Extradosed Finback Design and Progressive Span-by-Span Erection for the Selmon West Extension Project

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For the Selmon West Extension in Tampa, Fla., a creative and prototypical post-tensioned structural system was conceived to accommodate the progressive span-by-span segmental erection method needed to meet project constraints. As an enhancement to existing conventional techniques for segmental construction, the extradosed finback solution was used for its ability to efficiently reduce the depth, weight, and cost of the superstructure, and to provide structurally functional aesthetic elements in the form of finbacks at interior piers.

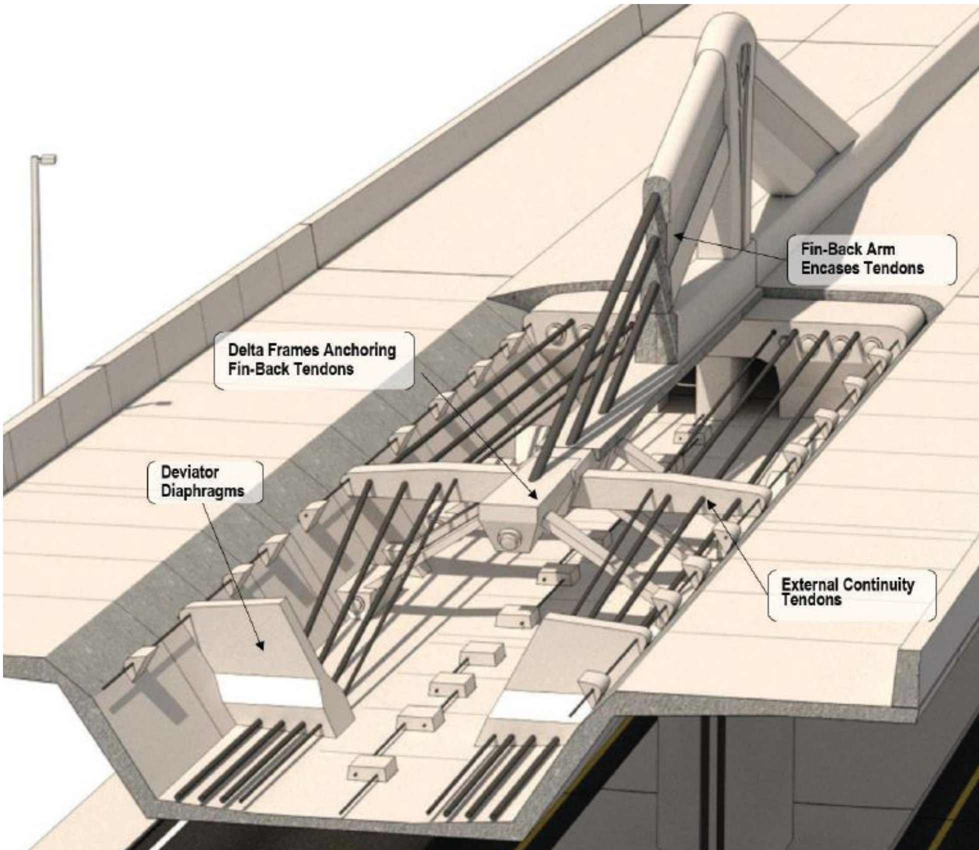
Extradosed Finback Design

Extradosed finback design combines a segmental post-tensioned box-girder bridge with many of the advantages of cable-stayed bridges without the complications and requirements of a typical cable-stayed structure. The extradosed tendons (tendons exterior to the superstructure cross section) in the finback replace several of the typical internal or external tendons normally contained within the concrete box-girder cross section. These extradosed tendons have shallow trajectories from the finback tendon anchorages just below the deck surface on each side of the pier and are deviated over short towers at each interior pier. The shallow angles of these tendons result in the transmission of a large compression force into the bridge deck, allowing the tendons to function in a similar manner to conventional flexural bridge prestressing. The cast-in-place finback behaves as a frame and allows direct transmission of load via tension through the precompressed finback arms down through the short tower and then to the foundations, providing robust and efficient load paths.

