PreCast Concrete Alternate Provides Unique Solution for Airport Terminal Bridge

A value engineering alternate using precast, prestressed concrete led to the redesign of the 17-span bridge structure that provides two-level access to the terminal building at the new Austin-Bergstrom International airport in Austin, Texas. The $4.6 million structure is 1400 ft (427 m) long with typical span lengths of 80 ft (24.4 m). An innovative design using standard precast, prestressed trapezoidal U-beams, together with stay-in-place deck panels, was employed. This design proved to be not only aesthetically attractive and structurally efficient, but also substantially reduced construction costs and construction time. This article presents the benefits and unique design features of the precast system, and describes the construction highlights of the project.
participant in the development of the 
U-beam. For background information 
on the development of the U-beam, see 
the article by Mary Lou Rails, P.E.1

The structure (see Figs. 1 and 2) is 
basically a meld between building 
structure and bridge. This unique pro-
ject mandated special consideration for 
architectural character and pedestrian 
appeal, illumination, water control, and 
the support of numerous building ele-
ments on the bridge. To better aid vis-
ualization, three-dimensional computer 
models (3-D CADD), photorealistic 
renderings, and video animation were 
used in presentations to the owner and 
airport architect. The alternate precast 
design was well received, and P.E. 
Structural was retained to complete the 
design and produce construction doc-
uments.

Fig. 3 shows the alternate super-
structure cross section as well as the 
profile of the original bid superstruc-
Fig. 3. Typical cross sections of bridge at terminal building (top) and at curved spans (bottom).

Fig. 4. West half of bridge plan.
ture. The hatched sections indicate the precast concrete U-beams, transition beams, and sub-deck panels. Fig. 4 shows a half plan of the bridge.

The purpose of this article is to present the advantages of the precast system, describe the unique features of the design and discuss the construction highlights of the project.

ADVANTAGES OF PRECAST SYSTEM

The redesigned precast system, utilizing precast beams and deck panels, offered both the contractor and owner many advantages over the original cast-in-place superstructure. Among those advantages are:

• More Efficient Use of Manpower — The contractor estimated that he would have needed a crew of 50 to 60 carpenters to build formwork and shoring for the cast-in-place bid superstructure. His reduced crew of 11 men concentrated on forming the substructure elements and deck overhangs. With the precast design, he was also able to reduce his concrete placing and finishing crews, needing only to cast the bents and abutments, deck topping and overhangs, and infill panels between beams at bents.

• Better Quality End Product — Since nearly all of the substructure is composed of precast elements that are produced in a controlled fabrication plant, the contractor was able to provide the owner with an end product of superior quality and durability as compared to a cast-in-place counterpart. Research at the University of Texas at Austin and elsewhere has shown that the use of precast, prestressed panels with a cast-in-place composite topping results in a more crack-free deck than a full depth cast-in-place concrete deck.

• Increased Safety — The inherent stability of the trapezoidal shaped U-beams eases hauling and increases safety during erection. Once erected, the insides of the U-beams provide stable work areas for crews placing precast deck panels. After they are placed on the beams, the panels create a continuous work surface for the completion of the remaining construction operations at deck level.

• Freed Space for Other Construction Activities — Eliminating the need for what the contractor referred to as a "sea of shoring," which would have been required to construct the cast-in-place bid structure, freed the area under the bridge for use as valuable construction staging areas for the bridge as well as the adjacent terminal building. Construction traffic under the bridge was unhindered during beam erection and deck placement. As a bonus, the erected beams and panels provided much appreciated shade and a cooler work environment during the hot summer months.

• Construction Time Savings — The contractor estimated that he shaved at least two to three months from his anticipated schedule due to the fact that the fabrication of the precast elements could be accomplished off site, simultaneous with the construction of the substructure. The straightforward structural system — simple span precast beams with partially precast deck supported on inverted tee two-column bents — further simplified and accelerated the pace of construction.

• Material Savings — The bid cast-in-place design would have required approximately 29,920 tons (27140 t) of concrete, and 1670 tons (1515 t) of mild reinforcing and prestressing steel. The precast alternate incorporates approximately 25,360 tons (23000 t) of concrete (a 15 percent reduction) and 1290 tons (1170 t) of mild reinforcing and prestressing steel (a 22 percent reduction).

