RAPID BRIDGE REPLACEMENT PROJECT for the TANGLEWOOD BRIDGE

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ABSTRACT

The Texas Department of Transportation (TxDOT) is implementing innovative bridge design and construction techniques to reduce traffic disruption and construction project duration while enhancing safety for the motoring public and constructability for the contractor. This initiative is supported by research projects, new design techniques resulting from research findings, and evaluation of field performance data for prefabricated systems in service. An example project in this initiative is a new bridge near Beaumont, Texas, that will use rapid bridge construction technology and precast concrete bridge components.

The replacement bridge will be a totally prefabricated bridge with limited on-site construction operations such as pile driving, precast member erection, connection grouting, and post-tensioning. The bridge structure will be completed in a period of four days or less. The bridge is 60 ft long and 35 ft wide, and it will comprise two precast concrete abutments supported by precast concrete piling and a single span of prestressed concrete box beams with an integrally installed railing. The project is scheduled for contract letting in the fall of 2005.

Keywords: Prefabricated, Precast, Concrete, Bridge, Construction, Accelerated.

INTRODUCTION

Transportation system owners are under increasing pressure to deliver projects more rapidly. Bridge construction is a primary example, and prefabricated bridge elements and systems are a key technology to meeting this goal. Prefabrication and other accelerated construction techniques can reduce construction time, increase work zone safety, mitigate environmental impact, improve quality, and lower costs.

State transportation agencies often partner with local municipalities or counties to construct off-system bridge structures. Off-system structures are so named since they are not on roadways owned and maintained by the state. When federal bridge replacement funds are used to construct these structures, the state becomes involved in their planning, design, and construction. The state is also responsible for the inspection of these structures regardless of how they were funded.

Off-system bridges are an important element of the Texas transportation system: 16,300 of Texas' 48,500 bridge structures are off-system bridges. 13% of these off-system structures are structurally deficient, and another 23% are functionally obsolete. Off-system bridge projects have the following characteristics:

- Off-system bridges are often shorter in overall length than on-system bridges (200 feet or less in length with one to three short spans).
- Off-system bridges are usually narrower in width (24, 28 or 30 feet) than on-system bridges.
- There is less free board provided so off-system bridges may be more prone to overtopping by floodwaters and the chances of drift in the waterway may be higher. Span-to-depth ratios need to be small to provide requisite hydraulic performance and to reduce the additional expense of raised approach work.
- The average daily traffic counts (ADT) may be lower but the size of the vehicles using the structures may be just as large (i.e. school buses and oil field equipment) as on-system bridges.
- Site access can be difficult for large construction equipment because of narrow width roads, sharp curves and steep grades leading up to off-system bridges. Distances and travel times from concrete ready mix plants can be problematic.
- Construction costs may be higher due to remoteness of the site.
- A detour route around a bridge site closed for construction can be very long due to the lack of other roads in the area. In some cases, closure of the bridge would leave residences or businesses land-locked, an unacceptable situation. Typical means of keeping the crossing open to traffic such as phased construction or building an adjacent temporary bridge might not be possible given right-of-way restrictions and the condition of the existing structure.

If this last characteristic holds true for a bridge replacement project, accelerated construction techniques are warranted.

The Tanglewood Bridge is a prototypical off-system bridge replacement project. The bridge was selected as a demonstration of accelerated bridge replacement in a low risk setting. The realigned alignment for the new structure allows the existing structure to be used by motorists during construction. It is envisioned that the demonstrated success of this project will lead to usage on projects where such alignments are unavailable and speed of construction is critical.

The existing structure is a multi-pipe culvert at an unnamed creek tributary of the Neches River. The culvert regularly overtops during storms and it is the only means of access to approximately 50 homes. (Figures 1 – 3) Rapid construction will improve work-zone safety because the bridge is on a tight 240 ft radius blind horizontal curve on a roadway with a 30-mph design speed. Minimal environmental impact is desired because the bridge is in an environmentally sensitive wetland, a coastal management area near the Bessie Heights Marsh of the Nelda C. Stark Wildlife Management Area. No equipment access will be allowed in the creek and hydraulic issues require a shallow depth superstructure solution.

The replacement bridge will be a totally prefabricated bridge with limited on-site construction operations such as pile driving, precast member erection, connection grouting, and post-tensioning. The bridge structure will be completed in a period of four days or less. The bridge is 60 ft long and 35 ft wide, and it will comprise two precast concrete abutments supported by precast concrete piling and a single span of prestressed concrete box beams with an integrally installed railing. The structure has a 20 degree skew and constant 1.5% cross slope. The project is scheduled for contract letting in the spring of 2005. Figure 4 shows the bridge layout.

Fig. 1 Aerial View of Project Location

Fig. 2 Existing Structure to be Replaced.

Fig. 3 Existing Structure During Heavy Rainfall.