The geometric design of the finback accommodates vertical and horizontal curves, as well as superelevations associated with the project. For curved horizontal alignments, the fin arms were angled to intersect the box girder at the centerline of the structure and the finback tendons were deviated slightly within the fin arms and tower. Additional reinforcement to accommodate tendon deviation loads was incorporated into the finback design. Superelevation is addressed with the finbacks being normal to the deck as opposed to vertical and plumb.

A single-plane extradosed finback is located within the 130 ft pier section (negative moment region) along the centerline of the bridge. Unlike conventional extradosed bridges, the extradosed tendons are completely encased in a cast-in-place concrete fin. This design protects the tendons from vehicular impact; significantly increases the stiffness of the overall structural system; and allows for the use of conventional post-tensioning hardware, ducts, and flexible wax filler instead of expensive cable-stay systems. Three large, multistrand extradosed tendons (up to thirty-one 0.6-in.-diameter strands) anchored at interior delta frames fully prestress the concrete fins and provide a significant portion of the negative moment capacity for the span. The extradosed finback tendons are designed as unbonded tendons and

Cutaway view of a finback and segmental box girder system showing post-tensioning tendons, delta frame finback tendon anchorages, and continuity tendon deviator locations. All Figures: Kiewit/AECOM.



Photograph showing stages of construction of finback structure of the Selmon West Extension. Temporary shoring towers to allow erection of the next section of the bridge using the progressive span-by-span method are shown in the foreground. Several spans with their finbacks are visible in the background. Photo: Tampa Hillsborough Expressway Authority.

are detailed to be fully replaceable, in accordance with the Florida Department of Transportation's post-tensioning requirements.

The box-girder segments making up the pier section are post-tensioned with multistrand top- and bottom-slab tendons before the concrete fin is constructed. The fins are monolithic with the box girder and median barrier at the approximate quarter points of the pier section, and the tower is cast integrally over the pier diaphragm. Thus, the pier section behaves similarly to a stiffened king-post truss and tends to rotate as a rigid body under unbalanced loading.

Between the fins and at the end spans, the drop-in section is composed of multiple precast concrete segments and configured like a typical box girder, which spans continuously from fin to fin and from fin to pier. Six external post-tensioning tendons are anchored at each pier diaphragm and run high through the pier section, then deviate down at the second finback anchor segment toward deviator diaphragms as the tendons approach midspan. Several internal bottom-slab tendons run through the drop-in section and are anchored in bottom-slab blisters. The external and internal post-tensioning create continuity between the pier sections and drop-in sections and provide the positive moment strength required at midspan. The described design allows for a shallower and lighter superstructure than could be achieved with conventional segmental construction. Where a conventional segmental box girder would generally require a depth of 10 ft for a 260 ft span, the extradosed finback design only requires an 8-ft-deep section, for a total span-to-depth ratio of 32.5 for the 260-ft maximum span.

When compared with a conventional balanced-cantilever erection design, this creative use of post-tensioned concrete for the superstructure reduced the concrete quantity (and weight) by 13%, and reduced the post-tensioning quantity by 16%. The reduced superstructure weight and associated construction loading on the permanent foundations also led to reductions in substructure size and quantities. The combination of quantity reduction and the single-heading construction scheme achieved significant cost savings and schedule compression over the concept design provided in the request for proposal.

