Figure 1: Fox Point residence.

An Affordable and Sustainable Building Design in New York City

By Dominick R. Pilla, P.E., C.E., S.E., R.A. and Xiaoli Tong, P.E.

Fox Point is a 48-unit affordable housing development pursuing a USGBC LEED Silver rating. Located in the Foxhurst section of the Bronx, this affordable apartment building is sponsored by the Midtown-based nonprofit Palladia, Inc. and aimed at providing housing for low income families with disabilities. In 2005, Palladia selected the design team of Oaklander Coogan & Vitto Architects(OCV) and Dominick R. Pilla Associates (DRPILLA), structural engineer, to design the project.

Fox Point is developed on a site which accommodates an L-shaped seven-story building above grade and a full cellar below, with a central stair shaft and an elevator core (*Figure 1*). The building has a typical floor height of 9 feet 4 inches, and a sloped mansard roof above the seventh floor with an average building height of 70 feet. Two green roofs are located on the fifth floor at the west wing and the seventh floor at the south part of the main building, respectively (*Figure 2*). The 48 units of studio and apartment comprise a total of 47,300 square feet of residential space. A public corridor is located in the building center, and a typical room depth is 25 feet.

As an affordable building, the main challenge facing the team was to develop a proper building construction type to meet the requirements of affordability and sustainability.

Figure 2: Green roof.

Building Construction Type

Three key factors were considered to determine a building construction type: code compliance, cost estimation and site condition.

Before 2008, the governing design code was the 1968 building code of the City of New York with yearly amendment. In this code, all buildings are classified into two construction groups: I – Noncombustible (masonry, concrete or steel building) and II – Combustible (timber building). Each group was further divided into 5 classes from A to E, dependent on its design fire rating. For the Fox Point residence, the permitted construction types are classes I-A to I-D (minimum 2 hours fire rating for exterior bearing wall, enclosure of vertical exits, passageway and shaft; 1 hour fire rating for other members) and classes II-A (heavy timber) and II-B (protected wood joist) with a sprinkler system. Therefore, the structural system choices included: masonry bearing wall building with protected/fire-treated wood/metal joist floors or precast plank floors; steel framing building with metal joist

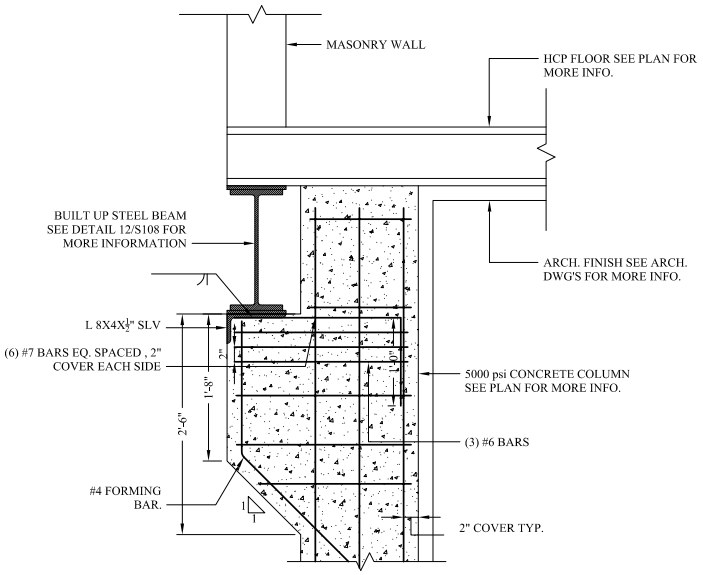

Figure 3: Corbels for wall set-back.

