Lying in the center of North Dakota, just a short distance north of Fort Lincoln (where General Custer began his fateful journey to the Little Bighorn), the historic city of Mandan has preserved its Old West legacy, in part, through an extensive renovation of Fort Lincoln. Situated at the intersection of Interstate 94 and the Missouri River, Mandan is also known as a railroad town. Indeed, the town has one of Burlington Northern’s major switching yards located in the heart of the city. The confluence of these railroad tracks and the traffic between Fort Lincoln and Mandan has brought about the construction of the first prestressed concrete railroad bridge in North Dakota.

Built in 1943, the original underpass on North Dakota’s Highway 1806 allowed for only two lanes of vehicular traffic, and the vertical clearance of the structure restricted its use by many trucks. However, the decision to replace the old structure posed several problems for the designers.

- The existing structure was located on the mainline of the Burlington Northern Railroad. Coal trains, many 100 units in length or longer, used the tracks each day. Therefore, it was imperative that traffic be maintained on three tracks at all times during the construction period.
- Elevation changes would not be allowed in the new design. The site is at the end of Burlington Northern’s switching yard; large displacements of the tracks would not be feasible.
- The existing underpass surface elevation was only 2 ft (0.61 m) above the ground water. To provide adequate vertical clearance, the new roadway had to be built below the water table.
- In 1989, North Dakota residents would be celebrating the state’s centennial anniversary. The crowds expected for the July celebration could triple the normal population of Mandan, and a major construction project would not be allowed in the downtown area at this time.
The first prestressed concrete railroad bridge in North Dakota spans 72 ft (21.9 m) and is built on 25 AASHTO Type IV girders. Completed 9 months ahead of schedule, the structure was made ready in plenty of time for the state centennial celebration.

Historically, railroad structures in North Dakota have been built with structural steel. However, after consulting with Burlington Northern officials in Denver, it was determined that a prestressed concrete structure would be a viable alternative. Preliminary estimates by the bridge design division revealed that the concrete alternative was, by far, the most economical solution, and the steel design was abandoned.

The new bridge, designed for a Cooper E-80 Railroad live loading, would be a single span structure 72 ft (21.9 m) in length, and it would allow for four lanes of vehicular traffic. An 8 ft (2.44 m) pedestrian walkway on each side of the roadway was also included in the design. With 25 AASHTO Type IV prestressed concrete girders, each 54 in. (1372 mm) deep, the structure was designed to carry four railroad tracks, one mainline and three spur tracks, for a total width of 81 ft (24.7 m). See drawings for details.

To accommodate train traffic while the bridge was being built, two shoofly (temporary) structures were let to contract in the spring of 1987. These were placed on each side of the existing structure, with ample room reserved for construction of the new bridge. Construction of the shoofly structures was completed in the fall of 1987.
1987 and work on the new structure was scheduled for the spring of 1988.

The citizens of Mandan, concerned that the project would interfere with the centennial celebration, wanted the project to be completed by July 1, 1989, the date the celebration was scheduled to begin; the heavy traffic occasioned by the celebration would be unmanageable if it had to be detoured around the underpass. This tight time frame dictated a healthy incentive clause in the contract for an early completion. An amount of $3000 per day would be paid for opening the overhead to rail traffic before October 15, 1988, and $5000 per day would be paid for opening North Dakota 1806 to vehicular traffic prior to August 15, 1989.

Before the actual construction of the replacement bridge could get started, the water table had to be lowered. The water table was approximately 10 ft (3.05 m) above the finished roadway, and several methods of solving the perpetual problem were explored.

Continuous pumping of the water was one method considered. This would require that 500,000 gallons (1892.5 m³) of water be pumped each day for the next 100 years. However, the prospect of constant pump and pipe repairs, a required back-up system, and the unknown effect on the city water supply made this solution unappealing. Another alternative was to use a steel sheet piling cofferdam which would encircle the entire underpass, but any faults in the system would be impossible to pinpoint and repairs would be extremely difficult and expensive.

