A NEW WELCOME AT THE PORT COLUMBUS INTERNATIONAL AIRPORT

by Kevin M. Gorak and Troy D. Jessop, RW Armstrong

Main Photo: The trio of structures provides a handsome solution for access around the expanded airport. Photos: RW Armstrong.

Crossover Taxiway Bridge Creates New Look

The Port Columbus International Airport located in Columbus, Ohio, recently undertook a major expansion project. The expansion consisted, in part, of a new connector taxiway between the airport's two runways to ease aircraft congestion on the east side of the airfield and provide the needed runway access for a proposed new Midfield Terminal. The new taxiway crosses the airport's new relocated primary entrance road named International Gateway. International Gateway is a depressed roadway that accommodates seven vehicular traffic lanes and two light rail transit tracks. Three single-span, post-tensioned bridges cross International Gateway for various uses at the airport. One of the structures is 74 ft 0 in. wide, carries vehicular traffic along the new airfield perimeter road, and connects to a new parking lot access ramp. Another structure is 29 ft 6 in. wide and provides for traffic circulation around the airport. The most notable structure is the Crossover Taxiway Bridge, which is 191 ft 3 in. long and 217 ft 6 in. wide. This bridge enables aircraft from the existing terminal building to access the outer runways of the airport.

profile

PORT COLUMBUS INTERNATIONAL AIRPORT CROSSOVER TAXIWAY BRIDGE / COLUMBUS, OHIO

ENGINEER: RW Armstrong, Indianapolis, Ind.

ARCHITECT: Rosales, Gottemoeller & Associates, Boston, Mass.

CONTRACTOR: C. J. Mahan Construction Company, Grove City, Ohio

CONCRETE SUPPLIER FOR DRILLED SHAFTS: Arrow Concrete, Columbus, Ohio

CONCRETE SUPPLIER FOR SUPERSTRUCTURE AND ABUTMENTS: Anderson Concrete, Columbus, Ohio

AWARDS: *2008 Portland Cement Association Bridge Award*

Impressive in its scale, the Crossover Taxiway Bridge accommodates the largest Group V aircraft loading while welcoming travelers entering the airport.

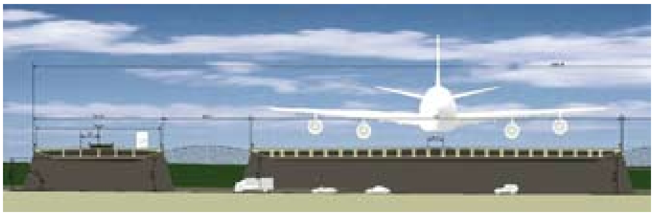

Illustration Inset (left)
The centerpiece of airport expansion structures is the Crossover Taxiway Bridge at the Port Columbus International Airport.

The scale of the abutment can be seen in this photo of a partially completed wall and the reinforcement in another segment ready for form installation.

Defining Goals and Selecting Alternatives

The Crossover Taxiway Bridge spans International Gateway and serves as a significant landmark. It creates a major visual impact for the public as they enter the airport. Consequently, aesthetics played a major role along with the basic design criteria set for the project. The goal was a slender structure with a large clear opening. However, the structure was also required to carry Group V aircraft loading, which includes the Boeing 747-400 series plane that weighs 894,000 lb. The structural depth of the bridge was an issue due to the impact on the design of the International Gateway road below the bridge. Since the road is a depressed section, a shallow superstructure would allow the road alignment to be higher and ensure an elevation above the water table. This would also help reduce the impacts associated with a storm-water pump station that was also under construction for the airport expansion.

A Structure Study Matrix was performed and 40 plausible conceptual alternatives were evaluated to satisfy the design parameters. Seven of these alternatives were then selected to be analyzed in more detail. They were selected based on cost, size, appearance, and constructability. A rating criterion to be used in selecting the proposed structure type was determined with input from the client. Some of the more important criteria to the Columbus Regional Airport Authority were capital cost, life-cycle cost, aesthetics, durability, and schedule. The winning alternate that received the highest score in the matrix was a single-span, post-tensioned box girder bridge that featured an arch-shaped profile.

Due to the geometry and required capacity of the structure, the design needed to utilize high-performance materials and a structural system that would allow for a sleek and durable structure. The result was a superstructure made integral with the substructure providing for frame action and a shallow depth using high-strength, post-tensioned concrete.

Structural Analysis and Design

The design of this integral structure required a three-dimensional finite element analysis that would account for construction staging and long-term material effects. The bridge consists of a cast-in-place, post-tensioned concrete box superstructure cast integral with the abutment walls that are supported by drilled shafts. The concrete box superstructure was wider than its length and was loaded by nontraditional live loads of various Group V aircraft. Due to these factors, two separate finite element models were used for analysis of the bridge design.

The first analysis modeled the cross-section of the concrete box with two-dimensional plate elements. This allowed for unique wheel configurations of various aircraft to be placed anywhere on the bridge deck. The resulting forces in the plates yielded results to design the transverse components of the superstructure. This included the transverse reinforcement and post-tensioning in the top slab of the concrete box. This model was also used to determine the distribution of the aircraft loading to the webs of the multi-celled superstructure. Since this structure is very wide compared to its length, it cannot be assumed that the aircraft loading will be distributed equally to the

CAST-IN-PLACE, POST-TENSIONED BOX GIRDER / COLUMBUS REGIONAL AIRPORT AUTHORITY, OWNER

BRIDGE DESCRIPTION: Single span, post-tensioned, cast-in-place concrete, box girder bridge with integral abutments, supported by drilled shafts

POST-TENSIONING SUPPLIER-CONTRACTOR: Freyssinet LLC, Sterling, Va.