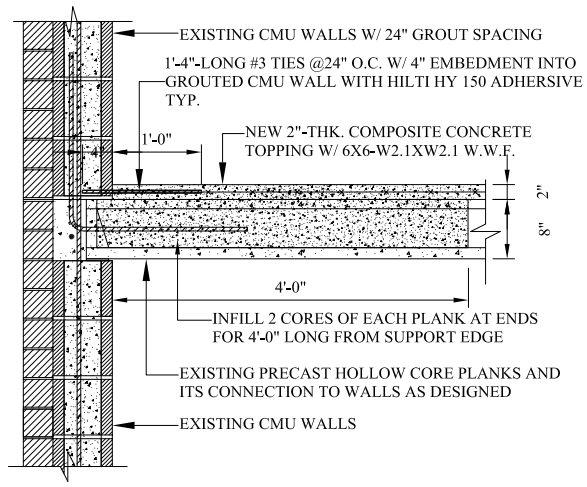

Figure 4: Plank strengthening.

floors or precast plank floors; and concrete frame building with cast-in-place flat slab floors.

Construction cost, field labor and equipment rental form a large part of the overall construction cost, since local costs in New York City are much higher than the national average. As a result, labor for masonry block and precast members cost less than cast-in-place members; masonry and concrete members cost less than metal or wood members in regard to fire protection work. Furthermore, the higher the building construction class, the lower the cost of insurance.

The site condition was investigated and the results showed the building's footing could bear on soft or intermediate rock. As a result, the footing design would not be significantly different between a heavy plank floor building and a light joist floor type under the same framing plan.

As a result of a comprehensive comparison of the above-mentioned factors, the selected construction type consisted of reinforced masonry bearing walls and precast hollow core plank floors. With floor planks shop constructed and assembled on site, the labor cost in the field is minimized and consequently a faster construction is achieved. A shorter construction duration is beneficial to budget control for overall construction cost. An additional advantage is that the selected construction type could be classified as IBC type IA with the highest

fire resistance, for which the lowest insurance premium is possible, reducing the building's maintenance cost.

Building Structural Design

To ensure an efficient building system, the project team kept close coordination through the overall design process, and the architecture allowed incorporation of structural elements in optimum locations – thereby allowing cost-effective structural design.

The seven-story building's foundation was designed using spread footings to bear on soft rock under load bearing walls and piers. The perimeter foundation walls were designed to retain the earth pressure as well as the walkway surcharge. In order to minimize the amount of site excavation of the hard rock, some part of the foundation walls were set back and corbels were installed to support the masonry walls above (*Figure 3, page 19*).

Except for exterior walls and shaft walls, one of the longitudinal middle corridor walls and one transverse partition wall at the west side of the main building were designed as load-bearing reinforced concrete masonry walls. Most walls are 8 inches thick above the 2nd floor, and 12 inches thick below. The west-side exterior walls vanish below the 2nd floor, and the walls above are picked up by precast concrete beams and cast-in-place concrete columns.

