SH 198 Bridges on Cedar Creek Reservoir

The Texas Department of Transportation's (TxDOT) top priority is safety. At the same time, we are committed to providing high-quality, longer lasting highways and bridges while reducing construction time and traffic congestion. We work to balance these priorities against a backdrop of challenges: a need for intensified construction activities to restore the nation's aging transportation system; capacity that has increased little in the past two decades; and growing communities and increasing traffic volumes. Fresh thinking and innovation are required to meet these challenges.

Prefabricated bridge construction can help minimize traffic delays and community disruptions by reducing onsite construction time and improving project quality, traffic control, and safety. Using prefabricated bridge elements and systems means that time-consuming formwork construction, curing, and other tasks associated with fabrication can be done off- site in a controlled environment without affecting traffic.

Although Texas has used prefabricated bridge elements for decades, the potential of prefabrication to reduce traffic interruptions and improve constructability has stimulated increasing bridge design innovation within TxDOT in recent years. TxDOT is developing new ways to incorporate prefabrication into bridge design as it responds to growing public demand for improved traffic flow in urban areas and minimal traffic disruption during construction.

A goal of the Cedar Creek Reservoir projects was to create a signature aesthetic design while providing rapidly constructible and cost efficient structures. The interior bent caps utilized the precast bent cap option that included a cap-to-column connection and a specific construction procedure. The connection design included reinforcing steel dowel bars that protrude from the columns into the precast caps via open ducts that are grouted after cap placement.

The Caney Creek project was the first of the three SH 198 bridges on Cedar Creek Reservoir to be rebuilt. The existing bridge was a 24-ft wide pan girder bridge, 1680-ft long. It had 42 spans of 40-ft each. There was 500-ft of causeway on each end of the bridge. The clearance over water was 3'-4". The new bridge is a twin 38-ft wide pre-stressed Tx70 girder bridge with 22 spans of 120-ft each, with a total span of 2640-ft. The causeway was eliminated and the clearance over water was increased to 8'-23'. The two-phased construction started in 2008 and finished in 2010. To speed up the construction, mostly prefabricated elements and accelerated bridge construction techniques were used to replace the bridge.

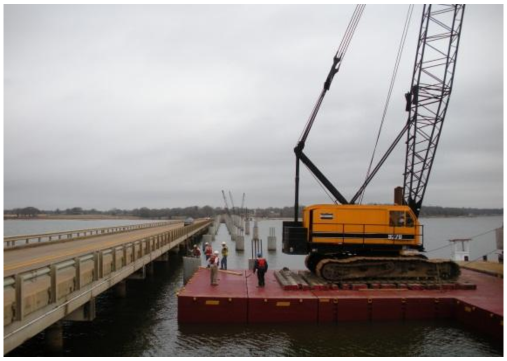


Figure 1. Existing Caney Creek Bridge

Figure 2. New Caney Creek Bridge

The Twin Creek project was the second SH 198 bridge rebuilt on Cedar Creek Reservoir. The existing 1840-ft pan girder bridge was replaced with a total length of 3840-ft - 32 spans of 120-ft each. The two-phased construction started in 2008 and finished in June 2012.

