Excellence in Stru

NCSEA Sixth Annual Awards Program

At their annual meeting in Denver this past October, NCSEA announced the winners of the 2003 Excellence in Structural Engineering Awards. This award program honors some of the most innovative projects in the world. Greg Schindler (KPFF Consulting Engineers), NCSEA Awards Committee Chair, and Jeanne Vogelzang NCSEA Executive Director, both commented on the number and quality of this year's entries. As with previous competitions, all of the entries represented exceptional projects. The panel of judges (see sidebar in this article) was assigned the difficult task of determining award winners for both building and bridge projects. This year, Outstanding Projects and Awards of Merit were presented in all five categories. Please join STRUCTURE magazine in congratulating all of the winners. More in-depth articles on the 2003 Outstanding Project Award winners will appear in the magazine over the course of 2004.

In any given year, awards may be presented for Outstanding Project and/or Award of Merit in the following categories:

- Small Bridges (Single Span up to 150 ft.
- Large Bridges (Multiple Span, or Single Span greater than 150 ft.)
- Buildings under $5M in Construction Value
- Buildings $5M to $25M in Construction Value
- Buildings over $25M in Construction Value

Outstanding Project

Small Bridge Category

Meydenbauer Park Bridge

Bellevue, Washington

TranSystems Corporation (Seattle, WA)

The Meydenbauer Park Bridge, crossing over a very attractive urban park, was structurally and functionally deficient. The solution was to replace it with a wider, stronger and more open long-span structure.

Since the bridge crosses a deep ravine with favorable foundation conditions, a flat arch concrete box girder configuration was selected. In developing the structure, a very shallow, variable depth box girder was chosen to give a light and graceful appearance. The piers were set well back and uphill from the main walkway in the park, to minimize intrusion on the park setting.

The inclined frame legs were proportioned for a relatively small lateral stiffness compared to the superstructure. This forced the bridge to resist the majority of seismic lateral loads at the abutments rather than the piers. A shear key transfers the lateral force from the superstructure to the abutments. Longitudinally, the inclined legs provide a self-centering mechanism by generating large axial loads under movement. The superstructure passes through the abutment back walls and is connected to the approach slabs. Expansion joints allow movement at the outboard ends of the approach slabs.

The inclined arch legs induce favorable compressive stresses throughout the structure, maximizing efficient use of concrete and reinforcing effectively post-tensioning the bridge with its own weight.

Jury of Awards

2003 Excellence in Structural Engineering

John Riley, P.E.
Quantum Engineers
Seattle, WA
NCSEA Representative

Jugesh Kapur, P.E.
Washington State DOT
Olympia, WA
NCSEA Representative

Dale DiLoreto, P.E.
WDY, Inc.
Portland, OR
NCSEA Representative

Joe Gehlen, P.E.
KGA
Vancouver, WA
CASE Representative

Lynn Iaquinta, P.E.
Veradale, WA
SEI Representative

Outstanding Project

Large Bridge Category

William H. Natcher Bridge

Kentucky/Indiana

Parsons Brinckerhoff Quade & Douglas, Inc. (New York, NY)

One of the longest cable-stayed bridges in the U.S., the William H, Natcher Bridge over the Ohio River carries Route 231 between Owensboro, Kentucky, and Rockport, Indiana. With its distinctive diamond-shaped towers, the four-lane, 1,373-meter-(4,505-foot) long crossing has been embraced by the community and is already an architectural icon in the area.

Innovations include… unique cable-anchoring systems, the continuity of the superstructure, and the use of counterweights rather than conventional tie downs. These unique features served to minimize construction costs, and will minimize inspection and maintenance costs.

The bridge is the first in the U.S. to feature cable stays anchored into steel frames inside the concrete towers and one of the first to provide enclosed chambers and platforms for easy access to the anchorages. The innovative transition design between the approach spans and the cable-stayed spans avoids expansion joints (a potential weak spot in most bridge designs), increases the stability of the structure and the life of the cable stays, and provides a smoother ride. The counterweight detail eliminates conventional tie-downs, which are costly and difficult to maintain.

The design of the cable-to-girder connection of the deck also facilitated construction. Using a bolted connection, rather than welding, eliminated fracture concerns and made field assembly easier. The cable-to-girder detail also provides easy access for inspection and maintenance of the cable anchors without special equipment.

