Photos: KCE Structural Engineers, PC

Capital View

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An expansion project within a stone's throw of the U.S. Capitol adds a little more steel to a notoriously concrete town.

EXPANDING A LARGE BUILDING IN A DENSE URBAN AREA IS NEVER EASY, ESPECIALLY FROM A STRUCTURAL STANDPOINT. It becomes even more difficult when the existing building needs to remain operational throughout the project.

Such was the case with Capital Gallery in Washington, D.C. Luckily, project owner Boston Properties was able to envision the possibilities and tasked KCE Structural Engineers, PC with adding seven floors to the three-story portion of an existing office building and parking structure—also designed by KCE in the 1970s—that was not originally designed for this expansion. The existing parking structure and office space, including an adjacent existing eight-story portion, were required to remain occupied during construction, and the existing roof of the three-story portion would need to be converted to floor use. In addition, the complex's central courtyard was to remain open as well for commercial catering and a restaurant tenant.

The building's location in a busy part of D.C. also added to the challenge, especially in terms of its proximity to stations for two different train systems. An Amtrak station and rail lines are located next to the site, as is a Metro (subway) station entrance. Utility issues also needed to be addressed. An underground steam line serving the United States Capitol and other government buildings, and an underground secure communication link tunnel between the Executive and Legislative branches of the U.S. government both ran through and under the building structure and had to remain operational.

Existing Conditions

In situ as-built conditions varied widely from what was shown on the 1970s design documents, changing continuously across the site. This variability required KCE to reevaluate and adjust the documents for the new gravity framing and lateral support system as new discoveries were made. Subsurface investigative techniques were limited by the need to keep the three-story office portion of the structure occupied "until the last minute," as well as the need to keep the parking garage functional, safe, watertight, dust-free, and relatively noise-free.

The existing roof slab's live load carrying capacity was 30 psf. However, the new design required an 80-psf live load (exceeding the code-required minimum of 50 psf for offices), plus a 20 psf allowance for partitions. Carbon fiber strengthening was not yet recognized by the local building jurisdiction, and in any case the capacity increase would have been in excess of ACI maximum limits. KCE designed a bonded concrete overlay system with shear connectors to increase the load-carrying capacity and level the sloped roof surface to make it useful as an occupied floor.

Structural steel shear collars were added under the slab around the columns to increase shear capcity. These consisted of rolled angle shapes, made up to suit existing concrete column dimensions, as three-sided "U's" with mitered corners.

Steel angles with shear studs were attached to some existing concrete columns for reinforcement. A new concrete shell will encase these assemblies.

Seven floors of steel-framed offices were added atop this three-story concrete structure from the 1970s.

They were set in place with high-strength Hilti epoxy anchors with the closure piece field-welded and epoxy-bolted. Epoxy was injected into any existing gaps between the back of the angle and the front face of the column. The angles were placed about 1 in. below the underside of the slab, and a non-shrink grout was dry-packed into the void.

Steel jacketing, concrete enlargement, and complete column replacement were methods used to increase the capacity of existing concrete columns. The steel jacketing methods used epoxy anchors and epoxy injection systems to bond either steel plate and/or steel angles to the existing columns, with head and base angle "seats" to transfer the additional accumulated load through to the newly modified columns and foundations.

Long Span

Washington D.C. has been and remains a "concrete town." However, the owner wanted a long-span, column-free space—with a panoramic historic view of the nearby U.S. Capitol building and Capitol Hill—while keeping the space on the lower three floors occupied as long a possible. A long-span composite steel framing system of girders and purlins with 3-in. metal deck offered the necessary spans for tenant flexibility, as well as architectural ceiling coffers, at the lowest cost.

The structure used long-span composite steel and concrete, reducing the number of columns requiring strengthening by one half, while at the same time doubling the required load-carrying capabilities of strengthened columns and footings.

When it came to the expansion, the design team made adjustments due to in situ slab reinforcing over columns and the column reinforcing itself that allowed for drilled-in high-strength epoxy anchors as column anchor bolts. Column removals, required due to the loading dock expansion and the addition of a central mechanical plant, were accomplished over occupied space with shoring systems designed by KCE, using special load transfer built-up girders and piggyback plate girders.

Prior to any other construction activity, KCE met accelerated schedule constraints by designing a method to install strengthened foundations while all garage levels, the commercial floor, and three office floors remained occupied.

These systems included micropile installations through various footings with shear transfer collars, four-section underpinning with lateral load transfer connections, above-lowest lift column shoring at the underside of the first framed deck with footing removal and replacement, and a saddle footing option that consisted of pouring a new footing over the existing footing and down around the sides, with lateral load connecting devices to the existing footing while temporarily hanging the column.

These foundation-strengthening systems were scheduled through the garage to limit the number of temporarily lost parking spaces to four at a time and to provide for 24-hour, continuous two-way driving aisle access.

The new below-grade central mechanical plant required the removal of large portions of structural slabs and walls below grade that had been providing structural lateral restraint to columns, as well as foundation walls.

New built-up plate girders and rolled sections provided the new permanent support. KCE designed temporary structural steel bracing systems to allow for this work, as well as a supplemental system to keep the surrounding public spaces safe and the adjacent Amtrak and Metro stations functioning around the clock.

Lateral force resisting systems continued down from the steel frame and added superstructure through the existing concrete structure via built-up and rolled steel section members that were tied to and work with the existing concrete frame, transferring the loads to the newly strengthened foundations.

The new elevator bank pit system required the pit wall extensions to be girders carrying new structural steel columns, and the steel K and X wind bracing to be placed from above through the existing three story building. These girders were supported by new hand-dug caissons and tied to existing caissons, which, as excavation commenced, were found not to be of the size, location, or geometry called for by the original documents.

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Dealing with Trains

Another facet of the expansion project was the fact that it subjected the immediately adjacent Metro structure to additional lateral loads. In addition, thanks to the ongoing construction of a glass-clad steel pipe truss canopy over the Metro station's entrance portal, the Capital Gallery expansion was required to use special protective steel shoring with horizontal bar joists and metal decking as a protective cover.

The adjacent Amtrak line and station, in addition to the Metro station entrance, limited crane access and required the support of a tower crane on the existing structure in addition to the use of truck crawler cranes supported by temporary shoring under the

The new elevator bank's pit walls function as girders carrying new structural steel columns and lateral bracing.

preexisting framed landscaped plaza area over the parking.

Raising the Profile

The owner and KCE, as well as the rest of the design and construction team, were able to overcome the obstacles of expanding an existing building in a busy area of the nation's capital and working above a continually occupied building—with no impact on adjacent transportation structures. And on top of that, they were able to raise the profile of steel with a prominent building in a high-profile location—and in a concrete town, no less. MSC

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