Creating a Level Playing Field

A BRIDGE AND A PARK BUILT OVER BUSY FREEWAY

by Robert L. Fernandes, Ross A. French, and S. Ping C. Liu, BergerABAM

The Northeast 36th Street Bridge and roundabout intersection in the city of Redmond, Wash., located 15 miles northeast of Seattle, was completed and opened to traffic in December 2010. The new bridge, a landscaped lid offering many pedestrian amenities, provides an overcrossing of State Route 520, which includes the well-known "floating bridge" that connects Redmond, the home of Microsoft World Headquarters and the University of Washington campus.

The new 414-ft-long bridge measured along the travelled way, connects two sides of the expanding Overlake neighborhood in Redmond, over SR 520, and adjoins a recently expanded Microsoft campus. The two arterials connected by the Northeast 36th Street Bridge are some of Redmond's most congested roadways. The new bridge will help to alleviate bottlenecks on nearby interchanges and the impacts of the projected population and employment growth in the Overlake area. Without the new bridge, the existing connections over SR 520 would be overwhelmed. The project is expected to reduce vehicle miles travelled by approximately 135,000 miles per year.

In keeping with Redmond's designation as the "bicycle capital of the Northwest," the Northeast 36th Street Bridge is optimized for pedestrian access and bicycle connections. It provides one traffic lane in each direction, bike lanes, sidewalks, and intersection improvements. It also accommodates the future Sound Transit Link Light Rail alignment and a connecting pathway that offers pedestrian access to the nearby Transit Center.

Double-Diamond Plan

The bridge passes diagonally over SR 520 and, according to Redmond's project manager, Dennis Apland, "is the product of a lot of clever engineering." The roadway crosses the highway at a 44-degree angle, rather than the more typical 90 degrees. The project is essentially two offset adjoining landscaped lids—a unique and innovative solution that prevented the project from becoming a much more costly tunnel project. The length of each lid along SR 520 is approximately 300 ft, just shy of the length that would trigger expensive fire suppression and ventilation systems for a tunnel designation.

The double-diamond design allowed the bridge to be built using standard construction methods, producing a much more cost-effective project overall. This solution also yielded minimal construction impacts on the major highway below.

The signature design of the Northeast 36th Street Bridge is the unique double-diamond shape, approximately 50,000 ft^2 landscaped lid spanning SR 520. All photos: BergerABAM.

profile

NORTHEAST 36TH STREET BRIDGE OVER SR 520 / REDMOND, WASHINGTON

BRIDGE DESIGN ENGINEER: BergerABAM, Federal Way, Wash.

GENERAL CONTRACTOR: Tri-State Construction Inc., Bellevue, Wash.

PRECASTER: Concrete Technology Corporation, Tacoma, Wash., a PCI-certified producer

REINFORCEMENT SUPPLIER: Pacer Steel Inc., Pacific, Wash.

BRIDGE DESCRIPTION: Two spans (150 and 164 ft by 300 ft wide) providing a traveled way bridge length of 414 ft supported on cast-in-place concrete abutments and a concrete center pier

A key challenge for the structural design was the center pier and the structure's seismic demands.

Excavation of the 250-ft-long central pier occurred during live traffic. During the setting of the center pier columns and the concrete placement for the center pier footing, up to two lanes of SR 520 were closed in each direction.

Design Challenges and Alternatives

The alignment was originally planned to cross SR 520 at approximately a 60-degree skew. This skew, combined with limited space for a bridge pier in the median of SR 520 and the need to keep the abutments out of the 280-ft-wide right-of-way, created some unique challenges—and opportunities—for the project participants. At a 60-degree skew, a new bridge constructed parallel to the proposed roadway alignment would have been a two-span structure, approximately 560 ft long with spans of approximately 280 ft. Structure depth and profile issues would have required radical changes to property access on either side of the crossing.

The arrangement of offset landscaped lids reduced the overall deck area that would have been required for a conventional continuous lid. It reduced the roadway alignment skew to about 45 degrees and allowed the lid to cross SR 520 at approximately 25 degrees. The resulting span lengths were 150 ft and 164 ft for the westbound and eastbound lids, respectively, which allowed the use of precast, prestressed concrete beams for the superstructure. This solution provided a vibrant urban connection for users, and was architecturally compatible with the other nearby crossings.

Construction of the center pier in the median of SR 520 required a 16-ft-deep shored excavation for the spread footing foundations.

Structural Design Features

The framing consists of 56, WSDOT WF83G, precast, prestressed concrete bulb-tee beams. The beams are 83 in. deep and feature a 49-in.-wide top flange. The beams were spaced at about 6 ft 4 in. in the 150-ft-long westbound lid and at 5 ft 0 in. in the 164-ft-long eastbound lid, almost flange to flange. The close spacing was a direct result of the need to design the landscaped areas of the lid for a total load of 510 lb/ft^2, in addition to the standard highway loadings under the roadway portion. The specified concrete compressive strength was 10,000 psi. The beams used 0.6-in.-diameter strands for the 38 or 42 straight strands and 22 or 24 harped strands.