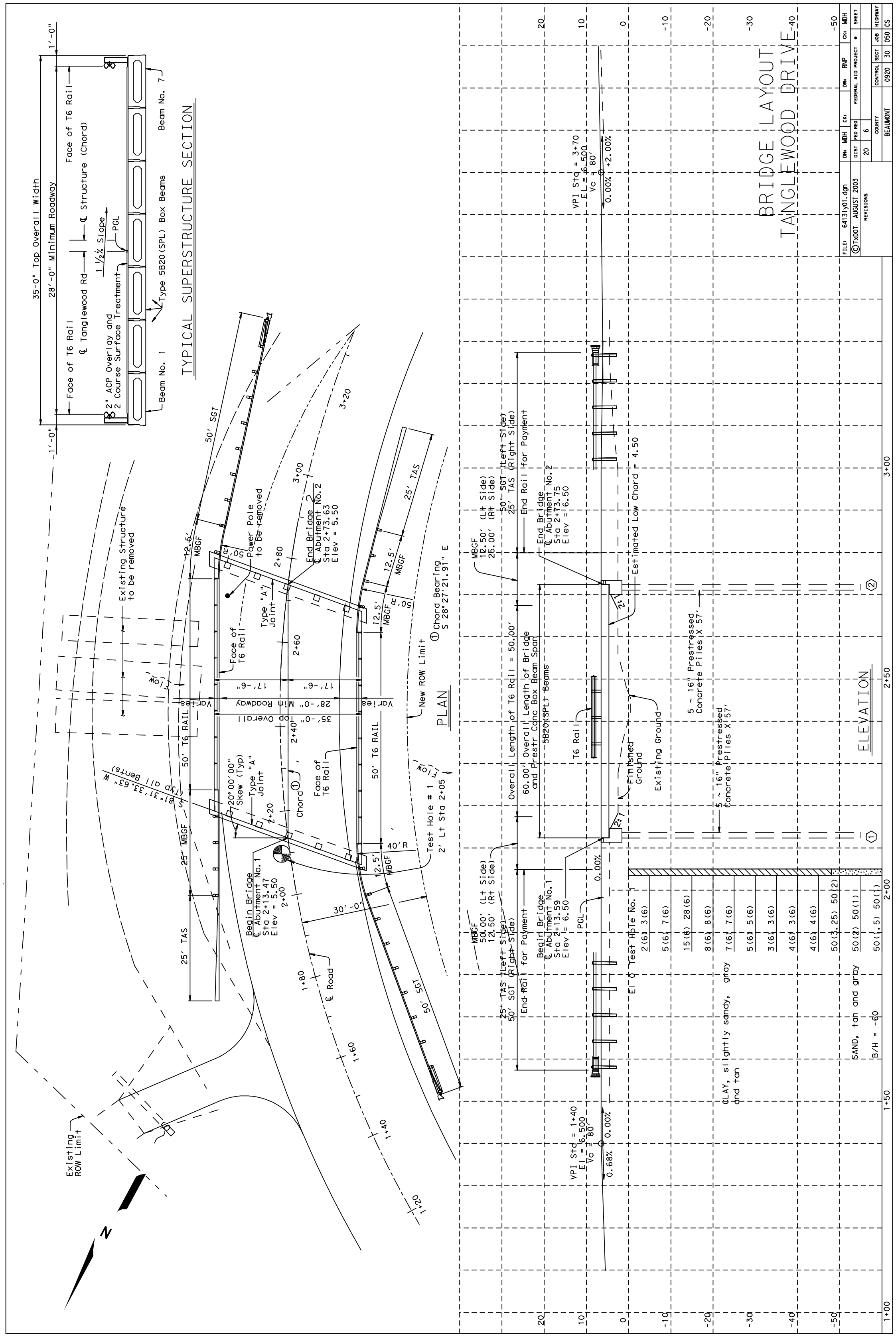


Fig. 4 Bridge Layout

BOX BEAM SUPERSTRUCTURE

The site constraints required a single span structure with minimal depth. The existing normal water surface elevation is only 3.5 ft below the highest possible finished profile grade line for the roadway. The abutments needed to be pulled far enough back from the centerline of the creek to provide adequate hydraulic opening and to avoid disturbing the channel. This evaluation suggested a 60 ft span, and hydraulic analysis indicated a 2 ft deep superstructure would allow passage of the 100 year flood event. A traditional slab and stringer bridge could not span this distance in this depth.

A system of precast prestressed beams placed side-by-side would be most effective in minimizing depth and maximizing construction speed. The AASHTO LRFD Bridge Specifications[1] refers to these as "Precast Deck Bridges", which typically incorporate precast/prestressed members with solid, voided, box, T- and double-T cross-sections. Solid/voided slab beams and box beams have the best span-to-depth ratio among these sections, though slab beams reach maximum possible span length around 50 to 55 ft in length. As such, box beams were a logical choice for the superstructure design. Figure 5 shows the superstructure cross-section.

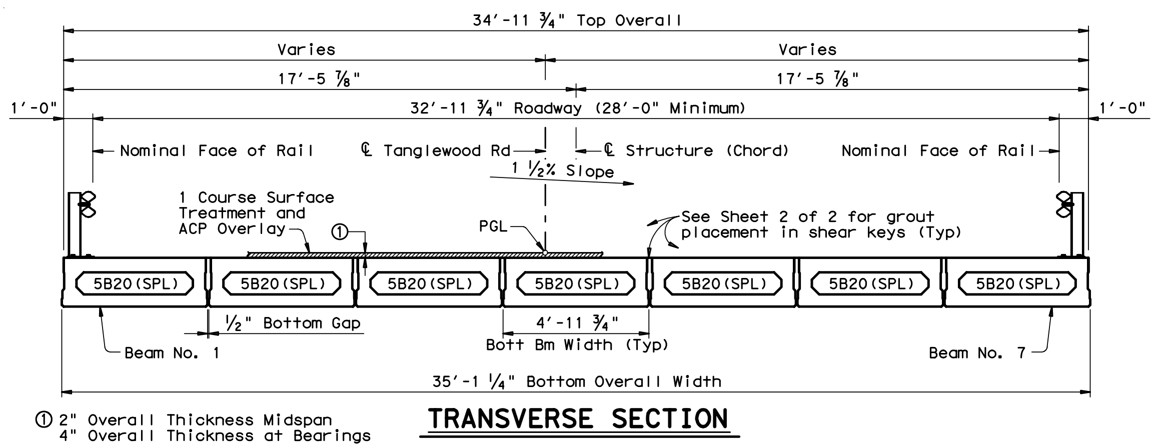


Fig. 5 Superstructure Cross-Section

CONVENTIONAL TXDOT BOX BEAMS

First used in the late 1960s, TxDOT box beams have featured cross-sections of 20 in, 28 in, 34 in, and 40 in depth, and 48 in and 60 in width. The shear keys of TxDOT box beams have been large compared to their AAHSTO/PCI counterparts, using the side form of the Type A prestressed I-beam shape for most depths. Blockouts for cast-in-place diaphragms provided a transverse tie and handling of wheel loads at the ends, as well as means for installing armor plate expansion joints in the field. The beams are placed side-by-side, the shear keys and diaphragms filled with a conventional concrete mix, and the bridge nominally post-tensioned transversely. The beam topping originally consisted of a sealing two-course asphalt surface treatment and a top surface of approximately 2 in of asphaltic concrete pavement. Similar to other states, TxDOT has experienced reflective cracking in the pavement and durability issues with these structures. To alleviate these problems, TxDOT has more recently used a nominal 5" composite concrete slab as a beam topping, though the option of direct topping with asphaltic overlay is still exercised on low volume roads.[2]

TANGLEWOOD BOX BEAMS

With the goal of a 4-day maximum construction time on the Tanglewood Bridge, cast-in-place shear keys and end diaphragms would require too much time for strength gain and curing. A special box beam design incorporating a smaller shear key, non-shrink grout, transverse post-tensioning at end and interior locations, and a simple joint system was developed for the project. The box beam cross-section is 5 ft wide and 20" deep, making it compatible with existing box beam prestressing lines of Texas fabricators. Figure 6 shows beam cross-section. Each beam will weigh approximately 25 Tons.

