POST-TENSIONING INSTITUTE ANNOUNCES WINNERS OF 2015 PTI PROJECT AWARDS

ABOUT THE AWARDS

The Post-Tensioning Institute (PTI) announced 11 winners for the 2015 PTI Project Awards, who were honored during the PTI Awards Presentation at the 2015 PTI Convention, April 26-28, 2015, in Houston, TX.

The awards recognize excellence in post-tensioning applications. Any structure completed or rehabilitated in the past 7 years that uses post-tensioning as a structural component was eligible. Entries were submitted by owners, architects, engineers, contractors, and post-tensioning suppliers. Awardees were selected by a jury of industry professionals and were judged based on creativity, innovation, ingenuity, cost-effectiveness, functionality, constructibility, and aesthetics.

The highest honor, "Project of the Year," was awarded to the **San Francisco-Oakland Bay Bridge New East Span Skyway**. This award is given to a project that demonstrates excellence in post-tensioning applications and stands out above all other entries. The project was submitted by T.Y. Lin International.

The remaining winners were selected from six categories, with an 'Award of' Excellence' given in each category, and an 'Award of Merit' presented to other projects deserving recognition. The categories and winners include:

- Bridges
  - Award of Excellence: **West 7th Street Bridge** in Fort Worth, TX, submitted by the Texas Department of Transportation
- Buildings
  - Award of Excellence: **Parkland Replacement Hospital** in Dallas, TX, submitted by Datum Engineers
  - Award of Merit: **Dumptop Residence** in Dallas, TX, submitted by Datum Engineers
- Industrial/Special Applications
  - Award of Excellence: **Glacier Skywalk** in Jasper National Park, AB, Canada, submitted by Dywidag-Systems International, Canada
  - Award of Merit: **Twin Vehicular Jacked Box Tunnels** in Lynchburg, VA, submitted by Dywidag-Systems International, USA
- Parking Structures
  - Award of Excellence: **Tapiola Central Parking Facility** in Espoo, Finland, submitted by Sweco Structures Finland
- Repair, Rehabilitation & Strengthening
  - Award of Excellence: **SBR Tank #1 Repairs** in Mount Carmel, PA, submitted by Concrete Protection & Restoration, Inc.
  - Award of Merit: **Dover Dam Safety Assurance Phase 1 & 2** in Dover, OH, submitted by Brayman Construction Company
- Slab-on-Ground
  - Award of Excellence: **Sky View Parc Tennis Facility** in Flushing, NY, submitted by Classic Turf Company, LLC
  - Award of Merit: **New Canaan High School Tennis Courts** in New Canaan, CT, submitted by R.S. Site & Sports

The PTI Project Awards program runs every 2 years. The next round will be held in 2017. To see examples of past winners, visit **www.post-tensioning.org**. If interested in submitting a project for the next awards program, details and an application kit will be available in 2016.

2015 PROJECT OF THE YEAR: SAN FRANCISCO-OAKLAND BAY BRIDGE NEW EAST SPAN SKYWAY

INTRODUCTION

After the 1989 Loma Prieta earthquake damaged the original East Span of the San Francisco-Oakland Bay Bridge, it was determined that the safest, most cost-effective solution was a total bridge replacement. The 2.2 mile (3.5 km) long San Francisco-Oakland Bay Bridge New East Span (East Span) (Fig. 1) opened to traffic on September 2, 2013, and includes four distinct but interrelated components: the 2047 ft (624 m) long, single-tower self-anchored suspension span (SAS); the 1.3 mile (2.1 km) long Skyway that rises to the SAS from the Oakland shoreline; the 4229 ft (1289 m) long Oakland Touchdown connecting the Skyway to California's Interstate 80; and the 1542 ft (470 m) long Yerba Buena Island Transition Structure that links the SAS to the island. The East Span is the world's longest single-tower SAS and the world's widest bridge at 258.33 ft (78.6 m).

Located in a high seismic zone between two major faults capable of producing large earthquakes, all East Span components, including the Skyway, have been designed to meet specific performance criteria. This includes the bridge's designation as a regional lifeline structure that must open to emergency traffic shortly after the occurrence of the largest anticipated earthquake; and a 150-year design life, or twice the normal bridge standard at the time.

Fig. 1—San Francisco-Oakland Bay Bridge New East Span.

The Skyway, the longest portion of the new East Span, was the first major contract in the immense replacement project. Preliminary design on the Skyway began in 1998, with construction started in 2002 and completed in 2007.

SKYWAY POST-TENSIONING

The Skyway (Fig. 2) consists of twin viaducts that are precast segmental bridges, erected in balanced cantilever (Fig. 3), with a typical span of 525 ft (160 m). For typical spans, the box girder is 29.5 ft (9.0 m) deep at the pier and 18 ft (5.5 m) deep at its midspan. Designed to carry five lanes of highway traffic in each direction, each box girder is a slender, single-cell box with wing panels and measures approximately 78.2 ft (23.8 m) wide with standard shoulders (Fig. 4).

The Skyway is lighter and more slender than traditional concrete box designs and uses construction materials to their full potential. High-performance, low-permeability 8000 psi (55 MPa) concrete was used throughout the superstructure. The outside panels are lightweight concrete. The concrete box section is post-tensioned longitudinally, transversely, and vertically to minimize concrete cracking.

The longitudinal post-tensioning consisted of three sets of tendons: cantilever tendons located in the top slab, continuity tendons located in the web, and span tendons located in the top and bottom slab. The cantilever tendons were stressed during cantilever construction immediately after each segment was erected. Typically, six tendons were anchored at each segment face—two tendons per web and one tendon per edge beam. Each tendon consisted of 0.6 in. (15.2 mm) strands. There were a total of 60 cantilever tendons in the section at the piers.

The span tendons located in both the top and bottom slab were used in the central part of the spans to provide continuity between adjacent cantilevers. Span tendons were anchored in anchorage blisters located inside the box at the intersection between the webs and the slab or external wings. A typical span carried 12 span tendons in the top slab and 16 span tendons in the bottom slab. Each span tendon consisted of nineteen 0.6 in. (15.2 mm) strands.

Continuity tendons consisted of twenty-five 0.6 in. (15.2 mm) strands, with typical spans carrying a maximum of 16 tendons, anchored at the piers. Transverse tendons comprised four 0.6 in. (15.2 mm) strands in flat ducts located above the longitudinal cantilever tendons. The anchorages are located at the edge of the slab. The average spacing between transverse tendons was approximately 39 in. (990 mm). Vertical post-tensioning was required in the webs to limit tensile principal stresses in the webs. High-strength 1.4 in. (35.6 mm) bars with anchorage plates at the top and bottom of the web were used.

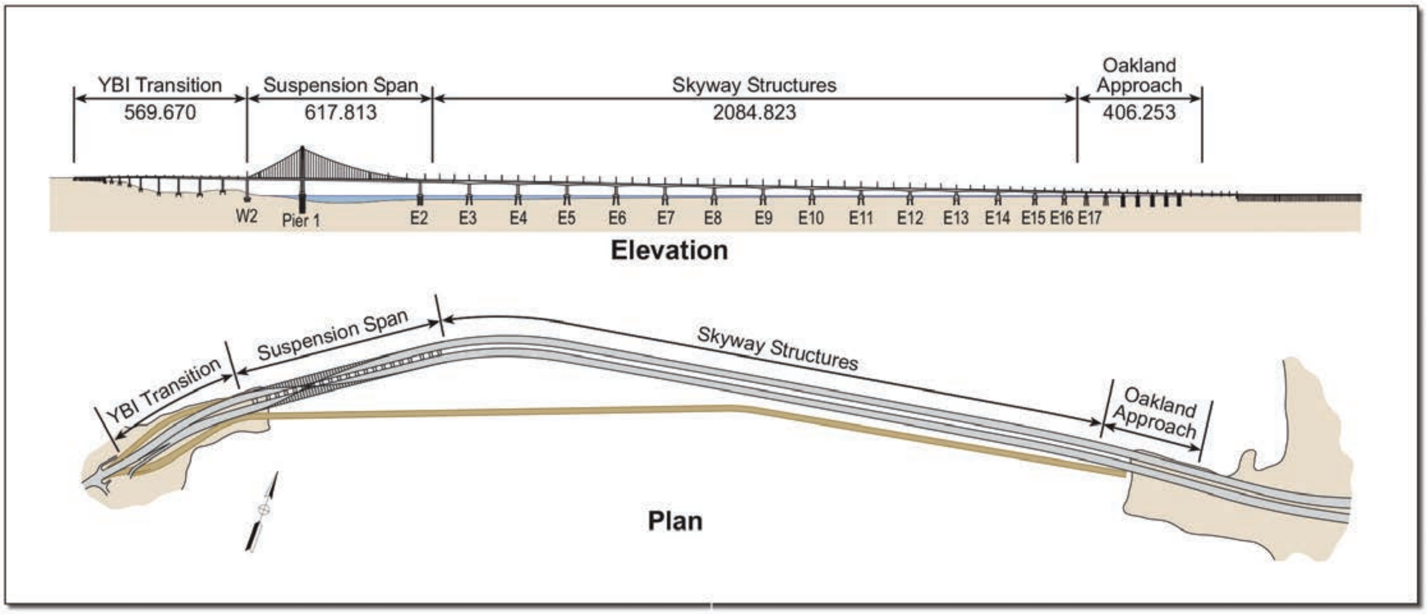


Fig. 2—The new East Span's four components (in meters).