Completion of the cast-in-place concrete deck was complicated by the geometry of the project. In order to simplify the casting, an unbroken planar surface was specified. The deck over the beams varied in thickness from 8 to 10.5 in. The top mat of reinforcing steel was epoxy coated. The roadway crown section was accomplished with asphalt, varying in thickness from 2 to 6 in. The remainder of the deck was covered with soil up to 36 in. deep.

A key challenge for the structural design was the center pier and the structure's seismic demands. To maintain WSDOT standards for shoulder widths and sight distance on SR 520, the width of this pier could not exceed 6 ft. This constraint, combined with the need to let the offset beams rotate freely and independently due to the deck weight and landscape surcharge, required the introduction of an expansion joint at the center pier where the two offset lids overlapped. This joint allows rotation, but was detailed to prevent horizontal movement of the superstructure, relative to the pier, in both the transverse and longitudinal direction. This, in-turn required the abutments to be founded on a series of fourteen 6-ft-diameter drilled shafts. The shafts were not required for vertical load but were required to create a deep abutment wall capable of developing the passive pressure required to limit the longitudinal movement of the two spans in a seismic event. The center pier

TWO DIAMOND-SHAPED OFFSET LIDS OVER A DIVIDED FREEWAY USING PRECAST, PRESTRESSED CONCRETE BULB-TEE BEAMS AND CAST-IN-PLACE CONCRETE DECK WITH CENTER PIER USING PRECAST CONCRETE COLUMNS PROVIDING A DIAGONAL ROADWAY AND UNIQUE MEANDERING PEDESTRIAN WALKWAYS / CITY OF REDMOND, WASHINGTON, OWNER

STRUCTURAL COMPONENTS: Fifty-six WSDOT bulb-tee beams, 83 in. deep with 49-in.-wide top flanges with cast-in-place composite concrete deck 8 to 10.5 in. thick and 14 precast concrete columns, 4 ft by 4 ft by 29 ft 5 in. tall in the center pier

BRIDGE CONSTRUCTION COST: Bridge: approximately $10 million; Total: $21.4 million

Respecting the Environment through Innovative Engineering

The Northeast 36th Street Bridge prioritized environmental design and is optimized for pedestrian and bicycle access and an enhanced user experience. Its features include the following:

- Reduced the amount of impervious surface that blends seamlessly into the surrounding environment.
- The illusion to the user of not being on a bridge as views and noise are blocked by the attractive landscaping and bridge barrier.
- Park-like amenities and ample lighting installed for public safety, comfort, and enjoyment.
- Wide, meandering sidewalks separated from the automobile zone by planter strips and connected to all major access points and local businesses including the use of ramps, crosswalks, and handrails.
- A direct connection to a multiuse path and popular 5-mile interurban trail system to maximize community and sustainability elements.
- Bridge barrier raised by approximately 3 ft relative to a typical barrier. Raised planted islands block noise and visual distractions. Undulating sedimentary walls constructed at the sidewalk edge provide seating and a barrier from the landscaped beds. These plantings reduced the area of impervious surface and absorb storm water before adding to runoff. A bridge drain system, including a waterproofing membrane, drainage mat, and an inlet and pipe system collects additional water on the bridge and delivers it to the city's stormwater system.
- The number of trees removed from the site was minimized. Extensive plantings restored the site to its pre-built condition. No new roadways were created as part of the project.
- On-site rocks were re-used to create new rock walls adjacent to the roadways.
- Shallower beams were used than if the structure was built on a larger skew. This avoided the need for special cranes and larger equipment. It led to reducing the size of walls and the quantity of fill at the ends of the bridge, which also reduced the cost of the project.

The Northeast 36th Street Bridge includes one through-lane in each direction. Bicycle lanes, generous sidewalks, and lush landscaping are included. The roadway crosses SR 520 at a 44-degree angle, rather than the more typical 90 degrees.

Precast columns . . . recovered about 4 weeks of the original 6-week delay.

itself was approximately 260 ft long, consisting of 14 columns supported on a 10-ft-wide spread footing. The center pier provides only vertical support for the structure, as its lateral movements are limited.

Precast Concrete Columns

Construction of the center pier spread footing in the median of SR 520 required a 16-ft-deep shored excavation. Because WSDOT was paving SR 520 at the time the project was bid, construction of this pier was delayed by 6 weeks. Because the beam supplier was extremely busy at this time, the 6 week delay was projected to have a ripple effect on the delivery and erection of the beams, and the subsequent completion of the deck construction and approach paving. The weather-sensitive approach paving and substantial completion of the project would be delayed by as much as 6 months. In order to expedite the construction of the center pier and recover the schedule, a decision was made to redesign the 14 columns to be precast concrete rather than cast-in-place. The columns were cast on site and erected in the median where footing cages had been assembled. This recovered about 4 weeks of the original 6-week delay, allowing the remainder of the pier construction and beam erection to proceed in accordance with the contractor's original plan to pave the approaches and complete the project in the fall.

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Fourteen columns were precast and erected in the median, recovering 4 weeks of potential project delays.