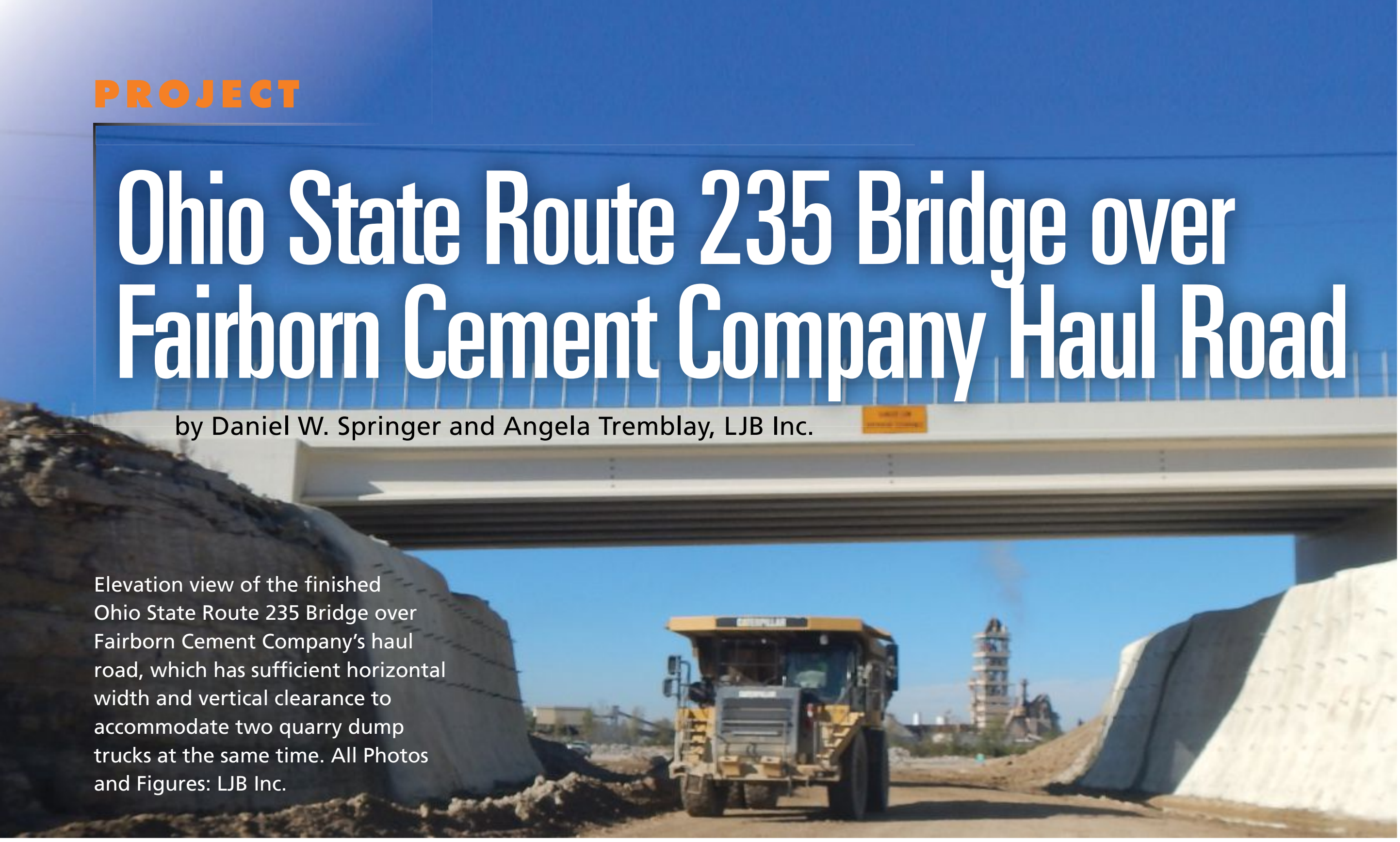
PROJECT

Ohio State Route 235 Bridge over Fairborn Cement Company Haul Road

by Daniel W. Springer and Angela Tremblay, LJB Inc.



Elevation view of the finished Ohio State Route 235 Bridge over Fairborn Cement Company's haul road, which has sufficient horizontal width and vertical clearance to accommodate two quarry dump trucks at the same time. All Photos and Figures: LJB Inc.

