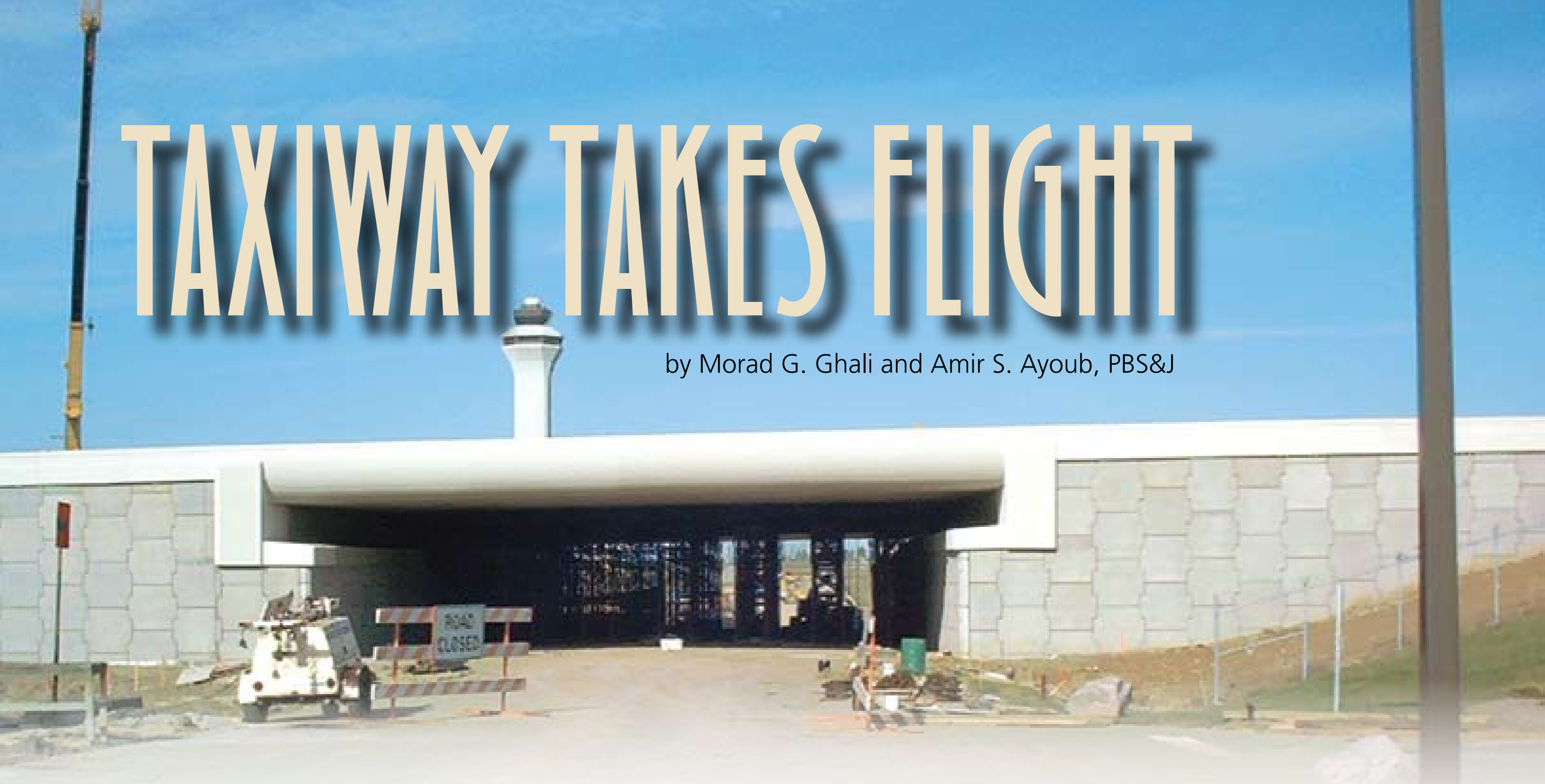
TAXIWAY TAKES FLIGHT

by Morad G. Ghali and Amir S. Ayoub, PBS&J



The new taxiway at the Cincinnati/Northern Kentucky International Airport features a single post-tensioned, cast-in-place span to support the required loading and maximize clearance above the roadway. Photos: PBS&J.