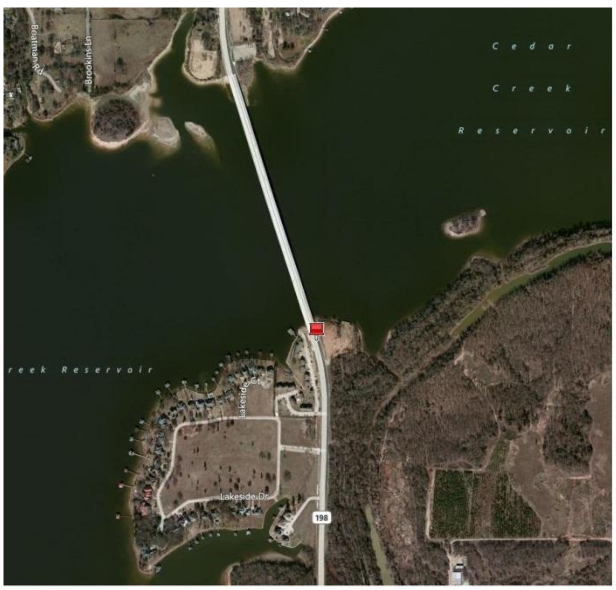


Figure 3. Satellite photo of the Caney Creek Bridge

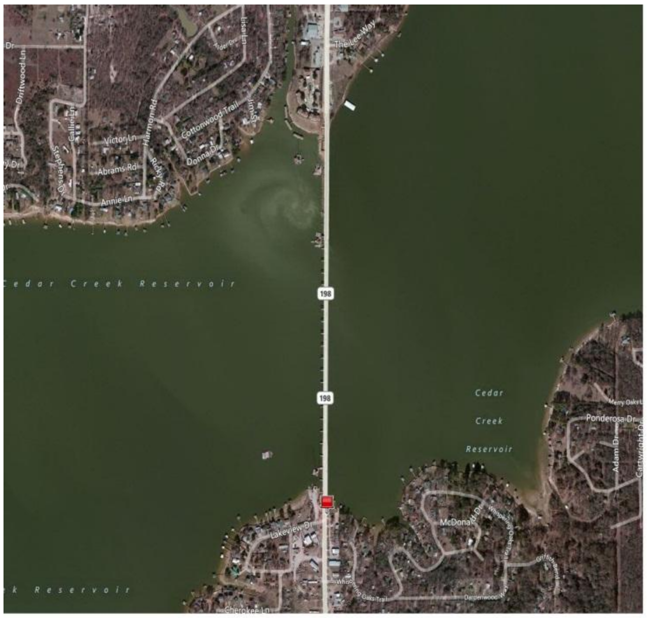


Figure 4. Satellite Photo of Twin Creek Bridge

Figure 5. Twin Creek Bridge

FOUNDATION, SUBSTRUCTURE AND SUPERSTRUCTURE;

Foundation:

The bridge foundation typically uses drilled shaft, 42 in. diameter at the abutments and 48 in. diameter at the interior bents. The drilled shafts are designed to resist the accidental forces for causeway boats. The contractor used a split casing for drilled shaft concrete. One of the connection in the split casing was broken when concrete was pumped into the split casing. Then they had to remove the concrete and used a closed casing for drilled shafts for the entire project.

Precast Bent Cap

The caps are precast caps with 4.0’ X 4.0’ dimensions. The precast caps were stored in a manner to avoid chipping or cracking before placement. Specific instructions were given to the contractor requiring that the caps be supported on firm blocking until placed and shimmed into final position. The caps were placed on columns after the column concrete achieved a flexural strength of 355 psi or 2500 psi compressive strength. Friction collars were used to support the caps at the proper elevation prior to grouting. All grout for the precast connection consisted of prepackaged, cementitious, non-shrink grout in accordance with ASTM C-1107 and additional specifications. The grouted duct connection type is inexpensive, construction tolerances are acceptable, and there is very minimal interference with cap reinforcement. Considering the durability of the connection, they are well protected connectors and have very limited exposed top surface. The connection type is a very simple anchorage design approach.

The precast bent cap option accelerated the construction of the 21 consecutive bents and avoided the difficulties of handling formwork and materials over water. To achieve a strong, ductile, durable and constructible precast cap-to-column connection, the designers based the precast cap design on the TxDOT research project 1748, “Development of Precast bent Cap System”, which was conducted by the University of Texas, Austin. Four-inch diameter steel corrugated ducts were precast at full height into the cap. These ducts consist of eight no. 11, grade 60 reinforcement bars that extend from the tops of the cast-in place concrete columns. Spiral reinforcement in the cap around the perimeter of the connection zone improves the strength and ductility and provides service-level crack control. (See Figure 6 & Figure 7)
The connection was designed in the following steps:

- Frame analysis was used to determine connection actions. Connection and column forces were determined by the worst-case boundary conditions such as a pinned or rigid connection at the top of the column.
- A connector configuration was selected based on spacing, clearance, and minimum connection reinforcement requirements. The configuration was also patterned to maximize the eccentricity of the bars and to fit within the limits of flexural reinforcement steel of the bent cap.

