HSC for Route 22 Bridge over the Kentucky River

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High strength concrete was used for the precast, prestressed concrete beams.
Photo: Aerial Innovations of Tennessee, Inc.

Route 22 Bridge over the Kentucky River near Gratz, KY, has the longest span for a post-tensioned, spliced, precast, prestressed concrete girder bridge in the United States. That honor was achieved by spanning 325 ft (99.1 m) across the Kentucky River. The other three spans that make up the bridge are one at 175 ft (53.3 m) and two at 200 ft (61.0 m).

The bridge did not start out being precast concrete but was originally designed to use steel plate girders. Prestress Services Industries, LLC (PSI) asked to submit a precast concrete alternate that saved the state of Kentucky over $800,000. PSI employed the design firm of Janssen & Spaans Engineering, Inc. to perform the redesign of the bridge.

Bridge Design

The bridge was redesigned to use four precast, prestressed concrete girder lines and four spans. Six girder segments and two pier segments were used to make up each girder line for a total of 32 pieces. Span 1, 175 ft (53.3 m) long, comprised two segments with lengths of 90 ft 9 in. and 84 ft 3 in. (27.7 m and 25.7 m) that were spliced together. Span 2, 200 ft (61.0 m) long, comprised one end of the 138-ft (42.1-m) long cantilevered pier segment and a 131-ft (39.9-m) long drop-in girder segment. Span 3, 325 ft (99.1 m) long, utilized one end of each of the 138-ft (42.1-m) long cantilevered pier segments and a 185-ft (56.4 m) long drop-in girder segment. Span 4, 200 ft (61.0 m) long, utilized one end of the 138-ft (42.1-m) long cantilevered pier segment and two girder segments with lengths of 57 ft 6 in. and 73 ft 6 in. (17.5 and 22.4 m) that were spliced together.

The girder segments were modified bulb-tee beams with a 3-ft 4-in. (1.02-m) wide bottom flange and a 5-ft 1-in. (1.55-m) wide top flange. The cantilever pier segments varied in depth from 16 ft (4.88 m) over the piers to 9 ft (2.74 m) at the ends of the cantilever. The girder segments had a constant depth of 9 ft (2.74 m). The web was 8 in. (200 mm) thick and

contained four post-tensioning ducts. All segments were pretensioned in the plant and then post-tensioned in the field.

High Strength Concrete

The concrete specified for girder segments in Spans 1, 2, and 4 was normal weight concrete with a 28-day compressive strength of 7,500 psi (52.MPa). The actual final strengths ranged from 7,800 to 11,000 psi (53.8 to 75.8 MPa) with most cylinders breaking close to 10,000 psi (69.0 MPa). The prestressing strands were cut and the girders released from the forms at a minimum compressive strength of 5,500 psi (38 MPa) after 14 hours of curing. This was achieved by adding 105 fl oz/yd^3 (4.06 L/m^3) of high-range water-reducing admixture to the mix and using 752 lb/yd^3 (446 kg/m^3) of Type III cement. The same normal weight concrete mix used on the girder segments was also used for the pier segments. The girders were cured at concrete temperatures up to 140°F (60°C) with steam heat to ensure the release strength would be achieved overnight. The prestressing strands were 0.6-in. (15.2-mm) diameter Grade 270 and the non-prestressed reinforcement was standard Grade 60, epoxy-coated bars.

At 185 ft (56.4 m) long, the drop-in girder segments for Span 3 (over the river) needed to be braced together in pairs for stability during transportation and erection. PSI used a semi-lightweight concrete mix, consisting of normal weight fine aggregate, 42% normal weight coarse aggregate, and 58% lightweight aggregate to reduce the unit weight to 125 lb/ft^3 (2001 kg/m^3). Even with the reduced concrete unit weight, the beams still weighed 129 tons (1150 kN) each, or 258 tons (2300 kN) for the pair. The concrete compressive strengths specified for the semi-lightweight concrete were the same as those for the normal weight concrete. Actual strengths averaged 6,450 psi (44.5 MPa) at 14 hours and 8,570 psi (59.1 MPa) at about 14 days.

Special forms had to be constructed to cast the pier segments. The formwork height of 16 ft (4.88 m) necessitated the use of concrete pump trucks. At 169 tons (1500 kN) each, these were the heaviest individual pieces on the project. Since these pier segments were cantilevered, the prestressing strand was located in the top flange of the segment with minimal prestressing in the bottom flange.

Transportation

Transportation of the girder segments proved to be a challenge in itself. The girder segments for the approach spans could be transported by truck using 13- and 15-axle trailers. The pier segments and drop-in segments over the river were too large and heavy to transport by road. Therefore, they were placed on barges and transported on the river. Unfortunately, the locks along the waterway were not operating. Even though the girders were not needed for a few months, they were shipped by barge during the high water of spring 2009 so they could float over the locks. The pier segments and drop-in girders over the river were erected by C.J. Mahan Construction Co. during the summer and fall 2009 with the balance of the girders for the approach spans erected during the 2010 winter. The bridge was finished by Haydon Bridge Co., the prime contractor, on schedule in the fall of 2010.