

Overview of the Pennsylvania Standard Plans for Low-Cost Bridges

FRED W. BOWSER, FRED S. FABER, Jr., HEINZ P. KORETZKY, and M. G. PATEL

ABSTRACT

As one of several steps to address the massive and worsening bridge problem, the Pennsylvania Department of Transportation decided to develop ready-to-use, low-cost bridge design standards for small bridges. Buchart-Horn, Inc., retained by the department, developed the standardized bridge plans for 18-35 ft, 30-90 ft, and 90-130 ft span ranges, using steel, concrete, and prestressed concrete materials. The standards for timber and buried structures will be published soon. Three types of superstructures and two or three types of substructures, including pile-supported footings for each series, have been incorporated. Each set of standards includes and illustrates step-by-step procedures for developing a set of bridge plans from the standards. The data assembly (computations) sheets and blank plan sheets for a bridge with spaces provided for dimension insertion are included. The user completes them based on field information, geometry, and soil conditions. The completed sheets become construction plans. The contractor, when preparing bids, has the option of building the structures specified in the contract or developing an alternate structure from the standards based on the predefined parameters in the contract. The plans are approved for federally funded projects. The ultimate goal is to expedite and economize bridge replacement efforts while minimizing inconvenience to the public. Although this is not an ultimate answer, it is a step in a positive direction. The productivity realized using these standards will be enhanced when they are incorporated in the Computer Aided Design and Drafting system.

Because the structural portion of bridge engineering is nearly a perfect science, several attempts have been made to standardize bridge design, drafting, and construction. However, because of the uniqueness of each bridge, due to such things as variations in soil condition, highway geometry, required waterway opening, traffic conditions, and environmental aspects, each bridge is nearly custom tailored. During the early years when bridges were constructed at certain alignments and the approaches were built to meet the bridges, standardizing bridges was relatively simple. The Pennsylvania Department of Transportation (then the Department of Highways) in the 1920s and 1930s had developed and used bridge standards for width, span, skew, and vertical opening. Design standards for concrete arches, as an example, were published as early as March 1924. Bridges were constructed using these standards without developing custom-tailored detailed drawings.

Even though the standardized bridge plans lost their popularity due to geometric constraints, the design standards continued to evolve to simplify, expedite, and economize the bridge design process.

In the 1960s, when alternate bidding for bridges was in full swing, detailed standards for prestressed concrete structures were issued that simplified and virtually eliminated the need for long-hand superstructure design. These standards were further refined and updated in the 1970s.

In 1981 the department contracted with Buchart-Horn, Inc., consulting engineers from York, Pennsylvania, to develop ready-to-use standard plans for bridges spanning from 18 to 130 ft. These plans were to be developed to reflect low life-cycle construction cost, ease and speed of construction, and attention to safety, volume, and type of traffic and availability of materials. The consultant initiated a study to determine the current state of the art of "standard bridges." Federal and neighboring state agencies, vendors, material suppliers, and contractors and their societies were contacted to collect data on readily available products, bridge types, and innovative fabrication and construction practices (1). Site visits were also made by the consultant to inspect actual structures for study and evaluation. After analyzing the collected data, the consultant was required to narrow down superstructure types to five. Based on the consultant's study, projected life-cycle costs, and considering competitive materials, the department selected three types of superstructure for standardization. This in practice reduced the choice from 19 possible bridge superstructure types to three each for the 18-35 ft, 30-90 ft, and 90-130 ft span ranges. The substructure types were narrowed down from seven to three for the 18-35 ft span, to two for the 30-90 ft span, and to four for the 90-130 ft span ranges. The selection was based primarily on ease of construction, fabrication, and erection; economy; and proven performance.

The 18-35 ft and 35-90 ft span range standards were developed using the working stress design (WSD) method and published in June 1982 and October 1982, respectively. Since then the department has switched to load factor design (LFD) combined with increased live load and other design criteria modifications.

