
Kelsey-Seybold Clinic
Administrative Offices

View of entrance to new Administrative building.

Built to tilt

How Tilt-Up concrete construction was a best-fit design solution for Kelsey-Seybold Clinic's new administrative facility.

By Adam J. Cryer, P.E.

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Kelsey-Seybold Clinic is a prominent healthcare provider in the Greater Houston area offering a full range of medical services to the public. From allergies to cancer treatments, the clinic combines general practitioners, specialists, nurses and caregivers to provide a myriad of medical treatments across its 21 multi-specialty clinics and employs some of the latest medical technology in providing its services. So, when the company set out to construct a new four-story administrative facility in Pearland, Texas, it opted for a tried-and-true construction technique that has seen measurable growth in popularity in recent years, and for good reason.

The organization's recently completed 165,000-square-foot administration facility exemplifies many of the structural advantages offered by Tilt-Up construction, as well as several design features that building designers are using to create office buildings of greater architectural import than previously possible. The project also illustrates the ease with which structural steel and complex concrete panel geometries can be integrated to create unique structures that aid the Tilt-Up industry in shifting away from prior misconceptions about the construction method's perceived limitations.

Tilt-Up construction

In the Houston area, as in other parts of the country, the design and construction of site-cast concrete panels for low-rise buildings is becoming more ubiquitous by the day. What was once a construction method favored only for constructing warehouses and industrial facilities is now commonly considered during the conceptual design phase for development of office buildings, retail centers, hospitals and beyond.

View of four-story panels at East building elevation.

Tilt-Up construction consists of casting concrete panels on the building slab (or on nearby temporary casting beds), then lifting them into place with cranes. Once erected, panels are braced to the ground until the interior steel structure of the building can be erected and a "pour strip" can be constructed to anchor the panels permanently to the building slab. Transfer of forces between internal steel structure and perimeter panels is facilitated through the use of embedded steel plates, with headed stud anchors, which are cast into the panels. Panels typically extend below grade to help reduce potential for moisture migration under the building slab and are supported at each end by a foundation element, which eliminates the need, and cost, of constructing a continuous perimeter grade beam or foundation wall.

Previously, design of Tilt-Up panels was completed through use of hand calculations and spreadsheets. Panels were discretized into segments and internal panel forces were calculated in orthogonal directions, similar to the ACI 318 design procedure for two-way slabs. Modern computing capabilities have allowed for more accurate calculation of panel stresses and strains through use of finite element techniques. This method allows for more efficient use of steel reinforcing in panels and for more accurate estimation of panel deflections and dynamic response.

The recent boost in Tilt-Up popularity among designers, developers and owners can be attributed to several factors. The ability to incorporate design elements such as complex reveal patterns, stacked and rotated panels and cantilevered building corners (creating unobstructed corner views) has opened the eyes of many architectural designers and fueled a shift in perception about the Tilt-Up method's so-called limitations. Panels can accept all standard cladding materials, including brick/stone masonry, and serve as a structural substrate for EIFS and stucco wall assemblies. Plus, the use of recessed spandrel glass in panels has opened the door to architectural building elevations with continuous strip windows that give Tilt-Up design relief from the common "punched opening" aesthetic that most industry professionals think of when they conjure up thoughts of "tilt" buildings.

In addition, advancements in design and panel erection techniques are allowing Tilt-Up construction to reach new heights. Three- and four-story designs are becoming more common and design methodologies for construction of five- and six-story Tilt-Up buildings, using vertically stacked load-bearing panels, are being put into production as well. Crane capacity is typically the governing factor for setting maximum panel dimensions, not the panels themselves. Furthermore, concrete panels offer a unique structural efficiency by serving as both load-bearing elements at the building perimeter and as the primary, often sole, lateral load resisting system.

For the Kelsey-Seybold project, 10-inch-thick panels with 4,000 psi 28-day strength concrete, reinforced with two layers of #4 bars at 12 in. on-center each way, were used at the perimeter of the building. Additional reinforcing was included at areas of high stress concentration, such as at openings that were located near panel boundaries and where high point loads occur (e.g., stacked panel bearing points, steel girder support locations). The panels are typically separated by 3/4-in. joints that allow for tolerance during the panel erection process and to account for volumetric changes of the panels due to thermal effects.

Steel structure and foundations

For the Kelsey-Seybold project, the elevated floors consist of 2-1/2-in. normal-weight concrete over 2 in. composite steel deck, using 3/4-in.-diameter shear studs to attain composite beam behavior. Wide-flange steel girders and columns support the floor framing to the interior of the building, while the Tilt-Up panels serve as very stiff boundary support elements for the floor joists at the perimeter, reducing potential for undesirable floor vibration. The roof diaphragm consists of a 1-1/2-in. 'B'-profile steel deck over bar joists at a maximum spacing of 6 feet on-center.

