

By MARK EMERY

The “Anatomy & Physiology” Of the Structural Fireground

Part 4 – Strategic Perspectives of Building Construction: Type III and Type V



Jason Fratini

FREE STUFF

For your convenience, I've captured on a single page the key strategic considerations for each of the five types of building construction. Send me an e-mail request and I'll reply with a Strategic Classification of Building Construction PDF: mark.fci@comcast.net. You can also find the Strategic Classification PDF, as well as other strategic information, available for download at www.imsalliance.com/ITAC.

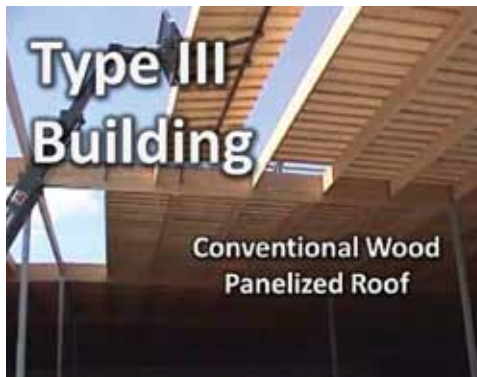
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Past installments of this series introduced the strategic classification of building construction. Ordered strategically, based on perceived fire resistance, the five basic types of building construction were listed as follows:

- Type I – Fire Resistive**
- Type II – Non-Combustible**
- Type IV – Heavy Timber**
- Type III – Ordinary**
- Type V – Wood Frame**

Because a Type IV building is more robust and thus more fire resistive – strategically – than a leaner Type III building, they are listed out of order numerically. The August 2009 installment discussed Types I, II and IV. This month, we finish the strategic classification of building construction with Type III, Ordinary, and Type V, Wood Frame.

Before we get started, fireground decision-makers must keep in mind the fundamental function of building design and building construction. The purpose of a structure's gravity-resistance system – trusses, columns, girders, lintels, cables, purlins, joists, headers, buttresses, etc. – is to deliver the dead load and live load of the building to the earth as



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compression. That's it, nothing more and nothing less. After ensuring that all dead load and live load will be delivered to the earth as compression, the secondary function of building design and construction is to create a secure and comfortable habitat for human occupation.

Type III Ordinary Construction

Ordinary Construction is a cinch to identify. Just look for some kind of masonry, right? Well, yes – and no.

Remember the Command-O-Quiz at the beginning of the July 2009 article? Buildings such as the one shown in the opening photo feature concrete-block or tilt-up concrete walls. It was impossible to correctly answer the Command-O-Quiz until after you stepped inside and viewed the roof. Let's revisit the Command-O-Quiz: You are standing outside a concrete tilt-up big-box warehouse store. In one hand you hold a pencil, in the other hand a pre-plan form. After entering the date, name of the business, address, contact information and hydrant locations, there is a box that asks: Type of Building Construction? In this blank box you would enter "Type _":

- a. I
- b. II
- c. III
- d. IV
- e. V

If you know building construction, you know that there are *two* possible correct answers: the big-box warehouse store is either Type II, Non-Combustible, or Type III, Ordinary.

Once inside the building, if you look up toward the ceiling and see a wood roof – say a lightweight panelized roof system (metal plate connected trusses supported by glue-laminated girders that are in turn supported by unprotected steel columns) this structure would be classified strategically as Type III, Ordinary. Don't let the presence of unprotected steel columns



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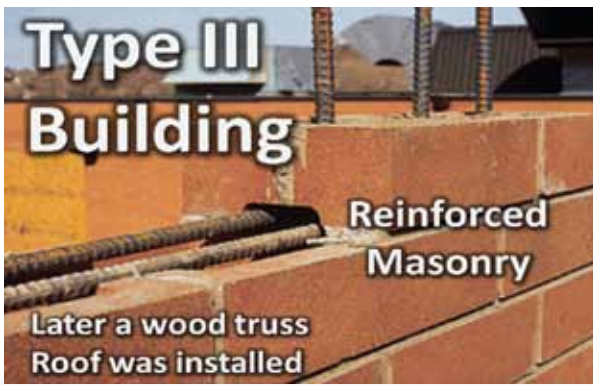
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throw you; the load-bearing roof structure is combustible, so, to keep it simple, the strategic classification is Type III, Ordinary. On the other hand, if you look up toward the ceiling and see that the roof load is delivered to the columns by *unprotected* steel girders and steel purlins, it is a Type II, Non-Combustible building.