INNOVATIVE CONSTRUCTION AND POST-TENSIONING METHODS

Given the vast complexity of Skyway construction, it was essential to perform constructibility reviews at various design phases, including fabrication and erection methods. A battery of mockups was performed to verify constructibility and circumvent challenges in the field, allowing construction operations to maintain or accelerate erection operations and reduce impacts on the schedule. The balanced cantilever method of construction was used to compensate for the high cost of constructing seismically resistant foundations in the soft bay mud. It also allowed longer span lengths, with the variable-depth segments erected in both directions, working outward from the piers.

The 452 concrete segments for the Skyway box girders were cast in a special precasting yard in Stockton, CA (Fig. 5). Match-cast in an enormous mold, concrete sections were placed in sequence, with ridges employed on the adjoining surfaces to provide proper alignment and assist in holding segments together during final assembly. After being match-cast and stored for up to 6 months to reduce the effects of creep and shrinkage, the segments were barged about 70 miles (113 km) to the construction site. Weighing up to 750 tons (680 metric tons) each, the Skyway segments are the largest of their kind ever cast. At the construction site, custom-designed self-launching erection devices (SLEDs) were used to lift the huge segments up to 135 ft (41.1 m) above the water and into place on the cantilevers. The SLEDs were first anchored to the pier tables using post-tensioning bars embedded in the tops of the webs. A cast-in-place concrete closure placement was made between the pier table and the first segments. Once the pier table and segments were post-tensioned together (Fig. 5), the SLEDs were advanced onto the leading segment and re-anchored. The next pair of segments were

Fig. 3—Balanced cantilever construction.

Fig. 4—Skywalk structure looking toward Oakland.

then erected and post-tensioned together. The process was repeated, with the SLEDs advancing outward from the pier table, until all pairs of segments of a typical cantilever were erected. The post-tensioning system was designed specifically for the Skyway project's high-strength concrete.

DESIGNED FOR SEISMIC RESILIENCE

The Skyway viaducts consist of four massive frames connected by expansion joints, which resist seismic motion by allowing the frames to move and slide while maintaining

Fig. 5—Skywalk box girder in precasting yard.

overall structural rigidity (Fig. 7). While the expansion joints on the original bridge could only accommodate a few inches of movement during an earthquake, the expansion joints on the new structure can accommodate several feet of movement. Skyway frames are also typically connected at midspan by 60 ft (18.3 m) long hinge pipe beams. Resembling massive metal tubes, the hinge pipe beams are constrained against longitudinal movement in one cantilever and are free to slide in the adjacent cantilever. This permits the Skyway frames to expand and contract at the hinge locations. During an earthquake, the hinge pipe beams constrain the two parts of the structure to move together transversely and vertically, limiting damage to the expansion joints above. In case of overstress, the softer steel ("fuse") midsection absorbs the strain, minimizing damage to the remaining length. If needed, the damaged fuse portion can be replaced.

Bay Area geology also presented enormous challenges for the design of the Skyway foundations. As the bridge alignment progresses east toward Oakland, the Franciscan bedrock drops steeply and the piers overlie deep deposits of young and old bay mud, which are, in turn, underlain by interlayered clays and sands of the lower Alameda formation. The foundation piles for the Skyway were driven up

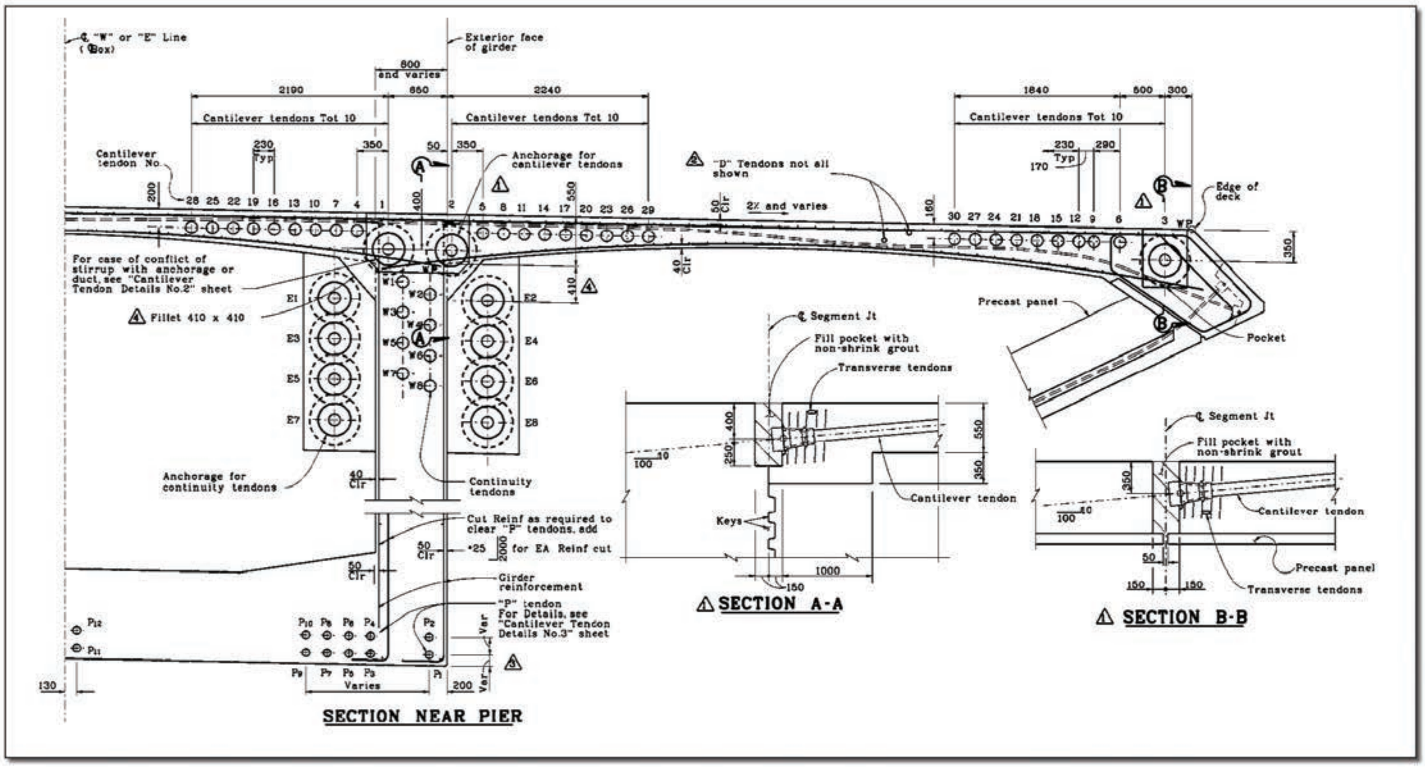


Fig. 6—A cross section shows the extensive post-tensioning used in the box girder.

