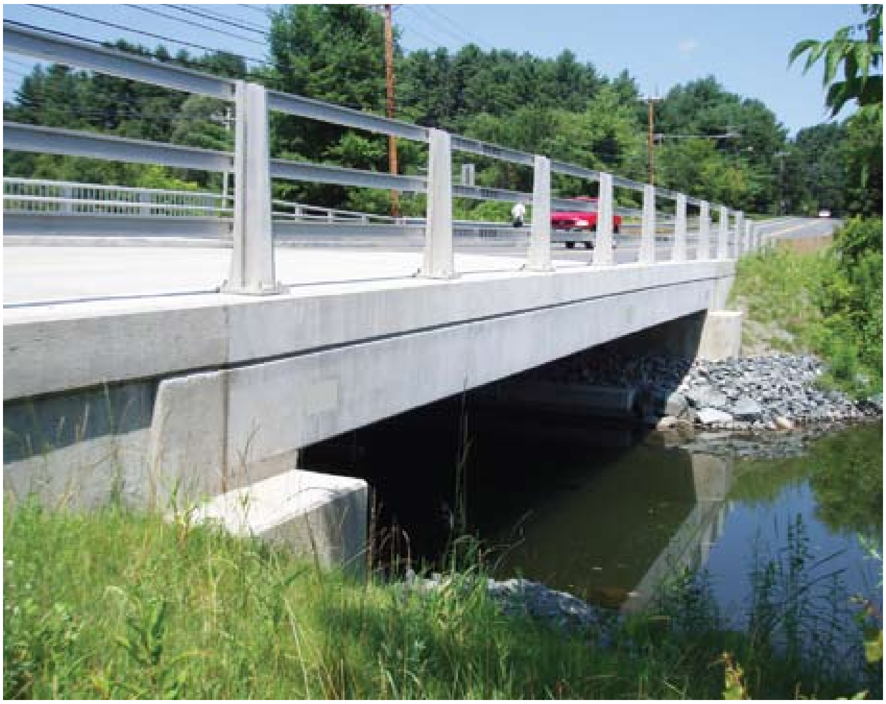
PRECAST DESIGN

The first bridge to be constructed in the state of New Hampshire using the design-build format has proven a success. The project also features the first use in the state of adjacent, voided, precast, prestressed concrete slab beams with integral abutments combined with expanded polystyrene (EPS) geofoam blocks behind the abutments. The construction approach and design techniques offer great potential for future designs that are attractive, quickly constructed, and cost effective.

The new structure, located in Hanover, N.H., over Mink Brook, replaced an existing steel bridge with a precast, prestressed concrete span supported on integral abutments and a single row of steel H-piles driven to bedrock. Early in the design process, the team realized that a precast concrete design was the only solution capable of meeting the tight construction scheduling—but it also proved to be more cost effective than structural steel would have been.

New Hampshire design-build project features self-consolidating and high-performance concretes



Mink Brook Bridge features adjacent, voided, precast, prestressed concrete slab beams with integral abutments.

profile

NEW HAMPSHIRE ROUTE 10 BRIDGE OVER MINK BROOK / HANOVER, N.H.

ENGINEER: Parsons Brinckerhoff (PB), Manchester, N.H.

GEOTECHNICAL ENGINEERING CONSULTANT: Golder Associates, Manchester, N.H.

PRIME CONTRACTOR: R.S. Audley Inc., Bow, N.H.

PRECASTER: J.P. Carrara & Sons Inc., North Clarendon, Vt., a PCI-certified producer

PRESTRESSING STRAND: Strand-Tech Martin, Summerville, S.C.

AWARDS: *PCI Design Award, Best Bridge with Spans Less than 75 feet, 2007*

MEETS TIGHT SCHEDULE

by Keith Donington, PB

Railing anchor bolts were preset in the curb parapets prior to casting at the precasting plant.

The bridge's combination of voided slabs and integral abutments eliminated the need for expansion joints.

