Everyday ABC in Texas

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INTRODUCTION

Though not as flashy as highly publicized rapid bridge replacements, Texas has seen great success in utilizing prefabricated elements from the ground up to increase speed and quality in almost all aspects of bridge design and construction. With readily available materials that allow for production of high-performance concrete at low cost, the Texas Department of Transportation (TxDOT) is particularly reliant on precast concrete elements. There are a large number of precast concrete producers in Texas, and as an industry they have an excellent history of collectively pursuing and implementing innovative prefabricated technology. Similarly, TxDOT works with steel fabricators and manufacturers of many other bridge elements to implement new ideas and technology. As more and more emphasis is being placed on speedy construction, Prime Contractors around the state have increasingly embraced the concept of maximizing the use of prefabricated elements. In addition to drastically increasing construction production rates, utilizing prefabricated elements also ensures high quality since the products are fabricated in highly controlled plant environments. Finally, utilizing prefabricated elements drastically increases safety by reducing the amount of construction time and by eliminating much of the more dangerous work (e.g. forming and casting bridge caps in the air). For decades, Texas has relied on precast superstructure and deck elements. In recent years there have been great advances in the use of other bridge elements, including: caps, columns, railing, and unique elements (e.g. winged slab beams). The presentation will cover what Texas has done, is doing, and plans to do with prefabricated elements that allow us to design, build, and maintain high quality, economical bridges all over the state.

PREFABRICATED ELEMENTS

Due to speed of construction and increased quality and safety, the use of prefabricated elements is TxDOT's primary technique for accelerated bridge construction. In the past, TxDOT traditionally only used prestressed beams and panels, but now refabricated elements can encompass practically every element from the foundation up.

Prestressed Beams

TxDOT's first bridge using pretensioned and precast concrete beams started with the *Texas and New Orleans RR Overpass* in Kennedy, Texas, which was completed in 1957. The first significant use of the prestressed I-beam in Texas was over Corpus Christi Harbor in 1959. The bridge was made up of 2,000 ft. of 40 and 60 ft. prestressed concrete I-beams. This was also during the time that the Federal Aid Highway Act of 1956 signed by Eisenhower, provided over $25 Billion over a 12 year period for the development of the Interstate Highway System. As the Interstate Program gained momentum, Texas was able to report the lowest cost per square foot of bridge deck in the country (1). The use of precast elements was a major factor in this low cost. In addition to ensuring low cost and high quality, it also became apparent during these early stages that the use of prefabricated bridge elements also significantly sped up construction. Extensive communication between TxDOT Bridge Division engineers and Texas contractors, along with the development of standard shapes contributed to the rapid development of precast beams in Texas. For several years, the standard details were fine-tuned to fit fabrication capabilities and a variety of geometric configurations. Currently, TxDOT bridge standards support the use of 6 different prestressed beam types: slab beam, box beam, X-beam (spread box beam), TxGirder (I shape), U beam, and decked slab beam. In 2018, roughly 96% of Texas span bridges were built using precast prestressed concrete beams (2).

Prestressed Precast Deck Panels

Prestressed concrete partial depth deck panels (PCP) span between beams and replace the bottom half of the cast-in-place bridge deck. Once in place, the panels form a safe and convenient work platform, enhancing safety, economy and speed of construction. They were first used in Texas in 1963 as an experiment on three bridges for US 75 Expressway in Grayson County. PCP's did not gain popularity until the bid item for reinforced concrete slab began to be measured by the square foot with the specification allowing the contractor to use removable forms, stay-in-place metal deck forms, or PCP's (3). To ensure consistent design, detailing, and construction practices, TxDOT issued the PCP bridge standard in 1978 and continues to maintain and update the standard as research and construction and fabrication practices have progressed. TxDOT has been using precast concrete panels on a large scale since the early 1980's. Today, approximately 97% of prestressed beam bridges use prestressed concrete panels. Not only do the PCP's allow the contractors to quickly construct bridge decks, but it provides for a far safer work environment by eliminating all or most of traditional deck forming.

TxDOT has also used full depth, full transverse width precast panels on different bridges to accelerate bridge construction. The details were developed based on research done under NCHRP 12-65, which developed a system without longitudinal post tensioning. Three bridges in Texas were built with full depth, full transverse width precast panels in the late 1980's (Lubbock Spur 327), 1990's (Georgetown Precast Pavements), and more recently in 2008 (Ozona Live Oak Creek Bridge). Live Oak Creek Bridge consisted of 88 full depth deck panels that were transversely prestressed and passively reinforced longitudinally. TxDOT is currently looking for additional opportunities to expand the use of these panels.