The time schedule given in Table 1 has been established for completion of the series. During 1980 the department reintroduced an alternate bidding policy under which contractors are permitted to bid on their own design in lieu of the department-supplied design that is part of the contract proposal. The bridge low-cost (BLC) standards were introduced in time to assist the contractors in designing alternates. Not only do these standards save substantial design and drafting time for the department, they also permit the contractor to quickly develop biddable bridge quantities for an alternate bridge of his choice, from the standards, without fear of rejection of his design after the project is awarded.

FORMAT OF STANDARDS

The standards are composed of design sheets and con-

TABLE 1 Time Schedule

Steel and Concrete Structures			Buried Structures			Timber Structures		
Span Range (ft)	Bridge Low-Cost Standard	Issue Date	Span Range (ft)	Bridge Low-Cost Standard	Issue Date	Span Range (ft)	Bridge Low-Cost Standard	Issue Date
18-35	520	10/83	6 ^a	530	8/84	18-35 ^b	550	5/84
30-90	510	7/83				30-90 ^b	540	2/84
90-130	500	11/83						

^aWill be dictated by the physical limitations of the buried structure types selected for presentation.

^bOnly working stress design (WSD) criteria will be used.

struction sheets. The design sheets include (a) general information, design criteria, instructions for use, and design examples for each type of substructure and superstructure and (b) data assembly sheets for each superstructure and substructure type. The construction sheets include (a) detailed drawings for each superstructure type with left and right skews, (b) detailed drawings for each substructure type with left and right skews, and (c) stakeout sheet.

To provide maximum versatility, these standards accommodate (a) any curb-to-curb width between 22 and 48 ft and (b) any structure skew angle between 45 and 90 degrees. Standardized substructures are provided with variable heights (bottom of footing to top of stem) from 4 to 16 ft for 18-35 ft spans, from 4 to 20 ft for 35-90 ft spans, and from 5 to 22 ft for 90-130 ft spans.

The bridge superstructure and substructure types given in Table 2 were selected for the bridge standards. With three types of superstructures and two to four types of compatible and interchangeable substructures from which to choose, the designer is able to adapt the standards to fit most applications.

TABLE 2 Superstructure and Substructure Types

Superstructure Types	Substructure Types
18-35 ft Span Range (2)	
Adjacent prestressed box beam	Concrete breastwall
Adjacent precast channel beam	Concrete stub abutment
Concrete deck on steel beams	Concrete pile cap
30-90 ft Span Range (3)	
Adjacent prestressed box beam	Spread footing cantilever
Concrete deck on prestressed spread box beams	Pile-supported stub
Concrete deck on steel beams	
90-130 ft Span Range (4)	
Composite steel I-beam	Spread-footing stub
Composite prestressed I-beam	Pile-supported stub
Composite prestressed adjacent box beams	Spread-footing cantilever
	Pile to supported cantilever

All superstructure types employ a cast-in-place concrete safety parapet that is cost-effective on a life-cycle basis because of minimal maintenance costs.

DESIGN PROCEDURE

Because the drawings cannot be reproduced here, the descriptive design procedure method has been used. The standards can be obtained, however, by writing to PennDOT Publication Sales Store, Room 110, T&S Building, Harrisburg, Pa. 17120.

Before using these standards, the designer must obtain basic survey and geometric data for the proposed construction site. Information concerning the foundation material and elevation of potential foundation bearing areas must also be obtained. When the necessary data assembly and construction sheets have been selected, the designer is ready to begin producing final contract drawings. The following simple steps are followed in the plan preparation process:

1. Complete the data assembly sheet for the superstructure type selected: (a) Answer the listed questions. (b) Fill in the control stations and elevations table. (c) Complete the control dimensions table; reference to supplemental tables, figures, and geometric equations is required; work the table from top to bottom. (d) Determine the deck geometric condition by making the test comparison indicated under "Deck Configuration" (for steel beam structures only). (e) Complete the reinforcing steel table as required. (f) Complete the superstructure quantities table. (g) Compute elevations and dimensions for substructure design by filling out the appropriate tables.