Only Partial Removal Needed

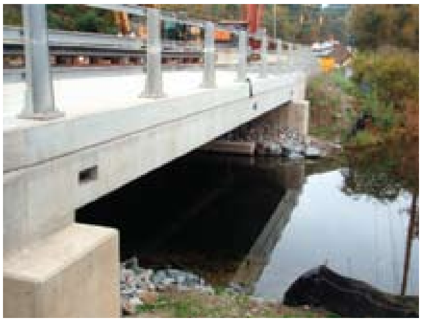
The bridge design required only partial removal of the existing bridge before constructing the new structure. This approach eliminated a significant amount of in-water demolition and minimized excavation depths. That in turn reduced the impact to the stream, environment, and existing slope vegetation. The portions of the existing bridge that remained intact were carefully selected to allow clearance for pile-driving in addition to serving as protection against scour for the new substructure.

Initially, the design-build team suggested dewatering near the abutments to remove parts of the existing wingwall foundations and to install vertical supporting piles. That approach proved too difficult and jeopardized the construction schedule. As a result and to completely avoid the existing footings, the new piles were battered in both the transverse and longitudinal directions at both abutments. This maintained stability of the structure during the temporary first stage of construction as well as for the final, as-built condition.

The bridge's combination of voided slabs and integral abutments, which was adapted from a detail supplied by the Northeast regional office of the Precast/Prestressed Concrete Institute, eliminated the need for expansion joints. It previously had been used by the New York State Department of Transportation with good results.

The precast beams were set on temporary bearing pads and made integral with the abutments when the backwall concrete was placed during the same placement as the deck overlay. The prestressing strands extending from the beams and reinforcement from the deck into the backwall resulted in a rigid connection. Thermal movements are accommodated by bending in the single row of steel H-piles oriented with their weak axis parallel to the abutments and located on a line behind the existing abutment footing. This resulted in a minimum span length of 48 ft.

The superstructure and integral abutments, together with the pile foundation, act as a rigid-frame system. It was analyzed under dead and live loads, as well as lateral loads using a two-dimensional GT-STRUDL-based plane frame computer model. Soil and pile stiffness together with the point of fixity of the piles were evaluated by geotechnical engineering consultants on the project. Those factors were included in the model together with stiffness properties of the beams and integral abutments to determine internal forces.



The adjacent slab beams were transversely post-tensioned at the abutments and midspan to help prevent longitudinal cracking along the shear keys.

PRECAST, PRESTRESSED CONCRETE VOIDED SLAB BEAMS / NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION, CONCORD, N.H., OWNER

BRIDGE DESCRIPTION: 48-ft-long, single-span voided slab bridge

STRUCTURAL COMPONENTS: 12 typical voided slab deck beams, two fascia voided slab deck beams, and two railing-curb parapets

BRIDGE CONSTRUCTION COST: $694,805

The use of self-consolidating concrete provided superior appearance and long-term durability.

The bridge's cross-section comprises fourteen 3-ft-wide, 21-in.-deep adjacent precast, prestressed concrete voided slab beams constructed with self-consolidating concrete, eliminating the need for concrete vibration. The resulting concrete is totally homogeneous with a uniform surface finish and is free of "bug" holes. It also provides a superior appearance and long-term durability. To further enhance that durability, a calcium-nitrite corrosion inhibitor was added to the mix.

EPS Blocks Stabilize Abutments

EPS blocks were placed behind the integral abutments to minimize lateral passive soil pressure on the abutments and wing walls. That placement, in turn, reduced fixed-end movements at the abutments and enhanced flexibility of the frame system. The lateral pressure from the EPS blocks acting on the back face of any vertical concrete wall or bridge abutment is considered nearly equal to zero.

High-performance concrete (HPC) was used in the 5-in.-thick deck on the beams, rather than the more customary bituminous paving on a waterproofing membrane. HPC also was used for the backwalls and approach slabs. The HPC overlay was reinforced to integrate the beams' backwall ends with the abutments, so the bridge could be designed without expansion joints. Galvanized welded wire reinforcement was used in the concrete deck.

