

One Structure, Many Uses

BY ERIKA WINTERS-DOWNEY, S.E.

Mixed-use projects are a hot item these days, and structural steel framing can be the best solution to accommodate the various uses within.

COME HOME, PARK YOUR CAR, HIT THE GROCERY STORE. Then go to the gym, swim a few laps, and see a movie. Sounds like a busy night, right? In a mixed-use building, you might never have to go outside to accomplish all of this.

As more people are returning to urban cores to live and work, they require necessities that sometimes aren't available nearby such as gyms and markets. Consequently, many building developers are providing everything in one package. Common combinations for mixed-use buildings are offices over parking or condos over parking and retail. But multiple combinations are possible, including ones that feature the amenities mentioned above.

Structural steel provides unique advantages for these buildings. For example, it can accommodate large variations in bay size. It can also be continued vertically through several different uses without the need for a dedicated transfer level, and

avoiding a transfer level also avoids the coordination issues that come along with it.

The Magic of Nine

The number-one challenge with mixed-use buildings is structural coordination between parking levels located below office or residential levels. However, it is possible to plan your structural grid to eliminate or minimize the number of columns that need to be transferred. Understanding efficient parking layouts is key to integrating them into residential or office structures.

Nine is an important number, because the typical 90° parking space is about 9 ft wide by 18 ft long. A two-way traffic lane with 90° parking spaces on both sides is usually 24 ft across, for a total width of 60 ft (18 ft + 24 ft + 18 ft). With structural steel, it's not only possible, but also economical, to span the whole 60-ft. bay with a single member.

In AISC's Steel Solutions Center, we primarily see two types of parking column grid patterns when framing with metal deck: 60 ft by 27 ft and 60 ft by 18 ft. Each has its advantages. For example, the 27-ft bay width results in fewer columns (and fewer foundations), while an 18-ft bay width is advantageous when you need to use lighter, shallower girders; with infill beams laid out at 9 ft on center, an 18-ft girder only has one center point load, while a 27-ft girder has two at its one-third points. Also, shorter girders can help satisfy tight deflection tolerances for perimeter members. If the parking floor slab is a one-way post-tensioned system, the grid is almost always 60 ft by 18 ft.

To make a seamless transition between a garage and the rest of the building, the condo, hotel, or office grid above can be laid out in increments of 9 ft. For example, you might want to suggest laying out condo units on a 27-ft or 36-ft module instead of a typical 30-ft module. If the parking spaces in your facility are 8 ft or 8 ft, 6 in. wide, adjust your "magic number" accordingly.

Fire Protection, Untangled

Sorting out fire protection requirements is key

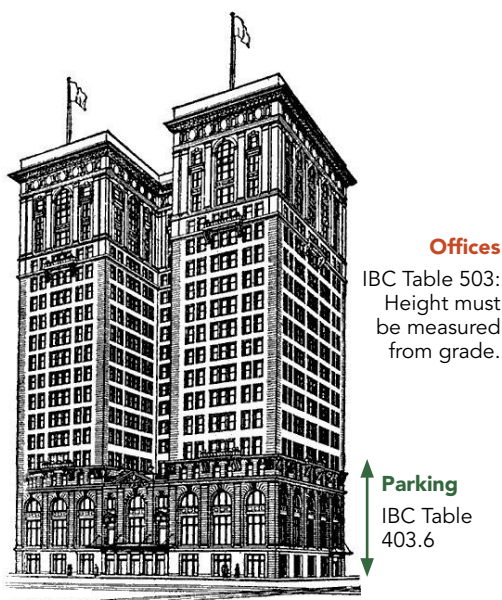


Figure 1. Mixed-use building height limitations per construction type.



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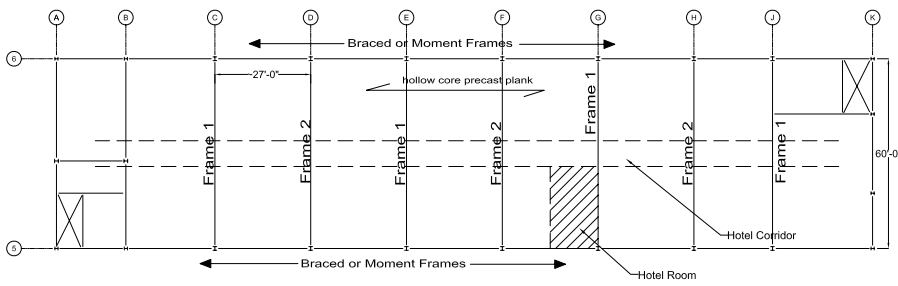


Figure 2. A typical staggered truss layout for the hotel portion of a mixed-use building.