Precast Bent and Abutment Caps

Conventionally reinforced precast bent caps were introduced in the 1990's and used to address issues with conventional cast-in-place caps. TxDOT found that the use of precast bents, compared to cast-in-place bents, improved concrete quality, increased worker safety, and decreased road closure times due to construction. For example, in 1994, TxDOT decided to precast inverted tee straddle bents for a ramp on US 290. Conventional caps would have led to the closure of the lower roadway for 41 days, but by using precast caps, the lower roadway was only closed for 6 hours (4). The use of precast bent caps also offers speed of construction through repeatability. An example of this is Redfish Bay Bridge which is a 0.5 mile structure that was built in 1994. The use of precast bent caps, allowed the contractor to place 44 identical bent caps over the Gulf Coast much faster and safer than if cast-in-place caps were used (4). In January 2012, TxDOT created precast reinforced concrete bent cap standards suitable for multi-column and trestle pile bents in Texas. These standards work with other bridge standards to effectively give contractors the option of precast bent caps on standard bridge projects. They build upon a two-decade history of custom precast bent cap designs using passive mild reinforcing steel at TxDOT. In recent years, TxDOT has developed precast prestressed bent cap designs which capitalize on the capabilities of Texas prestressing plants to generate a durable and accelerated construction product. Prestressed caps offer the same advantages as conventionally reinforced precast caps, but prestressing provides enhanced crack control. TxDOT released precast pretensioned bent cap standards in April 2017 and they are intended to be used as an alternate for bridges using standard drawings.

TxDOT has been precasting abutment caps since the early 2000's. This allows a bridge to be built completely out of precast elements. Bridges have been built with the backwall attached to the cap, as well as with the backwall cast in place after the cap was set. Conventional reinforcing can be used or pretension strands can be used like in precast bent caps. Wingwalls are either precast or the cap is tapered, depending on the surrounding environment. For a precast wingwall option, TxDOT attached the wingwall by bolting it to the abutment cap. The bolts were screwed into coil bolts that were casted with the abutment and then the wingwall was slid on through existing holes.

Foundations and Precast Columns

For foundations, TxDOT has employed the use of steel and precast prestressed piling to save construction time on projects. Steel piling is often coated in an anti-corrosion material to protect the steel and increase durability.

In the mid 2000's, TxDOT constructed a bridge with precast columns to cut down on interstate road closures. The columns consisted of a precast concrete hollow shell that was set on the column reinforcing cage. The steel from the drilled shafts were extended to tie the column steel to the foundation steel. After the hollow column shells were set, concrete was placed in the cavity. The design and details removed the need for the contractor to form up the columns, which would have taken several days to install. TxDOT has also constructed bridges with segmental precast columns to preclude the need for forming and pouring concrete. The joints for this type of column need to be grouted and were found to be a complicated process. TxDOT has not used this type of column on a lot of projects because the outcome did not present a large advantage.

COMPLETE PBES AND MODULAR BRIDGE REPLACEMENTS

For bridges that were in need of an accelerated construction schedule, TxDOT has built bridges where every element was prefabricated including the foundation, substructure, approach slab, superstructure and railing. These bridges have typically been smaller bridges where a road closure would mean an extensive detour for surrounding communities. Oftentimes, rapid construction also minimizes interruption to emergency services for nearby residents.

Bridges have also been rapidly constructed by employing modular systems. In 2016, due to an oversize load impact, TxDOT needed to quickly replace steel beams and a concrete deck with minimal road closures in Houston, TX. Thinking outside of the box, TxDOT designers worked with contractors and fabricators to develop a plan to lift the new steel beams with the preformed metal deck attached to most of the beams. This provided an immediate working surface and allowed the contractor to quickly lay rebar and pour the concrete bridge deck in phases. Another project in Dallas, TX, which is currently under construction, also employs the use of modular components which will be constructed off site, lifted into place, and joined with closure pours between units. The work will be done in two weekend closures that reroutes mainlanes to frontage roads. The plans provide options for the contractor and also include weight and width comparisons.

THE FUTURE

Moving forward, TxDOT will continue to research new technology and innovations. Throughout the years, research has played a huge role in TxDOT's ability to advance prefabricated systems for use on bridges around the state. TxDOT plans to keep moving forward and is currently researching the following ABC type projects: precast columns, modular bridge components, utilization of UHPC bridge superstructures in Texas, and closure joint materials for side-by-side ABC among others.

SUMMARY

Precast prefabricated elements have served the state of Texas well. TxDOT has developed a multitude of standards and design policies to make each component that is fabricated repeatable and consistent. TxDOT's ability to partner with contractors to evaluate schedules and explore alternative contracting strategies also ensure the success of constructing bridges faster, safer, and that are more durable.

REFERENCES

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