• Cost Savings — Construction costs were reduced from a bid price of $5.2 million for the cast-in-place design to $4.6 million for the U-beam structure, including cost of redesign. Net savings were 11.2 percent.

• Unique Appearance — As a design constraint, the overall geometry of the precast alternate needed to match that of the bid structure. Although the structural depth of both designs is practically identical, the bid structure had a continuous flat bottom soffit. The structural aesthetic for the redesigned bridge evolved from the geometry of the U-beam.

Fig. 5. Cross section of precast U-beam.
The effect of the trapezoidal shaped U-beams coupled with the complimentary detailing of the substructure (see section below) creates a unique large-scale coffered ceiling above the pedestrian space, expands the space vertically, and visually lightens the bridge structure. The end result has generated positive feedback with regard to geometry, proportions, and visual appeal. The structure is user-friendly and engaging.

- **Structural Concrete Finish — Low Maintenance Structure** — The contractor made a substantial investment in steel and laminated plywood forms for the cast-in-place elements in order to achieve comparable quality of concrete finish to that of the precast elements. No additional finishes or treatments were applied to the structural concrete, providing the owner with a virtually maintenance-free structure that will continue to develop a desirable patina with age.

**UNIQUE DESIGN FEATURES**

The precast, prestressed structure has several distinguishing design features as described below:

- **Typical Spans and Dimensions** — Similar to the original design, the precast, prestressed bridge has 17 spans for an overall length of 1400 ft (427 m). The typical length of each span is 80 ft (24.4 m) with a maximum span of 111 ft (33.5 m). The typical beam spacing is 14 ft 1½ in. (4.32 m). The total width of deck is 101 ft 6 in. (31.0 m) for a total deck area of 131,000 sq ft (12200 m²).

- **Emphasis on Aesthetics** — Because the bridge structure is essentially a visual extension of the terminal building, the aesthetic quality of the bridge and its relationship to the terminal building were of utmost importance. Effort was made to emulate the high-tech feel and clean lines of the terminal building.

- **"Marriage" of Building and Bridge** — As opposed to a typical highway bridge, this structure meets transportation needs as well as providing pedestrian access to the terminal and supporting building elements at the upper level. At the lower level, the superstructure serves as a canopy for deplaning pedestrians.

- **U-Beams** — The relatively short typical U-beam spans of 80 ft (24.4 m) in the straight portion of the bridge adjacent to the terminal building did not approach the practical limits for the 40 in. (1016 mm) deep standardized trapezoidal U-shaped section (see Fig. 5), leaving sufficient reserve capacity to resist additional loads (see below). The controlling U-beam spans occurred at the curved ends of the elevated structure. The outside beams in the curved portion are the longest in the system, and must resist the additional load of the increased width of the curved cantilevered slab.

Resistance of the non-composite U-beam section at these locations to self-weight and to construction loads resulting from the placement of the slab would have required excessive concrete strengths and/or reinforcement. These beams (a total of four) were designed using shoring to alleviate this condition by taking advantage of the strength of the composite section to resist the dead weight of the cast-in-place slab.

- **Support of Building Elements** — Centered over the first interior U-beams, granite faced concrete columns supporting the 20 ft tall x
30 ft wide (6.10 x 9.14 m) steel canopies are located at a 40 ft (12.2 m) spacing at the centerlines of bents and at midspan between the bents in the straight portion of the elevated structure.

Intermediate canopy columns at midspan are founded in wide diaphragms that are cast into the U-beam at the fabrication plant with couplers provided for vertical column reinforcement. At the north face, pedestrian bridges (also constructed using precast U-beams designed by P.E. Structural Consultants), which connect the building/bridge structure to the nearby parking structure, are supported by brackets cast onto the side of the outermost U-beam in four spans.

- **Transition Beams** — Custom precast, prestressed rectangular sections were fabricated with pockets to receive the building beams and dapped ends to fit the bent cap. The 5 ft 11 in. (1.80 m) depth of transition beams is dictated by the required alignment with the building elements. It should be noted that the beams are by far the heaviest elements in the elevated roadway structure.