Outstanding Project

Buildings under $5M in Construction Value

Stacy Park Reservoir Seismic Retrofit

St. Louis, Missouri

Horner & Shifrin, Inc. (St. Louis, MO)

The Stacy Park Reservoir is the main potable water reservoir for the city of St. Louis. To protect the water supply for the City's 350,000 residents, that St. Louis Water Division opted to retrofit the Reservoir to survive the 2,500-year earthquake. The retrofit is based on FEMA 273 for an "Immediate Occupancy" level of service (completely ductile behavior).

Constructed in 1929, the Stacy Park Reservoir is an in-ground concrete tank 600-feet by 800-feet in plan, 35-feet deep and contains 100 million gallons. The concrete roof is supported by 1,680 interior columns, and is subdivided into eight individual slabs separated by expansion joints. The main seismic vulnerability was the eight separate roof slabs supported by tall and very slender columns.

The challenge was unusual: to retrofit a reservoir with little ductility to resist the 2,500 year earthquake while not requiring construction inside the reservoir. The solution: Passive Seismic Dampers (PSDs) on the exterior of the reservoir. This system links the 8 individual roof slabs together and transfers the inertial load from slab to slab through the PSDs to the perimeter wall. The perimeter wall is loaded normal to its length, and the loads are then resisted by passive soil resistance.

This system permits all construction to be on the exterior of the reservoir, and saved the Owner 57% of the cost of the shear wall alternate. Not only was the need for the construction of a smaller, temporary reservoir eliminated, the PSD alternate also saved six months in construction time.

Outstanding Project

Buildings $5M to $25M in Construction Value

5th and Jackson Building

Seattle, Washington

DCI Engineers (Bellevue, WA)

The 5th and Jackson Building, located in downtown Seattle, is a ten-story commercial/office building with two levels of underground parking garage. The building footprint covers nearly the entire site, with little room for shoring. There are two underground Metro bus tunnels that traverse the entire length of the site. Both tunnels are made of thin concrete shells sensitive to any overloading.

Concrete construction was an obvious choice for the foundations and the two underground garage levels. For floors above ground level, however, steel framing was used to reduce the building weight. In comparison to an all-concrete structure, the total structural weight was reduced by 40%, significant in terms of reducing the gravity load and seismic demand on the foundation.

A mat foundation supported by caissons was selected to transfer building loads to the soil below the tunnels. Where the building must be built over the tunnels without footing support, concrete basement walls were designed as deep beams with the mat footing and the floor slab as beam flanges. At the south end, two 18-inch concrete walls are used as cantilevered beams to support the structures that are built above the existing machine rooms for the Metro bus tunnels. Along the west property line, the caissons and mat foundations are used as the internal bracing to support 8-inch micro piles for shoring.

To place mechanical and electrical ducts with minimum beam penetrations, the 24-inch deep girders are placed along the long direction, and the 12-inch beams were placed along the short direction. This allowed all mechanical and electrical ducts to go under the 12-inch beams without any penetration.

Outstanding Project

Buildings over $25M in Construction Value

Reliant Stadium

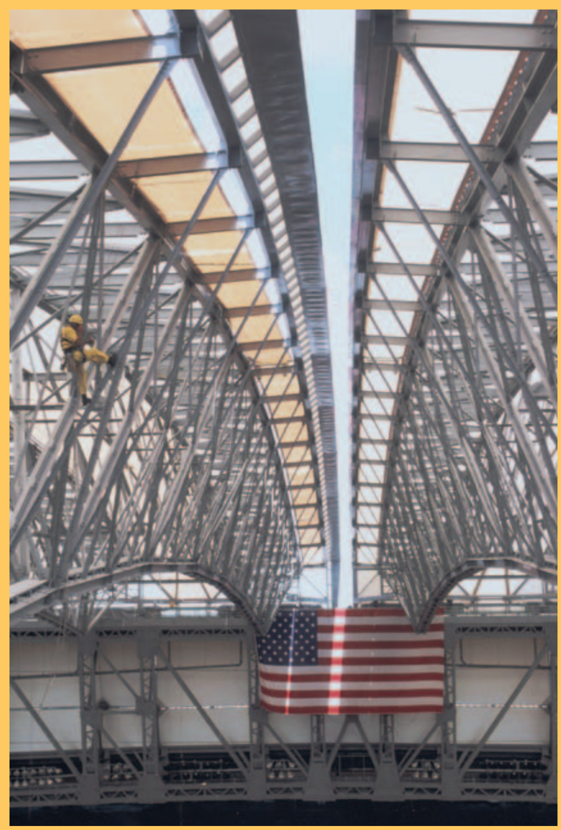
Houston, TX

Walter P. Moore (Houston, TX)

