Table 1—Recommended Proportioning Guidelines for Extradosed Prestressed Concrete Bridges

Parameter	Guideline
Common span range	300 to 600 ft
Side span-to-main span ratio	0.6
Girder depth at tower*	25 to 35
Girder depth at midspan†	50
Tower height above deck‡	1/10

* Guideline on ratio of main span length-to-girder depth at tower.
† Guideline on ratio of main span length-to-girder depth at midspan.
‡ Guideline on ratio of tower height above deck-to-main span length.

Application of Recommendations

The side span-to-main span length ratio for the Pearl Harbor Memorial Bridge is 0.48, which is at the low end of the recommended range. The span length was selected for the Pearl Harbor Memorial Bridge based on geometric constraints. In final design, the result of this relatively short side span was an uplift condition at the anchor piers under certain live-load conditions.

A concrete counterweight was cast inside the box girder at each anchor pier to balance this uplift condition and result in a net positive reaction under all load conditions. It is noted that if the side spans were shortened even more, this uplift condition would become a significant design issue. Therefore the lower range limit to the side span ratio is an important design parameter.

The tower height selected for the Pearl Harbor Memorial Bridge (measured from deck level to the uppermost cable) is 60 ft. This gives an *H*/*L* of 1/8.6. The tower height for the Pearl Harbor Memorial Bridge was selected with a slightly taller tower height than the suggested value, but well within the suggested range. This decision was made based on the wide deck of the bridge, and the desire to reduce demand on the girder system.

A girder depth of 16.4 ft at the towers was selected in order to provide adequate negative moment capacity for the cantilever construction of the girder prior to installation of the first stay. This gives a span-to-depth ratio of 31.4, in the middle of the recommended range. At midspan, a depth of 11.5 ft was selected. This depth was chosen in part to provide a 6.5 ft internal clear height within the box girder for inspection access purposes. This depth gives a span-to-depth ratio of 45, close to the recommended range. For more information about this bridge, see *ASPIRE*™ Fall 2012.

Closing Remarks

Extradosed prestressed concrete bridges are an emerging bridge technology, applicable to bridges in the 300- to 600-ft span range. Basic proportioning parameters for this bridge type are well understood and are summarized in Table 1.

Reference

1. Stroh, Steven L., 2012. *On the Development of the Extradosed Bridge Concept*, a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Department of Civil and Environmental Engineering, College of Engineering, University of South Florida, Tampa, February 8, 2012.

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For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.

AESTHETICS COMMENTARY

by Frederick Gottemoeller

In the Fall 2012 issue of *ASPIRE*, I commented on the aesthetics of the Pearl Harbor Memorial Bridge in New Haven, Conn., identifying three aesthetic challenges for extradosed bridges:

- the appropriate shape for the towers
- the appropriate size and shape of the girder
- striking a good visual balance between the girder and the towers

This article provides specific proportioning guidelines for tower heights and girder depths based on structural considerations. Aesthetic considerations suggest that girder depths should be near the shallow end of the depth range to have the best appearance. However, aesthetic considerations don't provide such clear guidance with regard to tower height. Considering the tower only, one might think that taller would be better. But the eye judges the combination of tower, cable array, and girder together, not the three elements separately. The eye most strongly reacts to the ratio of the tower height and the girder depth (at the tower) to the span length. The higher that ratio (thus the shorter the tower) the more graceful will the bridge appear. Inevitably the short tower will appear stubby. So, what is the solution for that?

The two Japanese bridges deal with a short, stubby tower by tapering it vertically. The Odawara Port bridge minimizes the apparent thickness of the tower at the top by accommodating the cable anchorages in a separate element that protrudes from the body of the tower. The contrast in thickness between the base and the top makes the top seem smaller than it really is.

The Ibi River bridge takes a different approach. It uses a compound taper to minimize the width of the tower as soon as it emerges from the deck. Having a single row of towers and planes of stays along the median simplifies the appearance of this bridge and makes the structural achievement seem even more dramatic.

In tower design, as in any aesthetic endeavor, it is wise to remember that there are many options available.