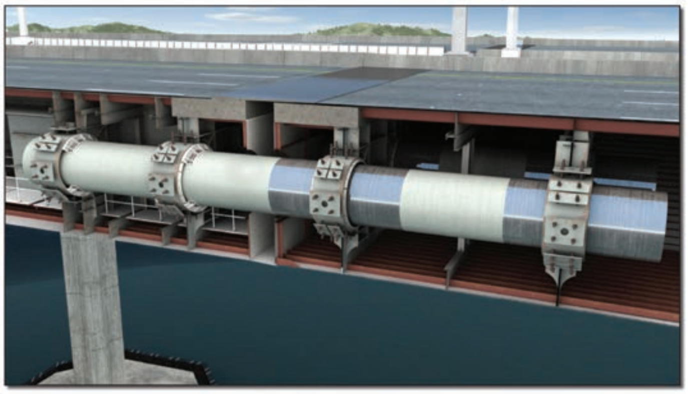


Fig. 7—Cutaway rendering of a deck hinge pipe beam.

to 300 ft (91.4 m) below the water's surface to anchor into stable soils, and at a slight batter, or angle, to increase lateral resistance under seismic loads. While this battering method has been used to create secure foundations for offshore oil rigs, this is the first time this method has been used for bridge construction of this scale. The piles are generally tipped 13 ft (4.0 m) into lower Alameda sands. The Skyway viaducts use a total of 160 pipe piles, each weighing approximately 400 tons (363 metric tons).

STRATEGIC PROJECT MANAGEMENT

Due to tremendous concerns about the original bridge after the Loma Prieta earthquake, the California state legislature passed Senate Bill 60 in 1997, providing funding for a simple viaduct replacement bridge. In 2013, when the new East Span opened, the approved budget for the entire bridge was $6.4 billion. Of that amount, the approved budget for the Skyway contract was $1.044 billion—$323 million of which represented federal funds.

To save on costs, the entire East Span project was divided into discrete contracts, enabling more competitive bids, increasing the opportunity for a number of companies to be involved on the project, and accelerating the schedule. A highly organized approach was applied to managing the planning and delivery of the complex project, including a detailed schedule to manage the multiple contracts. This helped identify and manage construction timelines, the use of staging areas, and any potential space conflicts between contractors. To maintain traffic flow during construction, the original bridge was kept operational until the new bridge opened.

SOCIAL AND AESTHETIC CONSIDERATIONS

A years-long process of more than 100 public meetings allowed Bay Area communities the ability to comment on structure type, bridge alignment, and other design elements. Because the San Francisco Bay is home to large, diverse communities of plant, fish, and marine mammal life, the project team also worked with environmental groups to develop and implement a comprehensive program to safeguard the environment during construction activities.

One innovative technology used during Skyway construction was the marine pile driver energy attenuator, which creates a dense shower of underwater bubbles. This "bubble curtain" protected fish and other marine life by enveloping the Skyway pilings and dissipating the shock waves produced by the force of the pile driving. In addition, because certain bird species have roosted on the original bridge for decades, special nesting platforms under the Skyway, nicknamed "Cormorant Condos," provide a nesting habitat in the same general area.

Local and regional transportation needs were also carefully considered. The inclusion of 10 ft (3 m) wide shoulders minimizes traffic disruption on the Skyway from stalled vehicles and accidents. In response to community demands, a 16 ft (4.9 m) wide, 2 mile (3.2 km) long bicycle/pedestrian path was included in the bridge design. "Floating" alongside the eastbound Skyway viaduct onto the SAS, the path will eventually extend all the way to San Francisco, offering an alternative to auto, bus, or ferry transportation and a new link in the Bay Trail.

The new East Span features a sleek, aerodynamic profile that minimizes its visual mass, as evidenced by the graceful, side-by-side decks of the Skyway that ascend from the Oakland shoreline to connect seamlessly with the parallel roadways of the SAS. The shape of the Skyway box girder cross section complements the steel section on the SAS to the west and provides aesthetic continuity of form. Pentagonal-shaped light poles along the Skyway structures also reflect the shape of the SAS tower.

Along with the clean, modern appearance, what is also important is the users' improved visual experience. The Skyway presents panoramic views of the San Francisco Bay and features a cutting-edge lighting system, with high-performance LED lights that spread a bright, uniform glow across the roadway. While the quality and distribution of light on the road will create a safer driving experience for motorists, the longevity of the lighting system will also increase safety for maintenance workers.

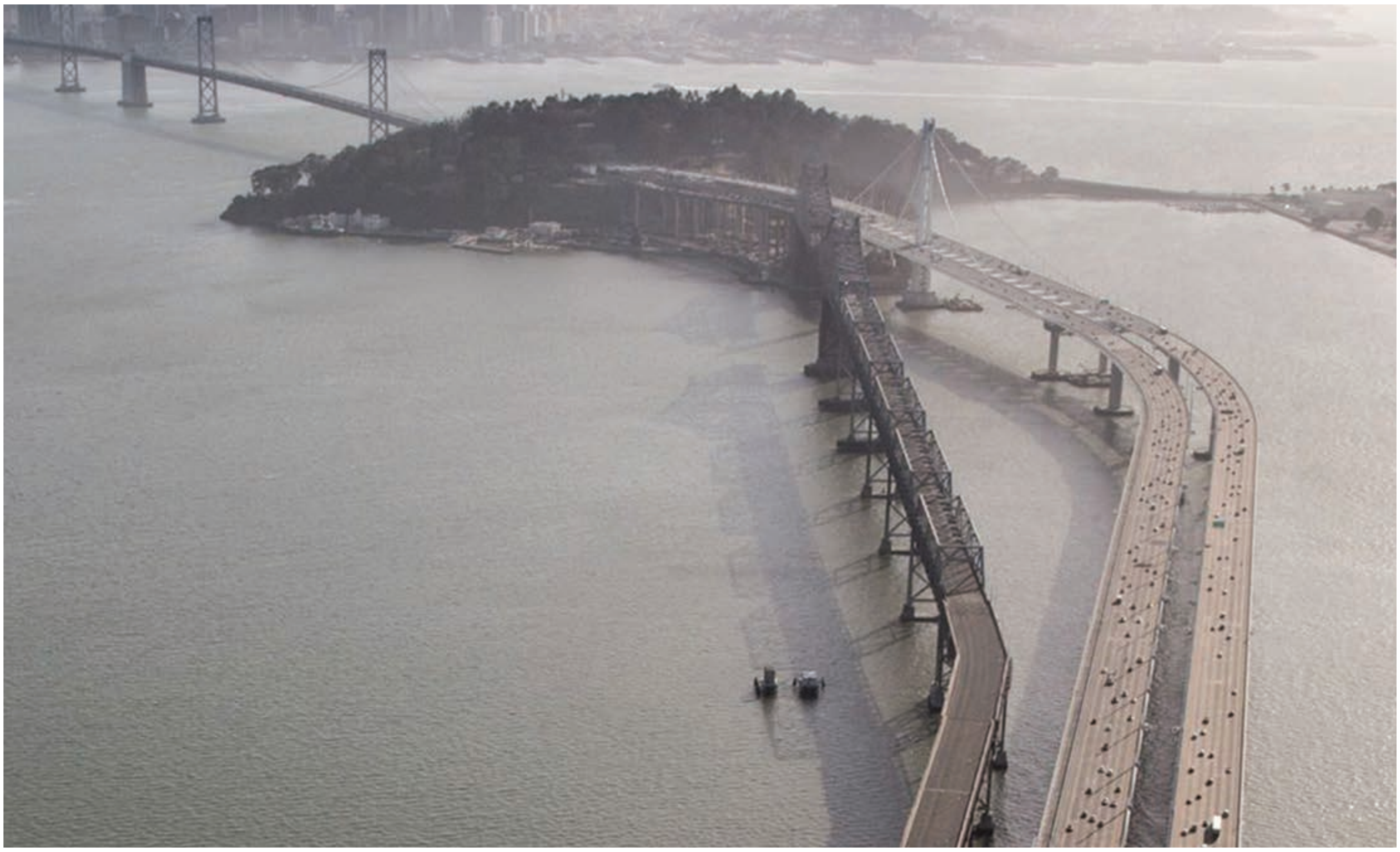
CONCLUSION

As the longest portion of the new East Span, the Skyway exemplifies innovation in design and constructibility, using construction materials and post-tensioning to their fullest potential. The project's location in a high seismic zone presented many unique challenges, including a 150-year service life—twice the bridge standard at the time. Deep foundations required installation through bay mud to anchor in stiff soils, using technology from the oil industry. Critical seismic design elements were incorporated, such as midspan hinges and the use of pipe beams across the hinges. This tremendous effort led to a seismically resilient, visually compelling Skyway structure that will serve the people of the Bay Area and the State of California for generations to come.

