A simple skylight retrofit in a Manhattan high-rise becomes a complete roof overhaul.

TOP Heavy

BY MARCO SHMERYKOWSKY, P.E., AND ANDREW STEINKUEHLER

IF YOU HAD TO sum this high-rise alteration project up to someone outside of the AEC industry, you'd tell them it was a basic skylight installation. If you were trying to impress your industry friends, maybe you'd add that the project took place in a century-old, 18-story office building on Fifth Avenue in Manhattan.

But most historic high-rises are constantly being altered or renovated, whether for a new tenant or an owner looking to make their building more appealing to potential renters. And anyway, it's just a skylight installation. You put in a 25-ft by 8-ft skylight, make a few structural modifications here and there to increase architectural head room and available floor space, and you've got a much more appealing location for potential tenants. Easy, right?

Actually, no. The project ended up needing an entirely new structural support system, and the design team at Shmerykowsky Consulting Engineers was also tasked with increasing the head room below existing roof trusses *and* maximizing overall floor space—a difficult task considering that the simplest way to do the former (posting down to the floor below) would get in the way of accomplishing the latter. Not so simple after all.

Existing Space

The project took place on the building's 18th floor, below the roof level. The central roof structure consists of a standard pitched roof with the main ridge spanning in the east-west direction, and the "hips" of the roof are located on the east and west ends of the main ridge. The structure consists of a metal roof deck spanning between W8 purlins, and the purlins for the main roof span between two roughly 39-ft-long trusses supported on building columns; the original trusses had a depth of 6 ft at mid-span. The roof hips connect to the main ridge purlins approximately 7 ft away from the main trusses, and the support for this connection point is created by the cantilevering of the ridge beam past trusses.

At some point during the life of the building, three dormers were added to the original sloped roof area. The original structure consisted of cinder-crete slabs, shallow beams and posts down to the floor below, and the main framing bay between building columns was approximately 26 ft wide. Within each of these bays, the original purlins were located 8 ft, 9 in. on center.

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Making Space

Now for the fun stuff! Shmerykowsky was tasked with maximizing floor space on the 18th floor, and the designers felt that they could accomplish this by creating more column-/post-free open space along the floor's south side. The aforementioned dormers had increased the headroom along the south side of the floor when they were originally installed, but the previous alteration left the supporting posts in place.

After examining the existing purlin members in the field, the team determined that the members were too shallow to support roof loads while simultaneously covering the distance between the base of the roof and the roof ridge in a single span. Field investigation revealed that there was an additional existing post at the purlin's mid-span buried within a concrete masonry unit (CMU) wall running the perimeter of the floor.

Since the new framing for the new dormer roofs was bearing on the existing purlins, a two-part modification was required. First, a new girder was installed in each dormer bay spanning between building columns. Next, a new "horizontal" purlin was installed par-

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▲▼ At some point during the life of the building, three dormers were added to the original sloped roof area. The original structure consisted of cinder-crete slabs, shallow beams and posts down to the floor below, and the main framing bay between building columns was approximately 26 ft wide. Within each of these bays, the original purlins were located 8 ft, 9 in. on center.

▲▼ The skylight also required an additional support structure that would work as an independent framing system and would be located above the roof deck surface. A box frame constructed of HSS12×8 and HSS12×4 members was developed by the engineers and arranged so that the new frame would bear on a total of eight support posts, which were coordinated with the roof purlins below.

allel to the roof deck between the mid-span post and the new east-west girder. All of this work required that the existing roof structure was temporarily shored so that the existing purlins could be removed and the new steel could be added. Once the new steel was installed, the new load path essentially replicated the original load path.

With goal one—opening up additional floor space—achieved, the team now had to figure out a way to increase headroom. We opted to replace each existing truss with two shallower trusses on either side. Each of these trusses spanned 39 ft, 3 in., with a depth of 5 ft at mid-span, and were constructed with HSS6×3 chords and HSS3×3 vertical and diagonal members. These truss pairs would be supported on brackets attached to the sides of the existing columns.

The structural design also had to account for the fact that new tenants in the space might choose to treat the new trusses as architecturally exposed structural steel (AESS) rather than cladding it or installing a drop ceiling. The team felt that hollow structural sections (HSS) would lend the new trusses a cleaner, more aesthetically-pleasing profile (a truss made up of angles would need to be connected via bolted connections, which would both decrease available headroom and lack the streamlined look of a welded HSS truss).

The installation process posed its own challenges. Luckily, the top floor was unoccupied and a freight elevator made removing existing steel and bringing up new members possible. As the new trusses were being installed, the design team had to be sure to prevent deflections in the existing roof structure. Therefore, the contractor was instructed to preload the trusses by jacking both ends of each truss pair for a predetermined amount. Once the new truss pairs were preloaded and connected, the original trusses were removed. Finally, to engage

An exterior view of the 25-ft by 8-ft skylight.

The structural team decided to support the roof hips with new ridge beams that would span between existing building columns, which were conveniently located at the center of each roof hip's base as well as at the center of each exterior truss.

the new truss sets as a single structural unit, connecting members were added at each panel point between the trusses.

A New Opening

Then there was the skylight itself. The primary challenge in creating the new skylight opening stemmed from the fact that the roof hips were supported by cantilevered purlins. Before the skylight opening could be cut, a new support structure for the roof hips would need to be in place. For a number of reasons, particularly the need to maximize available floor space, the new support structure could not introduce any new posts or columns. That meant that the new structure would have been fully integrated into the existing roof steel.

After careful consideration, the structural team decided to support the roof hips with new ridge beams. These ridge beams would span between existing building columns that were conveniently located at the center of each roof hip's base as well as at the center of each exterior truss; the new beams were simply supported.

The skylight also required an additional support structure that would work as an independent framing system and would be located above the roof deck surface. A box frame constructed of HSS12×8 and HSS12×4 members was developed by the engineers and arranged so that the new frame would bear on a total of eight support posts, which were coordinated with the roof purlins below. Small spans of deck there originally spanned to the ridge purlins were re-supported by ledge angles as required.

The project resulted in a handsome new space, complete with new AESS trusses and more room and sunlight for the building's tenants. ■

General Contractor
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Architect
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