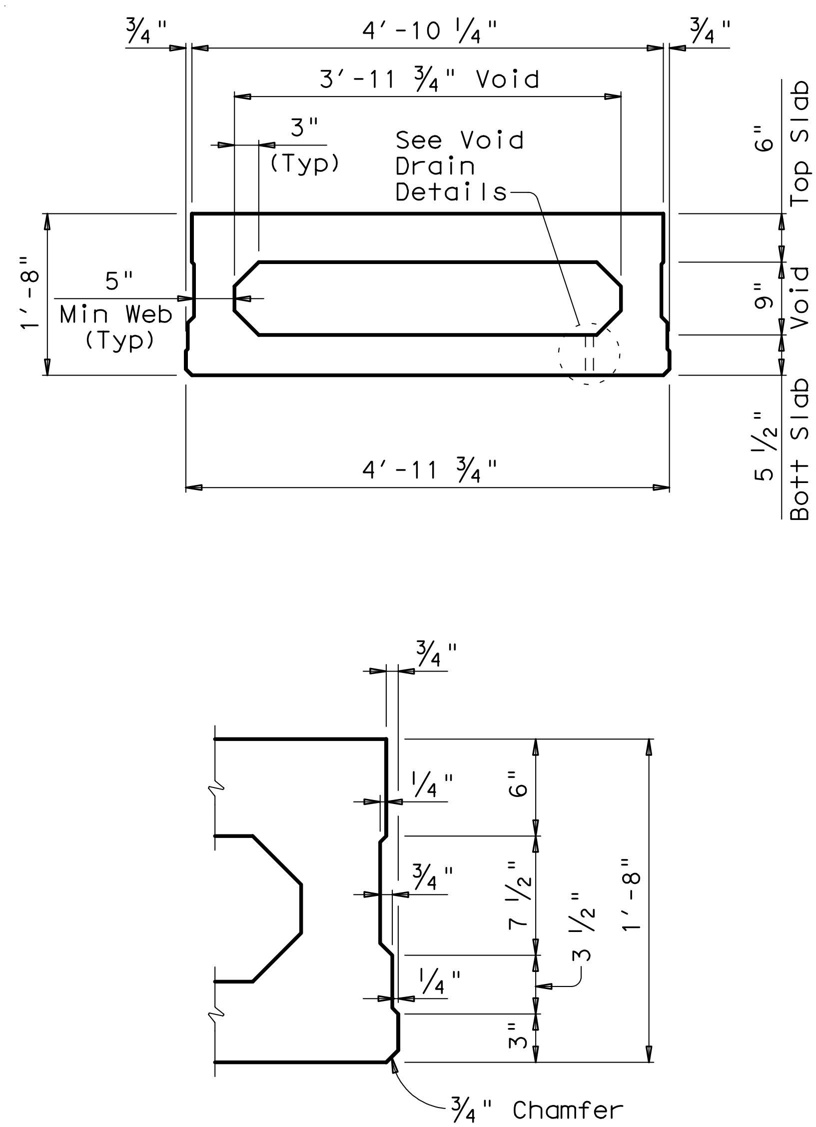


Fig. 6 Beam Cross-Section

Because of their past performance problems, the transverse joints have been investigated extensively in recent years. These recent investigations have examined the depth of the grouted portion of the shear key, the shear key grout material, and the amount and arrangement of post-tensioning (if used).[3,4,5,6]

Smaller grouted shear keys have been used with the AASHTO/PCI sections that were originally developed in the early 1960s.[7] Figure 7 shows the dimensions of these sections and their shear keys. Typical past design practice placed the beams side-by-side with a nominal ½" gap, placing a backer rod or similar forming material just below the bottom of the shear key, and filling with grout. As such the filled shear key would represent a depth of approximately 20% to 50% of the total depth. In these multibeam bridges, wheel loads force adjacent members to deflect simultaneously. In addition to the shear force transfer required, differential torsional rotations in the beams cause tension and compression in the transverse direction.[8] The shallower shear keys tend to crack and leak leading to durability problems. In recent years, designs incorporating deeper grouted shear keys have been developed to combat this problem.[3,5,6]