- **Lighting** — Suspended fixtures, which provide both uplighting and ground level illumination, highlight the coffered ceiling effect of the underside of the superstructure. The fixtures are placed in two rows per typical span and between each U-beam. The precast deck panels were cored with 4 in. (102 mm) diameter holes [between prestressing strands spaced at 6 in. (152 mm)] to receive round junction boxes. Conduits for wiring were laid out on the panels and cast into the topping slab.

- **Substructure Details Repeat Geometry of Precast Beams** — The bent cap cross section, with the bent infill panel, is shown in Fig. 6. Note that the faces of the inverted-tee ledges, which are typically vertical, are canted from the vertical at the same 4:1 slope as the web of the U-beam. The cast-in-place infill panel between precast beams extends the canted faces of the bents to the underside of the precast bridge deck. Bent end windwalls complete the

---

Fig. 8. Erection of precast U-beam.

Fig. 9. Precast U-beam in place.

Fig. 10. Precast stay-in-place deck panels.
closure for the U-beam superstructure and provide a unified appearance (see Fig. 7). The consistency of bent cap and beam geometry combine with the relative proportions of structural elements to provide an aesthetic that has been very well received.

- **Drainage** — The space between U-beams, between the face of the bent cap stem and the infill panel, provides a chase in which to conceal the routing of the deck drainpipes. To achieve a watertight canopy, bridge deck surface water is collected in deck drains and routed through the bent cap and columns into storm drains.

- **“Pigeon-Free” Design** — The bent infill panels also eliminate bird roosting areas by closing in the ledge of the inverted tee bents between adjacent precast beams. Because the structure serves as a canopy above heavily used pedestrian areas, this feature was of paramount importance to the owner.

**CONSTRUCTION HIGHLIGHTS**

Bid documents for the new Airport Terminal, including the elevated bridge structure, were released in May 1996, and the contract was awarded to the contractor in August 1996. Value engineering redesign efforts began in April 1997 and the Value Engineering Change Proposal documents for the redesigned bridge structure were issued in December 1997.

The precast U-beams and transition beams were manufactured by Texas Concrete Company (a PCI Plant Certified Member) headquartered in Victoria, Texas. A total of 121 Type U40 beams comprising 9631 linear ft (2945 m) were produced. In addition, 11 precast transition beams totaling 820 linear ft (250 m) were fabricated. The precast beams were shipped to the project site, a distance of about 100 miles (160 km), by truck trailer.

In addition to the U-beams and transition beams, 99,540 sq ft (9727 m²) of stay-in-place deck panels were used on the bridge.

Figs. 8, 9 and 10 show various phases of erection of the precast com-

---

Fig. 11. Completed bridge in service. Overhead pedestrian bridges can be seen at left.

Fig. 12. Underside view of completed bridge.

Fig. 13. Side view of completed bridge.

Bridge construction was substantially complete by December 1998. Afterwards, the bridge was used for construction traffic and access during the completion of the terminal building construction.

Figs. 11, 12 and 13 show various views of the completed project. The new airport facility was open to the public in May 1999.

CONCLUDING REMARKS

This bridge has already attracted local and regional attention, having been featured in a newspaper article and a regional construction magazine. Both articles focused on the unique characteristics of the precast concrete system. In addition, the project has been very well received by the owner, architect, contractor, and the public.

By utilizing the newly developed U-beam section, responding to the unique demands of the project, and developing specialized details to address structural and aesthetic concerns, the precast alternate provides the owner with an aesthetically sensitive structure, while saving a significant amount of money and construction time.

A major contributor to the success of the project was the availability of the new standardized precast U-beam section. The U-beam section offers structural efficiency, aesthetic value, and in this project defined the geometric vocabulary which was used in the aesthetic enhancement and visual unification of the bridge structure.

Having participated in the development of this beam section, the authors are pleased that this bridge is the first U-beam structure to be built in the Austin area and that this bridge, in a sense, serves as a gateway to the Capital of Texas.

REFERENCE