Engineers for a new office building in downtown San Diego turn to trusses to tackle a transfer tribulation.

# Picking up the SLACK

BY SHAUN WALTERS, P.E., GARRETT MIFSUD, S.E., AND ERIC LEHMKUHL, S.E.

◄ Sempra Energy's new HQ building uses 1,600 tons of steel. ▼ A completed rendering of the building, which will open in June.

Photos: Courtesy of Cisterra and KPFF

**SAN DIEGO'S EAST VILLAGE** is where it's at.

The downtown neighborhood, home to the San Diego Padres' Petco Park, has seen several new projects and renovations in recent years.

The majority of these projects have been geared toward retail and residential use in an effort to create a vibrant entertainment district. However, Sempra Energy's new 16-story headquarters building is nearing completion in the area, serving as a pioneer for future office development and offering tenants spectacular views of not only Padres home games but also San Diego Bay and the Coronado Bridge.

The project site is home to the oldest operating fire station in the city (in service since 1938) along with two other historically significant buildings. The new facility provides approximately 330,000 sq. ft of office space with four levels of subterranean parking and an additional three levels of aboveground parking.

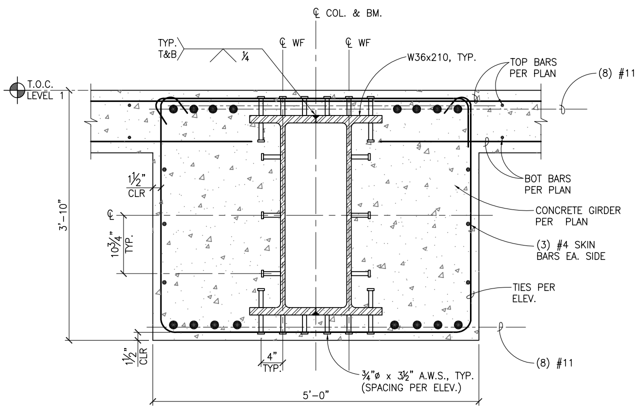
A fast-paced construction schedule and complex building program required the concrete parking decks and core wall lateral system to be integrated with a steel-framed floor and column system. The sequencing allowed the steel and core wall system supporting the tower to be erected early without being held up by the complex plaza and above-grade parking decks. Implementing the steel-framed floor also benefitted the architectural program by limiting column sizes and increasing bay widths, and resulted in encased steel beams and columns. The W14×90 and W14×132 columns were designed to withstand numerous levels of construction loading alone and the total design load acting compositely once encased.

At certain locations, such as where parking decks were sequenced behind, the steel columns had to be braced with steel beams. With a resourceful framing layout and vigilant coordination among the contractors, these beams were integrated into the deck and eventually encased in slab bands.

## Stacking Up

The interaction of stacked office space over underground parking is always a challenge when it comes to column layout. The south face of the building is askew and faces home plate of Petco Park while the parking below is arranged to maximize the number of spaces. In order to solve the issue without a transfer girder, either the garage drive aisle or the building geometry would have had to make a compromise. Neither was an option.

**Shaun Walters** (shaun.walters@kpff.com) is a project engineer, **Garrett Mifsud** (garrett.mifsud@kpff.com) is a project manager and **Eric Lehmkuhl** (eric.lehmkuhl@kpff.com) is a principal, all with KPFF Consulting Engineers in San Diego.




A detail drawing of a transfer girder section.

The column load requiring the transfer was over 900 tons and the span was 43 ft. Generally, transferring this load would be straightforward using a full-floor-depth transfer girder. Unfortunately, this solution would have created a dead end in the first level of the parking garage—plus, adding depth beyond the allocated space would have increased the first subterranean story height and ultimately required pushing the entire garage to a lower elevation. The only remaining option was to design a girder to transfer the column load over the span. With a depth of 3 ft, 10 in., accomplishing the task seemed impractical if not impossible at the time.