In December 2018, a new Ohio State Route 235 (SR 235) bridge opened about 10 miles north of Xenia, a small city in Greene County, Ohio. The bridge allows a new haul road beneath SR 235 to connect Fairborn Cement Company's existing quarry on the west side of SR 235 to a new quarry east of SR 235. With this underpass, Fairborn Cement Company can extend its mining operations for at least the next 30 years. The project also keeps the vehicular traffic associated with mining activities and large rock-hauling trucks off public roadways, minimizing impacts on the surrounding community and improving safety along SR 235.

Unique Project Delivery

Very few privately funded projects have been completed on state routes in Ohio. This project required unique project management and presented design and construction challenges for the entire project team, including coordination of a large, diverse design team, a bridge maintenance agreement between the Ohio Department of Transportation (ODOT) and Fairborn Cement Company, ODOT-permitted closure of SR 235, and meeting Mine Safety and Health Administration (MSHA) requirements.

Because this was a privately funded project, there was a lot of flexibility in the procurement process of contractor selection. Therefore, the project was delivered using the designer-led design-build approach, where the lead bridge designer held the contract for both design and construction work. The first phase of the project included all preliminary coordination and engineering necessary to decide where the bridge would be constructed, and determination of the most cost-efficient structure type. This phase involved field survey, geotechnical investigations, environmental review, preliminary roadway and traffic design, and a structure-type study.

In the second phase, the bridge designer completed the engineering and design plans, which were approved by ODOT and then issued to five contractors for competitive bidding. Because the project was privately funded, the bidding process included contractor interviews as well as estimates of construction costs. After contractor selection, the project team proceeded with final coordination, design adjustments, and project management services during construction.

Fairborn Cement Company established a maintenance agreement with ODOT specifying that Fairborn Cement will maintain the bridge as long as the company exists. ODOT will provide the

profile

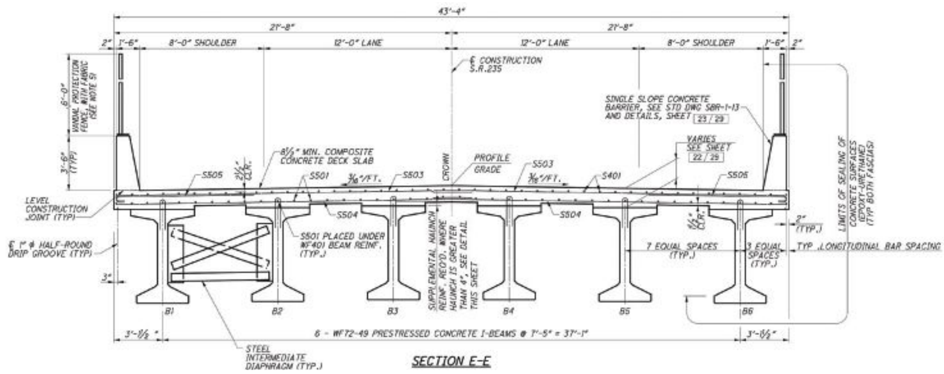
STATE ROUTE 235 OVER FAIRBORN CEMENT COMPANY HAUL ROAD / XENIA, OHIO

BRIDGE DESIGN ENGINEER: LJB Inc., Miamisburg, Ohio

OTHER CONSULTANT: Rock Stabilization Design Engineer: Resource International Inc., Columbus, Ohio

PRIME CONTRACTOR: Eagle Bridge Company, Sidney, Ohio

PRECASTER: Prestressed Services Industries LLC, Decatur, Ind.—a PCI-certified producer



Typical section of the bridge with ODOT-standard WF72-49 prestressed concrete I-beams spaced at 7 ft 5 in. with a composite 8.5-in.-thick cast-in-place, reinforced concrete bridge deck for the 145-ft-long span bridge.