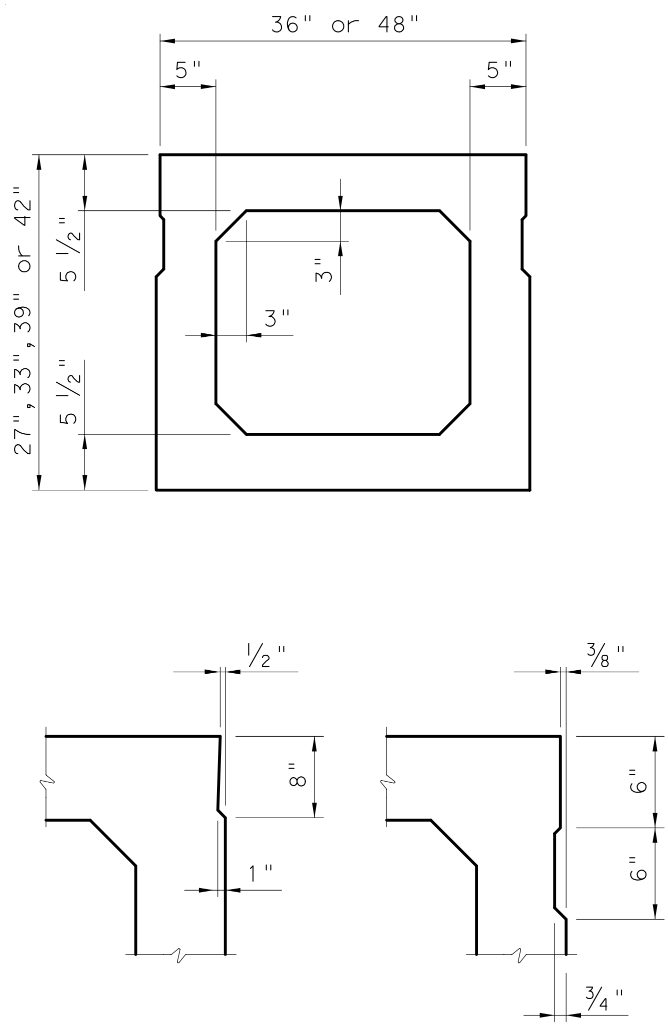


Fig. 7 AASHTO/PCI Box Beam Sections

Another area of focus with shear key performance has been the grouting material and installation procedures. Grouts simply composed of batched cement, sand, and water exhibit shrinkage cracking. Most designs specify non-shrink prepackaged cementitious grouts. Alternate grouts such as magnesium ammonium phosphate mortars and polymer modified concretes have been reported to have superior performance.[4] Currently, many owners consider these materials risky given the care and expertise required for their installation. In the case of non-shrink cementious grouts, the keyed surfaces should be cleaned and pre-wetted to enhance bond.[7]

Transverse post-tensioning is necessary to provide tensile capacity and limit cracking across the shear key joints. The post-tensioning is provided either in the form of high-strength threaded bars or strands at solid beam diaphragm locations. TxDOT standard box beams without composite concrete topping typically use a single ½" diameter 270 ksi monostrand or 5/8" diameter Grade 150 threaded bar at a 10 ft maximum spacing. The AASHTO LRFD Bridge Specifications arbitrarily require 250 psi of effective prestress across these joints. El-Remaily developed a methodology to estimate the post-tensioning required to resist the transverse flexure due to live load and composite dead loads.[5] The developers of this method and a few states have advocated the use of upper and lower levels of post-tensioning at each diaphragm to counter the positive and negative bending that will occur. In the case of the Tanglewood project, it was impractical to provide two separate upper and lower post-tensioning locations in the diaphragms due to the shallow section. Diaphragms were provided at the ends and at a spacing of just under 10 ft using single unbonded 1" diameter Grade 150 threaded bar. The threaded bars were preferred because they are easier to install, achieve a higher post-tensioning force per section, and provide greater joint stiffness.

ABUTMENTS AND FOUNDATIONS

TxDOT typically uses "stubbed" or "perched" abutments, constructed by driving piling or drilling shafts and placing a cap, backwall, and wingwalls on top. The cap supports the beams and transfers their loads to supporting drilled shafts or piling. The backwall separates the embankment from the beam ends, while the side wingwalls keep the sideslopes away from the structure and provide a mounting for the guard rail to bridge rail transition.[2]

For the Tanglewood project, a typical stubbed abutment was selected but with a precast cap and backwall section. Wingwalls were not required because of the thin superstructure depth, gentle topography, and lack of need for wingwall mounting of the rail. The cap was designed longer than the superstructure width so flanking earwalls or cheekwalls could protect the beams from earth slopes.

PRECAST PRESTRESSED PILE FOUNDATIONS

This region of Texas has deep clays of low to moderate strength that indicate the use of prestressed concrete piling. From a construction speed perspective, piles are preferred to drilled shafts. For shallow superstructure sections, the combined depth of backwall and cap is small enough to permit the use of vertical piles instead of battered piles to resist lateral earth pressure and live load surcharge behind the abutment. The design for the Tanglewood project utilizes 5 vertical 16" square prestressed concrete piles with a length of 57 feet each at each abutment. The lengths were conservatively set to allow the piles to be either driven to proper elevation or cut off, avoiding the time intensive process of a pile buildup. It is estimated that it will take approximately 45 minutes to deliver, handle, and drive each pile.

PRECAST ABUTMENTS

Figure 8 depicts the general details for the precast abutments. The precast abutment section is almost 40 ft long, and includes a 3'-3" wide by 3'-0" deep cap and 1'-0" wide by 1'-10½" tall backwall. Total weight is approximately 35 Tons, a size that can be handled by a single crane with two lifting locations. The precast section utilizes conventional Grade 60 reinforcing and TxDOT Class "C" concrete of 3,600 psi compressive strength. The precast abutment section can be precast by a fabricator or the contractor, and is required to conform to requirements of TxDOT Standard Specifications Item 420 "Concrete Structures", including the requirements for 4 days of curing.

PILE-TO-CAP CONNECTIONS

The pile-to-cap connections utilize a precast void measuring 1'-11" x 1'-11" x 2'-0" over each pile location. The pile must project a minimum of 1'-4" into this void, which is subsequently infilled with non-shrink cementitious grout using a 6" diameter access hole from the top of the cap. This detail allows approximately ±3" variation in pile plan and vertical location. In previous work, TxDOT has developed connections between precast piles and precast bent caps using grouted vertical ducts and grouted pocket connections in association with conventional steel reinforcing.[9] While these details provide better tensile capacity, they are more time-consuming and have less construction tolerance.

Previous work has established that simple embedment of precast prestressed piles into cast-in-place caps can sufficiently develop the capacity of the piles.[10] As long as sufficient bond strength is developed between the grout and the precast members, similar performance can be expected. The Tanglewood project specifies a corrugated form, sandblasting for roughening, and high pressure wash to remove latent material for the precast abutment blockouts. The precast piles require 3 ~ 1" wide x ½" deep saw grooves or roughening to ¼" amplitude, as well as sand-blasting and water-blasting. Figure 9 indicates these details.

After driving piles and excavating enough room, the cap is lowered into place and supported either on friction collars attached to the outside piles or temporary reaction footings. Shims or adjustable jacks will allow for elevation adjustment. Once final grade and plan location has been achieved, the blockout forms beneath the cap can be installed and the connections grouted. After the grout obtains a compressive strength of 3000 psi, beams may be placed. The same grout will be used for both the box beam shear keys and for the pile-to-cap connections.