Location: Oakland, CA
Submitted by: T.Y. Lin International
Owner: California Department of Transportation (Caltrans)
Architect(s): n/a
Engineer(s): T.Y. Lin International/Moffatt & Nichol, Joint Venture
Contractor: Kiewit/FCI/Manson, Joint Venture
PT Supplier: Schwager Davis, Inc. (SDI)

Jury Comments:

- This is a perfect 10—truly an engineering feat when you take into account how heavy each segment is
- The only way they could have created this solution was through PT—the performance requirements drove the solution
- PT used in all three directions to control cracking
- Built for resistance in all conditions
- Skyway exemplifies innovation in design and constructibility, using construction materials and post-tensioning to their fullest potential in a seismic zone



2015 AWARD OF EXCELLENCE: WEST 7TH STREET PRECAST NETWORK ARCH BRIDGE

The West 7th Street Bridge (Fig. 1) in Fort Worth is believed to be the world's first precast network arch bridge. The six 163.5 ft (49.8 m) post-tensioned network arch spans connect downtown Fort Worth to its vibrant cultural district. Separate pathways along the bridge's outer edges provide safer, improved mobility for pedestrians and cyclists, while the public area below offers a shady respite from the Texas sun. Complete replacement of the aging 981 ft (299 m) long by 88 ft (26.8 m) wide bridge disrupted traffic for only 4 months, for $209 per square foot ($2250/m^2) of bridge deck. The project partners made every effort to minimize inconvenience to local residents and businesses. Throughout the construction process, multiple methods of communication were used to keep the public informed about the project progress and potential impacts to traffic.

ARCHES

The arch tie contains four tendons, each with nineteen 0.62 in. (15.7 mm) diameter strands. The tendons were tensioned to approximately 916 kip (4075 kN) each, which is a total force of approximately 3664 kip (16,298 kN) in the tie for the completed structure. The advantage of using post-tensioning in the arch was the flexibility of staged tensioning and de-tensioning for various construction loadings. The arches went through multiple construction stages: they were cast monolithically on their side, then rotated, and finally transported to the bridge site. The two arch rib tendons were initially tensioned to approximately 916 kip (4075 kN) each to accommodate construction staging and then de-tensioned to approximately 458 kip (2037 kN) each for the completed structure.

Twelve identical 280 ton (254 metric ton) arches were cast on their sides in a casting yard located four blocks from the bridge site. A specialized lifter was used to raise and rotate the arches into a vertical position (Fig. 2). Self-propelled mobile transporters were then used to move the arches onto columns that are located just outside the existing bridge railings. For speed and aesthetics, the arches were designed to be free standing.

STRESSING HANGERS

A tight weave of hangers was chosen for both aesthetics and speed of construction. The density of 1.75 in. (44.5 mm) diameter stainless steel bars made the hangers more of a visual component but also allowed for closer floor beam spacing, and allowed for the elimination of longitudinal stringers that are customary for through-arch bridges. To

Fig. 1—West 7th street precast network arch bridge.

Fig. 2—Specialized lifter raising and rotating arches into a vertical position.

Fig. 3—Stressing of hangers.

simplify the stressing of the hangers (Fig. 3), the arch tie was lifted by 13 rams connected through a common manifold, the bar hand-straightened, and double-nuts tightened.

FLOOR BEAMS

One-hundred-two similar precast, pretensioned floor beams made with self-consolidating concrete were plant-cast and shipped 200 miles (320 km) to the site. Over the river, the floor beams were placed by threading the beams through the top of the arches. A tilt meter was used to ensure the beams were not angled more than 37 degrees from horizontal. Stability of the arches depended on creating a full-moment connection between large, non-planar precast pieces. A thin layer of epoxy mortar joint was spread across the top of the floor-beam plinths, squeezed lightly, then fully post-tensioned once hardened.

Bar post-tensioning systems were used for the floor beam-arch tie connection, along with temporary construction connections including lifting frames, strongbacks, and horizontal bracing between arches. These connections allowed for minor adjustments during construction.

BRIDGE DECK

To speed construction and increase safety, panels were used continuously from abutment to abutment. Four in. (102 mm) panels were used for the majority of the deck, but increased to 6 in. (152 mm) where they cantilevered 4 ft 9 in. (1.4 m) at expansion joints. A minimum 4.5 in. (114 mm) thick cast-in-place layer completed the slab.

OFF-THE-FORM FINISH

The mixture designs and careful fabrication of the arches and floor beams eliminated the need for painting. The arch concrete is some of the most sophisticated ever produced for a TxDOT project, as there were a multitude of difficult requirements: high strength, high slump, low shrinkage, and low heat due to the massive arch knuckle.

COMMUNITY

The West 7th Street Bridge stands out as elegant, yet unpretentious, like the people for whom it was designed. Celebrated at its opening with fireworks and a public festival, the bridge has quickly become a reliable transportation connector for the Fort Worth community, and a popular locale for special moments, play, and coming together.

*Note: This project was a featured case study in the August 2015 PTI *JOURNAL*.

Location: Fort Worth, TX
Submitted by: Texas Department of Transportation
Owner: City of Fort Worth
Engineer(s): Texas Department of Transportation
Contractor: SUNDT Construction, Inc.
PT Supplier: VSL Structural
Other Contributors: Aluma Systems, Inc.; Burkhalter Rigging, Inc.; GST Manufacturing; Hamilton Form Company; Heldenfels Enterprises, Inc.; Infinity Engineering, USA, Inc.; LUSAS; RJ Watson, Inc.; TXI, Inc.

Jury Comments:

- Very unique with lifted-in-place arch ties and using post-tensioning to control everything
- Incredible cost-effectiveness
- Impressive to see flexibility created by over-tensioning, then de-tensioning
- Don't see this every day

2015 AWARD OF EXCELLENCE: PARKLAND REPLACEMENT HOSPITAL

This significant hospital replacement project (Fig. 1) was primarily driven by the need to create a facility that would meet the functional requirements of today's medical environment. The original facility, built in the 1950s, was functionally inadequate for twenty-first-century needs, and many complaints and state-issued mandates pushed the owner to reach out to consultants to develop a new architectural and engineering vision. Based on the defined requirements, a large structure evolved, resulting in unusual structural engineering challenges. The form consisted of a 62 ft (18.9 m) cantilever coupled with a 120 ft (36.6 m) span over an opening; both support seven stories above. This concept allowed for more windows and minimized the distances to the elevator core.

ALTERNATIVE SYSTEM STUDY

The initial step for the structural engineers was to meet to define potential structural systems to be priced by the general contractor.

- The first option involved a two-story structural steel transfer girder between the 10th and 12th floors. The deflections were unacceptably high and the steel tonnage was clearly unrealistic.
- The second option included adding steel diagonals from the 10th floor to the roof to create a seven-story truss. This proved to be a more cost-effective steel system alternative.
- The third system priced was a seven-story cast-in-place concrete structure supported on a two-story, post-tensioned transfer girder system. This system did not come without constructibility concerns. The major issue was the five-story-tall shoring required to support the dead weight of the cast-in-place concrete transfer girders during construction.
- The fourth system considered was a hybrid system to possibly combine the benefits of both steel and concrete. The system consisted of a concrete structure below the transfer girder and a steel frame above. This system was evaluated but the cost of construction was affected by coordination between two subcontractors working in the same area.

After evaluation of the four structural systems, the post-tensioned girders with concrete structure were chosen (Fig. 2). The premium associated with this system was determined to be acceptable considering the functional benefits of the layout of the medical spaces. The post-tensioned transfer girders were the most practical and, by far, the best solution for deflection control. Post-tensioning allowed the use of staged stressing to control the elevation and deflection of the floors as the building was being constructed.

Fig. 1—Parkland Replacement Hospital.

Fig. 2—Parkland Hospital PT transfer girder under construction.

QUALITY CONTROL PROCESS

Quality control was another extremely important part of the success of this complex project. In addition to a highly successful designer and contractor team effort, the usual testing laboratory inspections, concrete testing, and all of the preplanning that goes into a project, the contractor also proposed building a mockup of the highly congested corner condition.

This benefited the project in many ways. First, the post-tensioning anchors were larger than expected. The manufacturer had ceased making the anchors that were in the catalog and the ones they delivered were much larger. Therefore, they required additional space and created a congestion issue that had to be addressed. Congestion factors were studied in this mockup and responses to each were defined. In response to the findings, the thickness of the wall at the anchors was flared to create more room at the end of the wall to reduce the congestion (Fig. 3).

It was extremely important to monitor and test a mass concrete placment during construction. Mass concrete testing simulations were performed in advance in large concrete pier caps, providing adequate information to allow a large mass concrete placment. There were 88 maturity meters installed in the forms. With these maturity meters on the inside of the walls and on the forms of the walls, the heat of the concrete and the differential of the heat of the concrete in the middle of the wall and at the formed edge of the wall could be measured. This focus helped prevent internal cracking in the concrete.

