

Demystifying Concrete Segmental Design

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The development of post-tensioned concrete and its application to concrete segmental bridges began in Europe after World War II to address war damage and steel shortages. The firms of Freyssinet (France) and Dyckerhoff & Widmann (Germany) were among the primary proponents of post-tensioned concrete segmental design. The technology rapidly spread and was introduced to the United States in the early 1970s. Meanwhile, as the technology evolved, so did the need for reference documents for designers of these unique structures.

Origins in the United States

The first concrete segmental bridge built in the United States was the JFK Memorial Causeway on Texas Park

Road 22 in Corpus Christi, Tex. (Fig. 1). This bridge was constructed for \$2.5 million using the precast concrete balanced-cantilever method and opened to traffic in 1973. Segments for this bridge were cast off site and joined using epoxy resin and post-tensioning tendons. (See the Summer 2021 issue of *ASPIRE*[®] for information on the long-term performance of this first-of-a-kind structure.)

The bridge was designed referencing the prior knowledge and experience gained in Europe, as well as research conducted by Dr. John E. “Jack” Breen and colleagues at the University of Texas at Austin. A summary report derived from this research, *Design Procedures for Long-*

Span Prestressed Concrete Bridges of Segmental Construction, was funded by the Texas Highway Department (TxDOT) and published in 1969.¹

Less than a year after the completion of the JFK Memorial Causeway, the Pine Valley Creek Bridge in San Diego County, Calif., opened to traffic in 1974. This structure consists of twin bridges constructed using the balanced-cantilever method, with constant-depth, cast-in-place segments. At that time, creep and shrinkage were not well understood. To accommodate creep and shrinkage, constructors used a system of hydraulic jacks to induce a bending moment into the segmental box girder before placement of the closure pours to create a stress condition that emulated a comparable structure built on falsework. This strategy proved highly successful—the structure has been in service for more than 50 years with no perceivable additional deflection. See Fig. 2 for a contemporary photo of the bridge.

The American Segmental Bridge Institute’s *Design Manual for Concrete Segmental Bridges* is a free downloadable resource.

Figure 1. JFK Memorial Causeway in Texas is recognized as the first precast, post-tensioned concrete segmental bridge built in the United States. Built in 1973, the structure connects Corpus Christi to North Padre Island. All Figures and Photos: American Segmental Bridge Institute.

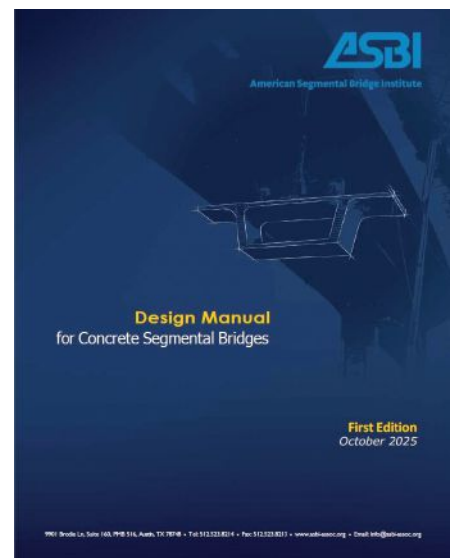




Figure 2. Pine Valley Creek Bridge in Pine Valley, Calif., is the first long-span concrete segmental box-girder bridge in the United States built using the cast-in-place balanced-cantilever method.

With these two projects completed within a year of each other, the concrete segmental method of construction was established in the United States. Nearly 500 additional concrete segmental bridges carrying vehicular traffic—along with countless others supporting light rail, people movers, heavy rail, and other transportation modes—have since been erected in the United States. Among the most notable examples is a concrete segmental bridge supporting a skyscraper for the Manhattan West project in New York City, a project featured in the Winter 2015 issue of *ASPIRE*.

Guidance on the design and construction of concrete segmental bridges in the United States was initially very limited. In 1978, the Post-Tensioning Institute (PTI) and the Precast/Prestressed Concrete Institute (PCI) copublished two documents, the *Precast Segmental Box Girder Bridge Manual*² and the *Post-Tensioned Box Girder Bridge Manual*,³ which provided guidance on the state of the practice at the time. In 1982, John Wiley and Sons published *Construction and Design of Prestressed Concrete Segmental Bridges*⁴ by Walter Podolny and Jean Muller. This book summarized many of the existing, and planned, concrete segmental structures at the time, and provided readers with insight into their designs. It is much revered to this day for the historical information it

contains. All three of these references are now out of print.

In 2016, the Federal Highway Administration (FHWA) published the *Post-Tensioned Box Girder Design Manual*.⁵ This manual provides information on the analysis and design of cast-in-place concrete box-girder bridges. However, it does not specifically address concrete segmental bridges and is only current through the sixth edition of the American Association of State Highway and Transportation Officials' *AASHTO LRFD Bridge Design Specifications*,⁶ published in 2012.

Current Practice

One current reference document for concrete segmental design is Chapter 14 of the fourth edition of PCI's *Bridge Design Manual*, which was published in 2023.⁷ The chapter is entirely dedicated to precast concrete segmental bridges and includes example calculations. The manual is available as a free download from the PCI website (<https://doi.org/10.15554/MNL-133-23>).

In 2025, the American Segmental Bridge Institute (ASBI) published the *Design Manual for Concrete Segmental Bridges*.⁸ This manual, which is available as a free download from the ASBI website (<https://asbi-assoc.org/resources>), provides updated information on the current state of the art in concrete segmental bridge

technology and design. It addresses both precast and cast-in-place concrete segmental bridges and therefore supplements the information found in PCI's *Bridge Design Manual*. Both the PCI and ASBI manuals are current through the ninth edition of the *AASHTO LRFD Bridge Design Specifications*.⁹

The ASBI manual is organized to follow the chronological sequence from concept development through final design and detailing. Additional resources are included in the appendices, including references, sample plans, and a design example for a cast-in-place balanced-cantilever superstructure. The first chapter presents examples of completed concrete segmental bridge projects, highlighting a wide range of solutions and the adaptability of concrete segmental bridges to project-specific needs and environments. Intermediate chapters address the various stages of design development for concrete segmental bridges. The concluding chapter covers sustainability, durability, and serviceability, and introduces emerging technologies related to both design and materials.

The intended audience for the ASBI manual includes owners, engineers, and contractors with little or no experience in concrete segmental bridges. This manual also serves as a compendium of design practices for the two most common

methods of constructing concrete segmental bridges—span-by-span and balanced-cantilever structures.

Throughout their history, concrete segmental bridges have undergone continual improvement. Early design assumptions related to prestress losses, creep and shrinkage of concrete, shear design, and geometry control have been significantly refined. This is not to suggest that older designs are deficient, but rather that modern designs are more precise.

Advancements in software have also enhanced designers' ability to efficiently analyze time-dependent effects, which are integral to concrete segmental bridge behavior. Preliminary design requires analysis tools capable of modeling erection sequences as well as creep, shrinkage, and post-tensioning relaxation. While software has streamlined calculations, it remains essential for designers to understand the underlying mechanics. For this reason, the ASBI *Design Manual for Concrete Segmental Bridges* includes a design example of a three-span, cast-in-place balanced-


cantilever bridge constructed using the form traveler method.

Conclusion

While no single resource can make someone an expert, the new ASBI *Design Manual for Concrete Segmental Bridges* offers a strong foundation in concrete segmental methods and can serve as a gateway to a deep understanding of concrete segmental bridge design and construction.

References

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- Chapter 3 – General Design and Testing
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