Reliant Stadium set new world standards for operable roof design. The elaborate operable roof is a direct response to the disparate requirements of the NFL (open stadium) and the Houston Livestock Show and Rodeo (indoor arena). The $450 million facility was erected on a hyper-track schedule of 30 months, covers over 12 acres and comprises 1.9 million square feet.

In developing the first-of-its-kind moving roof, the team solved a myriad of challenges.

- Translucent fiberglass fabric roofing decreased the weight of the roof.
- The roof moves on 36-inch-diameter steel wheels atop parallel steel rails 354 feet apart. Innovative two-wheel transporters economically resolved vertical deflections in the 925-foot long steel rails.
- Two trapezoidal supertrusses span 875 feet between supercolumns, cantilevering over each column to support two giant bi-parting roof panels.
- A first-of-its-kind computerized system of (40) 5-hp electric motors drives the roof panels, creating an opening of 175,000 square feet.
- A new stress relief detail (the four bar linkage) provides needed construction and thermal tolerances for the tri-chord roof trusses that span between the rails.
- The entire roof is supported on four massive super columns, each a 153-foot-tall hollow concrete shape that doubles as a mechanical chase. Up to 50% cement was replaced by flyash and slag for the 13,000 psi concrete used in the super columns.
- The event floor was raised to grade to eliminate flooding. The move sped construction and saved $10 million.



Slate Covered Bridge

Swanzey, New Hampshire

Merit Award – Small Bridge

Hoyle, Tanner & Associates, Inc.
(Manchester, NH)

Analysis revealed that the tunnel or wooden peg connections between truss lattice members in the 143-foot long, single span wooden Town Lattice Truss Covered Bridge would not be capable of resisting the shear loads near the ends of the truss. Modifications were made by increasing the thickness of selected lattice members, and utilizing a notched connection to increase connection capacity where required.

Glulam was used for the deck and floor beams to accommodate the HS15 live load and reduce the dead load. A sawn plank deck was installed on top of the glulam deck so that aesthetics were not compromised. Sawn lumber was utilized in all portions of the bridge, except the floor beams and deck.

The original Covered Bridge was lost to arson in 1993. A fire retardant paint was specified for the new bridge. A computer controlled detection system, consisting of a small wire run through key portions of the bridge alerts the fire department. A deluge sprinkler and dry hydrant system were installed to allow the fire department to direct large amounts of water quickly to all portions of the bridge.

LaGuardia Airport

Taxiway Bridges over Flushing Bay

Flushing, New York

Merit Award – Large Bridge

Port Authority of New York and New Jersey (Newark, NJ)

LaGuardia Airport's (LGA's) two intersecting runways and their supporting taxiways extend into Riker's Island Channel. More than 3,000 piles support more than 2,000,000 square-feet of prestressed, post-tensioned concrete deck structure. In 1997, Boeing announced the introduction of a new aircraft, with a tightly spaced 172,000-pound main gear load that would overstress the existing deck structures.

The challenge was to reinforce the existing taxiway deck areas while keeping the facility in operation. Heavy construction would have to occur under the over-water deck with very limited headroom, large tidal fluctuations and strong currents. Solutions included:

- Bonding carbon fiber composite strips to the existing slab for reinforcement at access hole locations.
- Installation of 351 concrete-filled steel pipe piles (averaging 115 feet long) in up to 40 feet of water, 351 precast pile caps, and 310 precast, prestressed concrete girders.
- Use of silica fume, slag and a corrosion inhibitor in the precast concrete mix, as well as galvanized reinforcing bars, to ensure a long service life.

Additional lines of piles, pilecaps and girders were introduced between, and parallel to, the existing girder lines. The girders support the underside of the existing slab, cutting the clear span by more than half and forcing the strengthened deck to act as a one-way slab.

