improvements in the thermal performance of studs for exterior walls. The National Renewable Energy Laboratory (NREL) Research Support Facility substantially completed in 2010 and 2011 in Golden Colorado is a prime example of the use of innovative CFS exterior walls in an ultra-high performance building. (http://www.hpbmagazine.org/attachments/article/12170/12F-Department-of-Energys-National-Renewable-Energy-Laboratory-Research-Support-Facility-Golden-CO.pdf). The 220,000 sf facility scored a LEED Platinum rating from the US Green Building Council. The CFS studs used in the building were an innovative design that reduced the amount of steel in the webs to reduce heat flow. Others in the CFS industry are developing similar "thermal" studs and/or assemblies using conventional studs that exceed even the toughest standards. However, standard C-sections themselves can be constructed to meet any energy code or standard right now. Performance will only get better in the next few years.

Material usage

Most framing materials arrive on site as components. Although there are some pre-cast concrete systems, they are not typically employed in mid-rise buildings as often as in one or two story buildings. Masonry is nearly 100% assembled on site with block, mortar, cladding ties or connectors, and reinforcement. Wood can be panelized but that is not the norm except in some the single-family markets around the country.

The loadbearing framing in a CFS building almost always arrives onsite as premanufactured wall panels. Stick framing is just not very cost-effective. There is no learning curve after more than two decades of experience by an industry that adopted advanced framing and design methods from its birth. Thus, the CFS industry has the infrastructure in place to take advantage of the shorter construction cycle that panelization offers. But even more important from a material perspective, panelization all but eliminates waste since it is built in a controlled environment. Even interior non-bearing partitions studs that are used in tenant fit-outs are delivered cut to length. The very small amounts of cut-offs used for bracing or blocking are easily recycled.

BIM, or building information modelling, is another technology that has increased the efficiency of CFS buildings. The CFS industry is one of the early adopters of BIM. The result is little to no redo of framing or other systems since the building is carefully designed as an integrated system.

Taken together, the adoption of technologies such as BIM and panelizaion means efficient designs with little to no waste. You just can't get the same result from stick built wood construction or masonry.

Last, the light weight and high strength of CFS make it the perfect material for urban redevelopment projects. No need to tear down older concrete or masonry structures and start over or spend large amounts of money reinforcing them in order to provide enough square footage to justify projects economically – add additional stories with CFS on top of the existing building. This is exactly the approach that developers of different projects have taken. As an example, the Piatt place project in Pittsburgh was finished in 2019 as a redevelopment of a long-standing department store.

CFS panel construction (Left to right: exterior wall panel installation, CFS panels ready for shipping, Panels on construction site waiting installation).

The Piatt Place plans called for the addition of three stories of residential units on top of the existing building. The solution was to use light-weight cold-formed steel on top of the original building. According to multi housing news, "the property is a shining example of how a non-green building can be reincarnated with a sustainable structural material—cold-formed steel—to become a model of green development, and how it can help revitalize a city." (https://www.multihousingnews.com/post/pittsburghs-piatt-place-a-model-in-green-evolution/).

Recycling

According to the Steel Recycling Institute, steel is "the world's most recycled material, with more than 65 million tons of steel recycled annually." No other major structural material can claim anywhere near this track-record of recycling. Even the USGBC recognizes the high recycling content rate of all steel by providing a minimum 25% default recycled content value for steel. It is so well accepted that designers are not even required to provide proof if they claim 25%.

High recycled content has a clearly measurable impact on resource depletion. It the case of steel, it also reduces production energy costs through the use of electric arc technology that uses high levels of recycled steel to make new products. Perhaps as important is that steel can be recycled over and over again without decreasing the quality of the end product. Theoretically, it should never end up in a land fill.

With an increasing interest in re-use of building materials, the recycled content and recyclability of steel is important to all buildings. Due to its attachment with screws, steel can easily be deconstructed and reused or recycled. Its light weight compared to other materials makes it easy to move around and transport for other uses or taken back to the mill to be made into new steel products. The industry has an extensive recycling infrastructure in place that is unmatched by the other framing material industries.

Durability

Durability and resilience have almost become meaningless in the rush to proclaim one's product better than others. But like sustainability, there are some tried and true items that are observable and measurable in terms of their impact on a building's performance and cost to operate over time.

The impact on costs to operate a building due to dimensionally instability of wood products is just one area where steel demonstrates superior durability. Others include life span, termite resistance, and resistance to mold and mildew.

Wood rots and concrete spalls, requiring repairs and member replacement. Masonry needs repointing throughout its life time. When was the last time a building's steel structural members had to be "repaired" or replaced? When used in accordance with industry standards and practices, zinc coated steel will last for hundreds of years beyond the life of a building, even in the most severe environments.

Termite damage repair and control is estimated by the USDA to cost over $2 billion annually in the United States (http://www.srs.fs.usda.gov/idip/termites/mission.html). This estimate doesn't include damage from the rapidly expanding territory covered by the Formosan termite, which adds another $1 billion to the total. Steel and concrete are obviously not good food choices for termites. Nor is wood if it is treated with expensive chemicals. But do we want chemicals in the ground around and inside buildings occupied by people when there are choices that don't increase risks to health?

The International Residential Code published by the International Code Council lists six allowable methods for addressing termite protection in buildings. Most of the methods require expensive maintenance programs, chemicals, or barriers to try to keep termites from accessing wood. There is only one framing material that doesn't need to be specially treated or that is prohibitively expensive – cold-formed steel. It just so happens that CFS is also the preferred method that will prevent damage from Formosan termites, which is why it is the overwhelming favorite building material in Hawaii where the Formosan termite has ravaged wood buildings for the past few decades. Formosan termites, unlike other subterranean termites, can establish colonies through the air. They can easily defeat barrier systems. Only materials like CFS that are naturally resistant to termites can be used with confidence. Now that the Formosan termite's territory is expanding through the U.S. gulf coast states, steel will continue to make sense as the material of choice over wood in preventing damage. In addition, although the IRC applies to residential buildings generally under 4 stories and the International Building Code is somewhat silent on acceptable methods to protect larger buildings, it is safe to assume that termites won't differentiate which code was used and will attack larger buildings as often as smaller ones.