Thus, we have two simple unifying characteristics for the *strategic* classification of Type III, Ordinary Construction:

1. Exterior walls that are made of *non-combustible* material
2. Interior load-bearing components (floor and roof structure) that are *combustible*

It doesn't matter whether the non-combustible exterior walls are made of brick, block, concrete, metal or adobe; if the roof and floor structure is made of combustible material, it is strategically classified as Type III, Ordinary. To keep things simple, there are two *strategic* categories of Ordinary Construction:

1. Legacy, *unreinforced* (usually conventional)
2. Contemporary, *reinforced* (usually lightweight)

As mentioned previously, whether legacy or contemporary, all Ordinary Construction features a non-combustible exterior accompanied by a combustible interior.

Try this: You enter the concrete tilt-up big-box store blindfolded. While you're standing in the middle of the store, the blindfold is removed. You look up at the roof structure and see a metal roof deck supported by lightweight steel bar-joist trusses. What type of building construction is the big-box store? You don't even need to see the

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The San Diego Fire Museum



Load bearing masonry wall replaced by unprotected steel columns



Timber girder supported by a single unprotected steel column

walls to make this determination: it would be strategically classified as Type II, Non-Combustible. Without seeing the exterior walls, you would know that they are made of a non-combustible material such as concrete or masonry.

Just as with Type V, Wood Frame, you will find Ordinary Construction that is conventional and Ordinary Construction that is lightweight. You will find conventional (legacy), unreinforced masonry buildings and you will find lightweight (contemporary), reinforced masonry buildings. You can find conventional panelized roof systems and you can find lightweight panelized roof systems. Example: timber purlins (conventional) vs. metal plate connected or metal tube web truss purlins (lightweight). It is not uncommon to find Ordinary Construction that feature a lightweight roof, yet has a conventionally joisted floor; next door you may find Ordinary Construction that features both a lightweight roof and a lightweight floor. It's impossible to make this important determination when viewed through the windshield.

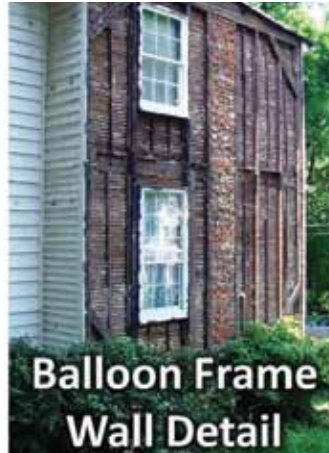
These days, a through-the-windshield size-up of building construction can be a crapshoot. For example, because it doesn't convey the type of building construction, declaring "large concrete tilt-up" has no strategic value. *Concrete tilt-up* is not a type of building construction; it is either Type II or Type III. The only way to determine the type of construction is to step inside and view the roof structure (or consult a pre-plan).

Recall from part one of this series (April 2009) that the *basic* structural hierarchy of a building is comprised of four components: columns, girders, purlins and joists. (In panelized roof systems, *joists* are sometimes referred to as *sub-purlins*). No matter if the roof is supported by giant heavy timbers or pee-wee trusses, the most important component of the structural hierarchy is the column (and a load-bearing wall that serves the same purpose as a column). Although all buildings feature a structural hierarchy, not all buildings feature the same structural hierarchy components and materials. For example one building may feature columns in its hierarchy while the building next door may have replaced the columns with steel rods in tension. An interesting example of this is the San Diego, CA, Fire Museum.



From the street (through the windshield), the humble fire museum building would be classified as Type III, Ordinary, and appears strategically benign. After stepping inside the two-story portion of the building and studying the floor/ceiling system, the museum becomes a no-offensive building. The gravity-resistance system supporting the upper floor is downright scary. For a building like the San Diego Fire Museum to make the strategic leap from benign to scary, it has evolved following a typical progression:

1. The original two-story portion of the building was around 25 feet wide (from a two-story B-wall to the two-story D-wall).
2. To expand the occupancy left or right, you would remove the unpenetrated first-floor load-bearing masonry wall (in this case, the floor-one B-wall of the two-story occupancy).
3. This was done by transferring the load of the floor above to timber girders and columns that replaced the load-bearing masonry wall.
4. Later, to make more room to sell stuff (or, in this case, to accommodate larger fire apparatus), many of the timber columns had



to be removed.

5. After the timber columns were cut and removed, a short stub remained near the ceiling at the bottom of the girders.

6. To transfer the load formerly delivered to the columns, cold-drawn steel rods were installed; the steel rods transfer the load from above to adjacent girders.

7. The steel rods pull upward on each column stub; this upward pull is achieved by tightening turnbuckles that spice the steel rods. Thus, even though the rods are in tension, the upward pull generates compression within the column stubs.