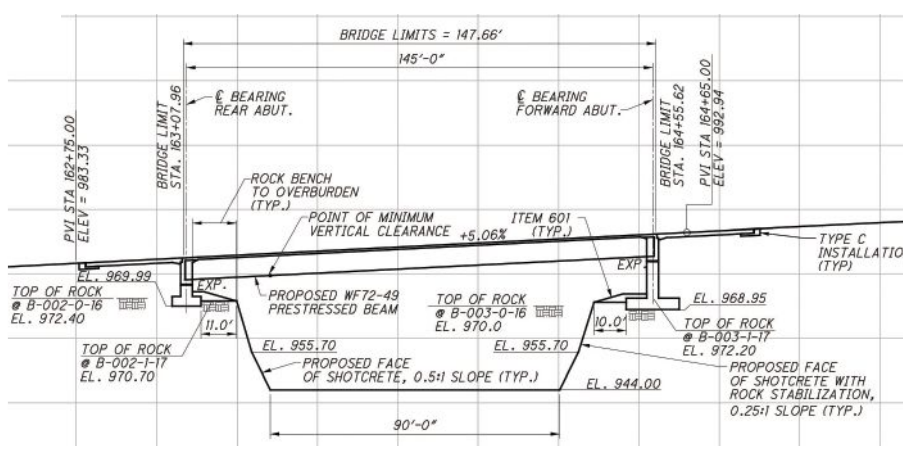
annual bridge inspection services as required by ODOT for all bridges in the state, issue reports to Fairborn Cement Company, and offer maintenance and repair recommendations. Any necessary bridge repairs will be coordinated between the two parties.

Selecting Bridge Location and Structure Type

Determining where to construct a bridge on SR 235 to create a new quarry haul road was a critical aspect of the project. SR 235 is approximately 50 ft above the quarry floor, and when the preliminary design began, the western floor excavation ended about 200 ft west of SR 235. The initial field survey and geotechnical exploration were important in finding a bridge location that would not only provide a convenient alignment for the haul route but also minimize the height of the bridge abutments above the underlying bedrock.

After several options were presented to Fairborn Cement Company, a structure-type study was completed and coordinated with ODOT to determine the final location and bridge type for the project. The structure-type study included initial construction and life-cycle costs and determined that a 145-ft-long single-span bridge with wide-flange precast, prestressed concrete I-beams was the most cost-efficient structure to meet the requirements of the 90-ft-wide haul road with a minimum 35-ft vertical clearance. The haul road width allows two large CAT-775F dump trucks to safely pass beneath the bridge at the same time, and the vertical clearance allows the trucks to safely pass beneath the bridge with their beds fully extended upward. A shorter (60 ft) span that would allow only one truck to pass beneath the bridge at a time was considered, but an economic analysis determined that the greater initial cost of a longer bridge would be offset by increased efficiency in the mining operations over the next 30 years. Because Fairborn Cement Company had the expertise and equipment required for rock excavation, it performed much of the blasting and excavation work to cut the haul road, which reduced its total cost for bridge construction.

The 72-in.-deep beams were produced with semi-lightweight concrete (125 lb/ft^3) to reduce the shipping weight. The beams were placed using one crane on the quarry floor and one crane above on State Route 235.



Bridge profile showing the significant height difference between the two abutments, which is due to the relatively level bedrock elevations and the 5.06% grade of State Route 235. The semi-integral abutments on spread footings were set back from the rock face to allow access for bridge inspections.

OHIO DEPARTMENT OF TRANSPORTATION, OWNER (CONSTRUCTION PRIVATELY FUNDED BY FAIRBORN CEMENT COMPANY)

BRIDGE DESCRIPTION: Single-span, 145-ft-long, wide-flange prestressed concrete I-beam bridge with composite reinforced concrete deck on semi-integral, reinforced concrete wall-type abutments supported by spread footings on underlying bedrock stabilized with post-tensioned rock bolts and nontensioned rock anchors supporting a reinforced shotcrete wall

STRUCTURAL COMPONENTS: Six ODOT WF72-49 prestressed concrete I-beams, 8.5-in.-thick cast-in-place concrete deck with epoxy-coated reinforcement, cast-in-place concrete spread footings, wall-type abutments, and reinforced shotcrete walls

BRIDGE CONSTRUCTION COST: $2.9 million

AWARD: 2020 American Council of Engineering Companies of Ohio Honor Award

Substantial wall-type abutments were constructed with cast-in-place concrete and epoxy-coated reinforcing bars to support the 145-ft-long single-span superstructure. The spread footings are founded on underlying bedrock.

The 40-ft bridge roadway width was coordinated with ODOT to ensure that it adhered to ODOT's design guidelines and specifications for a rural principal arterial route with average daily traffic of 4720 vehicles and a design speed of 60 mph. The bridge is on a tangent alignment and was strategically designed with no skew to simplify the design and construction. The 5.06% straight profile grade was designed to match the existing grade along SR 235 to limit the bridge approach roadway work and minimize overall construction costs for the project.

