State officials liked the benefits of post-tensioned, haunched slab bridges and produced their own designs

by Stanley W. Woods

Reinforcing steel and post-tensioning ducts in a haunched slab bridge.

Department of Transportation officials in Kansas have become big believers in the use of concrete haunched slab bridges. The state has approximately 25,500 bridges, with about 5000 on state highways, and concrete haunched slab bridges comprise an extensive inventory in that number.

"These three-span structures work very well with the topography in Kansas, and our numerous stream crossings," explains Loren Risch, Bridge Design Engineer. The Kansas Department of Transportation (KDOT) previously had standards for reinforced concrete haunched slabs with center spans from 39 to 72 ft, using 4000 psi compressive strength concrete. As the center span length was limited to 72 ft, the design could only be used for shorter stream crossings. Subsequently, a consultant developed new standards for post-tensioned, haunched slab bridges that extended the span range to 92 ft in addition to providing a high performance bridge superstructure.

The longer spans fit very well with the wider stream crossings, says Risch. In creating these designs, KDOT followed the lead of Sedgwick County, one of their larger counties, which started using these bridges two years earlier. This was mentioned in the Spring 2007 issue of *ASPIRE*.™

Standard Plans Developed

The slab soffit features a parabolic profile with minimum depth at midspan and maximum depth at the pier. Longitudinal post-tensioning tendons are draped in a parabolic profile and provide the primary reinforcement to carry the loads. A nominal post-tensioning using straight tendons in the transverse direction is provided for distribution of loads and confinement. Nominal reinforcement is provided in both directions in the top and bottom of the slab for temperature and shrinkage stresses as well as to assist in the positioning of the post-tensioning ducts. Concrete design strength is 5000 psi.

Kansas Standardizes

Reinforcing steel and cable ducts just before the concrete placement.

The consultant developed standard plans to meet several different situations and to provide usable plans for the smaller counties. Four span arrangements are available in continuous three-span configurations of 50-65-50 ft, 55-72-55 ft, 62-82-62 ft, and 71-92-71 ft. Six roadway widths of 28, 32, 36, 40, 40 with an offset centerline for interstate bridges, and 44 ft.

The slabs are designed for a traffic barrier, a future wearing surface of 25 psf and HL-93 live load. These bridge standards all offer right-angle crossings. An example set of plans for a 30-degree skewed post-tensioned bridge is also available. "There have been some problems with the skewed bridges when careful attention was not given to the intersection of cable ducts and transverse reinforcing steel," explains Ken Hurst, State Bridge Engineer.

LEAP Software has produced a computer program for design and analysis of the slabs. The superstructure can be designed to satisfy current AASHTO Standard Specifications HS25 live load and the AASHTO LRFD Bridge Design Specifications HL-93 live load.

Design Used Statewide

These bridges are all let to contract, either by KDOT or one of the larger counties, and they are used statewide. One contractor has been the successful bidder in many cases. The state specifications require the post-tensioning contractor to be at the site at least three times during construction to oversee the contractors work when the ducts are placed, when the post-tensioning is applied, and when the ducts are grouted.

Kansas is very concerned about grouting the ducts and follows the American Segmental Bridge Institute (ASBI) specifications. Grouting must be done no more than 7 days after tensioning, using bagged grout placed by an ASBI certified contractor. So far, the state has built 11 of these bridge types with three more planned. Sedgwick County has built approximately 24 bridges.

Reinforced concrete haunched slab bridges cost between $65 and $75 psf, while the post-tensioned concrete haunched slab bridges cost between $75 and $85 psf. This slightly higher cost is expected with the longer span lengths. "The cost is slowly declining as contractors become more familiar with this method of construction," Hurst notes.

Other states have noticed the efficiencies. Iowa and Ohio officials have inquired about their use, and an Ohio developer has built at least one. Texas also inquired, but their typical bridge features flat slab concrete construction. The post-tensioning contractors also have inquired, Hurst adds, as they want to promote the design to bring them more business. "I am surprised this idea hasn't taken off a bit faster."

One design pushed the limit to a 102-ft center span and a depth-to-span ratio of 1:42. The bridge was built close to the ground and looks very good at the site, Hurst says.

The current standards for post-tensioned concrete haunched slabs are limited to three-span arrangements. Unlike the standards for the reinforced concrete haunched slabs, post-tensioned concrete slab designs cannot be extended to multi-span applications in a straightforward manner. The additional length of tendons results in an increased loss of prestressing force, which may require an increase in the initial force.

KDOT may in the future develop standards for multi-span applications. The maximum total length of post-tensioned concrete slab bridges, without introducing a strand splice or interior span joints, is expected to be about 600 ft.

The standards are available from KDOT in three components—Users Manual, Plan Standards, and Special Provisions. To learn more, visit www.ksdot.org

For more information on this or other projects, visit www.aspirebridge.org.

After the concrete has gained strength, the cables are post-tensioned and strand elongation measured.

The use of post-tensioning has extended span lengths up to 92 ft.

The design of the post-tensioned concrete, haunched slab bridge offers a graceful profile and slender appearance for the superstructure

Concrete Haunched Slabs