- The connector configuration was selected by evaluating strength and serviceability performance. Strength was evaluated in terms of an axial load-bending moment response of the cross section with the connection configuration. Shear friction at the bedding layer and joint shear were also evaluated. Serviceability performance was evaluated by traditional elastic analysis under service loads.
- Uncoated reinforcing steel with Grade 60 was selected for the connection, since the structure is in a non-corrosive environment.
- Confining spiral reinforcement steel for each connection was provided to enhance ductility and increase section strength.
- To facilitate rapid bent cap production, TxDOT allowed its standard four-day cure time to be interrupted by a maximum of 2 hours to facilitate removal of caps from the forms if a flexural strength of 355 psi and compressive strength of 2500 psi were achieved. Similar allowances were permitted for column curing for setting the caps.

Thedesigners used the specifications for grout performance based on requirements of ASTM C-1107, "Packaged/dry hydraulic-cement grout (non-shrinkable)", augmented by specific requirements; The following Table-1 shows the grout performance specifications:

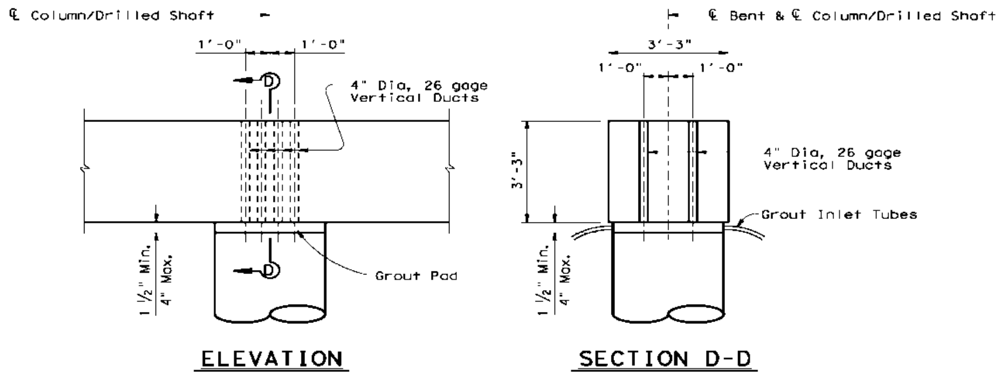
Property	Values
MECHANICAL	Age Compressive Strength (psi)
Compressive Strength(ASTM C-109, 2" cubes)	1 day 2500 3 days 4000 7 days 5000 28 days 5800
COMPATIBILITY Expansion Requirements (ASTM C827 & ASTM C-1090) Modulus of Elasticity (ASTM C-469)	Grade B or C ~ expansion per ASTM C1107 $2.8 – 5.0 \times 10^{6}$
Coefficient of thermal expansion (ASTM C-531) Flowability (ASTM C-939) CRD-C 611 Flow Cone) Set time (ASTM C-191) Initial Final Durability Freeze Thaw (ASTM C-666)	$3.0 – 10.0 \times 10^{6}$ /deg F Fluid consistency efflux time: 20-30 seconds 2.5-5.0 hrs 4.0 – 8.0 hrs 300 cycles, RDF 90%

Grout with metallic formulations, chlorides, and external additives was prohibited. Grout was pressure pumped from the bedding layer, using the open tops of the vertical ducts at the top of the cap as an indicator of a fully grouted connection.

An option to precast the bearing seats was provided, and the connector chose to do any one option. Cast-in place bearing seats provide flexibility and account for height errors, but precast bearing seat would not require casting over water. With either approach the contractor could choose a level cap and variable bearing seat height to accommodate the cross slope of the roadway.

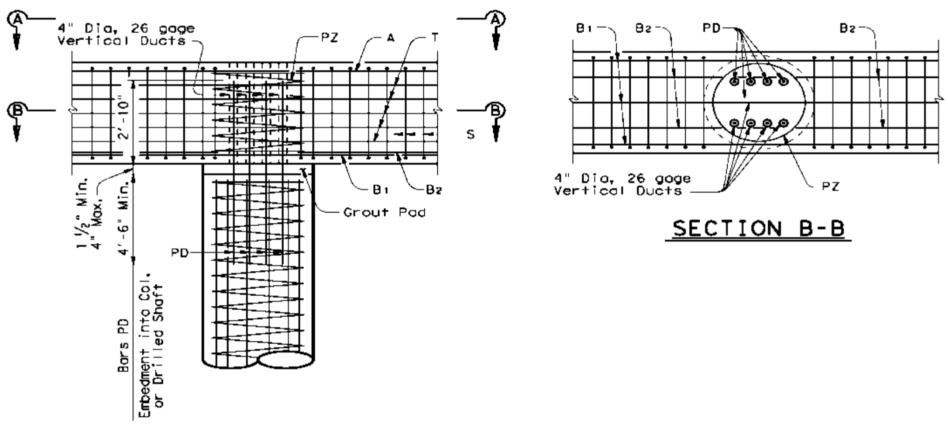
The contractor precast the bent caps. Pre-tied reinforcing cages were laid into steel forms and concrete was placed. When sufficient strength was achieved, the caps were removed and stored to continue curing. Drilled shaft and column construction were conducted while the precasting operation continued.