Severe depth limitations, heavy loads, and a short timetable created design challenges for this cast-in-place, post-tensioned concrete bridge

Designing the new aircraft-support bridge at the Cincinnati/Northern Kentucky International Airport required a novel approach due to severe loading and the structural depth requirements. With a clearance of only 16 ft 11 in. over the roadway, a careful design had to be developed that could support the heavy weight of the aircraft and emergency vehicles using this bridge.

After careful consideration of the options, a single 87-ft 2-in.-long, post-tensioned, cast-in-place bridge without any transverse joints was created. It was designed and detailed as a simple-span structure to carry the aircraft loading. To meet the variety of challenges, the 217-ft-wide bridge comprises three segments: two 72-ft 4-in.-wide outer segments and an inner segment that is 72 ft 2 in. wide.

The segments are separated by longitudinal expansion joints made of an expandable, watertight foam sealant and a strip-seal system at the roadway level. Dividing the width into three segments allowed the contractor to erect the falsework and cast the slab for each segment individually.

The post-tensioned voided deck is supported by plain elastomeric bearing pads that in turn are supported by 6-ft-deep by 4-ft 6-in.-wide end bents. Each bent is supported by thirteen 48-in.-diameter concrete drilled shafts. This approach was used due to the presence of limestone close to the soil surface throughout the entire project.

The 30-ft-long approach slabs on each side of the bridge consist of 24-in.-thick cast-in-place reinforced concrete slabs supported on one end by a bracket protruding from the post-tensioned slabs and on the other end by a 6-ft-wide reinforced concrete transverse sleeper pad. The approach slabs were designed as structural members on elastic foundations to carry the wheel load of the aircraft. The retaining walls for the approach backfill are made of

profile

CINCINNATI/NORTHERN KENTUCKY INTERNATIONAL AIRPORT TAXIWAY 'N' BRIDGE / ERLANGER, KENTUCKY

ENGINEER: PBS&J, Tampa, Fla.

PRIME CONTRACTOR: The Harper Co., Hebron, Ky.

POST-TENSIONING CONTRACTOR: DSI America, Bolingbrook, Ill.

GROUT SUPPLIER: Sika Corporation, Lyndhurst, N.J.

STRAND SUPPLIER: Sumiden Wire Products Corporation, Stockton, Calif.

The design team considered a variety of alternatives before selecting the structural system capable of carrying the heavy loading while providing necessary clearance below the bridge.

mechanically stabilized earth (MSE) walls designed to support lateral earth-pressure equivalent to that produced from the weight of the aircraft.

Driven by Aircraft Loading

This bridge design was driven by several key factors, particularly the requirements for aircraft loading and limited clearance below the bridge. The design followed the FAA's advisory circular 150/5370-10 in addition to *AASHTO Standard Specifications for Highway Bridges*. The FAA circular required a 1.6-million-lb, Group VI airport loading, following the required gear-configuration types, plus 83,000 lb for emergency vehicles.

The impact load was 30% for the superstructure elements, with maximum longitudinal breaking force set at 35% of the live load without impact. Earthquake loads were considered in accordance with AASHTO Specifications, division 1A, seismic design for seismic performance category A with a ground acceleration of 0.06g. Wind load on the structure and on the aircraft were based on a wind velocity of 100 mph.

The design team considered a variety of alternatives before deciding on the solution that would best create the structural system capable of carrying the heavy loading while providing necessary clearance below the bridge. AASHTO precast, prestressed concrete girders were considered but eliminated because the high load requirements would necessitate a deep beam profile. Likewise, post-tensioned concrete box girders were found to require deeper webs and a special design for the lateral bending of the top slab, necessitating a thicker top slab to resist the aircraft load.

The team then investigated the possibility of using a voided, post-tensioned, cast-in-place slab, with the design optimized by varying the size and location of the void within the slabs. After several trial designs, the voided, post-tensioned, cast-in-place slab option was found to provide the most cost-effective solution while complying with all project requirements and resolving the unique geometrical and strength requirements.

Multilayered anchor protection will prevent water recharge around anchorages that could result in tendon corrosion. All anchorages had a minimum of four levels of protection.

Voids within the post-tensioned cast-in-place slab consist of fourteen 30-in.-diameter precoated, galvanized, corrugated metal pipes capped at each end and spliced to prevent leaks.