8. Traveling through the girders that transfer their load to the columns the load of the second story is delivered to the foundation as compression.

I guarantee that computer-aided precision engineering did not contribute to this structural evolution. The San Diego Fire Museum today stands not as designed and not as originally built; from a strategic perspective, it exists “as is.” *As built*, the building was unreinforced masonry *conventional*; because of the slender steel rods; today, this building exists as an unreinforced masonry *lightweight* structure (strategically). If you have an “as is” building like this in your community, it should be deemed a “no-go, red-light” building. Exposed to the heat generated by a contents fire, the performance of the steel rods will be much different than the performance of the original load-bearing masonry wall or the performance of the timber columns.

Visualize the fireground progression: During a fire, heat will rise to the ceiling, the unprotected steel rods are at the ceiling; the steel rods will fail when heated to 800 degrees Fahrenheit; should the steel rods fail, gravity will send the upper floor, furniture, masonry bearing wall and roof into the first-floor apparatus bay as *compression*. (Note: The steel rods will fail when the rods themselves are heated to 800°F, not when the ambient temperature reaches 800°F.)

Firefighters should not be allowed in, on or near this building if there is evidence of heat generated by a contents fire. Remember, what you see through the windshield does not count as size-up; even if the smoke looks incipient and appears to not be a threat to firefighters, the no-value back-side of the fire-growth curve can look and feel exactly like the *early* front-side of the fire-growth curve, where there can be value. (See “Grading the Fireground on a Curve,” *Firehouse*®, September 2008.) A master craftsman fire officer is not seduced into an offensive position by light smoke showing on arrival; a master craftsman fire officer is not seduced by zero visibility and low heat. Before offensive entry, a master craftsman fire officer determines which side of the fire-growth curve is being considered and whether there is value.

There is another *REALLY BIG* red flag to look for within conventional, unreinforced masonry (URM) buildings – in particular those buildings erected 100 or more years ago, the classic “taxpayers.” During a pre-plan visit, one of the first things to look for is the replacement of an unpenetrated load-bearing masonry wall with unprotected steel columns. The load-bearing walls of an unreinforced masonry taxpayer always run front to back – from the street to the alley (from side A to side C). It was common for the original ground-floor commercial occupancy to expand left and/or right (toward side B and toward side D). The gravity-resistance challenge was what to do about the unpenetrated, load-bearing masonry walls that were in the way; remove this bearing wall and the roof and floors above end up at street level (or in the basement).

To prevent catastrophic failure when the bearing walls are removed, they were replaced with a timber or steel girder and the whole thing supported by unprotected steel or timber columns. During a significant fire, the performance of these unprotected columns will be much different than the performance of the original, unpenetrated, load-bearing masonry wall. I’ve seen buildings where the failure of a single column would cause the collapse of the entire building!

To exacerbate the problem, further modification of older unreinforced masonry buildings was intended to remove the columns. Column replacement was achieved by transferring the load of the roof and floors above with an inverted king post made of cold-drawn steel rods (as in the San Diego Fire Museum).

Type V Wood Frame

At the bottom of the strategic classification food-chain is Type V, Wood Frame. Of the five types of building construction, Wood Frame is the only type that allows all load-bearing structural members – studs, joists, rafters, purlins, girders – to contribute fuel to a fire. Building codes (unreassuredly) refer to Wood Frame as “unprotected combustible.” In other words, all load-bearing structural members can burn. That’s the bad news. The good news is gypsum Sheetrock. (Note: Because Type III and Type IV buildings also feature “unprotected combustible” load-bearing structural components, I prefer to call a Type V building “Wood Frame.”) “Type X” fire-rated Sheetrock contains gypsum and is used to protect all this combustible load-bearing fireload and prevent the passage of fire to adjacent areas. (Note: Sheetrock protects the combustible load-bearing system from one direction – from the occupied side).

How many carpenters and Sheetrock installers know the primary purpose for taping and mudding Type X sheetrock seams?



Sure, doing so makes the wall smooth and easy to finish, but the primary reason sheetrock is taped and mudded is to protect the steel. Sheetrock is attached using metal screws or nails. Like all steel, when they are heated, the screws and nails will elongate. When the screws and nails elongate, the ability of the Sheetrock to resist the passage of fire is compromised. The primary purpose of the tape and mud is to protect the steel fasteners that are an integral part of the fire-resistive assembly! Subordinate to that is a smooth finish.