"All of the steps presented—from selecting the system, designing the system, teamwork between the design professionals and the contractor, all of the close attention to details, constructibility, and quality control—were key ingredients that led to a very successful project (Fig. 4). We are all quite proud of how smooth it went together, considering how complex it was."

Fig. 3—PT girder mockup.

Fig. 4—PT girder under construction.

Location: Dallas, TX
Submitted by: Datum Engineers
Owner: Parkland Health & Hospital System
Architects: HDR and Corgan Associates
Engineers: Datum Engineers, Gojer & Associates, and AG&E
Contractors: BARA (A joint venture of Balfour Beatty, Austin Commercial, H.J. Russell & Company, & Azteca Enterprises)
PT Supplier: VSL
Other Contributors: Concrete & Shoring Contractor; Capform, Inc.; Reinforcing Steel Supplier; CMC Rebar

Jury Comments:

- The design is driven by post-tensioning for vibration control
- Truly can appreciate this project – very remarkable – the magnitude is unbelievable
- Greatest example I've seen in buildings PT
- Having an engineer on-site was huge

2015 AWARD OF EXCELLENCE: GLACIER SKYWALK

The Glacier Skywalk (Fig. 1), located at the Columbia Icefield Glacier Discovery Centre on the Icefields Parkway, is Canada's newest iconic attraction. Visitors participate in an interpretive experience along a fully accessible cliff-edge walkway that leads to a 35 m (115 ft) cantilevered, glass-floored observation platform 280 m (918 ft) above the Sunwapta Valley. This spectacular location has been noted as one of the most unique ecosystems in the world, and offers an ideal venue for learning about the ecology, geology, glaciology, and natural history of the Columbia Icefield region.

The Icefields Parkway, built in the late 1930s to provide opportunities for visitor use and enjoyment, is one of the most spectacular scenic drives in the world. Brewster Travel Canada commissioned the design and initiated a competitive proposal process that allowed proponents complete flexibility in their design after only being provided with a general project scope. The startling shape and sweep of the promenade is meant to encourage tourists to get out of their cars and onto the land.

Two of the most challenging aspects of this project were the remote location and the severe mountain climate. The construction season in this area is very short and with additional restrictions in place to avoid impact to the park's wildlife, such as mountain sheep, construction planning was vital. The site is located a 3-hour mountain drive to the nearest metropolitan city. There is no access to power, phones, or cellular reception in the area, further complicating the construction.

The main structure is constructed of weathering steel and a curved catwalk in glass juts its multifaceted face off the scree cliff. This is architecture that depends on the mountainside to support the trapezoidal steel box girders that allow the gigantic cantilever. The iron oxide of the rocks is the same material that forms on the Corten, causing it to gradually morph from orangey-brown to nearly black. At the same time, the daring walkway floats midair, as if it operates independently of the rock.

Two foundations were excavated and numerous double corrosion-protected (DCP) rock anchors and micropiles

Fig. 1—Glacier Skywalk. (photo credit: Brewster Travel Canada)

Fig. 2—Post-tensioned anchor bolts.

were installed in the rock to support the concrete foundation. This work often required the crew to position equipment and personnel right at the cliff edge. Cliff-scaling methods needed to be adopted to allow this work to be safely completed.

The concrete foundation is post-tensioned with horizontal threadbars to provide the confinement necessary to support the steel structure and disperse the forces from the cantilever.

Post-tensioned anchor bolts (Fig. 2) with a permanent free length were installed in the foundation and serve to secure the trapezoidal steel girders. The post-tensioning force eliminates any fatigue in the bolts compared to passive bolts. With such a large cantilever and live loading, this was a major concern, as the connection is critical. Confined space inside the box girders made layout of the number of bolts very sensitive to dimensional deviations.

The installation of the glass floor frame was an incredible feat of Canadian engineering design and construction. Numerous Canadian and international partners worked together on this project to ensure a seamless and environmentally sensitive installation process of the unique walkway structure. Two multistrand tendons (Fig. 3) follow the parabolic curve with an additional compound curvature to provide the required uplift to balance the overturning moment. The tendons had to be installed and stressed while the steel frame was being supported by the crawler crane. Limited site congestion meant that multiple rams needed to be used, as there was no room to move equipment once the crane picked up the steel frame. Manual lifting frames were installed in place to support

Fig. 3—Parabolic multistrand tendons.

Fig. 4—Stressing the parabolic tendons.

rams also because of the limited site access (Fig. 4). Stressing had to be coordinated with many survey points to ensure accurate geometry of the final structure because no adjustments could be made once the frame was released from the supporting crane. The permanent post-tensioning tendons were grouted afterward for corrosion protection.

Location: Jasper National Park, Jasper, AB, Canada
Submitted by: Dywidag-Systems International Canada
Owner: Brewster Travel Canada
Architect(s): Sturgess Architecture
Engineer(s): Read Jones Christofferson Engineering Calgary
Contractor: PCL Construction Management
PT Supplier: Dywidag-Systems International Canada
Other Contributors: BAT Constrution, BOVA Steel, Josef Gartner

Jury Comments:

- A lot of points for ingenuity and creativity
- I was so impressed when I first reviewed this project—phenomenal
- There were multiple uses of post-tensioning to anchor the structure and to control flexion
- Looking at durability and long-term functionality gives weight to the project

2015 AWARD OF EXCELLENCE: TAPIOLA CENTRAL PARKING FACILITY

USE AND ADVANTAGE OF POST-TENSIONING IN STRUCTURE

Post-tensioning (PT) and cast-in-place methods were selected because of the nature of the underground cave construction project (Fig. 1). Easily adapted architecture to uneven rock surface, watertight floor structure, high-quality finish, and cost-effectiveness were driving this solution forward. PT was used in beam slab structures. Slab thickness was typically 7.9 in. (200 mm) for 27.2 ft (8.3 m) spans with loading of 115 lb/ft^2 (5.5 kN/m^2). Beam height was typically 35 in. (900 mm) and width 23.6 in. (600 mm) for span length of 47.6 ft (14.5 m) (Fig. 2 and 3).

PROJECT SUMMARY

This parking cave project was the start for renewal Tapiola area in the city of Espoo, Finland. In the overall project, all parking facilities will be relocated underground and the released space on ground level will be reserved for pedestrian traffic and other new activities (Fig. 4). This parking cave's first phase will have 1669 parking spaces, and another smaller underground car park in Tapiola related to this one has 337 parking spaces. Together, they have space for 2006 cars and therefore form Finland's largest underground cave park. There is also space for future expansion. There will be also charging points for electrical cars in every floor. This parking cave will provide parking space not only for people using the commercial services in Tapiola, but it will also work as connecting parking for the new metro line (from 8/2016). A large amount of the commercial buildings in Tapiola centrum will be demolished and rebuilt in the next 15 years.

For more information about renewal of Tapiola centre, visit, **www.tapiolankeskus.fi/en/Welcome-to-Tapiola**.