A special template formed the final lift of concrete for the columns and helped accurately locate the projecting connection dowels. When the columns had cured sufficiently, the caps were loaded onto barges and transported for erection. Friction collars were placed on the columns to support a work platform and to provide temporary support and grade adjustment for the 56 ton caps. Once the cap was placed in the correct grade, special circular collar forms were placed at the bedding layer between the cap and column to assist in pressure grouting. These forms had one input for the pressure grouting and three vents to ensure full grouting of the bedding layer. Workers finished the top of the grout once it reached the top of the vertical ducts at the top of the bent cap. The contractor estimated placement time of one bent per day, saving about six months over traditional cast-in-place concrete cap. This allows for easy inspection from the ground and improves work-zone safety by preventing construction work over water.



DETAILS SHOWING DUCT PLACEMENT

Figure 6



DETAILS SHOWING DUCT REINFORCING

Figure 7

Figure 8. Precast Cap and Connection Detail

Super Structure:
The Caney Creek Bridge has TX 70 precast prestressed concrete girders with 11-ft spacing for an overall width of 40-ft. The precast panel option was used for partial depth of the concrete deck. Panel placement started at the centerline of the bents and continued to the end without thickened end slab. The precast panel placement saved time and money. It improved worker safety and minimized formworks. The deck slab has 54 precast concrete panels that are 8 ft. long x 8.6 ft. wide x 4in thick for each span of 120-ft center to centerline of bent.

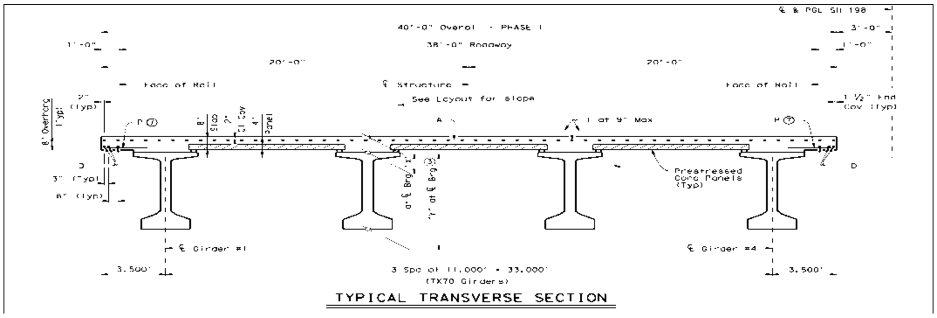


Figure. 9

Figure. 10

Precast Panel Placement:
The deck slab consists of 4-inch precast panels and 4-inch cast-in place slab. The panels start at the center line of each bent and run towards the next span. There is no thickened end slab. Bars “E” were placed over the centerline of each bent for continuity. The panel lengths are very critical for placement. The gaps between the panels were corrected by placing backer rods.