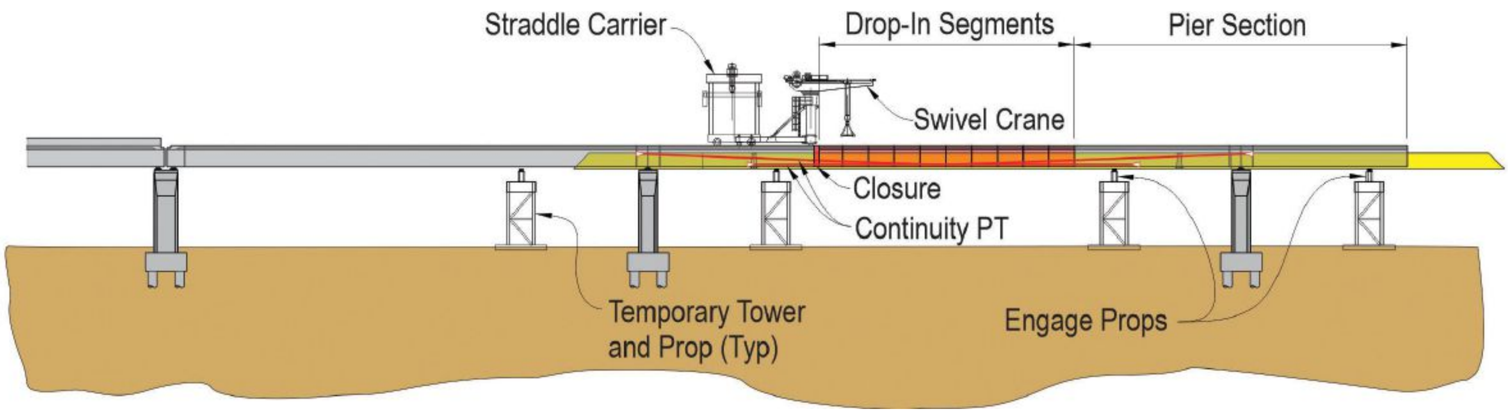
Extradosed Finback Construction Sequence

Construction of a finback bridge is a hybrid solution that combines balanced-cantilever and span-by-span techniques, referred to as progressive span-by-span erection. Use of underslung erection girders resulted in a top-down construction approach that created an elevated work zone. Segments were delivered from the casting yard to the project site and placed from atop the completed portions of the viaduct.

As spans were completed, temporary towers were advanced. Segment installation, post-tensioning, and erection girder advancement activities were performed at night when the inside lanes next to the median could be closed.

The following steps describe the construction sequence for each unit:

- Construct temporary towers adjacent to piers. Launch erection girders (supported by three towers).
- Deliver precast concrete segments via completed bridge. Place pier-section segments on erection girders with swivel crane.
- Roll cantilever-section segments into position over pier on erection girders. Epoxy joints, and tension top and bottom cantilever-section tendons.
- Engage jacks at towers supporting pier section. Lower erection girders and adjust for drop-in segments. Place segments with swivel crane. Roll segments into position, epoxy joints, and cast closure pour. Tension continuity tendons. Inject flexible filler to protect the tendons shortly after all continuity tendons are tensioned, within 14 days of tendon placement at most.
- Advance erection girders, straddle carrier, and swivel crane. Construct next pier section using the previously described steps.
- Construct drop-in section between completed pier sections.
- Advance erection girders, straddle carrier, and swivel crane. Cast finback at previous pier. Tension finback tendons, which run continuous from one delta-frame anchor in the box girder over the tower, with the appropriate deviation radii, and back down to the other delta-frame anchor.



Schematic of progressive span-by-span erection with drop-in segments (orange) in place. Launching girders are shown in yellow. Finbacks are not shown because they were not installed until the construction operation moved to the next span.

- Continue previously described steps to complete unit. Construct remaining barriers (that is, the barriers that are not part of the median barrier in the finback assembly).

Conclusion

As the Selmon West Extension shows, the combination of the extradosed finback design and the progressive span-by-span erection method offers the following advantages:

- A constant-depth single-cell concrete box girder that is 20% shallower than a conventional segmental design
- Improved redundancy by providing an additional load path
- Reduced foundation loads
- Smaller footprint in the median to avoid turning-lane impacts on surface-street traffic
- Reduction in substructure and post-tensioning quantities
- Spans of up to 260 ft

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