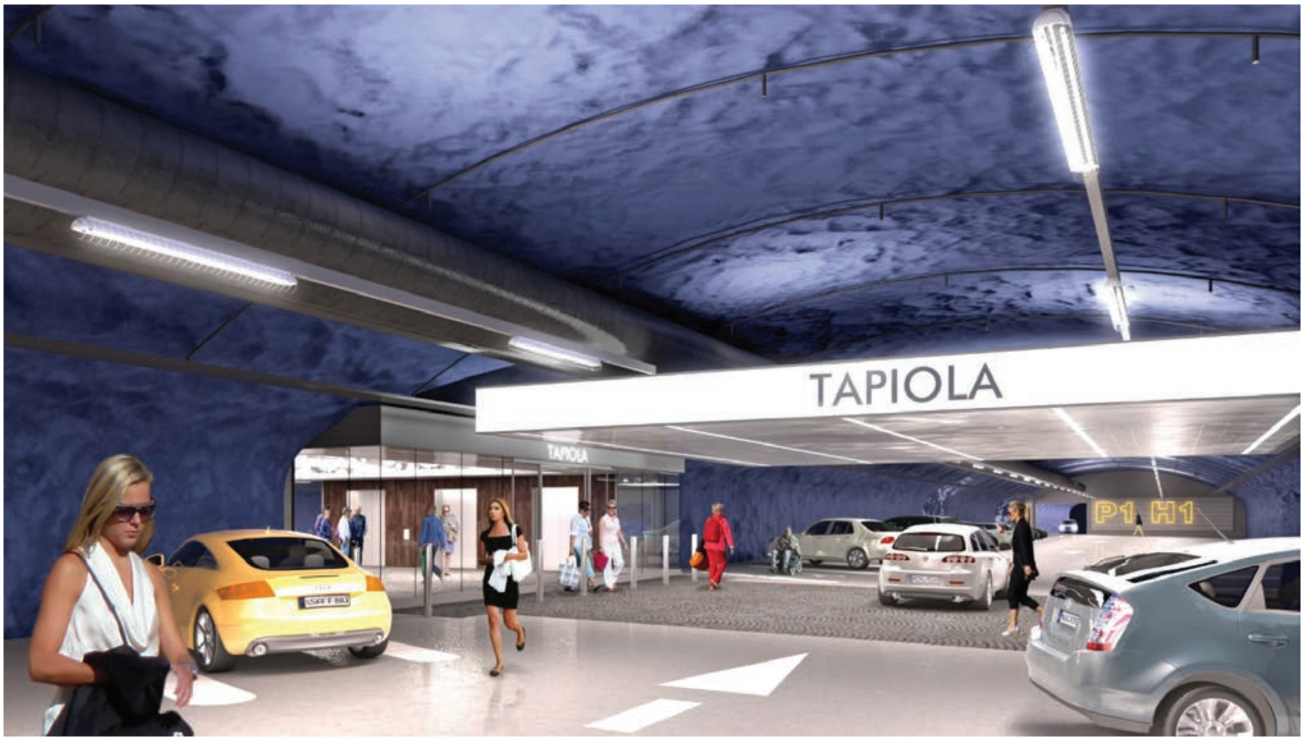


Fig. 1—Rendering of underground cave parking.

Fig. 2—Typical parking deck support structure.

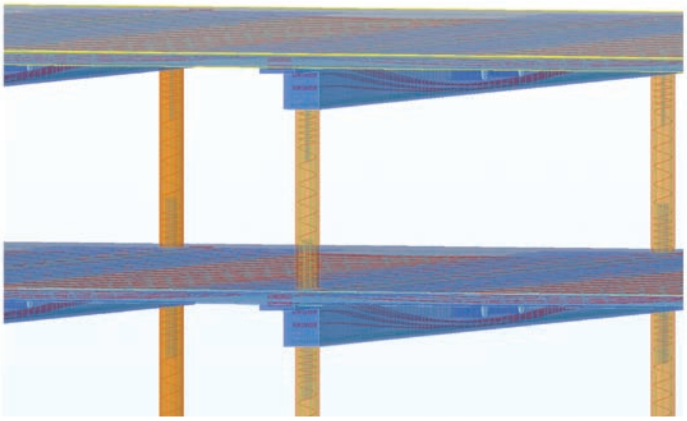


Fig. 3—PT layout for typical beam and slab.

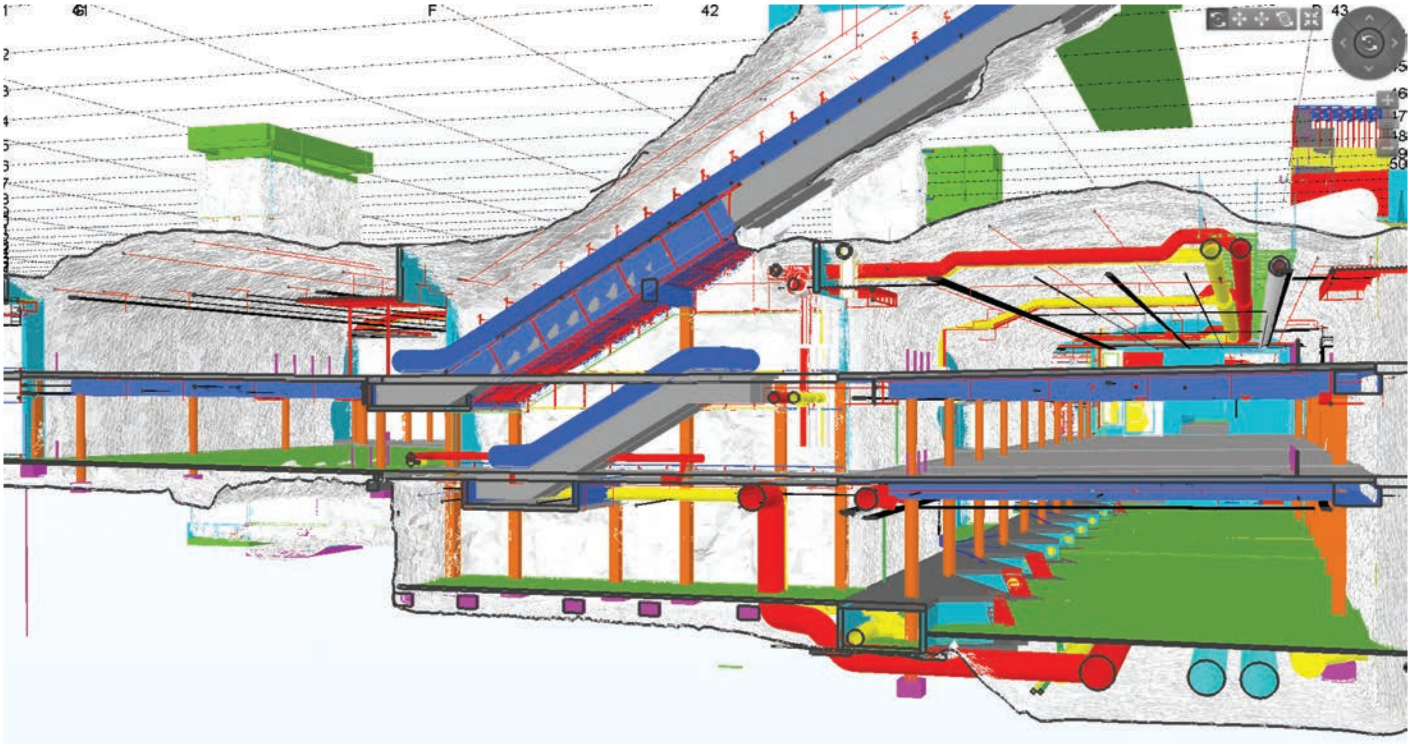


Fig. 3—Parking garage section.

Location: Espoo, Finland
Submitted by: Sweco Structures Finland
Owner: Apiolan Keskuspysäköinti Oy
Architect: Arkkitehtitoimisto Hkp Oy
Engineer: Sweco Structures Finland
Contractor: SRV Rakennus Oy
PT Supplier: Lemminkäinen Infra Oy (MK4 Unbonded System)

Jury Comments:

- It has it all—the innovation, the aesthetics, the constructibility, and functionality
- Impressive that the project used PT underground
- Intriguing that concrete was poured up against the rock
- Great use of space

2015 AWARD OF EXCELLENCE: SBR TANK #1 REPAIRS

BACKGROUND

The Mount Carmel (PA) Municipal Authority (MCMA) Wastewater Treatment Plant (Fig. 1) serves Mount Carmel Borough, parts of Mount Carmel Township, and Cunningham Township in Columbia County. The plant was built in 1975 and consisted of a secondary contact stabilization designed for 1.5 mgd (5.7 mld) average daily flow and organic capacity of 2500 lb (11,120 kg) per day.

Critical plant upgrades and construction of the new SBR tanks were performed using stimulus funds and were completed in August 2010. In October 2012, the devastation of Hurricane Sandy took its toll on the newly constructed SBR tanks.

HURRICANE SANDY—THE DAMAGES

In addition to sewage overflows, flood waters from Sandy severely damaged the treatment plant SBR #1 tank. Flood waters from Sandy's torrential downpours overflowed into the floodplain, forcing the flood waters into an undetected abandoned deep mine located in close proximity to SBR Tank #1. The hydrostatic pressure exerted by the flooding mine forced the mat foundation of SBR Tank #1 to buckle (Fig. 2) resulting in a chain reaction when the forces were released by the post-tensioned (PT) system embedded in the slab. Overall resulting damage included slab buckling, foundation movements, foundation wall displacement, walkway displacement, and column structural damage.

REPAIR SEQUENCING

Immediately upon discovery of the structural failure, an extensive shoring system was designed and installed to stabilize the structure while the adjacent tanks, SBR #2 and SBR #3, stayed in operation. Temporary shoring consisted of the installation of a grid of wide flange beams to laterally brace the structure and prevent any further movement.