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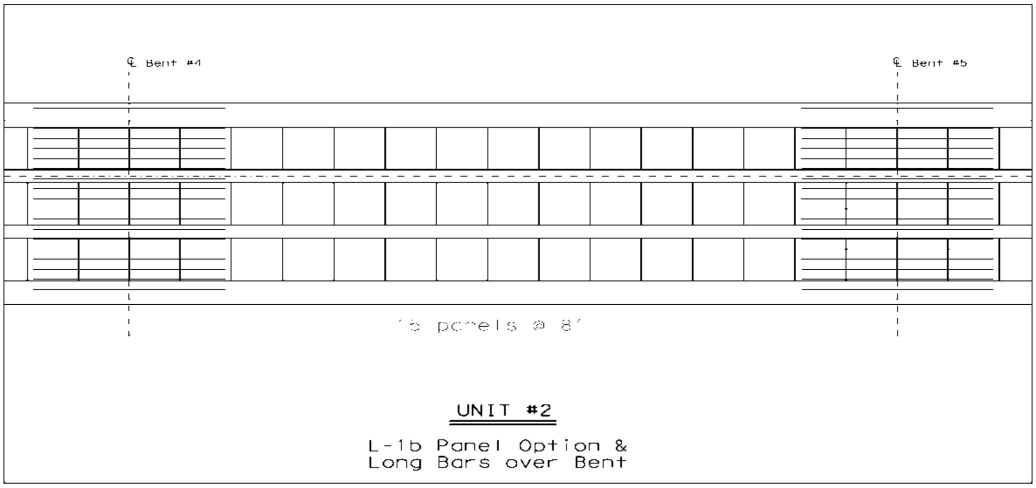

Figure. 11

Figure 12. Precast Panel Placement

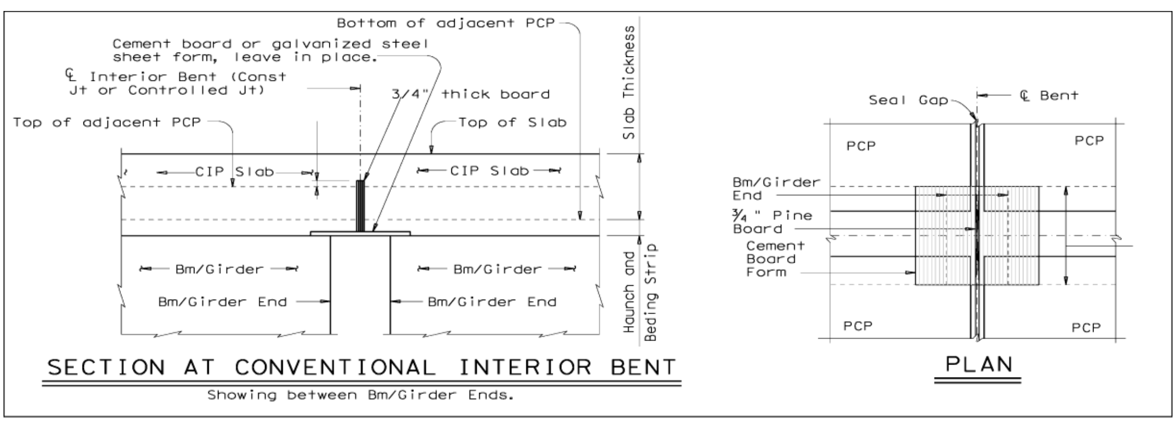

Figure. 13

Figure 14. Caney Creek Bridge (completed structure)

Project Schedule:

The contract was awarded for Caney Creek Bridge on May, 2008 and work started in June. Construction was completed and the bridge opened to traffic in 2010.

The contract for Twin Creek Bridge was awarded in July, 2010. Construction was completed and the bridge opened to traffic in June, 2012

Construction Contracts:

The total contract amount was $21.8 million for Caney Creek and $21.0 million for Twin Creek. Primary contractor: Concho construction company Inc.

Conclusion

Traditional reconstruction of cast-in-place caps requires a minimum of six months or longer than the precast bent cap option. The total construction time was reduced for both bridges. The clean lines of the bridges and the precast cap option with the open rail provide an attractive solution. The rapid construction of the interior bents without cast-in place concrete minimized the construction time and work zone duration. This also saved the cost of formwork and traffic disruption. The lessons learned from the Caney Creek Bridge were applied to the Twin Creek project. The precast panel option increased the speed of the deck construction process and reduced construction duration by one year.

Figure 15. Two point lifting of precast bent cap

Figure 16. Placing precast bent cap into column connection dowels in phase 1

Figure 17. Lowering Precast Bent Cap into friction collars

Figure 18. Placement of precast bent cap for 21 bents at Caney Creek

Figure 19. Caney Creek – Phase 2 (Phase 1 completed and open to traffic)

Figure 20. TX 70 Girder - Lifting and Placement

Figure 21. Column with friction collars