CAST-IN-PLACE CONCRETE, TWO-WAY POST-TENSIONED VOIDED-SLAB AND CAST-IN-PLACE STRUCTURAL APPROACH SLABS / KENTON COUNTY AIRPORT BOARD, OWNER

BRIDGE DESCRIPTION: Simple span, cast-in-place concrete, two-way post-tensioned voided-slab, 4 ft 6 in. thick, 87 ft long and 217 ft wide, and 24-in.-thick cast-in-place structural approach slabs designed for aircraft loading

BRIDGE CONSTRUCTION COST: $10.2 million (including approaches)

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The concrete slab, which is 4 ft 6 in. thick, was post-tensioned both longitudinally and transversely. The voids were formed using 14 corrugated metal pipes, 30-in. in diameter, in each segment, spaced at 4 ft 6 in. on center. The pipes were precoated and galvanized in accordance with Kentucky state standards. They were capped at each end and spliced to ensure they were free of leaks. The centers of the corrugated pipes are offset from the center of the slab toward the bottom, to reduce the dead load while providing greater resistance on the compression face.

The longitudinal post-tensioning of each slab segment consists of 30 tendons. Each is composed of twenty-seven 0.6-in.-diameter strands. Two additional ducts were provided and capped for future use. The transverse post-tensioning features four 0.6-in.-diameter strands at $11\frac{3}{8}$ in. from the top of the slab. All post-tensioning strands are seven-wire strands conforming to ASTM A416 270 ksi low-relaxation steel.

New Post-Tensioning Specifications Used

The post-tensioning specifications developed by the State of Florida were used as a guide to increase the durability and performance level of the bridge. The specifications consisted of five key elements: an enhanced post-tensioning system, fully grouted tendons, multilayered anchor protection, watertight bridges, and multiple tendon paths.

The enhanced post-tensioning system was designed to ensure the grout inlets/outlets were suitable for inspection from either the top or front of the anchorage. Three levels of protection for the tendons were provided within the concrete element. These consisted of ensuring sufficient concrete cover, using plastic ducts, and completely filling the annular space between duct and strands with grout. All anchorages for the post-tensioning system had permanent grout caps made from fiber-reinforced plastic and were sealed with neoprene O rings. Additional recommendations such as spacings and inspections were followed as well.

The contractor was required to submit a detailed grouting plan to ensure the tendons would be completely grouted. Shop drawings were required to include all details of the post-tensioning system and grouting plan. Grout pumping rates and pressures were required to reach the rate of 16 linear ft to 50 linear ft of duct per minute with the pressure not to exceed 145 psi at the grout inlet. A fluidity test of the grout from the discharge end was performed using a flow cone to test the efflux time. Inspections were performed using probes or endoscopes, and the grout inlets and outlets were sealed with threaded plugs.

Multilayered anchor protection was used to avoid water recharge around anchorages that could result in tendon corrosion. All anchorages had a minimum of four levels of protection, comprising grout, a permanent grout cap, encapsulating epoxy grout, and a seal coat.

Water tightness was ensured by providing 2-in.-diameter drain holes at each end of the 30-in.-diameter pipes that formed the voids. The bottom edges of the post-tensioned slab were curved to prevent water from accumulating and dripping.

The final element, providing multiple tendon paths, was achieved with 30 longitudinal tendons of twenty-seven 0.6-in.-diameter strands in each slab segment. Multiple tendon paths will provide more structural strength in the event a tendon is lost. Provisions were made for any future strengthening through the addition of two conduits provided in the slab.

Construction Sequence

Construction proceeded smoothly. After driving and casting the drilled shafts, the end bents were formed and cast, and the MSE walls constructed. The falsework for the cast-in-place slab was put in place, and the reinforcing steel, 30-in.-diameter void pipes and post-tensioning ducts were set in place. The concrete was cast and longitudinal and transverse post-tensioning of the slab was completed. Construction of the approach slab and sleeper pad did not begin until the fill within the limits of the MSE walls had been completely compacted.

The result of this attention to detail and key concerns is a bridge that will support heavy aircraft loads for many decades of service to come. Performance was improved by using post-tensioning enhancement strategies that will help reduce inspection and maintenance needs over its entire service life. The project provides an attractive, functional design that was completed on schedule and within budget.

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Falsework for the cast-in-place slab was put in place after completing the end bents and MSE walls.

The final lift of concrete for the voided slab is consolidated and screeded.

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