The site's soil conditions, including discovery of a shallow groundwater table during early geotechnical investigations, dictated that the primary foundation elements be drilled straight-shaft concrete piles. Depending on loading conditions, pile depths varied in length from 28 to 70 ft. below grade and from 24 to 48 in. in diameter. Piles were grouped under pile caps where loads from the superstructure necessitated higher capacities. The project program also called for construction of cast-in-place concrete tunnels underneath the new facility to serve as code-required fire exits. The tunnel walls were designed to carry both hydrostatic pressures and lateral forces from retained soils.

Lateral resistance

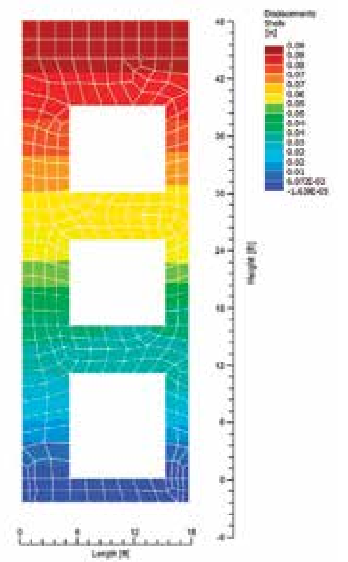
The growing market for Tilt-Up construction in hurricane-prone regions, like the Gulf Coast, is in large part due to its characteristic durability and high in-plane and out-of-plane lateral load-carrying capacity. Concrete walls offer maximum shear capacity, low inter-story drift and greater resistance to overturning forces, as compared to typical lateral steel bracing. From a structural standpoint, panels serve as columns, braces and building envelope all rolled into one. That level of building efficiency, paired with the reduction in construction time versus a traditional building system, illustrate the attractiveness of this method to the AEC industry.

For the same reason, Tilt-Up designs are also of particular interest for projects that require resistance to blast forces, such as petrochemical facilities and government buildings. Design techniques that now consider more complex material behavior, such as strain-rate effects, produce economical wall designs that provide superior protection from both debris and blast forces themselves. The inherent in-plane stiffness of Tilt-Up panels, combined with special panel-to-panel connection detailing, also represents a natural resistance to progressive collapse, which is often a requirement for construction of government facilities. In addition, continuous embed plates are typically cast into panel openings to provide anchorage for blast-resistant doors, windows, dampers, etc.

Construction photo of braced Tilt-Up panels following panel erection.

Cost benefits

For decades, Tilt-Up construction has represented a marriage of the cost advantages seen in cast-in-place concrete with the time savings associated with precast concrete erection and placement (think precast concrete garages). This concept, which is now often referred to as "value office" design, has gained prevalence due to its advantageous impact on the bottom line of construction budgets. General contractors quote an average of $10 to $15 per square foot reduction in project cost over traditional construction methods. This reduction is, in part, due to the minimized time required for workers to assemble the building envelope, which in turn trims the overall construction schedule. Plus, casting concrete panels on-site translates to shipping savings, as compared to traditional precast concrete techniques. Tilt-Up construction can also curtail capital costs of building ownership (maintenance, energy consumption, etc.), which makes these buildings attractive to developers and end-users alike.



Typical panel deflection contours resulting from finite element analysis.

View of hybrid steel and concrete panel structure during construction.

Challenges

The project encountered some challenges during design and construction, but open communication among the design team facilitated direct and timely solutions throughout all phases. Foremost among those challenges: The fourth floor of the building was not added to the building design until the construction document phase of the design process. The structural engineer's use of modeling software allowed an expedited redesign of columns/footings, Tilt-Up panels and lateral load resisting systems to accommodate the revision. The building's unique use of acute and obtuse angles with mitered corners necessitated fabrication of customized panel-to-panel connections. In several locations, panel legs were thickened and stirrups were added to provide adequate bearing and flexural strength required to resist gravity forces paired with Category 3 hurricane wind pressures.

Kelsey-Seybold's new facility opened in the summer of 2013 and serves as critical new space for the healthcare provider's administrative needs. The project epitomizes how structural designers can marry the use of various structural building materials to reach an optimal solution that answers all design challenges. Although Tilt-Up may not represent a new technique in building construction, its versatility and cost-reducing potential have led to its recent resurgence in the current market, and in Kelsey-Seybold's case, provided means for operational expansion within their preferred timeframe.

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