Environmental Protection

The bridge was constructed within the limits of the New Hampshire Department of Transportation wetlands permit. Wildlife crossings beneath the bridge along both banks were provided. A stormwater pollution prevention plan was prepared in compliance with the permit requirements of the Environmental Protection Agency's Phase II National Pollutant Discharge Elimination System Program. The team's continuous coordination with the Hanover Conservation Commission, which manages the Mink Brook Nature Preserve, ensured that the appropriate landscaping and seeding mix for restoration would be implemented once the project was complete.

The design-build approach and design techniques offer great potential for future bridges.

The HPC also was used to provide a second line of defense for the transverse post-tensioning that interconnects the beams, helping prevent longitudinal cracking of the grouted shear keys. Such a condition has typically occurred on more heavily trafficked adjacent, precast beam-type bridges. The overlay acts compositely with the beams for superimposed dead loads and live loads, providing more structural efficiency compared to a non-composite overlay.

The HPC used in the approach slabs included pozzolan admixtures to produce a low permeability concrete with improved durability. Using this mix eliminated the need for the customary waterproofing membrane over the slabs, which saved time. The approach slabs were set 1-1/2 in. below finished grade, rather than level with the deck concrete, to allow for a bituminous top course to be placed simultaneously with the roadway approach's bituminous overlay paving.

Railing anchor bolts were preset in the curb parapets prior to casting at the precasting plant. This resulted in parapets that matched the beams and produced both time savings and superior concrete quality.

To remove the existing bridge, the deck was longitudinally saw-cut into sections between the stringers. With a crane located behind each abutment, the beam and deck pieces were lifted onto a trailer for disposal. The existing abutments and wing walls were saw-cut horizontally and removed above the cut with an excavator-mounted hydraulic hammer.

Phased Construction Implemented

Two-phase construction was used to replace the existing bridge, with traffic maintained in an alternating one-way pattern using temporary traffic signals. Implementation of the one-way traffic pattern was delayed until after the school year, to avoid disrupting bus routes and was removed when school returned in the fall. This created a very aggressive construction schedule based on the amount of bridge work required in a limited window of time.

The first construction phase involved replacement of the east side of the bridge. Pedestrian traffic, which was maintained throughout construction, was relocated to a temporary sidewalk structure adjacent to the west fascia of the existing superstructure.

During the second phase, when the west side was replaced, both vehicular and pedestrian traffic used the bridge's newly constructed east side. Pedestrian traffic was separated from vehicular traffic using a temporary guardrail system installed with removable anchors. This ensured that the pedestrians remained on the west side of the traffic, which aided the flow, as sidewalks on both bridge approaches were on the west side of the highway.

The design approach provided key benefits to the environment while meeting local users' needs for minimizing disruption and producing a cost-effective structure. Costs also should be minimized throughout the life of the project due to the attention paid in the initial planning stages to durability needs and corrosion resistance. This project and its design-build approach offer key elements that can be used in the future in New Hampshire and in other states to reduce construction time and both short- and long-term costs.

Keith Donington is senior supervising structural engineer with PB, Manchester, N.H.

NRMCA

National Ready Mixed Concrete Association

Founded in 1930, the National Ready Mixed Concrete Association (NRMCA) is the leading industry advocate. Our mission is to provide exceptional value for our members by responsibly representing and serving the entire ready mixed concrete industry through leadership, promotion, education, and partnering.

NRMCA works in conjunction with state associations on issues such as quality, business excellence, promotion, and regulatory concerns. We strive for constant communication on the latest information, products, services, and programs to help our members expand their markets, improve their operations, and be their voice in Washington.

NRMCA offers certifications for both ready mixed concrete production facilities and personnel. Certified producers strive to provide the highest quality ready mixed concrete in the safest and most efficient ways possible.

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NRMCA is also the principal sponsor of the Concrete Technology Forum, an annual symposium on state-of-the-art concrete technologies. The Forum brings researchers and practitioners together to discuss the latest advances, technical knowledge, continuing research, tools, and solutions for ready mixed concrete.

For more information, contact the National Ready Mixed Concrete Association, 900 Spring Street, Silver Spring, MD 20910, 888-84NRMCA (846-7622), www.nrmca.org.