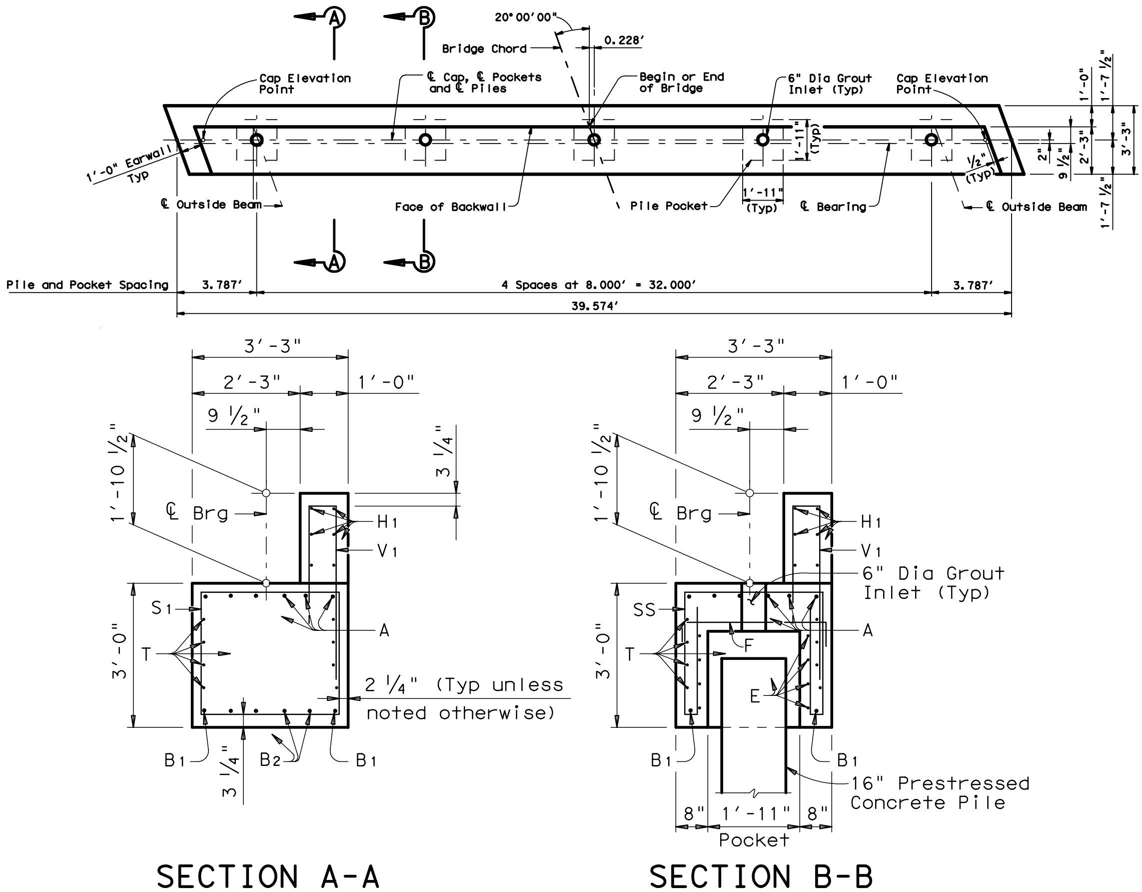


Fig. 8 Precast Abutment Details

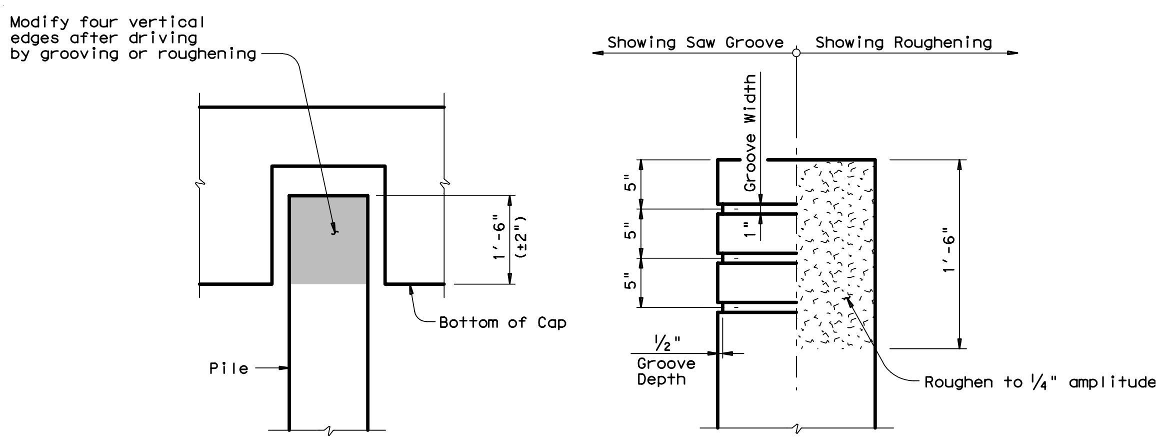


Fig. 9 Pile Connection Detail

OTHER BRIDGE DETAILS

Installation of piles, precast abutments, and superstructure are major tasks in the accelerated bridge construction. However, additional items include backfill of the abutments, bridge expansion joints, bridge rail, and riprap protection.

ABUTMENT BACKFILL

Backfill will be required to fill the excavation behind the precast abutments. On off-system bridges such as this, ordinary backfill material obtained from excavation or other sources is usually specified. In addition, this backfill material is placed using ordinary compaction in 8 in thick lifts. Ordinary backfill compacted in this manner would take a few hours to complete and cost $10/CY.

Cement-stabilized backfill, flowable backfill, or gravel backfill are other options that exhibit less settlement and build more quickly, though at a greater cost. Cement-stabilized backfill involves select aggregate, usually sand, combined with a minimum 7% hydraulic cement and water. Cement-stabilized backfill has been the traditional means of abutment backfill in areas with concerns for approach settlement with or without a bridge approach slab. Because cement-stabilized backfill must be placed in lifts and compacted, it still takes some time. Flowable backfill involves a fluid mixture containing cement, water, sand, fly ash, and entrained air with the possible addition of course and/or fine aggregate and admixtures. Flowable fill is thin enough to flow when placed, self-leveling, and self-compacting. The material is low strength with 28-day compressive strengths typically between 80 and 150 psi to permit future excavation, but strong enough at early age to carry traffic within hours.[11] It is estimated that flowable backfill for this project may take minutes to complete and cost $75/CY. TxDOT is finalizing selection of the backfill method for this project.