I-95, Interchange 8, Southbound Off Ramp

Stamford, Connecticut

Merit Award – Large Bridge

Tectonic Engineering & Surveying Consultants, P.C. (Rocky Hill, CT)

To provide the required length for the I-95 Interchange 8 Southbound off-ramp, a new bridge was constructed over LaFayette Street, the Metro-North Railroad, and Myrtle Avenue. The bridge superstructure consists of a five-span continuous steel plate girder and composite reinforced concrete deck with span lengths (in feet) of 203, 250, 250, 250, and 195. The five-span structure is continuous between the two abutments to eliminate the need for expansion joints at the interior piers.

The reinforced concrete abutments and wingwalls are full height cantilever type, founded on steel H-piles. The reinforced concrete piers consist of two column rigid frames with continuous footings found on steel H-piles.

Numerous construction methods were studied to erect the steel beams over the tracks. The contractor elected to launch the entire span over the tracks by placing the steel beams on rollers in the eastern spans, and horizontally jacking the three girders across the tracks until they reached the splice location on the west side. The girders were vertically jacked approximately 3-feet, until the sections lined up and the field splice was completed.

Catholic Church of St. Joseph

Structural Repairs

Menomonie, Wisconsin

Merit Award – Buildings under $5M in Construction Value

Construction Technology Laboratories, Inc. (Skokie, IL)

Constructed in 1963, the Church consisted of a concrete, hyperbolic parabolid shell roof and brick masonry walls. Continuous edge beams acted as collectors to carry stresses to the buttresses. The roof shell projected beyond the edge beams to form a canopy over the main entrance. Two fin walls, comprised of unreinforced brick, were introduced and shell concrete beyond the edge beams was significantly thickened. The fin walls were laid up to the canopy soffit without mechanical attachment (i.e., the structure relied on friction to transfer shear forces).

Structural repairs included a reinforced concrete diaphragm to accommodate interfacial shear forces at the sloping canopy soffit via shear friction reinforcement, and the interface with masonry was configured as a series of "stair steps" so that for gravity loads, horizontal shear forces in the fin walls are eliminated (i.e., fin walls are subjected to axial forces only). The fin walls were designed and reconstructed as reinforced masonry elements and tied to the new diaphragm.

Chicago Avenue Pumping Station

Roof Deck Replacement

Chicago, Illinois

Merit Award – Buildings under $5M in Construction Value

HDR Engineering, Inc. (Chicago, IL)

The Station is designated as a Historical Landmark and continues to function as a key component of the City's water distribution system. The existing roof was a unique system framed in wrought iron. The roof deck included arched, corrugated iron deck panels that spanned 7-feet between purlins, and was topped with a lightweight "Cinder Concrete" fill that served as a base to support slate shingle roofing.

Access to the underside of the roof for deck removal and replacement was a significant challenge. The pump room floor supports four high performance pumps approximately 60 feet below the eaves, with an additional 20 feet at the ridge. Floor supported scaffolding was not feasible, due to restrictive clearances around operating pumps and the need to maintain the functionality of a bridge crane situated approximately 1½ feet below the bottom chord of the main wrought iron trusses. The solution was to develop an ultra-light structural concrete to permit the reconstruction of the roof system under the unique double duty of the roof framing (as a scaffold supporting unit and as an active roof system).

Oklahoma State Capitol Dome

Oklahoma City, Oklahoma

Merit Award – Buildings $5M to $25M in Construction Value

Frankfurt-Short-Bruza Associates, P.C. (Oklahoma City, OK)

The State Capitol of Oklahoma was originally completed in 1917, at a time when World War 1 was escalating, so a much smaller Saucer Dome was constructed. In 1998, a feasibility study concluded that the existing Capitol structure was capable of supporting the estimated 1,500 tons of additional weight that a new Dome would impose.

Structural steel was selected for the primary framing. Anchor bolts were embedded 18 inches into the existing concrete beams without cutting existing rebar. This resulted in each column having a unique base plate that was field welded to the column.

A 110 foot square by 28 foot tall temporary enclosure was supported by these columns. The enclosure provided was capable of supporting 5,000 pound point loads above and below. The top surface was a smooth concrete topping to facilitate rolling scaffolding. It also supported stationary scaffolding with a self-weight of 120,000 pounds.

The platform was designed so that portions could be removed to allow the Dome to be built "through" the enclosure without exposing the open building below. In the final stages, the 16 radial beams of the platform projected through 16 window openings.

