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Bridge Design - Steel Plate Girders

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STEEL PLATE GIRDERS

1.1 INTRODUCTION

Girder bridges are structurally the simplest and the most commonly used on short to medium span bridges. Figure 1.1-1 shows the Central Viaduct in San Francisco. Steel I-section is the simplest and most effective solid section for resisting bending and shear. In this course straight composite steel-concrete plate girder bridges are discussed. Design considerations for span and framing arrangement, and section proportion are presented. A design example of the three span continuous composite plate girder bridge is given to illustrate the design procedure. For a more detailed discussion, reference may be made to texts by Chen and Duan (2014), Baker and Puckett (2013), FHWA (2012), and Taly (2014).

Figure 1.1-1 Central Viaduct in San Francisco

1.2 STRUCTURAL MATERIALS

1.2.1 Structural Steel

ASTM A 709 or AASHTO M 270 (Grades 36, 50, 50S, 50W, HPS 50W, HPS 70W and 100/100W) structural steels are commonly used for bridge structures. Chapter 6 provides a more detailed discussion.

1.2.2 Concrete

Concrete with 28-day compressive strength $f_c' = 3.6$ ksi is commonly used in concrete deck slab construction. Caltrans MTD 10-20 (Caltrans, 2008) provides concrete deck slab thickness and reinforcement. The transformed area of concrete is used to calculate the composite section properties. For normal weight concrete of $f_c' = 3.6$ ksi, the ratio of the modulus of elasticity of steel to that of concrete, $n = E/E_c = 8$ is recommended by AASHTO (2012).

For unshored construction, the modular ratio n is used for transient loads applied to the short-term composite sections, and the modular ratio $3n$ is used for permanent loads applied to the long-term composite sections.

1.3 SPAN AND FRAMING ARRANGEMENT

1.3.1 Span Configuration

Span configuration plays an important role in the efficient and cost-effective use of steel. For cases where pier locations are flexible, designers should optimize the span arrangement. Two-span continuous girders/beams are not the most efficient system because of high negative moments. Three- and four-span continuous girders are preferable, but may not always be possible. For multi-span continuous girders, a good span arrangement is to have the end span lengths approximately 70 to 80 percent of the interior span lengths. Equal interior span arrangements are also relatively economical. A span configuration with uplift due to live load plus impact should be avoided.

The use of simply supported girders under construction load and continuous girders through steel reinforcement for live load can be an economical framing method (Azizinamini, 2007). This type of framing presents possible advantages over continuous beam designs by eliminating costly splices and heavy lifts during girder erection. The potential drawbacks are that more section depth may be required and the weight of steel per unit deck area may be higher. This framing method needs to be investigated on a case-by-case basis to determine whether it can be economically advantageous.

When simply supported span configurations are used, special attention should be given to seismic performance detailing.

1.3.2 Girder Spacing

As a general rule, the most economical superstructure design can be achieved using girder spacing within an 11 ft. to 14 ft. range. For spans less than 140 ft., 10 ft. to 12 ft. spacing is preferred. For spans greater than 140 ft., 11 ft. to 14 ft. spacing is recommended. The use of metal deck form panels will limit the spacing to about 16 ft. Girder spacings over 16 ft. may require a transversely post-tensioned deck system. Parallel girder layout should be used wherever possible.