Repair sequencing was systematically designed to stabilize the structure while allowing the adjacent tanks to stay in full operation.

Repair challenges

The tank structure consisted of three SBR tanks, three pre-react tanks, three digester tanks, and a gravity thickener tank. The tank was constructed with precast concrete wall panels and bridge sections installed on a cast-in-place and PT foundation slab/footing. The precast sections were set

Fig. 1—SBR Tank #1 overall view.

Fig. 2—Damage to SBR Tank #1.

in place into receiving keyways and temporary bracing was installed. The precast sections have 1 in. (25 mm) conduit through each panel and 0.60 in. (15 mm) PT strands are threaded through the wall and bridge components. Partial tension is applied to the tendons, followed by grouting of the joints and full tensioning of the tendons. When performing repairs to this type of structure, the stress on the tendons has to be maintained or temporary restraint measures have to be provided. The contractor elected to perform repairs to the damaged bridge structure using a phased repair approach that maintained the stress on the tendons at all times.

Heavy structural steel bracing was installed to prevent further displacement of the tank wall and consequential damage that could render the wall "unrepairable." The shoring was constructed of vertical W18 x 86 compression struts spanning the width of the tank and horizontal W24 x 117 whalers that transferred the load from the "intact" interior wall to the "displaced" exterior wall (Fig. 3). This temporary shoring structure was used to return the displaced wall and footing to its original position. The extensive temporary shoring was then removed from the tank so that the post-tensioned slab could be reconstructed and retensioned (Fig. 4).

Other highlighted challenges during construction include the following:

- Active plant, which was required to remain open and operational for the duration of the construction;
- Topography of the site due to previous mining operations; and
- Two large aeration lines that had to remain in service and were at an unknown location adjacent to the wall that was to be repaired.

CONCLUSIONS

This project was a perfect example of the importance of a repair contractor, engineer, and owner working together to provide a durable, economical, and quality repair. Through communication, innovation, and strategic planning, the project was a success from beginning to the end. It was the commitment of the contracting, manufacturing, and engineering team to furnish the owner with accurate solutions to complex restoration problems by providing the highest technical support offered by a repair team. Dynamic design details and innovation demanded that the engineer and contractor deliver to the owner a level of service and technical assistance that far exceeds industry standards.

Fig. 3—Extensive shoring to stabilize wall during repair.

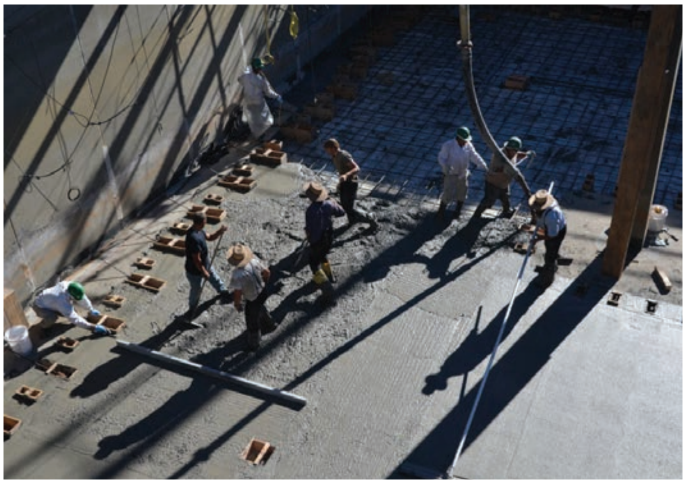


Fig. 4—Replacement of PT slab.

Location: Mount Carmel, PA
Submitted by: Concrete Protection & Restoration, Inc.
Owner: Mount Carmel Municipal Authority
Engineer: Thorton Thomasetti, Inc.
Contractor: Concrete Protection & Restoration, Inc.
PT Supplier: Dywidag-Systems International USA, Inc.

Jury Comments:

- Impressive that they kept other tanks in service and functioning while performing repair
- The urgency of addressing the problem at hand was huge, as was the significance of addressing risk—the solution addressed the risk and consequence in a timely manner
- A lot of ingenuity
- Best write-up

2015 AWARD OF EXCELLENCE: SKY VIEW PARC

PROJECT SUMMARY

The client approached Classic Turf Company looking to construct two tennis courts and a multisport court on top of a seven-story parking garage (Fig. 1). During the construction of the parking structure, the designers did not take into consideration that this particular area was going to be the site tennis courts. The main problem with the existing parking structure was that the slope of the deck was completely wrong for the construction of tennis courts. There were also weight restrictions on the existing structure that needed to be maintained. Due to the weight restrictions, adjusting the existing slope with processed gravel or asphalt was not an option. Several engineers and contractors were unsuccessful in coming up with a design for functional athletic courts that would satisfy the weight restrictions of the existing parking structure. An elevated deck was constructed using ridged foam insulation boards stacked up and plywood screwed to the aisles of insulation (Fig. 2). The height of the aisles ranged from 2 ft to 2 in. (610 mm to 51 mm). All electrical conduits were run underneath the elevated platform for the tennis court lighting and outlets. A 4 in. (102 mm) thick post-tensioned slab was then installed on top of the elevated deck (Fig. 3 and 4). The slab was designed to have a residual force in the center of 120 psi (5.7 MPa).

After the slab was completed, custom fence post brackets were fabricated and installed on the edge of the post-tensioned slab (Fig. 5). We were unable to secure the posts to the existing precast planks of the garage deck. Fencing was completed and the final sports surface was installed.

Fig. 1—Sky View Parc.

USE AND ADVANTAGE OF POST-TENSIONING

To build tennis courts with the proper pitch and orientation, the existing structure had to be manipulated. However, there were load restrictions that had to be maintained, which affected the amount of material that could be installed on the deck, as well as maintaining the existing waterproofing and surface water runoff on the parking structure. An elevated platform was constructed using ridged foam insulation boards and plywood. This elevated platform adjusted the existing slopes of the parking deck, making it suitable for the tennis courts to be installed on top of the deck. A post-tensioned slab was the only option that would be able to survive in these unique conditions by spanning the distances between the ridged insulation aisles and withstanding the movements of not only the elevated platform but also the parking structure below.

Fig. 2—Tapered ridged foam and plywood elevated platform.

Fig. 3—PT deck installed on the platform.

Fig. 4—Casting 4 in. (102 mm) PT slab.

Fig. 5—Custom fence post brackets on the edge of the PT slab.

Location: Flushing, NY
Submitted by: Classic Turf Company, LLC
Owner: Sky View Parc
Architect(s): Moss Gilday Group
Engineer(s): Classic Turf Company, LLC
Contractor: Classic Turf Company, LLC
PT Supplier: Builders Post-Tension, Inc.

Jury Comments:

- Couldn't just use asphalt because they were limited by the design aspect of the roof
- Ingenious to keep the structure light by using foam
- Great application of post-tensioning—very gutsy

2015 AWARD OF MERIT: DUMPTOP RESIDENCE

A large part of the architectural concept of this residence (Fig. 1) was the integration of the structure and the site. The site is on top of a steep cliff. The location of the house was to be on the edge of the cliff and soar out over the cliff.

Because post-tensioning was the only structural framing system that had a chance of accomplishing the architect's vision, the analysis was undertaken using ADAPT software. Deflection of the edges of the cantilever slabs was the most critical structural design criteria. Two issues drove the design criteria. The first one was to only allow edge deflections that would not be visually detectable. The second criterion was to establish differential deflections between floors that would work well with the glass curtain walls along the north face.

The total deflection at the edge of the slab varied due to the slope of the edge of the slab; this had to be controlled to create a straight edge. Also, the deflection of the supporting slab band had to be added to the slab deflection to account for total deflections impacting the design criteria.

It was an effort that required considerable effort by the architect, the mechanical engineer, and the structural engineer to satisfy functional requirements, architectural expression, and structural requirements.

For simplicity of construction and due to the exposed edges of the slab, the structural engineer studied all of the different structural conditions to establish the same thickness of the slab throughout the structure. At the end of this study, the floor and roof slab was established at 13 in. (330 mm) thick. The outer edge of the top of the roof slab was sloped down to create a thinner, 9 in. (229 mm) thick slab edge.

Post-tensioning the slab of this structure was the only available solution for the structural engineer and played the most important role in the construction process to create the architect's vision.