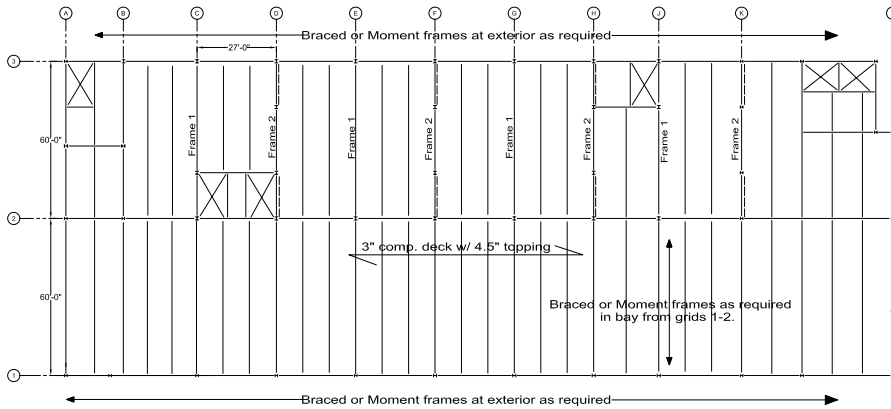


Figure 3. A typical staggered truss layout for parking levels in a mixed-use building.

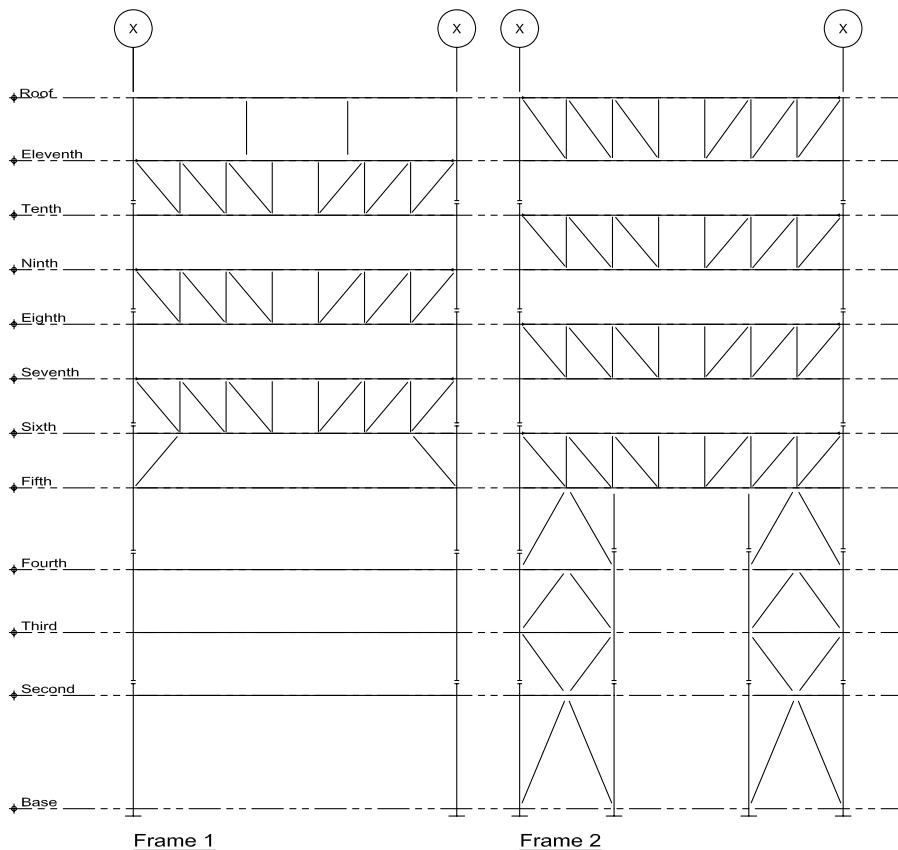


Figure 4. Typical staggered truss frame elevations. Lateral bracing in the direction parallel to the trusses continues down through the lower levels of the structure.