The ultimate solution was a large concrete "bathtub." The structural design was straightforward, the tub could be built using conventional materials, and repairs could be made from the surface. The slab was designed to be 350 ft long x 75 ft wide (106.7 x 22.9 m), varying in depth from 2 to 8 ft (0.61 to 2.44 m). The 4850 cu yds (3708 m³) of concrete seal would be totally encased with 3743 sq yds (3130 m²) of 60 mil (1.52 mm) waterproof-
Fig. 3. A large concrete “bathtub” was created to lower the existing water table. Here, workers are pouring the seal slab.

Fig. 4. The concrete seal was encased in a waterproofing system.
Fig. 5. Trucks delivered girders to the jobsite. The timing of the deliveries was crucial because train traffic could not be delayed.

ing (Bituthene 3000 waterproofing system with PVC waterstops). Because of the massive pours required, the specifications called for a maximum concrete temperature of 60°F (16°C) and a minimum placement rate of 100 cu yds (76 m³) per hr.

With these preliminary problems addressed, and with the conditions of the completion times determined, the underpass was let to contract on March 25, 1988. The low bidder was Industrial Builders, Inc., of Fargo, North Dakota, and the contractor was on the jobsite in less than a month to begin construction.

Careful attention to the details and delivery schedules of all materials helped the contractor maintain an aggressive timetable. In addition, a hot, dry summer facilitated the use of two construction shifts to work around the clock.

The prestressed concrete girders were produced in Menoken, North Dakota, which is about 20 miles (32.18 km) from the jobsite. The 54 in. (1372 mm) girders proved to be an excellent choice: the depth was the minimum needed, and the weight allowed for a lower impact factor than the comparable steel design. A special thickened end block was used. Provisions were made in the girders to attach cast-in-place diaphragms at the third points.

The detensioning strength of the concrete, 5500 psi (38 MPa), controlled the design. With only two girders produced at each setup, it was imperative that the design strength be attained overnight. A Type III cement with superplasticizer was used to achieve this goal. The average strength attained after 1 day was 6282 psi (43 MPa), and the average strength at 21 days was 7112 psi (49 MPa). The pre-stresser worked 6 days each week to meet an anticipated July 15 delivery date.

On July 25, the girders were delivered to the jobsite. Careful coordination with the railroad was required because the shoofly structures were used to situate the trucks.
Fig. 6. To help the cranes in the unloading process, the delivery trucks were driven on the shoofly.

Fig. 7. Two cranes were used to unload each girder.
Fig. 8. After this photograph was taken, the final four girders were put in place. All 25 girders were placed in position within 2 days.

Fig. 9. Stay-in-place forms were used to hasten deck construction. Shown here is the deck steel in place prior to the pouring of the concrete.
Fig. 10. North Dakota's first prestressed concrete railroad bridge was opened to rail traffic on August 16, 1988, and the underpass was opened to vehicular traffic in November.

Two cranes were used to set each beam in place, and all 25 girders were in place within the next 2 days.

Stay-in-place deck forms were used to hasten the deck construction. Within 5 days, the diaphragms had been formed and poured, the deck had been formed, and the reinforcement had been placed, ready for the deck concrete. The deck was placed in 1 day. Within another 8 days, the deck had attained a concrete strength of 5000 psi (34 MPa) and the superstructure was ready for ballast and tracks.

On August 16, 1988 — only 144 days after the project was let — rail traffic was back to normal in Mandan. On November 12, the entire project was completed, 9 months ahead of schedule. The cost of the structure was approximately $7 million, which includes a $1.5 million bonus for early completion and $700,000 for the shoofly structures.

The designers of this project had wanted a structure that could be constructed quickly and that would be maintenance free. Prestressed concrete has proved to be the right choice. The citizens of Mandan, who helped drive the piling, pour the concrete and manufacture the girders, have a structure of which they can be justifiably proud as they prepare for their centennial celebration.

Credits
Owner: State of North Dakota and City of Mandan, North Dakota.
Engineer: North Dakota State Highway Department. Ray Zink, chief engineer; Forest Durow, bridge engineer; David Leer, design engineer; and Doug Fercho, project engineer.
Contractor: Industrial Builders, Inc., Fargo, North Dakota. Warren Diederich, owner; and Ron Langeberg, project superintendent.
Precast Prestressed Concrete Manufacturer: North Dakota Concrete Products Co. (a Member of the Cretex Companies, Inc.), Bismarck, North Dakota.