EXPANSION JOINTS

Expansion joints allow for expansion and contraction of the superstructure due to temperature changes and for rotation and translation due to live load. Open armor joints or sealed expansion joints are typically used in new construction (Figure 10). The joint openings are typically in the range of ¾” to 2” and the steel plate protects the corners of the concrete against damage due to wheel loads. These joints are not ideal for accelerated construction because they require cast-in-place closure pours for anchoring their projecting steel stud attachments. With conventional concrete mixes, these cast-in-place closure pours would require a minimum of 4 days curing. Precasting the steel plate into the abutment backwall or beam ends is not practical given concerns with construction tolerances.

In the case of short span structures, the amount of thermal expansion is minimal. The 60 ft span of the Tanglewood bridge is expected to experience a maximum of ±¼” of longitudinal deformation. In these situations, TxDOT often uses a “Type A” joint, involving a ¾” opening with bituminous fiber material, a backer rod, and 1½” of silicone sealant (Figure 11). However, the Type A joint is typically used in applications where the abutment backwall and top of CIP slab or CIP diaphragm concrete represent finished grade. The Tanglewood bridge uses an ACP overlay on the superstructure to accommodate variations in beam camber and precast abutment backwall elevation. This is of little consequence since the approach roadways already involve ACP overlay. However, simply carrying the overlay over the joint will result in cracking and rutting in the overlay. To avoid this, a special joint detail involving saw cutting the overlay over the joint and applying hot poured rubber is used (Figure 12). The fabric joint underseal reinforces the protective surface treatment and prevents the pavement from being forced into the opening below. While the 1" opening is the maximum possible installed joint width from a pavement performance perspective, it is necessary to provide some tolerance for the backwall location and lengths of the precast beams. Traditionally, TxDOT provides 2" to 3" gaps for prestressed concrete beam sections, but the lack of a cast-in-place diaphragm dictates the smaller opening.

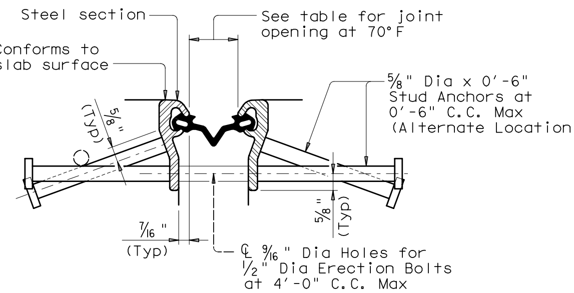


Fig. 10 Example of Sealed Armor Expansion Joints

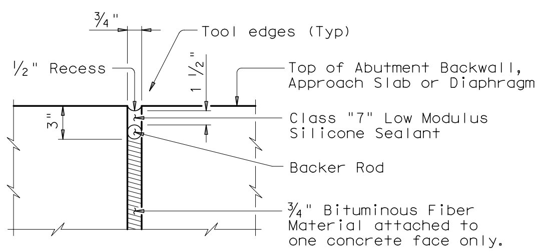


Fig. 11 TxDOT Type "A" Joint

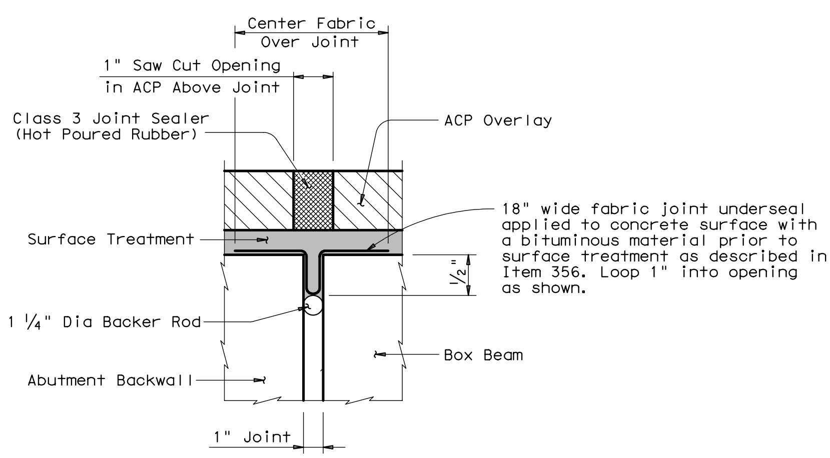


Fig. 12 Joint for Tanglewood Bridge

BRIDGE RAIL

The bridge rail consists of 50 ft lengths of TxDOT Type T6 rail, an open steel beam and post railing often used on low speed off-system bridges (Figure 13). The railing is 27 in high with two W-beam members welded back to back and posts spaced at 6.25 ft. This rail system restrains errant vehicles using the strength and flexibility of the tubular W-beam sections while the weak posts are intended to break free in the vicinity of the impact. Since the posts fracture at the base plate, little or no damage is carried into the bridge superstructure. The T6 rail is essentially a prefabricated element that can be preassembled as part of the outer beams or installed quickly after the beams are erected. Attachment anchors for the rail base plates are cast into the box beam cross section by the fabricator.

RIPRAP PROTECTION

Traditionally, TxDOT uses concrete riprap, stone riprap, or gabions to protect the header banks at bridge abutments against scour and erosion. However, in the case of the Tanglewood Bridge, the gentle topography and slow stream flows made riprap protection unnecessary.

Fig. 13 Texas Type T6 Bridge Rail

CONSTRUCTION SCHEDULE AND CONTRACTUAL PROVISIONS

Because this is an accelerated bridge project, TxDOT developed a detailed construction schedule with the aid of critical path method scheduling software. This provides an understanding of the relationship of all the tasks and estimated duration for the replacement. Because of the timeframe involved, the scheduling was based on an hourly resolution. Based on a 12 hour workday, the CPM schedule indicated that replacement in 96 hours was feasible (Figure 14). Based on 24 hour workday, the CPM schedule indicated that replacement in 48 hours was feasible.