Location: Dallas, TX
Submitted by: Datum Engineers
Owner: Mary Cook
Architect: Booziotis & Company Architects
Engineer(s): Datum Engineers, Inc.
Contractor(s): Sebastian Construction Group
PT Supplier: Ready Cable, Inc.
Other Contributors: Concrete Forming Sub – BEAM Concrete Construction, Inc.

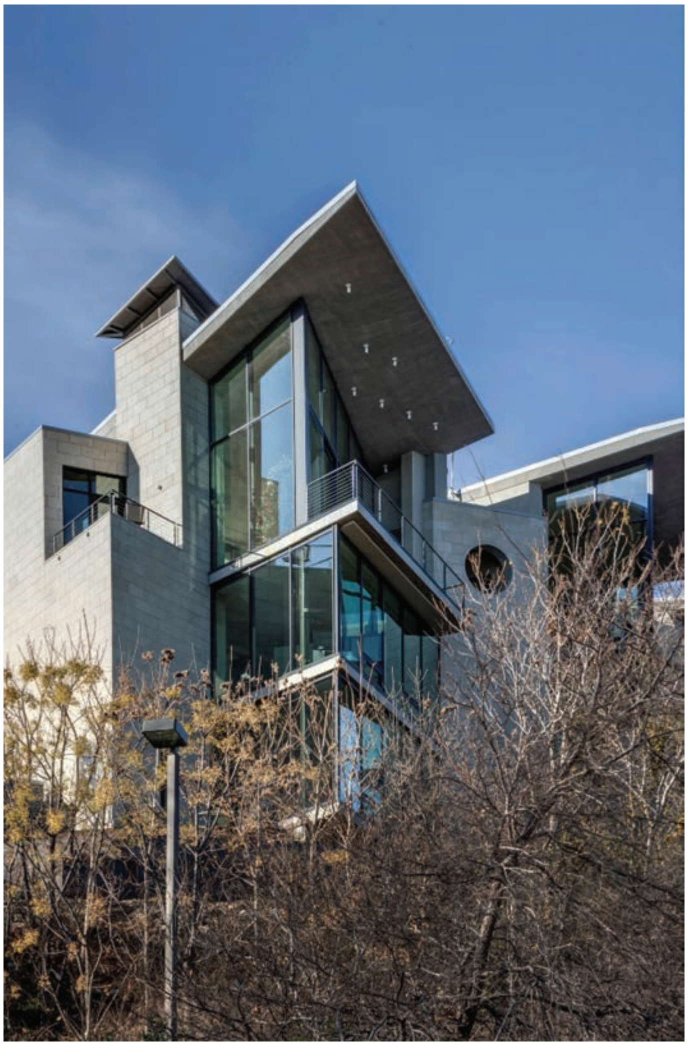


Fig. 1—Dumptop Residence.

2015 AWARD OF MERIT: TWIN VEHICULAR JACKED BOX TUNNELS

Liberty University, with plans to grow the on-campus student population to 16,000 by 2020, had to overcome an access obstacle posed by the absence of safe and efficient ingress and egress to and from the west side of the campus.

A set of side-by-side 16 ft high by 28 ft wide and 130 ft long (4.9 m high by 8.5 m wide and 39.6 m long) jacked box tunnels (Fig. 1) was agreed on as the best way to construct four new travel lanes beneath the existing rail lines. To overcome the challenge of potential embankment blowout, an innovative change to the conventional pushing approach was devised by Brierley and Dywidag-Systems International USA, Inc. (DSI). The twist: build a reaction wall on the opposite side of the box tunnel launch pad to allow for pulling the tunnel into place using post-tensioning strand jacking systems. The cast-on-site reinforced concrete boxes included cast-in-place steel plates along the bottom to reduce jacking friction, injection ports for bentonite slurry to reduce friction during pulling of the boxes, and a 15-degree battered steel cutting shield in front of each box to help with penetration of the tunnel into the railroad embankment.

Six DSI 765 ton (694 metric ton) post-tensioning jacks were mounted on 4 ft (1.2 m) thick reinforced concrete blocks cast against the 23 ft (7.0 m) high soldier pile reaction wall. Working 'round-the-clock shifts, the first tunnel was in place in 14 days to within 30 ft (9.1 m) of the reaction wall, leaving sufficient soil to develop the passive resistance required to counteract pulling forces. For the second tunnel, the jack assembly was reversed and within 3.5 days, it was in place.

UNIQUENESS AND/OR INNOVATIVE APPLICATION OF NEW OR EXISTING TECHNIQUES

The innovation of building of a reaction wall on the opposite side of the box tunnel launch pad and pulling the boxes into place reduced costs by eliminating construction of a heavily reinforced thick concrete launching slab to counteract the jacking forces. This unique design confined the embankment during advancement of the box tunnel and alleviated loss of ground and settlement concerns expressed by Norfolk Southern.

Location: Lynchburg, VA
Submitted by: Dywidag-Systems International USA, Inc.
Owner: Liberty University
Engineer(s): Brierley Associates
Contractor: Southland Contracting
PT Supplier: Dywidag-Systems International USA, Inc.
Other Contributors: TGS Engineers, Norfolk Southern Railroad

Fig. 1—Twin vehicular jacked box tunnels.

2015 AWARD OF MERIT: DOVER DAM SAFETY ASSURANCE PHASE 1 & 2

The first phase of the Dover Dam Safety Assurance project helped to bring the dam up to modern-day safety standards to reduce the risk of failure. Thirty-six multi-strand anchors were installed in the spillway section. Anchors ranged in size from 19- to 48-strand, and were installed in holes ranging from 9 to 17 in. (228 to 432 mm) diameter; lengths varied from 103 to 153 ft (31.4 to 46.6 m); and the anchors were secured to bedrock. The project included design, fabrication, and installation of a temporary steel access platform and installation of a 2200 ft (671 m) soil nail wall.

The second phase of the Dover Dam Safety Assurance project included the installation of multi-strand anchors (Fig. 1) ranging from nine- to 54-strand installed in holes ranging from 9 to 19 in. (228 to 432 mm) diameter with drill tolerances of 1:150. Lengths varied from 80 to 180 ft (24.4 to 54.9 m). There are 21 anchors on the face of the dam and 83 five- to 13-strand anchors underwater in the apron. Dewatering was required and was accomplished using a system of precast walls and boxes. Precast and cast-in-place walls were built to increase the storage capacity of the pool behind the dam. Precast panels were detailed to match the existing structure. In most locations, the cast-in-place wall is supported on caissons.

Location: Dover, OH
Submitted by: Brayman Construction Corporation
Owner: Brayman Construction Corporation
Architect(s): U.S. Army Corps of Engineers, Huntington District
Engineer(s): U.S. Army Corps of Engineers, Huntington District
Contractor: Brayman Construction Corporation
PT Supplier: Williams Form (Phase 1), DSI (Phase 2)

Fig. 1—Installation of anchors.

2015 AWARD OF MERIT: NEW CANAAN HIGH SCHOOL TENNIS COURTS

There were six existing asphalt tennis courts at New Canaan High School, which were in need of a total rebuild. The concrete from the existing courts was reclaimed, milled, and used to establish the subbase for the new post-tensioned slabs. A new seventh court was added to the project and placed over a storm-water detention system. The first three center courts were formed and placed first with the use of intermediate stressing anchors. The two end courts were formed and placed approximately 15 days after the first three courts were placed. After all slabs were placed (Fig. 1), a 10 ft (3.0 m) high, schedule 40, eight-gauge fuse-bonded wire chain-link fence was installed around the perimeter of the court.

After 30 days of curing, surface preparation began. This process began with acid etching, power washing, and then application of the urethane coating, which helps the acrylic color bind to the concrete surface. One application of sand-filled acrylic resurfacer and two coats of acrylic color were squeegeed on the court surface to establish the new color and playing surface of the courts. Once the acrylic color dried, the line striping team laid out, masked, and hand-painted all the necessary playing lines.

This project also included the construction of a new 10 ft (3.0 m) wide access road, which was constructed before the placing of the new slabs, and a 348 ft (106 m) long, 5 in. (127 mm) thick, 4 ft (1.2 m) wide concrete walkway on the south side of the new bank of courts, which was constructed after.

Location: New Canaan, CT
Submitted by: R.S. Site & Sports
Owner: Town of New Canaan, CT
Engineer(s): Bryan Nesteriak
Contractor: R.S. Site & Sports
PT Supplier: VSL Structural
Other Contributors: Hinding Tennis, LLC, and Gateway Fence and Guardrail

Fig. 1—New Canaan High School Tennis Courts.