2. Complete the data assembly sheets for the substructure type selected: (a) Enter the abutment number in the drawing title block (a separate data assembly sheet is required for each abutment). (b) Complete the control dimensions table; refer to geometric equations and supplemental tables and figures as required. (c) Compute the work point station at the front face of the abutment stem and enter in the stakeout control table. (d) Complete the reinforcing steel table. (e) Complete the substructure quantities table.

3. Transfer the appropriate information from the data assembly sheets to the fill-in spaces on the standard construction sheets: (a) Information from the superstructure data assembly sheet should be placed in the appropriate fill-in slots in the standard superstructure drawings; coded letters and numbers are provided to facilitate the correct placement of dimensions and other data. (b) Elevations and dimensions for substructure design must be transferred from the superstructure data assembly sheet to the standard substructure drawings. (c) Information from the substructure data assembly sheets must also be transferred to the standard substructure drawings through the use of the codes provided. (d) Complete the appropriate stakeout drawing by reference to the substructure data assembly sheets.

4. Add titles and complete quantity estimates and add miscellaneous information: (a) Customize the standard drawings by adding necessary location and route number information to the title block of each sheet. (b) Compute quantities for excavation, structure backfill, and other items not specifically provided for on the data assembly sheets; all quantities should be posted in the quantity estimate block of the general plan sheet for the structure. (c) Add necessary information pertaining to utilities, hy-

draulic data, and roadway alignments. (d) Add sub-surface exploration information as required.

The completed set of drawings assembled from these standards should be reviewed and signed by a registered professional engineer before the plans are submitted to the department for approval. In the case of a contractor's alternate design, the approval of the plans by the department will officially allow the contractor to begin construction.

ADVANTAGES AND DISADVANTAGES

Advantages to the preparation of bridge design and construction plans using the BLC standards are that the standards

1. Give on the average a most economical structure based on life-cycle cost;
2. Allow expeditious design and drawings development (1 day bridge design and drawing are possible, if a computer is used);
3. Reduce project design costs;
4. Permit quick and reliable alternate design by contractors;
5. Induce keen competition among contractors and suppliers, and thus economize on initial construction costs;
6. Make a modified turnkey concept achievable;
7. Standardize details and thereby simplify construction; and
8. Reduce potential for costly errors.

Disadvantages of using the BLC standards are that

1. Standards are not usable for complex geometries and outside the preestablished parameters;
2. Designers lose the feel for the "right" proportioning of a structure and lose their proficiency in making the tedious computations required for conventional design;
3. Dimensional computation errors may not be caught because drawings are not to scale;
4. Regular supplementary geometry computations are needed for bridges having vertical or horizontal

geometry or both; the standards can hardly be used for bridges with sharp horizontal curves;

5. Some earthwork computations require scale drawings; and

6. Use of such detailed standards retards innovation.

WHAT LIES AHEAD

In the future the equations are to be computerized to achieve 1-day bridge design and drawing. This is a part of the consultant's assignment. However, completion of all the standards is the first priority. In addition, the standards will be incorporated in Computer Aided Design and Drafting to develop instant designs and drawings to scale.

The ultimate goal of this effort is to expedite any bridge replacement efforts and accomplish the project in an economical, cost-effective manner while minimizing the inconvenience to the traveling public. Although this is not an ultimate answer for dealing with the many bridge problems in the commonwealth, it is a step in the right direction. Complex structures will continue to require custom design by knowledgeable professional engineers.

REFERENCES

1. Phase A Summary Report--Data Gathering. Buchart-Horn, Inc., York, Pa., Oct. 1981.
2. Standard Plans for Low Cost Bridges (BLC-400). Publication 182. Pennsylvania Department of Transportation, Harrisburg, June 1982.
3. Standard Plans for Low Cost Bridges (BLC-410). Publication 183. Pennsylvania Department of Transportation, Harrisburg, Oct. 1982.
4. Standard Plans for Low Cost Bridges (BLC-500)--Load Factor. Publication 17. Pennsylvania Department of Transportation, Harrisburg, Dec. 1983.

Publication of this paper sponsored by Committee on General Structures.