Simply providing details that would allow the bridge to be built quickly is not enough to meet this goal in construction. Alternative contractual strategies are necessary to give the contractor motivation to complete the job in an accelerated fashion. These strategies include:

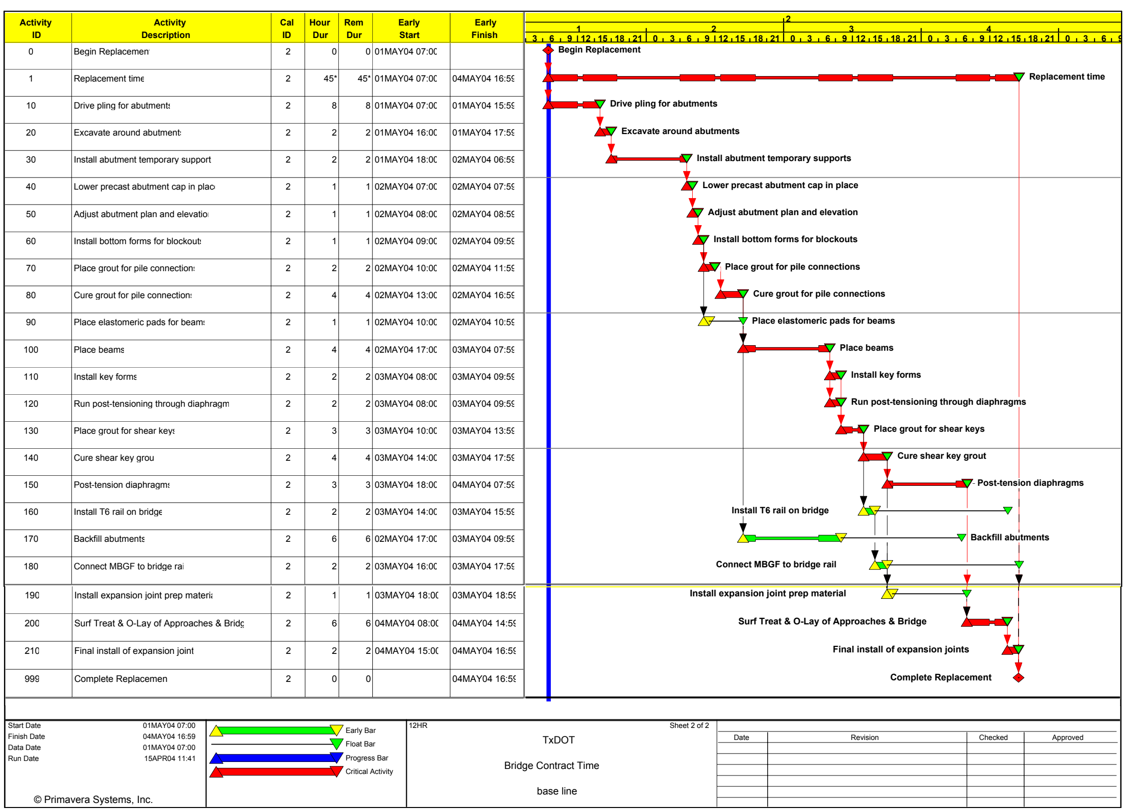
- Liquidated Damages – financial penalties for late delivery
- A+B Bidding – cost plus time bidding based on a combination of contract bid items (A) plus the time bid for construction multiplied by daily road user cost (B)
- Incentive/Disincentive – financial bonus or penalty for delivery before or after a set time, with a typical specified maximum
- No Excuse Bonus – modified incentive with no time adjustment for problems such as weather, utility conflicts, etc. regardless of who is responsible
- Lane Rental – assessed rental fee for lanes taken out-of-service during temporary lane closures for construction
- Calendar Day – project schedule based upon a number of days for completion, instead of days where work activities take place, effectively transferring weather risks to the contractor
- Work Week Definition – used in combination with the Calendar Day can define the number of days a week where work activities take place (5, 6, or 7)

The typical financial means for defining time are daily road user costs and TxDOT costs for administering the project.[12]

The Tanglewood Bridge replacement involves a separate alignment with approximately 430 feet of approach roadway work consisting of embankment fill, 8 in of asphalt stabilized base, and 2 in of ACP overlay. Off-system bridge replacements that involve maintaining the same horizontal alignment will typically have less approach roadway work. For this project, an accelerated bridge construction phase was defined separate from the other work items in the contract, primarily approach roadway work.

The accelerated bridge construction work period was estimated to be 96 hours based on the CPM schedule. Because of the short time frame involved, the traditional units of time were changed from days to hours during this accelerated phase. In addition, the working time definition was revised to 24 hours per day and 168 hours per week. Completion of the bridge replacement before the estimated 96 hours would result in a bonus of $500 per hour with a maximum award capped at 48 hours. While this exceeds combined user costs and contract administration costs, the bonus represents realistic costs for additional manpower and equipment necessary to complete the work in a rapid timeframe. The work outside the bridge replacement phase will be based on a 5-day per week calendar day definition. For the entire contract, time will be charged regardless of weather conditions, materials, or supplies which could impede the prosecution of the work. Time beyond the 96 hours allocated for the bridge construction phase and the duration allocated for the entire project will be charged via liquidated damages totaling approximately $400/day.

The date when the accelerated construction period could begin will not be predetermined in the contract. The contractor will have the flexibility to choose this date and time considering weather forecast and the availability of materials, manpower, and equipment. In a complete bridge closure situation, TxDOT would dictate a date/time or a series of possible dates/times that minimize impact on residents, motorists, businesses, and/or natural environment. These set dates would consider lead time for ROW acquisition, utility adjustment, permits, fabrication, weather, and any other relevant factors. The accelerated bridge construction period will commence with beginning Pile Driving and end with Backfilling Abutments and Installing Expansion Joint Prep Material. Work items such as installing approach guardrails/transitions/end treatments, surface treatment/overlay of the bridge, and final expansion joint installation are not included since they are associated with the more extensive approach work. While such tasks will be limited for replacement on the same alignment, these would need to be considered and accelerated on such a project.