REINFORCEMENT: JB Steel, Columbus, Ohio

COST: $10.5 million

webs and throughout the cross section of the structure.

The second finite analysis modeled the bridge with one-dimensional beam elements. It incorporated the distribution results from the previous analysis to design the flexural components in the superstructure, the connections at the integral abutments, abutment walls, and the drilled shafts. The drilled shafts were modeled with soil springs acting as the soil resistance. The stiffnesses of the springs were based on the modulus of horizontal reaction provided in the geotechnical report. This analysis also accounted for construction staging, material properties, and long-term prestress losses. The stresses in the structure were checked and verified that they did not exceed the maximum allowable compression and tension stresses during any construction phase. The long-term stresses after all losses have occurred combined with the various Group V aircraft loadings were also checked.

High-strength concrete with a specified compressive strength of 7200 psi in the superstructure used in conjunction with longitudinal post-tensioning resulted in optimized geometry of the multi-cell box. The 217-ft 6-in.-wide cross section consisted of 24 cells. The depth varied from 7 ft 6 in. at the abutment to 5 ft 0 in. at midspan. This provided the arch look that the airport authority desired. The utilization of post-tensioning was a key component for the slender design of this bridge. The superstructure required 5562 yd^3 of 7200 psi concrete, ninety-two 27-strand tendons for the longitudinal post-tensioning, and eighty-two 7-strand tendons for the transverse post tensioning. To ensure the integral connection between the superstructure and abutment, one hundred and ninety-four 1¾-diameter post-tensioning bars were used at each abutment. These abutments alone were massive structures, 230 ft long and 30 ft tall. The wall thickness varied from 6 ft 0 in. at the top to 7 ft 6 in. at the bottom. The abutments consumed 3055 yd^3 of 6000 psi concrete and were supported by 54-in.-diameter drilled concrete shafts.

Even beyond the structural and aesthetic features of design, another unique feature had to be accommodated within the bridge. Tubing was installed in the deck to prevent the structure from icing. This system consists of circulating glycol to radiate heat during winter conditions. The system is automated and is activated by sensors.

Construction Innovation

The contractor constructed the bridge without the use of falsework and in a very timely manner. The existing ground line at the site was approximately at the same elevation as the bottom of the proposed superstructure. Therefore, the contractor elected to build the superstructure on grade and then excavate underneath, rather than the other way, which would require falsework for the superstructure.

The goal was a slender structure with a large clear opening.

The shallow, tapered superstructure creates the desired lightness in this photo showing the Taxiway Bridge upon completion.

Careful attention to details such as sloped overhangs, barriers and rails, abutments, and lighting provides a pleasant experience for travelers.

The integral connection of the superstructure to the substructure, combined with the enormous width of the structure, required special construction design calculations and sequencing methods to prevent cracking from creep and shrinkage. Transversely, the structure was constructed in three separate units, allowed to cure for a specific period of time, and then connected by closure placements. Longitudinally, the superstructure also had to cure for a specified amount of time prior to connecting to the substructure to reduce unwanted forces due to shrinkage. The construction process required experienced personnel from the contractor and inspection team for the post-tensioning, grouting, and drilled shaft installation. To ensure the integrity of the drilled shafts, cross hole sonic logging was performed. This verified that there were no voids in the drilled shafts and that there was adequate concrete consolidation at the bottom of the shaft.

The construction of the Crossover Taxiway Bridge was completed in the spring of 2008 and the first aircraft traveled over the structure in November of that year. The design and construction of the bridge was a success for the owner, contractor, architect, and design engineers. The use of high-strength concrete, post-tensioning, and the structural system provided a slender, open structure for massive design loadings. The bridge truly greets people with an elegant entrance to the Port Columbus International Airport.

Aesthetics Revisited

The aesthetics of this structure were of utmost importance to the owner. One main feature desired by the architect and airport was the open, single-span with a slender, variable depth profile. It was feared that a typical, multi-span structure would present a constrictive, tunnel-like experience. Other concepts desired by the architect included a slope on the outside fascias of the superstructure, a reverse taper on the abutments, a modified concrete parapet with galvanized handrail, the geometry of the wing-walls, the use of deep recesses in the faces of the concrete abutments and wing-walls, and the unique lighting scheme under the structure. The lighting beneath the bridge consisted of that required by the Ohio DOT plus additional blue strip lights were placed for aesthetic purposes at carefully selected locations including the abutment recesses.

The authors are Kevin M. Gorak, senior project manager, who was a design engineer on the project and Troy D. Jessop, associate, who was project manager, RW Armstrong, Indianapolis, Ind.

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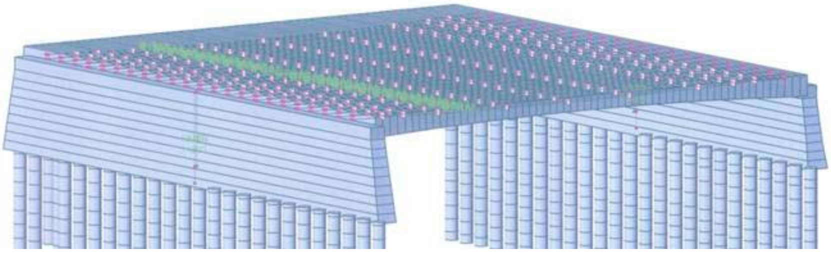
Rendering Elevation.



Analysis modeling.

Aerial View During Construction.

PORT COLUMBUS INTERNATIONAL AIRPORT CROSSOVER TAXIWAY BRIDGE / OHIO

PT Duct Layout

PT End Block.

Drilling Shaft Installation.

Bridge Construction.

View from along Bridge.