Ramp Control Tower

Philadelphia International Airport

Philadelphia, Pennsylvania

Merit Award – Buildings $5M to $25M in Construction Value

Klein and Hoffman, Inc. (Philadelphia, PA)

Due to limited available real estate, the US Airways Ramp Control Tower base was restricted to a 20-foot by 36-foot footprint.

The elevator and exit stair had to be located as far north in the structure as possible to provide a minimum 275 degrees clear line of sight toward the airfield from the control room. The tower cab had to be cantilevered significantly to the south from the six-column core structure.

The tower structure is designed as a fully braced structural steel frame supported on six steel columns sized to limit lateral displacement under design wind and seismic loads. Each column is supported on a single drilled shaft foundation, each 6-feet in diameter by 60-feet deep. Steel anchor piles are embedded the full length of each concrete-filled shaft to resist the significant overturning forces resulting from the tall, slender proportions of the tower structure and the unsymmetrical configuration of the cab area. Two drilled shafts actually function only as tie-down anchors for the structure.

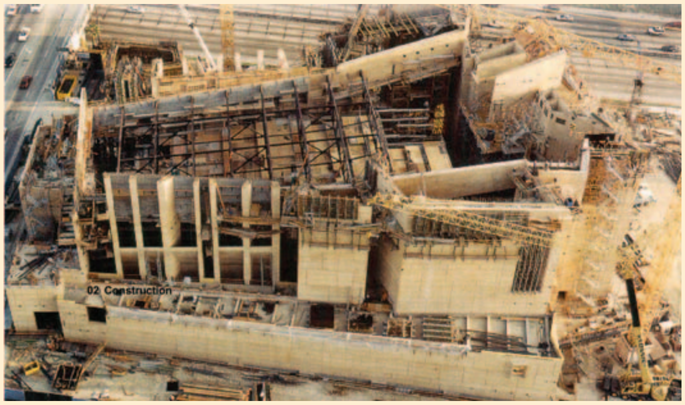
Cathedral of Our Lady of the Angels

Los Angeles, California

Merit Award – Buildings over $25M in Construction Value

Nabih Youssef & Associates (Los Angeles, CA)

Jose Rafael Moneo's vision of a monumentally-scaled abstract form created a unique structural engineering challenge. The Cathedral functioned as a monocoque – a structure in which the skin absorbs all or most of the stresses to which the body is subjected. The five building complex includes a 2-story, 150 ft. tall, 63,000 sq. ft. Cathedral, and a free standing campanile.



The reinforced concrete shearwall structure design called for 600,000 sq. ft. of exposed, visually finished concrete surface walls, varying in thicknesses from 12 to 58 inches. An irregular floor plan shape with many insets and nonparallel walls produced more than 850 non-repeating corner conditions, with multiple roof levels.

Seismic isolation was the most effective design. Located below the basement floor slab, an isolation plane consists of approximately 150 high damping rubber (HDR) bearings and 50 flat sliding bearings. The R-factor was reduced from the code specified value of 2.0 to 1.5. This resulted in a design base shear to 0.17W, an increase of 33% over a typical code design. A nearly elastic behavior of the superstructure was conceived utilizing these strength reduction factors in combination with the over-strength of the structural materials.

Torre Mayor Office Building

Mexico City, Mexico

Merit Award – Buildings over $25M in Construction Value

Canto Seinuk Group (New York, NY)

At 57-stories, the Torre Mayor Office building is currently the tallest building in Mexico City and in the American continent south of the US border. The tower superstructure encases steel columns in reinforced concrete up to the 30th floor, and steel structural framing above the 30th floor.

Part of the "Performance Based Design" criteria mandated that the building can be operational immediately, even after a large scale seismic event. A series of structural analyses were performed to establish the influence of various supplemental damping devices, including recently declassified technology, in performance of the tower.

Research also was conducted by Cantor Seinuk Group to investigate the optimal utilization of dampers, resulting in the formulation of a unique application of viscous damping elements. Granted a US Patent, this distinctive approach recognizes the strategic values of the arrangement, location and integration of the dampers with the conventional structural system.

Constructing such an office building to remain operational after a large scale earthquake would cost tens of millions of dollars more without the use of supplemental damping.▪