Superstructure Design

The bridge was designed for the American Association of State Highway and Transportation Officials (AASHTO) HL-93 live loading and a future wearing surface of 60 lb/ft^2, as required by ODOT. Six ODOT-standard 72-in.-deep WF72-49 prestressed concrete I-beams spaced at 7 ft 5 in. were used for the 145-ft-long span. The beams were designed with a draped strand pattern using 0.6-in.-diameter 270-ksi low-relaxation prestressing strands, a minimum concrete compressive strength of 6 ksi at transfer, and a final design strength of 7 ksi. Local precasters were consulted early in the design process to verify that routes were available to ship the large beams to the site. Semi-lightweight concrete (125 lb/ft^3) was recommended, and ultimately specified, to reduce the shipping weight of the beams by more than 16%. ODOT does not have a standard practice for using semi-lightweight concrete for prestressed concrete beams, but the material has been approved for previous value-engineering proposals. Material specifications and testing requirements were coordinated with ODOT and based on similar local projects.

The bridge cross section incorporated a composite 8.5-in.-thick cast-in-place, reinforced concrete (4.5-ksi) bridge deck with Grade 60 epoxy-coated reinforcement, which is the standard for bridge decks in Ohio. ODOT standard single-slope concrete barriers were used on each side of the 40-ft bridge roadway width, creating an overall bridge width of 43 ft 4 in. A 6-ft-tall vandal-protection fence was installed on top of the barriers.

Bridge Abutments and Rock Stabilization

The bridge structure-type study concluded that using spread footings founded on and keyed into the underlying bedrock for the cast-in-place, reinforced concrete wall-type abutments was more cost effective than using drilled shafts socketed into bedrock. The rear and forward abutments are 15 ft and 24 ft tall, respectively—the significant height difference is due to the relatively level bedrock elevation and the 5.06% grade of SR 235. The team used semi-integral construction at the abutments where the ends of the I-beams are supported by elastomeric bearings and the beams are encased in a 3-ft-6-in.-wide reinforced concrete end diaphragm that is rigidly connected to the bridge approach slab. The semi-integral end diaphragms connected to the approach slabs allow the bridge superstructure to expand and contract with respect to the abutments while eliminating joints at the ends of the span, thereby increasing the durability of the structure. The abutment footings were strategically placed a minimum of 10 ft horizontally from the top of the slope, which was more than the offset required for the bearing capacity, to enable annual ODOT abutment inspections to be completed more safely.

The poor quality of the underlying bedrock meant rock stabilization was required to support the spread footings. Rock stabilization was also essential to improve safety for the construction personnel working near the top of the rock slope. The top 5 ft of bedrock was laminated and required post-tensioned rock bolts, anchors, and wire netting to stabilize the laminated rock. Beneath this layer, nontensioned rock anchors were used in the competent bedrock as a conservative, long-term stability measure. After the rock was stabilized, geocomposite drainage curtains, reinforcing steel, and welded-wire reinforcement were placed on the rock face and covered with an 8-in.-thick layer of shotcrete. For added protection, an epoxy-urethane concrete sealer was applied to the entire shotcrete face.

Conclusion

From the outset, this project's critical success factors included providing a cost-efficient bridge solution, maintaining Fairborn Cement Company's budget, adhering to ODOT design specifications, ensuring safety during construction, meeting MSHA's safety guidelines for the quarry, and completing the project by the end of 2018. The design team met all objectives.

Concrete bridge construction provided a low-maintenance, durable, and long-term solution for the quarry haul road beneath SR 235—it not only allows Fairborn Cement Company to expand its mining operations but also improves safety for the community and residents in Greene County, Ohio, for many years to come.

Daniel Springer is a principal, project manager, and senior bridge engineer and Angela Tremblay is a senior bridge engineer with LJB Inc. in Miamisburg, Ohio.

Post-tensioned rock bolts, anchors, and wire netting were used to stabilize the upper layers of laminated rock. The remainder of the wall was connected to the rock using nontensioned anchors. An 8-in.-thick shotcrete facing with reinforcement was then placed on the rock face and sealed with an epoxy-urethane sealer for added corrosion protection.