There are two basic methods of wood framing a building: legacy balloon frame or contemporary platform frame. Balloon-frame walls were assembled on the ground and then lifted into place. If you needed a 30-foot two-by-four-inch stud, you simply “scabbed together” (nailed) two or three shorter two-by-four-inch boards. Although conventional vertical balloon framing is no longer permitted, there is an abundance of lightweight horizontal balloon framing. Because the material of a conventional beam has been removed along the I-beam web (or stem), a void is created when two wood I-joists intersect at a 90-degree angle; when solid conventional joists intersect there is no such horizontal void. *As designed*, this void is not supposed to remain; you will often find them as is. We don’t fight fire in an *as designed* world.

Worse yet is the parallel-chord truss floor system. Parallel-chord truss floors create a large combustible void that did not exist in a conventionally joisted floor. Because oxygenated air is the governing component of fire growth, fire will grow exponentially faster in a trussed floor/ceiling assembly than in a conventionally joisted floor/ceiling assembly. A conventionally joisted floor is compartmentalized (16 inches wide by the length and depth of the floor joists). The open-web truss floor is not compartmentalized; whatever the cubic feet of the trussed floor is how many cubic feet of oxygenated air there is available to support rapid fire growth (once fire penetrates the ceiling and enters the void).

In addition to the large void with plenty of air to support fire growth, the fuel is arranged like kindling for rapid fire growth. Along with plenty of oxygen and plenty of fuel, there are exponential connections where each web member intersects with a top and bottom chord. Whether lightweight or conventional, connections are the weakest point in any structural system.

Platform framing is the assembly of a vertical succession of single-story structures. A single-story building is erected at grade level. To serve as the second floor, another single-story building is erected atop the platform below, and so on; once you’ve gone as high as you need (or are allowed), a roof is assembled atop the stack of one-story buildings. Thus, we have the term “platform” frame.

Hybrid Buildings

There are many contemporary buildings that are strategic hybrids. A good example is the contemporary “taxpayer.” During the past 10 or 15 years, there has been a revival of the mixed-use, “Main Street U.S.A.” taxpayer configuration. Although similar in occupancy use, the construction is neither traditional nor conventional. The *strategic* classification of these hybrids is “five-over-two,” which means that the first floor is non-combustible concrete and the upper floors are lightweight wood (platform) frame. If the upper floors are framed using steel (studs, etc.), the building would be classified as Type II. Like the legacy taxpayers of 100 years ago, these hybrids feature commercial occupancies at street level with residential occupancies above. Although three floors are common, the vertical limit seems to be four or five floors.

Another hybrid that is becoming more common is the “Two-in-Five” structure. This is often seen in Type V, platform frame, multi-family buildings. The floor joists, typically trusses or I-joists, are sup-

ported by a steel I-beam girder and the steel I-beam is usually supported by steel columns. Thus, within the Type V building are Type II components. The purpose of the "Two-in-Five" hybrid is to take advantage of the tremendous strength and dimensional stability of structural steel. This strength allows a long, simple beam span that cannot be achieved with dimensional lumber. Yet another hybrid is the "Five-in-Two" structure, which is found in concrete tilt-up warehouses that feature unprotected steel columns, girders and purlins. The combustible panelized roof deck is comprised of plywood supported by dimensional lumber joists. This building would be strategically classified as Type II, Non-Combustible.

Call to Action

This is perhaps the most difficult time in fire service history to identify the type of building construction. Each of the five types of building construction, and their hybrids, will behave differently when exposed to the heat generated by a contents fire. Each type of construction features methods and materials that behave differently when exposed to the heat generated by a contents fire. Three of the five types of gravity-resistance systems are allowed by code to contribute fuel to a fire.

If you are mantled with the role and responsibility to make informed stra-

tegic fireground decisions, you must have a solid foundation of building construction knowledge and understanding. That means knowledge and understanding of building construction engineering principles. Next time, we'll review common building materials and important engineering principles used to resist gravity.



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SHARE YOUR BUILDINGS

Share your buildings with the *Firehouse*® Magazine community. E-mail a photo and a brief description of the occupancy and structural red flags and it will appear in a future article. This month's building is shared by a *Firehouse*® reader, Captain Joe Pronesti of the Elyria, OH, Fire Department.



Built in 1899, the six-story building is in Captain Pronesti's first-due response area. Originally built as a factory, the building is now a mixed-use occupancy with a nightclub on floors one and two, offices on floor three and 18 one-bedroom "flophouse" efficiencies on floor four. Floors five and six are vacant and used to store "junk." Thank you, Captain Pronesti and the City of Elyria Fire Department. The *Firehouse*® community appreciates your sharing this building in distress.

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