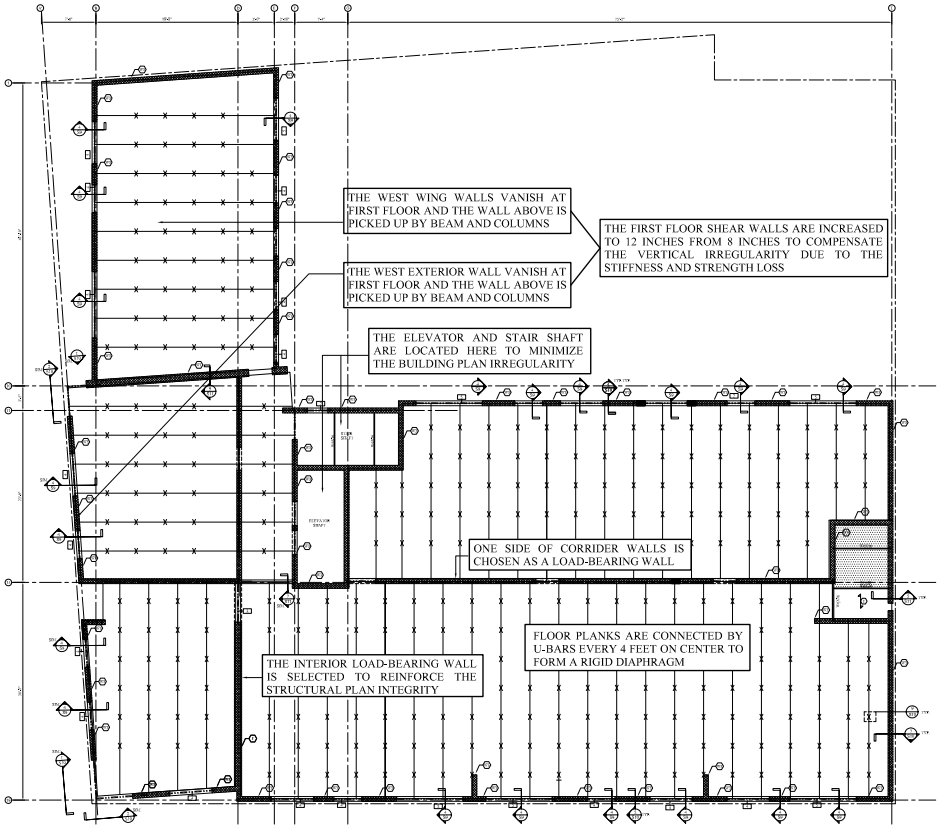

Figure 5: Typical floor plan.

Because only one interior load-bearing wall is used, the east portion of main building floors are framed by two rows of simply-supported planks with center to center spans of 31 feet and 25 feet, respectively. The west wing, as well as the west portion of the main building, is framed by one row of planks with a maximum span of 26 feet 6 inches. The building's floors consist of 523 pieces of 4-foot wide and 8-inch thick, no-topping, Elematic hollow core planks.

The floor planks are adaptable for varied equipment layouts. In the boiler room, the layout of mechanical equipment was adjusted prior to installation, so that the in-placed planks' capacities were undermined by approximately 8.5% in flexural strength and 6.3% in shear strength. A simple strengthening method was proposed to install 2-inch concrete topping to increase the effective depth and 2 cores infilling per plank to increase effective shear area (*Figure 4, page 19*).

The green roofs comprise 18 pieces of 10-inch thick planks and 12 pieces of 12-inch thick planks at the seventh floor and the fifth floor, respectively. The sloped mansard roof was framed by metal joists and corrugated decks.

The building's lateral force-resisting system is reinforced masonry shear walls with rigid diaphragms at each floor formed by planks, which are connected together by U-bars spaced at 4 feet on center as shown in *Figure 4*. In the main building, two intersected interior shear walls are placed to reduce the offset of the mass center to stiffness center. One of the interior shear walls connects to the west wing exterior shear wall so that it can continue the shear force transfer. The elevator and stair shaft cores are specially located as shown in *Figure 4* to reinforce the re-entrant corner. Planks are linked with shear walls at end joints by L-shaped bars (*Figure 5*), and (2) #5 reinforcement is placed in the cast-in-place end joint to form continuous bond beams at each floor level. The plan irregularity, due to the re-entrant corner, was considered when performing the diaphragm chord/drag member design and wall connection design per code. The stair and elevator shaft cores at the re-entrant corner decrease the torsional irregularity of the L-shaped plan. As the 1st floor shear walls at the west wing disappear, the story's stiffness and strength are compensated by increasing the interior shear walls' thickness to avoid a weak/soft story irregularity.

Conclusion

The selected masonry wall and floor plank system yielded a shorter construction duration as expected. The 7-story building itself was topped out in approximately 4 months once the foundations were in place, approximately one week per floor. The fast construction of the building made it possible to control the actual construction cost to $10.5 million, equivalent to a unit construction cost of approximately $222 per square foot, less than a local similar residential building. The use of precast planks and steel contributed 3 points to the LEED Silver rating of the building, based on the use of recycled content and regional materials.

Designed to promote health and well being of its occupants, Fox Point was opened in 2009. It currently provides permanent housing to 31 formerly homeless families and is renting to 17 low-income families or individuals from surrounding neighborhoods.▪

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