Activity ID	Activity Description	Cal ID	Hour Dur	Rem Dur	Early Start	Early Finish
0	Begin Replacemen	2	0	0	01MAY04 07:0C	
1	Replacement time	2	45*	45*	01MAY04 07:0C	04MAY04 16:59
10	Drive pling for abutments	2	8	8	01MAY04 07:0C	01MAY04 15:59
20	Excavate around abutments	2	2	2	01MAY04 16:0C	01MAY04 17:59
30	Install abutment temporary support	2	2	2	01MAY04 18:0C	02MAY04 06:59
40	Lower precast abutment cap in plac	2	1	1	02MAY04 07:0C	02MAY04 07:59
50	Adjust abutment plan and elevatio	2	1	1	02MAY04 08:0C	02MAY04 08:59
60	Install bottom forms for blockouts	2	1	1	02MAY04 09:0C	02MAY04 09:59
70	Place grout for pile connections	2	2	2	02MAY04 10:0C	02MAY04 11:59
80	Cure grout for pile connections	2	4	4	02MAY04 13:0C	02MAY04 16:59
90	Place elastomeric pads for beams	2	1	1	02MAY04 10:0C	02MAY04 10:59
100	Place beams	2	4	4	02MAY04 17:0C	03MAY04 07:59
110	Install key forms	2	2	2	03MAY04 08:0C	03MAY04 09:59
120	Run post-tensioning through diaphragm	2	2	2	03MAY04 08:0C	03MAY04 09:59
130	Place grout for shear keys	2	3	3	03MAY04 10:0C	03MAY04 13:59
140	Cure shear key grou	2	4	4	03MAY04 14:0C	03MAY04 17:59
150	Post-tension diaphragms	2	3	3	03MAY04 18:0C	04MAY04 07:59
160	Install T6 rail on bridge	2	2	2	03MAY04 14:0C	03MAY04 15:59
170	Backfill abutments	2	6	6	02MAY04 17:0C	03MAY04 09:59
180	Connect MBGF to bridge rai	2	2	2	03MAY04 16:0C	03MAY04 17:59
190	Install expansion joint prep materi	2	1	1	03MAY04 18:0C	03MAY04 18:59
200	Surf Treat & O-Lay of Approaches & Bridg	2	6	6	04MAY04 08:0C	04MAY04 14:59
210	Final install of expansion joint	2	2	2	04MAY04 15:0C	04MAY04 16:59
999	Complete Replacemen	2	0	0		04MAY04 16:59

Fig. 14 Replacement Schedule

FUTURE TXDOT BRIDGES FEATURING PREFABRICATED ELEMENTS

TxDOT is committed to delivering highway projects, including bridges, more quickly. Several bridge projects are under development with non-traditional prefabricated bridge elements.

WACO IH-35 BRIDGES

Four overpass structures carrying Loop 340 over Interstate 35 on the south side of Waco, TX will use a totally prefabricated bridge construction system. The system facilitates bridge replacement in a couple of weeks instead of many months. Replacement of bridges with minimal impact to traffic is critical on IH35 through South and Central Texas because it is the busiest segment of the Interstate Highway System and a key portion of the NAFTA trade corridor. The superstructure was designed with competing steel and precast concrete alternatives, and the concrete alternative was the low bid. The steel alternative featured trapezoidal steel box girders with a full depth, full length, and partial width precast bridge deck cast on each beam prior to erection. The concrete alternative featured trapezoidal precast prestressed girders with a similar deck that is cast prior to erection. In both cases, the girders with integral slab are placed side-by-side and small cast-in-place closure pours form the longitudinal connection.[13] A total of 5 precast steel girders or 7 precast concrete girders form the overall 58'-3" bridge width of two mainlanes bridges. A total of 4 precast steel girders or 76 precast concrete girders form the overall 48'-3" bridge width of two frontage road bridges. The bridges are designed for a shallow superstructure depth of 3'-4" to carry the 115 ft spans. The design also features precast substructure in the form of hollow precast column sections that directly support each beam line for the interior bent, and precast abutment caps. Both are supported by drilled shaft foundations.

FM 1684 FRP BRIDGE

Texas' second FRP bridge is currently being designed for a bridge replacement project on FM 1684 near Austwell in Refugio County in South Texas. The proposed bridge is a 50-ft long by 32-ft wide single-span crossing of a drainage channel. Prefabricated FRP beams and deck panels will comprise the superstructure. Because they are so lightweight, the FRP beams and deck are expected to support rapid bridge replacement, which is especially attractive in off-system bridge environments where heavy equipment may have access problems. The construction time of prefabricated FRP panels will be measured in hours compared to the one to three weeks associated with reinforced concrete. FRP bridge decks are also attractive for deck replacements when construction speed or increased live load capacity, resulting from the lighter weight material, is required. The high initial fabrication cost of FRP is tempered by the anticipated life cycle benefits of the durable material.

DRY CREEK BRIDGE

The Dry Creek Bridge is a bridge replacement project on FM 774 near Refugio, Texas. The rapid bridge replacement will involve a 5 to 7 day (or perhaps shorter) complete road closure. Reasons for rapid bridge replacement versus conventional methods involving longer term road closures or phased construction include a long detour route, limited ROW, avoiding construction easement in heavily vegetated areas, and minimizing interruption to emergency services for nearby residents. The three-span 150 ft long bridge will include a precast prestressed concrete double tee superstructure with ACP overlay, and precast prestressed trestle pile substructure with optional precast abutment and bent caps. The double tee superstructure will incorporate TxDOT-sponsored research on "Lateral Connections for Double Tee Bridges", which developed simplified connection methods.[14]

COMMISSION CREEK BRIDGE

The Commission Creek Bridge is a bridge replacement project on FM 1453 in Lipscomb County of the Texas Panhandle. The rapid bridge replacement will involve a 1 to 2 week complete road closure and is located in a remote region where delivery of concrete is difficult. The four-span 160 ft long bridge will be completely prefabricated. The substructure will consist of steel H-piles and precast bent caps. The superstructure will consist of precast prestressed slab beams with grouted shear keys and transverse post-tensioning.

CONCLUSIONS

TxDOT and other state DOT's are implementing prefabricated bridge techniques to accelerate construction. The Tanglewood Bridge is an example of a fully precast bridge that overcomes the specific challenges of a typical off-system replacement situation. By prefabricating components such as piles, beams, abutments, and rails, on-site construction operations can be minimized to a duration of under one week. Durable and constructable details, critical evaluation of schedules, and alternative contracting strategies are key components on such projects. TxDOT will be reporting on construction and in-service experience with these projects in the future.

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