to a successful mix-used project. Under the International Building Code (IBC), when there is more than one type of occupancy in a building, the whole building's fire protection system must be designed to the requirements of the stricter occupancy. (IBC 2006 Section 508.3.2.) If it is impractical or uneconomical to design the whole structure to the stricter requirements, the different occupancies may be separated by fire barrier walls or horizontal assemblies. (IBC 2006 508.3.3.)

Structural steel framing is considered non-combustible and is applicable in construction types I, II, III, or V. Construction types are defined in IBC 2006 Chapter 6. Passenger vehicle parking is generally classified as low-hazard storage, occupancy type S-2 in IBC Section 311.

If parking is located beneath another type of occupancy and can be considered "open" per Section 403.3.1, the applicable area and height limitations in Table 406.3.5 and Section 406.3.6 will apply to the parking portion. However, the height in both feet and stories of the portion above the parking area is governed by the limits in Table 503 and must be measured from grade plane (Section 509.7).

Per IBC 2006 Table 508.3.3, the horizontal boundary (i.e., floor slab) that separates parking and office or residential levels must provide a 2-hr rating, or sprinklers and a 1-hr rating if the floor uses a metal deck construction. In this case, it is convenient in most cases to select a floor assembly that will allow unprotected deck so that only the structural steel members need to be fire protected.

Even if the parking structure by itself requires little or no fire protection, keep this in mind: Columns (and the girders that brace them) passing through the parking structure and supporting a different occupancy type above require fire protection appropriate for the supported occupancy type. Remember, the more stringent fire protection requirement governs.

The UL designs that correspond to unprotected deck are in the D900 series—D900–D999. Metal deck assemblies with 4.5 in. of normal weight concrete (3.25 in. of lightweight concrete) provide a 2-hr rating with unprotected deck. These assemblies can be found in the UL Fire Resistance Directory and also are listed in some steel deck catalogs.

If climate conditions require a hardier floor system, a post-tensioned one-way slab is often used. This is often the case in

northern areas of the U.S. that commonly use de-icing salts or in structures near a saltwater body.

If none of these code-prescribed prescriptive options suit your project, IBC permits performance-based fire engineering (IBC 2006 703.3).

Easing Column Transfers

Like death and taxes, column transfers can be unavoidable, but costly 3- or 4-ft-thick transfer slabs between residential/office levels and parking levels aren't the only option. Sometimes, smart column layout will minimize the transfer's effect on the surrounding structure. For example, a common scenario is to transfer a column that lines up over a driving lane in the garage below. The beam spanning the lane is usually 60 ft long. Adding columns at the driving lane end of the parking spaces turns the 60 ft span into three spans of 18 ft, 24 ft, and 18 ft.

Story-high trusses are often a simple and elegant solution to transferring dissimilar column layouts, and they can easily be accommodated in a mechanical level. Another option is to locate upper columns in the same vertical plane as a major column line on the lower level (on a girder). This provides a more direct load path than locating the column on a secondary transfer member.

Consider Staggered Trusses

The staggered truss system works well for condos or hotels with regular layouts, and transfers easily to parking garages below (see figures). Trusses transfer gravity loads and lateral loads (in the direction of the truss) to the base of the building with the use of precast concrete plank floor diaphragms. One huge advantage of this system is that it eliminates most interior columns; the story-height trusses span the whole floor, carrying loads to the perimeter of the building. Lower-level spaces are nearly column-free for parking, ballrooms, etc. Moment frames or braced frames usually carry the lateral load in the direction perpendicular to the staggered trusses. In a building with a two-bay parking garage (typically about 120 ft wide), the condo tower would ideally rise out of half of this platform to be 60 ft wide—perfect for two units and a hallway. Staggered trusses work in a variety of configurations, so ask the Steel Solutions Center (866.ASK.AISC) for ideas for your next project. **MSC**