10 HUDSON YARDS

FILIGREE IN NYC

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Many engineers would agree that working on America's largest private real estate development is a significant challenge. Imagine that the development was situated directly above an active rail yard located in the heart of New York City. That development is none other than Hudson Yards, a 28-acre site stretched across four city blocks (30th to 34th Street, and 10th to 12th Avenue). The site is split into two phases divided by 11th Avenue, which runs directly through the center of the site. This divide creates a western yard and an eastern yard. While the western yard is yet to break ground, the eastern yard is open to the public and fully operational. Located on the eastern yard are both 10 and 30 Hudson Yards, designed by Kohn Pederson Fox (*Figure 1*). Even with the difference in height, the buildings appear very similar and are designed to complement each other.

While the outward appearances of the towers are similar, their structural systems could not be more different. The 1,269-foot 30 Hudson Yards consists of a concrete slab on composite metal deck supported by steel framing and steel columns, all laterally supported by a steel braced core and outrigger system, typical for a New York City office tower. The 895-foot-tall 10 Hudson Yards, however, is an all concrete office structure, atypical for New York City. It is the only one in New York to feature a gravity system comprised of post-tensioned beams and a filigree slab supported by concrete columns and a concrete core. This unique floor system provides several structural benefits in addition to creating an aesthetically pleasing floorplate, which can remain exposed in loft-type office spaces.

Figure 1. 10 (right) and 30 Hudson Yards (left). Courtesy of Kohn Pederson Fox

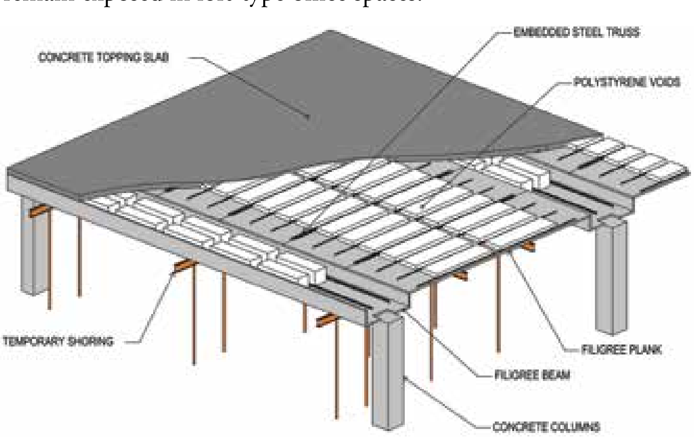

Figure 2. Typical filigree system overview.

Filigree System Overview

Filigree slab systems typically utilize 2¼-inch-thick, 8-foot-wide prestressed concrete planks compositely connected to a cast-in-place topping slab. Based on the shear demand of a particular bay, the planks can be obtained with or without polystyrene voids. Voided planks utilize polystyrene blocks adhered to the plank to reduce concrete volume and load on the supporting elements. The voids are located based on the shear demand of the slab and typically concentrated toward the center of the span where demand is low. Cast into the plank is a steel lattice truss that bonds to the field poured concrete, forming the composite filigree slab system.

The precast planks are designed to serve as both formwork for the weight of the wet concrete and to meet the positive moment demand of the composite slab. Before the production of the planks, the design team provides the maximum positive moments to the precast manufacturer. The manufacturer ensures that sufficient prestressed tendons and rebar are provided in the plank to meet the designer's needs. Often the planks ultimately are set on steel framing or "U" shaped filigree beams (*Figure 2*) to complete the floor framing system. However, the planks are also commonly used in typical two-way flat plate systems.

While 10 Hudson Yards utilizes the 2¼-inch-thick 8-foot-wide prestressed concrete planks, it did not use typical steel or filigree framing. Due to the typical 45-foot by 30-foot bays in the tower and the required clear floor-to-floor height, the design team decided to use a post-tensioned cast-in-place beam system in conjunction with voided filigree plank (*Figure 3*) to reduce the structural depth of the floor system. The typical beam size utilized in the tower is a 48-inch-wide by 21-inch-deep section; this allows for the use of 26-foot-long precast planks. To meet the required moment demand of the slab, the 2¼-inch voided plank was topped with a 6¾-inch-thick poured-in-place concrete slab (*Figure 4*). The composite 9-inch-thick system provides similar moment capacity to a traditional concrete reinforced slab of the same depth but at the equivalent weight of a 7-inch-thick slab. The reduction in mass has a positive cascading effect on the structure. The reduction in load reduces demand on the beams, columns, and foundations, which in turn reduces the overall cost of the structure.

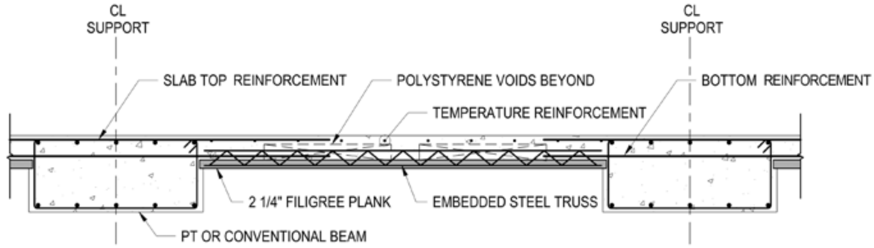

Figure 3. 10 Hudson Yards filigree slab and beam section.

System Advantages

The filigree system has a significant number of advantages over typical cast-in-place and steel-framed construction.

- The precast planks eliminate the need for formwork and decrease the number of shores per floor, significantly reducing congestion on the floors below active working decks.
- The system significantly reduces the effort and time required during the typical stripping and reshoring cycle. The shoring system used to erect the plank stays in place until the concrete reaches the specified strength. At that point, the shoring system can be dismantled and cycled up to the active deck to be reused on the floor above.
- The voided filigree system reduces concrete volume and overall building mass without sacrificing the moment capacity of the slab system.
- Coordination of sleeves, penetrations, and inserts takes place before installation of the precast plank, reducing comeback work and slab coring.
- The filigree slab and beam system provide clear, unobstructed spans allowing for high ceilings and the ability for MEP services to be easily hidden away into the void space between supporting beams.


Figure 4. Concrete pour on polystyrene filigree plank.

System Challenges

As with every floor framing system, there are drawbacks to consider when specifying filigree. The precast plank sizes can be rather large and difficult to maneuver due to their weight and shape, especially in windy conditions. The typical plank on 10 Hudson Yards required a team effort to place, as each plank weighs approximately 6,000 pounds. In addition to the construction workers on deck, each plank requires a crane to maneuver it into place. It is important to consider and coordinate this process well in advance and work it into the construction schedule to limit its effect on the project. The designer needs to also consider the availability of plank in regard to the project location. Casting plants capable of producing filigree plank need to be within an acceptable distance to the project site to recognize the potential economic benefits of the system.

Summary

Although not a common system, the structural and architectural advantages of the filigree slabs contributed immensely to the success of 10 Hudson Yards. The reduced weight of the composite system allowed for reductions in column sizes, beam depths, and foundation reinforcing. The reduction in beam depths and column sizes created a more desirable floorplate from both an architectural and leasing perspective when compared to the properties of a traditional cast-in-place or steel framed system. The reduction in concrete volume and reinforcing resulted in measurable monetary savings to the budget. When evaluating potential concrete and steel floor framing systems on your project team's next job, consider examining the viability of a filigree system.▪

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