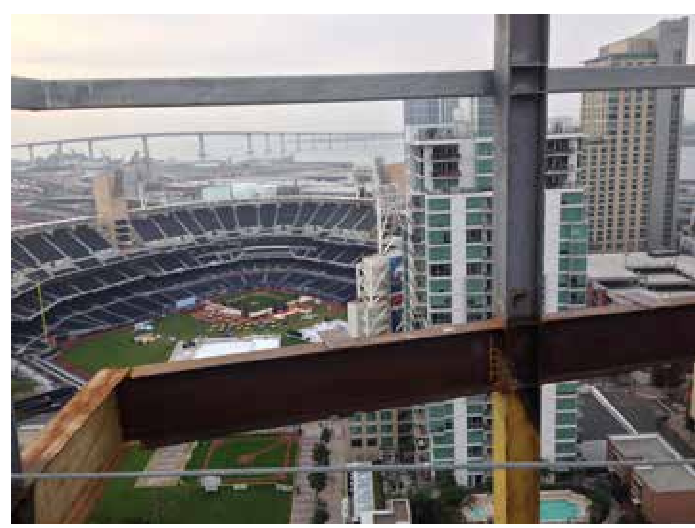
The first attempts at a solution involved many concrete beam iterations all with little success, namely due to the large shear force. At some point, the concept of an encased steel beam was realized. There were already encased steel erection beams in the upper levels, but these beams were attached to the core and stabilizing steel columns. This steel beam in the podium would need to connect directly to concrete columns and would require some very unusual details. Embedding a steel beam in the podium turned out to be the optimal solution, if not the only practical one. The total depth of the concrete girder, at 3 ft, 10 in., limited the girders to W36 and W40 sections—and once the reinforcement and coverage requirements were considered, the only viable option was the W36 series of sections. After evaluating individual sections, it was determined that two side-by-side W36×210s welded together along their top and bottom flanges would be the best solution.

The façade of the adjacent historic building, supported by stub beams off of soldier piles.

The AISC *Manual* gives three methods to determine the shear and flexural capacity. The flexural approach for determining nominal capacity involves the following options: a yield moment capacity check for the composite section, the plastic moment capacity of the steel section alone or the plastic moment capacity of the composite section, with the caveat that shear connectors are required to transfer the horizontal shear force. In most cases it's likely more economical to upsize the steel section and eliminate the many studs that the third option requires. In this case, the girder was limited by depth and shear demands, requiring a W36 that would not work using the first two options in the AISC *Manual*. The third option provided us the ability to significantly increase the flexural strength of the composite beam. Including composite action led to a shift in the neutral axis of about 7.5 in., increasing the flexural capacity of the section by over 50%. This increase in flexural capacity came at a cost of about 1,150 ¾-in. ø welded shear studs.

For the strength and serviceability analysis, RISA-3D software was implemented to model the two steel beams in parallel with a concrete beam using rigid links to account for the composite stiffness of the transfer girder. The girders were modeled with the floors and columns below to capture the appropriate force distribution. Stiffness

The building offers views of San Diego Padres games at Petco Park, as well as San Diego Bay and the Coronado Bridge.



The 16-story building serves as a pioneer for future office development in San Diego's East Village neighborhood.

assumptions of the composite beam were then bounded to confirm that the deflections would be acceptable over a wide range of unknowns. The steel beams proved to be invaluable in limiting deflections and providing an overall confidence level with regard to long-term deflection performance.

An added benefit of the encased steel transfer girder was that the steel columns and floor system of the office tower above could be erected immediately. The wide-flange tower columns were connected directly on top of the double W36 girder. The steel beams avoided the inevitable negotiations between engineer and contractor regarding how soon erection could proceed on concrete girders. Given the importance of these girders, a concrete-only solution would have likely required either the full 28-day strength to be achieved prior to loading or four levels of reshoring to the foundation. Fortunately, this sequencing issue was avoided altogether.

## Outside the Walls

The structural challenges facing the building projected beyond its face. Excavation of four levels immediately adjacent to three historic buildings was required to construct the new underground parking garage. The garage footprint also required demolition of a major portion of one of these historic buildings, with the stipulation that the existing storefront façade was to remain in place unaltered. This requirement led to an underpinning of the multi-story concrete façade wall over the 40-ft-deep excavation. The underpinning was accomplished by cantilevering steel beams off of the steel soldier piles, which were already required for the excavation. The existing concrete façade wall was structurally integrated into the new tower, and an existing loading dock doorway conveniently served as the entrance to the underground parking garage.

The building, which uses 1,600 tons of structural steel in all, is scheduled to open in June and is expected achieve LEED Gold certification. ■

**Owner/Developer**
Cisterra Development

**Architect**
Carrier Johnson + CULTURE

**General Contractor**
Turner Construction Co.

**Structural Engineer**
KPFF Consulting Engineers

**Steel Fabricator, Erector and Detailer**
Schuff Steel (AISC Member/Certified)

▲ A bird's-eye view of the transfer girders prior to being encased in the podium.

▲ A pair of transfer girders waiting to be lifted into place.

▼ Composite columns and erection beams prior to encasement in the above-grade parking decks.